KARNATAKA POWER TRANSMISSION CORPORATION LIMITED

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No: KPTCL/B19/345/85-86/26-27 (1)
E.O. No: 328339
Encl: FTC Procedure

Date: 15 JUN 2026

CIRCULAR

Sub: Implementation of First Time Charging (FTC) Procedure approved by KERC – reg.

Ref:
1. Karnataka Electricity Grid Code Regulations-2025 dated: 21.07.2025.
2. Procedure approved by KERC vide letter no: KERC/DDP/Vol-IV/2026-27/2018 dated: 21.05.2026.
3. Note approved by the Managing Director, KPTCL on 12.06.2026.

******

In compliance with Regulation 4.3(5) of the Karnataka Electricity Grid Code Regulations- 2025 and in consultation with the Grid Code Review Panel, a draft detailed procedure outlining the modalities for first-time energization and integration of new or modified power system elements was prepared and submitted to the Hon'ble Karnataka Electricity Regulatory Commission (KERC) for approval.

Accordingly, the Hon'ble Karnataka Electricity Regulatory Commission (KERC) has accorded approval to the First Time Charging (FTC) Procedure vide their letter cited under ref (2). The copy of the Detailed Procedure outlining the modalities for first-time energization and integration of new or modified power system elements is attached for kind reference.

Hence, all concerned stakeholders including Transmission System Users (TSUs), ESCOMs, Generating Companies, SLDC officials and other associated entities are hereby directed to strictly adhere to and comply with the approved FTC Procedure in all applicable matters.

The approved procedure shall come into force with effect from the date of approval by the Hon'ble Commission i.e., 21.05.2026 and all field offices / concerned authorities shall ensure meticulous compliance with the approved procedure and all actions undertaken henceforth shall be in accordance with the same.

15/6/2026

Chief General Manager (Tech)
KPTCL

Copy to:

1. The Chief Engineers (Elec), SLDC/ RT & R&D/ P&C, KPTCL, Bengaluru.
2. The Chief Engineers (Elec), Transmission (Operations) Zones, KPTCL.
3. The Financial Advisor, Regulatory Affairs, KPTCL, Bengaluru.
4. The Superintending Engineers (Elec), Transmission (Projects) Circles, KPTCL.
5. All ESCOMs / Generating Companies / Transmission System Users.
6. SPS to MD/ DP / DO, KPTCL, Bengaluru to place the same before MD / DP / DO.

ಕರ್ನಾಟಕ ವಿದ್ಯುಚ್ಛಕ್ತಿ
ನಿಯಂತ್ರಣ ಆಯೋಗ

KARNATAKA ELECTRICITY
REGULATORY COMMISSION

ಸಂಖ್ಯೆ : 16 ಸಿ–1, ಮಿಲ್ಲರ್ಸ್ ಟ್ಯಾಂಕ್ ಬೆಡ್ ಏರಿಯ,
ವಸಂತನಗರ, ಬೆಂಗಳೂರು – 560052.

No. 16 C-1, Millers Tank Bed Area,
Vasanthanagara, Bengaluru-560052.

KERC/DDP/Vol-IV/2026-27/2018

21.05.2026

The Managing Director,
KPTCL, Kaveri Bhavan,
Bengaluru-560009.

Sir,

Sub: Approval of FTC procedure - Reg.

Ref: 1. SLDC emails dated 11.05.2026.and 12.05.2026.
2. CEE/SLDC/727/31, dated 02.05.2026.
3. KERC/DDP/Vol-IV/2026-27/1951, dated 06.05.2026.
4. CEE/SLDC/2727-31, dated 24.03.2026.
5. KERC/DDP/Vol-IV/2025-26/1491, dated 19.01.2026.
6. KERC/DDP/Vol-IV/2025-26/591, dated 05.08.2025.

1. The Commission had notified Karnataka Electricity Grid Code Regulations, 2025 on 21.07.2025 in the Gazette. In view of this, the Commission vide letters cited reference (5) and (6) had directed the KPTCL to prepare and submit the procedures cited in Annexure-4 & 5 of these Regulations for approval and information of the Commission respectively, against the timelines specified, without fail.

2. SLDC vide its letter cited under reference (4) has submitted the draft First Time Charging (FTC) procedure for approval of the Commission.

3. The Commission has examined the proposal and also obtained the clarifications vide letter and emails cited under reference (1) and (2) required in terms of regulations, sought vide letter cited under reference (3).

4. In view of the above, I am directed to communicate approval of the Commission for **Detailed procedure covering modalities for First Time Energization/Charging (FTC) and integration of new or modified power system elements** and to take immediate action for implementation of said procedure in compliance of these Regulations.

Yours faithfully,

Secretary
Karnataka Electricity Regulatory Commission

Copy to:
1. Director (Operation), Chairman, Grid Code Review Panel, KPTCL, Bengaluru.
2. The Chief Engineer, State Load Dispatch Center, RC Road, Bengaluru.
3. OC/MF.

SLDC Detailed Procedure covering modalities for First Time Energization and Integration of new or modified power system element

[As per Karnataka Electricity Regulatory Commission
(Karnataka Electricity Grid Code) Regulations, 2025 (Dated 21.07.2025)]

Document Name:		**SLDC/FTE&I**	
Document Creation Date:		25/05/2026	
Version History			
Sl no	Description of Change	Date of Change	Revision No
1	Initial Document	25/05/2026	0.0

Table of Contents

Contents

SLDC Detailed procedure covering Modalities for First Time Energization and Integration of new or modified power system element: As per clause 4.3(5) of KERC-KEGC-2025

Introduction

This First Time Energization and Integration procedure is applicable to Intra-State transmission lines irrespective of voltage level/ownership, HVDC transmission lines and HVDC elements including Filter banks irrespective of voltage level/ownership, In-STS Transmission lines/Transformers/Reactors/FACTS Devices/Buses/Bays/any other element irrespective of ownership, Transmission lines/Transformers/Reactors/FACTS Devices/Buses/Bays/any other element connected at or emanating from In-SGS/In-STS substations, Generating Units those are intra state entities, Generating Transformer (GTs) /Station Transformers(STs) at generating stations those are intra state entities, Bulk Consumers or Load Serving Entities those are intrastate entities and Combined (Load & Captive) generation complex those are intrastate entities.

The Karnataka Electricity Regulatory Commission (KERC), vide Karnataka Gazette Notification No. KERC/KEGC/2025-26/514 dated 21.07.2025, has notified the Karnataka Electricity Grid Code (KEGC), 2025.

As per Clause 4.3(5) of the Karnataka Electricity Grid Code, 2025, First Time Charging (FTC) of any new or modified power system element connected to the State grid shall be carried out strictly in accordance with the procedure specified by the State Load Despatch Centre (SLDC). Compliance with the FTC procedure is mandatory and statutory, and shall be a pre-condition for energization, synchronization and commencement of operation. The same is quoted below:

"*4.3(5) SLDC, in coordination with STU and Grid Code Review Panel after due consultation of stakeholders, shall publish a detailed procedure covering modalities for first time energization and integration of new or modified power system element and finalize in line with NLDC first time energization/charging (FTC) procedure within sixty (60) days of notification of these Regulations and submit to the Commission for its approval. The procedure shall specify requirements for integration with the grid such as protection, telemetry and communication systems, metering, statutory clearances and modelling data requirements for system studies.*

Provided further that no connection shall be made unless first time energization and integration of new or modified power system elements is prepared and signed by all concerned parties.

4.3 (4) Post completion of all physical arrangements of connectivity and necessary site tests, the concerned user shall request the SLDC for permission of first time energization in the specified format as per the procedure published by SLDC."

Further, Annexure–4 of the Karnataka Electricity Grid Code, 2025 explicitly provides that the FTC Procedure shall be prepared and finalized after due stakeholder consultation by the Grid Code Review Panel (GCRP) constituted in accordance with Clause 2.2, and performing functions as specified under Clause 2.3, and then to be submitted to the Hon'ble Commission for approval & implementation.

The procedure shall specify requirements for integration with the grid such as protection, telemetry and communication systems; metering; statutory clearances; modelling data requirements for system studies and timeline for submission of data for system study.

In accordance with the above provisions procedure for first time energization and integration of a new or modified power system element belonging to any Intra State entity has been formulated to enable SLDC for secure and reliable integration of new elements. This procedure specifies the requirements to be fulfilled by the connectivity grantees prior to obtaining the permission of the SLDC. This procedure specifies operational and study requirements for integration of new or modified power system elements with the grid.

The following are prerequisite before First Time Energization and Integration of Power system elements in the grid:

a) Power Purchase Agreements (PPA), connectivity details and agreements.
b) Statutory safety clearances as per CEA or as per respective State government authorities,whichever applicable
c) PTCC clearance certificate (for transmission lines)
d) Compliances of various regulation/standards of CERC/KERC and CEA
e) Ensure to implement correct and appropriate protection settings as per RPC approved protection philosophy/guidelines and advised by STU
f) Real time SCADA data and telemetry at SLDC
g) Installation of meters as per provisions of CEA Metering regulations and as advised by SLDC for accounting purpose
h) Dedicated Voice /Data communication from generating Stations /substation in redundant and alternate path.
i) Static and dynamic modelling data for system studies
j) Compliances of relevant clauses of KEGC and operating procedures of SLDC
k) Compliance to any other regulations and standards specified from time to time

Based on the requirements, First Time Energization and Integration procedure is prepared by SLDC to be followed uniformly in all Discoms/Intra state entities and is divided into five sections as following:

Section 1: Common modalities to be followed for first time energization and integration of new or altered power system elements and issuance of certificate of successful trial run by State Load Despatch Centre (SLDC).

Section 2: Procedure for First Time Energization and Integration to In-STS, In-SGS connected conventional generating (Thermal, Gas & Hydro) plants, Bulk Consumers or Load Serving Entities and Combined (Load & Captive) Generation complex and issuance of Certificate of Successful Trial Run.

Section 3: Procedure for First Time Energization of Solar, Wind, BESS or Hybrid (Wind/Solar/BESS) Power Plants/Energy Storage/ Parks and issuance of Certificate of Successful Trial Run.

Section 4: Procedure for First Time Energization of new/refurbished HVDC and Issuance of Certificate of Successful Trial Run

Section 5: Procedure for First Time Energization of new/refurbished STATCOM/SVC and issuance of Certificate of Successful Trial Run

Section 6: Procedure for certification of commissioning of Communication equipment and issuance of certificate by State Load Dispatch Centre (SLDC)

For integrating new or modified power system elements in the grid, all concerned shall have to submit the Annexures (A1-A6), (B1-B5(a)), (B6-B8) and (C1-C5) as per the time line mentioned in Section 1 of this document in addition to the requirement described in the respective Sections.

Section 1: Common modalities to be followed for First time energization and integration of new power system elements and issuance of certificate of successful trial run by SLDC Charging/Energization of altered (including modified/replaced/upgraded) power system elements

Section:1(A) Common modalities for first time energization and integration of new power system elements and issuance of certificate of successful trial run by SLDC KEGC-2025 provides for preparation of detailed procedure covering modalities for first time energization and integration of new or modified power system element by SLDC. The same is quoted below:

"*4.3(5) SLDC, in coordination with STU and Grid Code Review Panel after due consultation of stakeholders, shall publish a detailed procedure covering modalities for first time energization and integration of new or modified power system element and finalize in line with NLDC first time energization/charging (FTC) procedure within sixty (60) days of notification of these Regulations and submit to the Commission for its approval. The procedure shall specify requirements for integration with the grid such as protection, telemetry and communication systems, metering, statutory clearances and modelling data requirements for system studies.*

Provided further that no connection shall be made unless first time energization and integration of new or modified power system elements is prepared and signed by all concerned parties.

4.3 (4) Post completion of all physical arrangements of connectivity and necessary site tests, the concerned user shall request the SLDC for permission of first time energization in the specified format as per the procedure published by SLDC."

In accordance with the above provisions, a procedure for first time energization and integration of new or modified power system elements belonging to any User of SLDC has been formulated to enable state grid users for their secure and reliable integration with grid. This procedure specify requirements for integration with the grid such as protection, telemetry and communication systems, metering, statutory clearances and modelling data requirements for system studies and timeline for submission of data for system study.

1. Scope and Applicability of the procedure:

This procedure is applicable for the following power system elements belonging to any User, as defined in KEGC-2025 and amendments thereof:

1. Transnational lines/elements irrespective of voltage level/ownership
2. Intra-State transmission lines irrespective of voltage level/ownership
3. HVDC transmission lines and HVDC elements including Filter banks irrespective of voltage level/ownership
4. Intra state Transmission lines/Transformers/Reactors/FACTS Devices/Buses/Bays/anyother element irrespective of ownership
5. Transmission lines/Transformers/Reactors/FACTS Devices/Buses/Bays/any other element connected at or emanating from In-SGS/In-STS substations
6. Generating Units those are intrastate entities.
7. Generating Transformer (GTs) /Station Transformers (STs) at generating stations those are intrastate entities.
8. Bulk Consumers or Load Serving Entities those are intra state entities.
9. Combined (Load & Captive) generation complex those are intra entities.

2. User Registration with SLDC:

All entities/asset owners intending to avail the Grid Access are required to be registered as a User with SLDC. The User registration form as per format is enclosed as Format-I.

3. Compliance to the extant regulations:

All entities/asset owners intending to avail the Grid Access shall be required to comply with all the applicable regulations as enacted or amended from time to time as per clause 4.2(1) of KEGC 2025 and amendments thereof.

4. Data Submission for carrying out Inter-connection Studies:

Entities/asset owners should get registered with SLDC as a 'User' at SLDC web portal, at the time of data submission for carrying out Inter-connection Studies. The User shall submit the necessary technical and modelling data of new power system elements six (6) months before the expected date of first energization as per following formats and models, for carrying out Inter-connection Studies, as per Clause 4.6 of KEGC 2025:

a. **Annexure A1**: Intimation by User regarding expected first time energization and integration of the power system element(s) along with the list of the desired documents being submitted.

b. **Annexure A2**: List of elements to be charged and their details.

c. **Annexure A3**: Single line diagram of the concerned sub stations, along with status of completion of each dia/bus/breakers clearly indicating which elements are proposed to be charged.

d. Technical details and Models and modelling data, as applicable for specific elements

5.Intimation to SLDC for first time energization and integration of power system elements:

All the Users intending to energize new power system elements falling under the scope of this procedure, shall intimate the SLDC about the details as per the formats given below, at least ten (10) working days prior to the anticipated date of first-time energization. The consideration of Day-1 for submission of application shall be as follows:

a. Application received till 15:00 hrs of a working day -Same day as Day-1
b. Application received after 15:00 hrs of a working day -Next working day as Day-1
c. Application received anytime on Non- working day -Next working day as Day-1

In case of any changes in the formats submitted at the time of interconnection studies, revised Annexures- A1 – A3 and model data (in respective formats) shall be submitted

a. **Annexure A4:** List of SCADA points to be made available to SLDC (SLDC would need all MW and MVAr data, voltage and frequency of all the buses, all the breaker and isolator positions, OLTC tap positions, Main-1/Main-2 protection operated signals, DC side SCADA data in case of HVDC station, data for FACTS Devices/ESS/Bulk Consumers as per requirement)

b. **Annexure A5**: Type and Location of Energy meters as per relevant CEA regulations
c. **Annexure A6**: Connection Agreement, site responsibility schedule wherever applicable along with all annexures

As per Clause 6 Sub-clause 7(1) of CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007 "Every connection of a requester's system to the grid shall be covered by a connection agreement between the requester and

(a)Appropriate Transmission Utility in case of connection to Inter-state transmission system or intra state transmission system as the case may be;
(c) Transmission licensee and Appropriate Transmission Utility, in case of inter-connection to a transmission licensee (tri-partite agreement).
7(2) The connection agreement shall contain general and specific technical conditions, applicable to that connection".

As per Clause 7 of CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007, a bi- partite/tri-partite (as applicable) agreement for Site Responsibility Schedule shall be submitted by the User. The following information shall be included in the Site Responsibility Schedule:

6. Site Responsibility Schedule

(1) A Site Responsibility Schedule (SRS) for every connection point shall be prepared by the owner of the substation where connection is taking place.
(2) Following information shall be included in the Site Responsibility Schedule, namely,-
   (a) Schedule of electrical apparatus services and supplies;
   (b) Schedule of telecommunications and measurement apparatus; and
   (c) Safety rules applicable to each plant and apparatus

Following information shall also be furnished in the Site Responsibility Schedule for each item of equipment installed at the connection site, namely:-
   (a) the ownership of equipment;
   (b) the responsibility for control of equipment;
   (c) the responsibility for maintenance of equipment;
   (d) the responsibility for operation of equipment;
   (e) the manager of the site;
   (f) the responsibility for all matters relating to safety of persons at site; and
   (g) the responsibility for all maters relating to safety of equipment at site",

Other than the documents mentioned above following additional documents, as applicable needs to be submitted to SLDC-

1. CEA Registration Certificate for generating units
2. CTU/STU charging instructions
   (It shall clearly mention about the assumptions and connectivity considered in the studies)
3. Safety Clearance issued by appropriate government (CEA/State Electrical Inspector) for energization, as per Central Electricity Authority (Measures Relating to Safety & Electric Supply) Regulations, 2023 and amendments thereof
4. Power and Telecommunication Coordination Committee (PTCC) clearance certificate for protection against electromagnetic interference

Within three (3) working days of submission of above formats and information/documents by the User, SLDC shall acknowledge the receipt of the same, as per **Format II**, and seek clarifications, if any. The User shall submit the desired information/documents to the SLDC within next three (3) working days.

7. Request for first time energization and integration and Notice for trial run:

The request for first time energization and integration of new power system element(s) and notice towards start of the trial run as per **Format III** shall be submitted by the User to the SLDC, not less than seven (7) working days (as per Clause 5.4 of KEGC 2025) from the proposed date of the trial run. There could be a separate schedule for test charging and the final schedule for trial run, which may be mentioned in the **Format-III** itself. The User shall submit the following documents in this regard:

a) **Annexure B1:** Request by the User for first time energization and integration and Notice for Fresh/Repeat Trial Run, as per Format-III

b) **Annexure B2:** Undertaking in respect of Protection systems, as per Format-III A

c) **Annexure B3**: Undertaking in respect of Telemetry and communication, as per Format-III B

d) **Annexure B4:** Undertaking in respect of Energy metering, as per Format-III C

e) **Annexure B5:** Undertaking in respect of Statutory clearances, as per Format-III D

f) **Annexure B5 :** Undertaking in respect of Cyber security requirement

8. Issuance of approval for first time energization and trial run:

On satisfying itself with the submitted information/documents by the User, SLDC, as per jurisdiction would issue a provisional approval for first time energization and trial run to the User as per Format IV within three (3) working days of receipt of above information/documents and clarifications/rectifications thereof.

On the designated day, the power system element should be energized. Trial run should be conducted as per the proposed timeline mentioned in Format III and as approved by SLDC through Format-IV. SLDC shall obtain real time code from SRLDC wherever applicable. All attempts would be made by the real time operating personnel at the SLDC to facilitate first time energization and trial run of the new power system element, subject to availability of real time SCADA data and favorable system conditions, as per Clause 5.4 (3) of KEGC, 2025 amendments thereof.

Quote

Clause 5.4 (3): The SLDC shall allow commencement of the trial run from the requested date or in the case of any system constraints, not later than seven (7) days from the proposed date of the trial run. The trial run shall commence from the time and date as decided and informed by the SLDC.

Unquote

Trial run of power system elements shall be performed in compliance with Clauses 5.4, 5.5 and 5.6 of KEGC 2025 and amendments thereof.

8. Submission of information by the User after completion of trial run:

After completion of trial run, following documents shall be submitted by the the User to the SLDC and beneficiaries:

a. **Annexure C1**: Submission of information for completion of trial run and Request for issuance of certificate of successful trial run, as per Format V
b. **Annexure C2**: SCADA values of the active and reactive power flows and related voltages during the trial run period.
c. **Annexure C3**: Interface Energy meter readings for the trial run period
d. **Annexure C4:** Outputs of Numerical relay or Disturbance Recorder (DR) and Station Event Logger (EL) during the trial run period, with time synchronized and in the standard format, as per RPC guidelines.
e. **Annexure C5** (for RE only): Plot along with raw values of weather parameters like ambient Temperature, GHI, Wind speed, wind direction, humidity and other relevant parameters required for corroborating the output from the plant as applicable

As per Clause 5.8 of KEGC, 2025 and amendments thereof, the concerned beneficiary may raise objection "in writing to the SLDC with a copy to all concerned regarding the trial run within two (2) days of completion of such trial run" in Format-VI.

The SLDC shall, within five (5) days of receipt of such objection, in coordination with the concerned entity and the beneficiaries, decide if the trial run was successful or if there is a need for a repeat trial run.

In case any objection by any concerned beneficiary is not received to the SLDC within two (2) working days of completion of trial run, it shall be deemed that there is no objection by any of the concerned beneficiaries.

9. Issuance of certificate of successful trial run:

Within two working (2) days of submission of the information and documents as per Format-V, SLDC shall check the submitted data/document and seek clarifications/rectifications, if any.

As per Clause 5.8 (2) of KEGC, 2025 and amendments thereof, within three (3) working days of submission of the information and documents as per Format-V or clarifications/rectifications by the User, whichever is later, SLDC shall issue the certificate of successful trial run of the power system element with electrical load as per Format VII. The consideration of Day-1 for submission of application shall be as follows:

a) Application received till 15:00 hrs of a working day -Same day as Day-1
b) Application received after 15:00 hrs of a working day -Next working day as Day-1
c) Application received anytime on Non- working day –Next working day as Day-1

Section:1(B) Common modalities for Charging/Energization of Altered (including modified/ replaced/ upgraded) Power System Elements

This procedure is applicable for charging/energization of already commissioned power system elements under following cases:

1. Charging/Energization of power system elements after continuous outage/shutdown for more than six months.

2. Charging/Energization of transmission line/bay after alteration (including modification/ replacement/ upgradation) under Planned/Emergency/Forced outage:

   a. Replacement and/or upgradation of substation equipment: CT/PT/CVT/CB /Isolator/LA/ Bushing/Wave trap
   b. Replacement of one phase of a failed Transformer/Reactor with a cold spare unit
   c. Replacement of one phase of a failed Transformer/Reactor with a hot spare unit
   d. Replacement of failed 3-ph Transformer/Reactor with new 3-ph Transformer/Reactor

3. Charging/Energization of transmission line after restoration of damaged/collapsed towers at the same location.

4. Restoration and charging /energization of transmission line through Emergency Restoration System towers, Interim bypass arrangement or Restoration and modification of transmission tower.

5. Charging/Energization after re-conductoring, re-bundling or similar other alterations involving change in nature of power flow in the line

6. Charging/Energization of transmission line after upgradation/increase in voltage level or line rearrangements including Loop-In-Loop-Out

7. Charging/Energization of transmission line after alterations involving change in course of transmission line i.e. in case of railway line/road/river crossing (with or without the use of ERS) and diversions or interim bypass arrangement or restoration and modification of transmission line/tower involving crossing of another line .

8. Anti-theft charging of already commissioned /new transmission line
   a. Idle charging (for anti-theft) of a section or complete line length of new transmission line which is not terminated at both ends.
   b. Charging/Energization of already commissioned transmission line (complete line length or a section) which is under breakdown/ outage

1. Application for charging/energization of altered (including modified/replaced/upgraded) power system elements:

The application for charging/energization of altered (including modified/replaced/upgraded) power system elements shall be submitted by user/asset owner to the SLDC, at least three (03) working days prior to the date of charging/energization. The following documents (as applicable) shall be enclosed along with the applications:

a) **Annexure B6:** Undertaking by the User for energization and integration of transmission line/bay after alteration (including modification/ replacement/ upgradation)
b) **Annexure B7:** Undertaking by the User for Energization and Integration of Transmission Line after Alteration (including Diversion/Modification/Tower height modification/ERS)
c) **Annexure B8:** Undertaking by the User for Anti-Theft Charging of Transmission Line

The specific requirements for charging/energization of altered (including modified/ replaced/ upgraded) power system elements has been tabulated in Appendix-1. The references mentioned in Appendix-1 are appended at the end of this document.

2. Approval by SLDC for charging/energization of altered (including modified/ replaced/ upgraded) power system elements:

For alterations of emergency nature falling under S.No. 1,2(a),2(b),2(c), 3, 4 and 8(b), The user shall submit the documents to SLDC control room in real time. After submission of above documents and statutory clearances, as applicable by the user/asset owner, SLDC Control Rooms shall issue code for charging or seek clarifications, if required.
For alterations of planned nature falling under S.No. 7 and 8(a), SLDC shall seek clarifications, if any within two (02) working days of submission of above documents and statutory clearances, as applicable by the user/asset owner. The user/asset owner shall submit the clarifications to the SLDC along with the supporting documents (as applicable). Upon receipt of satisfactory clarifications/documents, SLDC would issue a provisional approval for charging/energization of the concerned power system element to the applicant within two (02) working days of receipt of such documents and clarifications.

For either of the above mentioned alterations, after getting the provisional approval from SLDC, the user/asset owner shall seek real time code from SLDC to charge the altered (including modified/replaced/upgraded) power system element(s). In real time, the charging/energization of the concerned power system element(s) shall be facilitated in accordance with the operating procedure, subject to the validity of provisional approval, availability of real time data and favourable system conditions.

Documents to be submitted by the User to SLDC

Annexure	Subject	Formats
	Application for registration of entity with SLDC as "User"	As per Format I
Annexure A1	Intimation by User regarding expected first time energization and integration of new power system element(s)	As per Format I A
Annexure A2	List of elements to be first time energized and their details	As per Format I B
Annexure A3	Single line diagram of the concerned sub stations, along with status of completion of each dia/bus/breakers	
Annexure A4	List of SCADA points to be made available to SLDC	
Annexure A5	Type and Location of energy meters as per relevant CEA regulations	
Annexure A6	Connection Agreement, wherever applicable along with all annexures	
Annexure B1	Request by the User for first time energization and integration and Notice for Fresh/Repeat Trial Run	As per Format III
Annexure B2	Undertaking in respect of Protection systems	As per Format III A
Annexure B3	Undertaking in respect of Telemetry and communication	As per Format III B
Annexure B4	Undertaking in respect of Energy metering	As per Format III C
Annexure B5	Undertaking in respect of Statutory clearances	As per Format III D
Annexure B5(a)	Undertaking in respect of compliance to Cyber Security requirement	
Annexure B6	Undertaking by the User for energization and integration of transmission line/bay after alteration (including modification/ replacement/ upgradation)	
Annexure B7	Undertaking by the User for Energization and Integration of Transmission Line after Alteration (including Diversion/Modification/Tower height modification/ERS)	
Annexure B8	Undertaking by the User for Anti-Theft Charging of Transmission Line	
Annexure C1	Submission of information for completion of trial run and Request for issuance of certificate of successful trial run	As per Format V
Annexure C2	SCADA values of the active and reactive power flows and related voltages during the trial run period	
Annexure C3	Interface Energy meter readings for the trial run period	
Annexure C4	Outputs of Numerical relay or Disturbance Recorder (DR) and Station Event Logger (EL) during the trial run period, with time synchronized and in the standard format, as per RPC guidelines	

Annexure C5 (for RE only)	Plot along with raw values of weather parameters like ambient Temperature, GHI, Wind speed, wind direction, humidity and other relevant parameters required for corroborating the output from the plant as applicable	

Format-I

Appendix-IV

1. **Name of the entity (in bold letters):**
2. **Registered office address:**
3. **ESCOM in which registration is sought:**
    - **i.** BESCOM
    - **ii.** HESCOM
    - **iii.** GESCOM
    - **iv.** MESCOM
    - **v.** CESC

4. **User category**:
    - **i.** Generating Station (CEA Unique Registration No. for each unit)
    - **ii.** Seller
    - **iii.** Buyer
    - **iv.** Transmission Licensee
    - **v.** Distribution Licensee
    - **vi.** Trading Licensee
    - **vii.** Power Exchange
    - **viii.** Battery Energy Storage system
    - **ix.** QCA / Aggregators
    - **x.** Others

5. **User details (as on 31st March of last financial year):**

i. Category – Generating Station

- i. Total Installed Capacity
- ii. Maximum Contracted Capacity (MW) using In-STS
- iii. Points of connection to the In-STS

S.No.	**Point of connection**	**Voltage level (kV)**	**Number of Special Energy Meters (Main) installed at this location**

ii. **Category – Seller/Buyer/Distribution Licensee**

i. Maximum Contracted Capacity (MW) using In-STS

ii. Points of connection to the In-STS:

S.No.	Point of connection	Voltage level (kV)	Number of Special Energy Meters (Main) installed at this location

iii. **Category – Transmission Licensee (intra-State)**

a. Sub-stations:

S.No.	Sub-station Name	Number of Transformer	Total Transformation Capacity or Design MVA handling capacity if switching station

b. Transmission lines:

S.No.	Voltage Level(kV)	Number of Transmission lines	Total Circuit Kilometers

iv. **Category (Others): Please specify details**.

6. **Contact person(s) details for meters related to SLDC**:

i. Name:

ii. Designation:

iii. Landline Telephone No.:

iv. Mobile No.:

v. E-mail address:

vi. Postal address:

7. **Other Details:**

i. PAN No.:
ii. GST No.:
iii. Bank Account No.:
iv. Bank Name and Address:
v. MICR No:

The above information is true to the best of my knowledge and belief.

Place:

Signature of Authorized Representative

Name:

Date:

Designation:

Contact number:

Annexure A1

Format I A

Intimation by User regarding expected first time energization and integration of new power system element(s)

<Name of the User>

CEA Unique Registration Number (applicable for generating units):
SLDC User Application/Acknowledgement/Registration Number:
SLDC FTC Request Num/Unique ID/Case ID:
Name of the power system element (s):

Type of the power system element

- ☐ Generating Unit (RE/Non-RE)
- ☐ Transmission Line (AC/HVDC) Transformer
- ☐ Reactor
- ☐ Bus/Bays
- ☐ HVDC Pole/Block/Converter Transformer
- ☐ Filter Banks/ Capacitor banks
- ☐ FACTS Devices (STATCOM/SVC-TCR/SVC- TSC/FSC/TCSC/SSSC)
- ☐ Energy Storage System (Please specify the type)
- ☐ Bulk Consumer or Load serving entity (Please specify the type)

Owner of the power system element:

Expected Date and Time of First Time Energization: **Expected**

Date and Time of start of Trial Run:

Schedule Date of Commercial Operation:
(As per original scheme)

Project Scheme : TBCB / Other than TBCB

Associated elements/Associated Transmission System (ATS):
(In case co-ordinated Transmission /Generation evacuation project)

Site/Substation Contact Details:

Site/Substation Incharge Name:	
Site/Substation Incharge Designation:	
Site/Substation Incharge Mobile Number:	
Site/Substation Incharge Email Id :	
Site/Substation Control Room Email Id:	
Site/Substation Control Room Hotline/VOIP/Orange Number:	
Site/Substation Control Room Mobile Number:	
Site/Substation Control Room Landline Number:	

Details of Scheme Approval by Planning Committee / CTUIL/ CEA/RPC /STU–

Date of Meeting	Planning Committee/CTUIL/ CEA/RPC/STU Meeting number	MOM Item no. / Point No. /Serial No	Page No

Copy to be essentially enclosed

(Name and Designation of the authorized person with official seal)

Place:
Date:

Encl: Please provide full details.

- ☐ **Annexure A2**: List of elements to be first time energized and their details, as per Format-IB
- ☐ **Annexure A3**: Single line diagram of the concerned sub stations, alongwith status of completion of each dia /bus/breakers
- ☐ **Annexure A4**: List of SCADA points to be made available to SLDC
- ☐ **Annexure A5**: Type and Location of energy meters as per relevant CEA regulations
- ☐ **Annexure A6**: Connection Agreement, if applicable along with all annexures
- ☐ Details of Scheme Approval by Planning Committee / CTUIL/ CEA/RPC/STU – Relevant page

Annexure A2

Format I B
List of elements to be first time energized and their details

<Name of the User>

CEA Unique Registration Number (applicable for generating units):
SLDC User Application/Acknowledgement/Registration Number:
SLDC FTC Request Num/Unique ID/Case ID:

I. **List of Elements to be first time energized :**

II. **Element Details**

a. Transmission Line (AC/HVDC)

1	From Substation	
2	To Substation	
3	Voltage Level (kV)	
4	Circuit Number	
5	Owner	
6	Tower Configuration (Single/Double/Multi Circuit Towers)	
7	Total Line length (km) irrespective of ownership {owner-wise breakup should also be mentioned}	
8	Conductor Type and rated conductor temperature	
9	No of sub Conductors	
10	Conductor Ampacity (per phase per conductor per circuit)	
11	Thermal Capacity* (MVA) {Line capacity to be provided at Nominal Voltage and at specified conductor temperature & ambient temperature}	
12	Modelling Parameters (in per unit per circuit per kilometre at 100 MVA base):	
12(a)	Positive Sequence: R1 (Resistance), X1 (Reactance) and B1 (Susceptance)	
12(b)	Zero Sequence: R0 (Resistance), X0 (Reactance) and B0 (Susceptance)	
12(c)	Mutual impedance: Rom (Resistance), Xom (Reactance)	

b. Transformer

1	Type (Inter-Connecting / Station /Generating/Coupling)	
2	Transformer Number	
3	Make/Manufacturer	
4	Owner	

5	Voltage (HV kV /IV kV/ LV kV)	
6	Capacity (MVA)	
47	Configuration (Single Phase/Three Phase)	
8	Spare Transformer Unit (Yes/No)	
9	Transformer Vector group	
10	Total no of taps	
11	Nominal Tap Position	
12	Present Tap Position	
13	Tertiary Winding Rating and Ratio	
14	Transformer Percentage Impedance	

c. Reactor

1	Type (Bus/Line/Series)	
2	Reactor Number	
3	Make/Manufacturer	
4	Owner	
5	Substation Name	
6	Line Name (in case of Line Reactor)	
7	Rated Voltage (kV)	
8	MVAR Rating	
9	Configuration (Single Phase/Three Phase)	
10	Spare Reactor Unit (Yes/No)	
11	Type of Neutral Earthing (Whether NGR Connected/ Other)	
12	NGR Rating	
13	Percentage Impedance	
14	Switchable / Non-Switchable	
15	In case of Line Reactor, whether Convertible or Non-convertible as Bus Reactor	

d. FACTS Devices

1	Type (STATCOM/SVC-TCR/SVC-TSC/FSC/TCSC/SSSC)	
2	Make/Manufacturer	
3	Owner	
4	Substation Name / Line Name	
5	Voltage Rating (kV)	
6	MVAR Rating	
7	Number of Blocks and rating of each block	

e. HVDC Pole/Block/Converter Transformer

1	Type of HVDC link (Bi-pole/Multi Terminal/Back-to-Back)	
2	Make/Manufacturer	
3	Owner	
4	Substation Name	
5	Pole/Block Number	
6	Type of Converters: • Line Commuted Converter (LCC) • Voltage Source Converter (VSC)	
7	Rated DC Voltage (kV)	
8	Rating (Power-MW, and Current-Amperes)	
9	Converter Transformer- AC side Base Voltage	
10	Converter Transformer- DC side Base Voltage	
11	Converter Transformer- MVA Rating	
12	Converter Transformer- Impedance (in Ohms, in % on 100 MVA base and mention Voltage reference side)	

f. Filter Banks/Capacitor Banks

1	Type	
2	Make/Manufacturer	
3	Owner	
4	Substation Name	
5	Filter/Capacitor Bank Number and Sub-Number	
6	Rated Voltage (kV)	
7	Rated Output/MVAR Rating (at nominal voltage and fundamental frequency)	
8	Associated HVDC Pole Name and Number/ Associated RE plant Name and Capacity (MW)	
9	Switchable / Non-Switchable	
10	Whether used for mitigation of harmonics?	
11	Ambient Temperatur (°C)	

g. Bus-Bar/Bays

1	Substation Name	
2	Substation Owner	
3	Voltage Level (kV)	
4	Substation Bus Scheme/Arrangement	
5	Bus/Bay Type	
6	Bus/Bay Number	

7	Associated Transmission Element	

h. Generating Unit

1	Fuel/Source	
2	Installed Capacity of generating station (MW)	
3	Installed Capacity of generating station (MVA)	
4	Maximum Continuous Rating (MCR) (MW)	
5	Number x unit size (No x MW)	
6	Time required for cold start (Minute)	
7	Time required for warm start (Minute)	
8	Time required for hot start (Minute)	
9	Time required for combined cycle operation under cold conditions (Minute)	
10	Time required for combined cycle operation under warm conditions (Minute)	
11	Ramping up capability (% per minute)	
12	Ramping down capability (% per minute)	
13	Minimum turndown level (% of MCR)	
14	Minimum turndown level (MW (ex-bus))	
15	Inverter Loading Ratio (DC/AC capacity)	
16	Name of QCA (where applicable)	
17	Full reservoir level (FRL) (Metre)	
18	Design Head (Metre)	
19	Minimum draw down level (MDDL) (Metre)	
20	Water released at Design Head (M3/ MW)	
21	Unit-wise forbidden zones (MW)	
22	Associated Transmission System	

i. Battery Energy Storage System(BESS)

1	Substation Name	
2	HV side and LV side Voltage Level (kV)	
3	Type / Chemistry	
4	Make/Manufacturer	

5	Owner	
6	Design capacity of battery in terms of MWh	
7	Rated AC Power in terms of MW	
8	Self-Discharge rate	
9	Depth of Discharge (DOD)	
10	Life cycle of battery	
11	Number of Cycles per day	
12	Round trip efficiency (AC-DC, DC-AC and AC-AC)	
13	Number of series & parallel connected	
14	Power/energy rating cells and modules	
15	BESS design temperature	
16	Black Start capability (Yes/No)	

(Name and Designation of the authorized person with official seal)

Place:

Date:

Annexure A4

List of SCADA points to be made available to SLDC

(SLDC would need all MW and MVAr data, voltage and frequency of all the buses, all the breaker and isolator positions, OLTC tap positions, Main-1/Main-2 protection operated signals, DC side SCADA data in case of HVDC station, data for FACTS Devices/ESS/Bulk Consumers as per requirement)

<Name of the User>

CEA Unique Registration Number (applicable for generating units):
SLDC User Application/Acknowledgement/Registration Number:
SLDC FTC Request Num/Unique ID/Case ID:

Name of the power system element :

SNo	List of SCADA Points to be made available	IEC Address
1	Analog Point	
2	Digital Point	
3	SOE	

(Name and Designation of the authorized person with official seal)

Place:

Date:

Annexure A5

Type and Location of energy meters as per relevant CEA regulations

<Name of the User>

CEA Unique Registration Number (applicable for generating units):
SLDC User Application/Acknowledgement/Registration Number:
SLDC FTC Request Num/Unique ID/Case ID:

Name of power system element:

S no	Name of substation	Feeder/Element name	Location of installed Meter	Make of meter	Meter no	CT Ratio	PT/CVT Ratio

Declaration:

1) Whether tertiary of ICT would be taken on load: Yes / No
2) SEM has been installed on tertiary of ICT and the details are submitted

Note: NOC from local distribution licensee is to be submitted except when the drawal of power from tertiary of ICT by the licensee is in its capacity as an intra State entity

(Name and Designation of the authorized person with official seal)

Place:

Date:

Format II

<Name of SLDC>

Acknowledgement of Receipt by SLDC

This is to acknowledge that the intimation of expected first time energization of <Name of the power system element> has been received from <Name of the User/owner of the power system asset> on <date>.

Kindly complete the technical formalities in connection with energy metering, protection and real time data and communication facilities and inform us of the same not less than seven (7) working days before first time energization of the above power system element as per Formats III, IIIA, IIIB, IIIC and IIID.

Or

The intimation is incomplete and the following information may be submitted within three (3) working days of issue of this acknowledgment receipt.

1.

2.

3.

Date

Signature

Name: Designation:

SLDC

Annexure-B1

Format III

<Name of the User>

Request by the User for first time energization and integration and Notice for Fresh/Repeat Trial Run

Past references:
CEA Unique Registration Number (applicable for generating units): SLDC
User Application/Acknowledgement/Registration Number: SLDC FTC
Request Num/Unique ID/Case ID:
Name of the power system element (s):
Type of the power system element :

- ☐ Generating Unit (RE/Non-RE)
- ☐ Transmission Line (AC/HVDC)
- ☐ Transformer
- ☐ Reactor
- ☐ Bus/Bays
- ☐ HVDC Pole/Block/Converter Transformer
- ☐ Filter Banks/Capacitor banks
- ☐ FACTS Devices (STATCOM/SVC- TCR/SVC-TSC/FSC/TCSC/SSSC)
- ☐ Energy Storage System (Please specify the type)
- ☐ Bulk Consumer or Load serving entity (Please specify the type)

Owner of the power system element:

Scheduled dates for test charging:
(Detailed schedules along with timelines to be enclosed)

Expected Date and time of first time energization :

Proposed Date and time for
Commencement of Fresh/Repeat trial run

(Name and Designation of the authorized person with official seal)

Place:

Date:

Enclosures:

Annexures	Particulars	Dated
Annexure B2	Undertaking by the User in respect of Protection systems	
Annexure B3	Undertaking by the User in respect of Telemetry and Communication	
Annexure B4	Undertaking by the User in respect of Energy metering	
Annexure B5	Undertaking by the User in respect of statutory clearances	
Annexure B5(a)	Undertaking in respect of Cyber Security requirements	

Annexure B2

Format III A

< <u>Name of the User</u> >
Undertaking by the User in respect of Protection systems
(in compliance to Protection Code of KEGC 2025 and amendments thereof)

CEA Unique Registration Number (applicable for generating units):
SLDC User Application/Acknowledgement/Registration Number:
SLDC FTC Request Num/Unique ID/Case ID:

Name of the power system element (s):

Expected Date and time of first time energization:
Proposed Date and time for commencement of Fresh/Repeat trial run:

1. It is certified that all the protection systems have been tested and commissioned and would be in position when the element is taken into service, in compliance to the Protection Protocol as per Clause 8.2 of KEGC 2025 and amendments thereof

2. It is certified that the approval for implementation of new protection system has been obtained from STU, in compliance to Clause 8.3 (2) of KEGC 2025 and amendments thereof

3. It is certified that the network data required for performing protection settings study and protection settings implemented for each element mentioned above have been uploaded in the centralized database maintained by RPC and SLDC as per Clause 8.3 (3) of KEGC, 2025 and amendments thereof.

4. It is confirmed that all protection systems are in service and successful testing of communication signal from sending end to receiving end has been done.

Note: The extracted settings from the following listed relay settings* along with the network data, as applicable need to be uploaded in the aforementioned databases and a copy of listed relay settings shall be enclosed along with Annexure-B2:

S.No	***Transmission Line***	***Submitted (Yes/No)***	***S.No***	***Transformers and Reactors***	***Submitted (Yes/No)***
1	Line /Bus data for updating network model		1	Transformer/Reactor data for updating network model	
2	Main-1 and Main-2 Relay Settings		2	Differential Relay settings	
3	Graded Over-voltage settings		3	Over-flux settings	
4	Back-up Over-current and Earth Fault settings		4	Restricted Earth Fault settings	
5	STUB Protection and BCU Settings		5	Back-up Over-current and Earth Fault settings	
6	Bus Bar relay and LBB protection settings (also applicable for Bays)		6	WTI, OTI, PRD, OSR and Buchholz relay settings	

S.No.	***Generating Unit***	***Submitted (Yes/No)***
1	Generator/GT/UT data for updating network model	
2	Overcurrent/Overload/Unbalance Load Settings	
3	Over- and Under Voltage Settings	
4	Over- and Under Excitation Settings	
5	Over- and Under Frequency Settings	
6	Over-fluxing/Over-magnetization and Out of Step settings	
7	Stator/Rotor Overload and Stator/Rotor Earth Fault relay settings	
8	Impedance Protection Settings	

*The list is not exhaustive and Transmission Licensee/Generating Station may be required to submit and upload additional relay settings, as advised by SLDC/NLDC for requested elements.

(Name and Designation of the authorized person with official seal)

Place:
Date:

Annexure B3

Format IIIB

< Name of the User>

Undertaking by the User in respect of Telemetry and Communication

(in compliance with Clause 4.7 of Connection Code, KEGC 2025 and amendments thereof)

CEA Unique Registration Number (applicable for generating units):
SLDC User Application/Acknowledgement/Registration Number:
SLDC FTC Request Num/Unique ID/Case ID:

Name of the power system element (s):

Expected Date and time of first time energization:
Proposed Date and time for commencement of Fresh/Repeat trial run:

The list of data points that would be made available to SLDC in real time had been indicated vide communication dated____. It is certified that the following data points have been mapped and real time data would flow to SLDC immediately as the element is energized and integrated with the grid.

S no	Name of substation	Data pointt (analog as well as digital) identified in earlier Communication dated	Point to point checking done jointly	Data would be available at SLDC (Y/N)	Remarks (path may be specified)
1	Sending end	Analog			
		Digital			
		SoE			
		PMU Integration (if applicable)			
		Main Channel			
		Standby Channel			
		Voice Communication (Mobile No ,Landline No, Hotline No)			
2	Receiving end	Analog			
		Digital			
		SoE			
		PMU Integration (if applicable)			
		Main Channel			
		Standby Channel			
		Voice Communication (Mobile No ,Landline No, Hotline No)			

It is also certified that the data provided to main and backup SLDCs are through redundant ports (RTU/Gateway and communication equipment) and through different physical path (wherever possible) to ensure reliable and redundant data as per KEGC (as amended from time to time). Also, Voice communication is established as per KEGC. PMU communication has also been established (if applicable). The arrangements are of permanent nature. In case of any interruption in data in real time, the undersigned undertakes to get the same restored at the earliest.

(Name and Designation of the authorized person with official seal)

Place:

Date:

Annexure B4

Format IIIC

< Name of the User>

Undertaking by the User in respect of Energy metering

(in compliance with Clause 7.9(14) of KEGC, 2025 and amendments thereof)

CEA Unique Registration Number (applicable for generating units):
SLDC User Application/Acknowledgement/Registration Number:
SLDC FTC Request Num/Unique ID/Case ID:

Name of the power system element (s):
Expected Date and time of first time energization:
Proposed Date and time for commencement of Fresh/Repeat trial run:

Interface Energy Meters (IEMs) conforming to CEA (Installation and Operation of Meters) Regulations, 2006 have been installed and commissioned, as per metering scheme approved by SLDC. The IEMs are calibrated in compliance with CEA (Technical Standard for Grid Connectivity) Regulations 2007 and amedments thereof as per the following details:

S no	**Name of substation**	**Feeder/Element name**	**Location of installed Meter**	**Make of meter**	**Meter no**	**CT Ratio**	**PT/CVT Ratio**
1	Sending end						
2	Receiving End						

Data Format Conformity: Yes / No

S no	**Meter no**	**Meter Time (T1)**	**NavIC/GPS Time (T2)**	**Time Drift (T2-T1) shall be less than 1 minute**	**CT shorting removed (Y/N)**	**CT polarity as per convention checked (Y/N)**	**CVT/PT supply to the SEM checked Y/N)**
1	Sending end						
2	Receiving end						

Time Drift Correction carried out: Yes/No

The data from the above meters would be forwarded to the SLDC either manually on weekly basis or through AMR, as per Clause 7.9 (14) of KEGC 2025 and amendments thereof and also as and when requested by the SLDC.

(SLDC to indicate the email ids where the data has to be forwarded).

Details of any changes in CT/PT ratio or meter replacement/modification shall be submitted immediately to SLDC from time to time.

Enclosures: Dummy meter reading/data is enclosed in an encrypted format.

(Name and Designation of the authorized person with official seal)

Place:
Date:

Annexure B5

Format III D

< Name of the User>

Undertaking by the User in respect of statutory clearances

CEA Unique Registration Number (applicable for generating units):
SLDC User Application/Acknowledgement/Registration Number:
SLDC FTC Request Num/Unique ID/Case ID:

Name of the power system element (s):
Expected Date and time of first time energization:
Proposed Date and time for commencement of Fresh/Repeat trial run:

It is hereby certified that all statutory clearances in accordance with relevant KERC/CERC Regulations /CEA standards/CEA regulations for first time energization and integration and trial run of **<Name of the power system element>** have been obtained from the concerned authorities.

(Name and Designation of the authorized person with official seal)

Place:

Date:

Enclosures:

(i) Power and Telecommunication Coordination Committee (PTCC) route approval dated....[applicable for transmission lines only] as per Reg. 80 of CEA (Measures related to Safety and Electric Supply) Regulations, 2023 and amendments thereof.

(ii) CEA/State Electrical Inspector Safety Clearance dated…., as per Reg. 45 of CEA (Measures related to Safety and Electric Supply) Regulations, 2023 and amendments thereof

Annexure B5 (a)

< Name of the User >
Undertaking in respect of Cyber Security requirements
(in compliance with Cyber Security and Communication Code of KEGC 2025 and amendments thereof)

CEA Unique Registration Number (applicable for generating units):

SLDC User Application/Acknowledgement/Registration Number:

SLDC FTC Request Num/Unique ID/Case ID:

Name of the power system element (s):
Expected Date and time of first time energization:
Proposed Date and time for commencement of Fresh/Repeat trial run:

Details of Chief Information Security Officer (CISO) & Alternate CISO (Refer Article-2 of CEA (Cyber Security in Power Sector) Guidelines, 2021):

S/N	Name	Designation	Role (CISO / Alt-CISO)	Contact Number	E-mail

Details of Internet facing IPs on-boarded to CSK
(Refer Article 5c-1 of CEA (Cyber Security in Power Sector) Guidelines, 2021):

S/N	Public IP Pool details with range / CIDR	Service Provider name

It is hereby certified that necessary Cyber Security measures and controls has been suitably implemented and shall be kept operational / practiced immediately as the element is charged and commissioned.

Further, certified that:

1. The concerned utility shall intimate / has already intimated their details regarding Cyber Security compliance, as required, with the concerned Sectoral Computer Emergency Response Team (CERT) as prevailing guideline / practice.
2. The concerned utility / station has implemented / shall implement within a period of 6 months from date of commissioning of the element and shall follow the cyber security requirements and guidelines as provisioned in CEA (Cyber Security in Power Sector) Guidelines, 2021, failing which the plant / element would be liable to be disconnected from the grid without any notice.
3. The Utility shall carry out necessary Cyber Security Audit (as per periodicity provisioned in the CEA Guideline) of the complete IT / OT infrastructure associated with Data Acquisition, Control and all other related functions of the subject element through CERT-In empaneled third-party auditor. It is

also certified that the open vulnerabilities / non-conformities reported through such Audits shall be closed / addressed by the concerned utility within 1 month from date of vulnerability reported.

4. The data communication interface selected for reporting the necessary data of the element to the designated control centre shall comply to the provisions of CEA (Technical Standards for Communication System in Power System Operations) Regulations, 2020 and will follow the Cyber Security controls and requirements as per CERC (Communication System for inter-State transmission of electricity) Regulations, 2017, KEGC 2025 and any amendments thereof.

The undersigned also undertakes to co-ordinate with the concerned sectoral CERT and to abide by the requirement of CERT-In directions relating to information security practices dated 28.04.2022 (and Amendments thereof) and to report any Cyber incidence to the concerned agencies within the stipulated time.

(**Name and Designation of the authorized person with official seal**)

Place:

Date:

Annexure – B6

<Name of the User>

Undertaking by the User for energization and integration of transmission line/bay after alteration (including modification/ replacement/ upgradation)

To,
The Chief Engineer ,
State Load Dispatch Centre,
____________________________,

Sub: Charging/Energization and Integration of [**Element Name**] with **[Altered]** (Specify the type of alteration like modified/replaced/upgraded etc.) [**newCT/PT/CVT/CB/Isolator/LA/Bushing/Wave trap with ratings**] of **[User/Asset Owner]** at [**Substation Name**]

Expected Date and Time of Charging:

Sir,

There is alteration on [**old CT/PT/CVT/CB/Isolator/LA/Bushing/Wave trap with ratings**] of [**Element Name**] at [**Substation Name**] due to [**reason**] on [**Date**]. The [**old CT/PT/CVT/CB/Isolator/LA/Bushing/Wave trap with ratings**] of [___] make has been modified/replaced/upgraded by [User/**Asset Owner**] on [**Date**] with [**new CT/PT/CVT/CB/Isolator/LA/Bushing/Wave trap with ratings**] of [___] make.

I hereby undertake that

1. The said (**new CT/PT/CVT/CB/Isolator/LA/Bushing/Wave trap with ratings**) is not a new power system element to be charged for first time and is a **[Altered]** *(Specify the type of alteration like modified/replaced/upgraded etc.)* power system element.
2. We have complied with CEA (Measures relating to Safety and Electric Supply) 2023 (as amended) and all statutory clearances have been obtained for the said alteration. **2(a).** CEA/State Electrical Inspector Safety Clearance dated……, as per Reg 45 of CEA (Measures related to safety and electric supply) Regulations, 2023 and amendments thereof
3. After completion of the alteration works, all protection systems at [**Substation Name**] are in place.

4. There is no requirement of change in protection coordination at main and adjacent substations after completion of the **[<u>Alteration works</u>]** (*Specify the type of alteration like Diversion/Modification/Tower height modification etc.*) of the transmission line.

Or

Necessary protection coordination at main and adjacent substations after completion of the **[<u>Alteration works</u>]** (*Specify the type of alteration like Diversion/Modification/Tower height modification etc.*) of the transmission line has been carried out as per RPC guidelines.

5. There is no change in CTR/PTR w.r.t metering and telemetry. Healthiness of all telemetry channels is ensured and real time data including PMU data, if installed would flow to SLDC and/or SLDC immediately as the element is charged.

Or

There is change in CTR / PTR w.r.t metering and telemetry. Necessary activities for incorporation of changes at SLDC and/or SLDC have been done. Healthiness of all telemetry channels is ensured and real time data including PMU data, if installed would flow to SLDC and/or SLDC immediately as the element is charged.

6. There is no change in the configuration for PLCC/OPGW communication after completion of the **[<u>Alteration works</u>]** (*Specify the type of alteration like Diversion/Modification/Tower height modification etc.*) of transmission line. Healthiness of all available PLCC, OPGW communications etc. are ensured.

Or

Necessary changes incorporated in the configuration for PLCC/OPGW communication after completion of the **[<u>Alteration works</u>]** (*Specify the type of alteration like Diversion/Modification/Tower height modification etc.*) of transmission line. All available PLCC, OPGW communications etc. are restored and their healthiness is ensured.

7. There is no change in the length of transmission line after completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.).

Or

After completion of the the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.), the length of the transmission line is [**increased/decreased**] by _________m.

8. There is no change in the count of number of towers after completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) of transmission line.

Or

After completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.), _____ Nos. of additional towers are erected/removed in the transmission line. New erected/removed towers are __(tower identification numbers)

strike through whichever is not applicable

9. There is no change in the course of transmission line or change in the type of power flow after completion of the **[Alteration works]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.). Or After completion of the **[Alteration works]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.), there is change in the course of transmission line and/or change in the type of power flow. **9(a).** PTCC Clearance or Suitable Advisory on requirement of fresh PTCC Clearance by CEA is enclosed herewith.	

May kindly allow the energization and integration of [**Element Name**] with **[Altered]** (Specify the type of alteration like modified/replaced/upgraded etc.) [**new CT/PT/CVT/CB/Isolator/LA/Bushing/Wave trap with ratings**] of **[User/Asset Owner]** at **[Substation Name]**.

Thanking you,

(Name and Designation of the authorized person with official stamp/seal)

Place:
Date:

Enclosures:

a. CEA/State Electrical Inspector Safety Clearance dated……,
b. PTCC Clearance or Suitable Advisory on requirement of fresh PTCC Clearance by CEA dated ….

Annexure -B7

<Name of the User>

Undertaking by the User for Energization and Integration of Transmission Line after Alteration (including Diversion/Modification/Tower height modification/ERS)

To,

The Chief Engineer,
State Load Dispatch Centre,
______________________________,

Sub: Energization and Integration of [**Transmission line**] after **[Alteration works]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) by [**User/Asset Owner**]

Expected Date and Time of Charging:

Sir,

The **[Alteration works]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) of the [**Transmission line**] due to [**Reason**] was approved. The activity of [**Transmission line**] **[Alteration works]** was under execution by **[User/Asset Owner**] from [**Date of starting of Outage**]. In regard to the aforementioned **[Alteration works]**,

I hereby undertake that

1. The said [**Transmission line**] is not a new power system element to be charged for the first time and is a **[Altered]** (Specify the type of alteration like modified/replaced/upgraded etc.) power system element.
2. We have complied with CEA (Measures relating to Safety and Electric Supply) 2023 (as amended) and all statutory clearances have been obtained for the said **[Alteration works]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.). **2(a).** CEA/State Electrical Inspector Safety Clearance dated……, as per Reg 45 of CEA (Measures related to safety and electric supply) Regulations, 2023 and amendments thereof
3. After completion of the **[Alteration works]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.), all protection systems are in place.

4. There is no requirement of change in protection coordination at main and adjacent substations after completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) of the transmission line. Or After completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) of the transmission line, Necessary protection coordination at main and adjacent substations has been carried out as per RPC guidelines.	**strike through whichever is not applicable**
5. There is no change in CTR/PTR w.r.t metering and telemetry. Healthiness of all telemetry channels is ensured and real time data including PMU data, if installed would flow to SLDC and/or SLDC immediately as the element is charged. Or There is change in CTR / PTR w.r.t metering and telemetry. Necessary activities for incorporation of changes at SLDC and/or SLDC have been done. Healthiness of all telemetry channels is ensured and real time data including PMU data, if installed would flow to SLDC and/or SLDC immediately as the element is charged.	
6. There is no change in the configuration for PLCC/OPGW communication after completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) of the transmission line of transmission line. Healthiness of all available PLCC, OPGW communications etc. are ensured. Or Necessary changes incorporated in the configuration for PLCC/OPGW communication after completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) of the transmission line. All available PLCC, OPGW communications etc. are restored and their healthiness is ensured.	
7. There is no change in the length of transmission line after completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.). Or After completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.), the length of the transmission line is [**increased/decreased]** by **____**m.	
8. There is no change in the count of number of towers after completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) of transmission line. Or After completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.), **__** Nos. of additional towers are erected/removed in the transmission line. New erected/ Deleted towers are **_** (tower identification numbers)	

9. There is no change in the course of transmission line or change in the type of power flow after completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.). Or After completion of the **[<u>Alteration works</u>]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.), there is change in the course of transmission line and/or change in the type of power flow. **9(a).** PTCC Clearance or Suitable Advisory on requirement of fresh PTCC Clearance by CEA is enclosed herewith.	

May kindly allow the Energization and Integration of [**Transmission line**] after **[Alteration works]** (Specify the type of alteration like Diversion/Modification/Tower height modification etc.) by [User/**Asset Owner**].

Thanking you,

(Name and Designation of the authorized person with official stamp/seal)

Place:
Date:

Enclosures:

a. Schematic for the diversion/modification works carried out
b. CEA/State Electrical Inspector Safety Clearance dated……,
c. PTCC Clearance or Suitable Advisory on requirement of fresh PTCC Clearance by CEA dated….

Annexure – B8

<Name of the User>

Undertaking by the User for Anti-Theft Charging of Transmission Line

To,

The Chief Engineer,
State Load Despatch Centre,
________________________,

Sub: Anti-Theft charging of ___km length of [**Transmission Line**] from [**Substation Name**] end

Expected Date and Time of Charging:

Sir,

With reference to anti-theft charging proposal of **[Transmission Line]**, I hereby undertake that:

1. The said [**Transmission Line**] is an under-construction transmission line and is not terminated at both the ends. To prevent theft during construction, anti-theft charging from [**Substation Name**] end is required. Or The said [**Transmission Line**] has already been commissioned. Due to failure of towers in [**Details of transmission section**] section of transmission line, the line has lost completeness. To prevent theft during repair and restoration activity anti-theft charging from [**Substation Name]** end is required.
2. We have complied with all provisions of CEA (Measures relating to Safety and Electric Supply Regulations) 2010 (as amended). Approval of Electrical inspector statutory clearances shall be obtained by asset owner after completion and termination of the line at bays / substation at both ends and shall be submitted prior to charging/energization and integration of the complete line.
3. All protection systems are in place. Necessary protection coordination at main and adjacent substations after completion of the works of the transmission line has been carried out as per RPC guidelines.
4. The length of anti-theft charged section is _______km.
5. Anti-theft charged section of the said line will cover _____Nos. of towers. from location ______to ____(**tower identification numbers**)
6. All concerned parties, asset owners of both ends and Transmission line sections have already been informed in writing for anti-theft charging of the said line section.
7. All men and materials from the line have been removed. All safety measures are taken for anti-theft charging of the said transmission line.

May kindly allow the Anti-Theft charging of ___km length of **[Transmission Line**] from **[Substation Name]** end.

Thanking you,

(Name and Designation of the authorized person with official stamp/seal)

Place
:
Date:

Format IV
<Name of SLDC>
<u>Provisional Approval for energization, testing and trial run</u>

Approval no: **Date of Issuance:**

To,
<Name and Address of the User>,

Sub: Energization, Testing and trial run/operation of <Name of power system element>-Provisional approval

References:
1) Your application dated in Format_IA and IB
2) SLDC response and acknowledgement dated in Format_II
3) Your request and details forwarded on dated in Format III, IIIA, IIIB IIIC and

IIID Proposed Date and Time of Trial Run (as per Annexure-B1 dated …):

Madam/Sir

1. The above referred formats and associated documents have been examined by SLDC.
2. The provisional approval for first time energization, testing and trial run of <Name of the power system element> on or after dd/mm/yyyy hh:mm hrs is hereby accorded.
3. In the intervening period, if any of the conditions given in the undertakings submitted by you are found to be violated, the provisional approval stands cancelled.
4. Real time operation code from the appropriate SLDC shall be obtained for each element switching.

OR

The following shortcomings have been observed in the documents at S no 3) above.

i.
ii.

Please rectify the above shortcomings at the earliest to enable SLDC-to issue the provisional approval for first time energization, testing and trial run of <Name of the power system element>.

<u>Note</u>:

1. This Provisional Approval would remain valid till one month of the date of issuance or the validity of safety clearance issued by CEA /State EI, whichever is earlier. (Date of issuance of CEA-RIO/State EI Approval: *dd/mm/yyyy*)
2. Real Time Code will be issued subject to consent from Reliability team/RTSD of SLDC and /or NLDC (as applicable)

Thanking you,

Yours faithfully,

(Name and designation of authorized personnel with seal)

Annexure C1

Format-V

<Name of the User>

Submission of information for completion of trial run and Request for issuance of certificate of successful trial run

To,
<Name of SLDC>
<Name of Beneficiary (ies)>

Sub: Completion of trial run of <Name of the power system element>and request for issuance of certificate

Ref: i) Our application dated in Format IA and IB

ii) Your acknowledgement dated in Format II

iii) Our application dated in Format III along with Format IIIA, IIIB IIIC and IIID

iv) Provisional approval in Format-IV dated__________issued by SLDC.

v) Real time codes ______from SLDC dated___________

Madam/Sir,

Referring to the above correspondences, this is to inform you that the trial run of <Name of power system element> was carried out from______________to_____(time & date). Please find enclosed the following:

1. The plots of active (MW) and reactive (MVAr) power flows and related voltages during the …..hours (as applicable) trial run based on the substation SCADA is enclosed as Annexure C2.
2. The 15-minute time block wise Interface Energy Meter readings for the trial run period is enclosed as Annexure C3
3. Event Logger and Numerical Relay or Disturbance Recorder outputs indicating all the switching operations related to the element are enclosed as Annexure C4. It is further certified that
   - The recording instruments (disturbance recorder and event logger) are in compliance to Clause 8.7 of KEGC 2025.
   - DR analog and digital channels are in the standard format as per guidelines issued by SRPC.
4. Plot along with raw values of weather parameters like ambient Temperature,GHI,wind speed,wind direction,humidity and other relevant parameters required for corroborating the output from the plant as applicable

It is requested that a certificate of successful trial run may kindly be issued at the earliest.

Thanking you,

Yours faithfully,

<Name and Designation of authorized person with official seal>

Enclosures:

Annexure C2: SCADA values of the active and reactive power flows and related voltages during the trial run period
Annexure C3: Interface Energy meter readings for the trial run period
Annexure C4: Outputs of Numerical relay or Disturbance Recorder (DR) and Station Event Logger (EL) during the trial run period, with time synchronized and in the standard format, as per RPC guidelines.

Annexure C5(for RE only): Plot along with raw values of weather parameters like ambient Temperature,GHI,wind speed,wind direction,humidity and other relevant parameters required for corroborating the output from the plant as applicable

Format-VI

<Name of the Beneficiary>

Objection by beneficiary regarding trial run as per Clause 5.8 (1) of KEGC, 2025

Date:

To,
The Chief Engineer,
State Load Despatch Centre,
_____________________________,

Sub: Objection regarding trial run of <Name of the power system element> Sir,

Please find the following objection(s):

Name of the element	
Name of the beneficiary	
Duration of Trial Run	
Objection regarding the Trial Run	
Enclosure(s), if any	

Yours faithfully,

(Name and designation of authorized personnel with seal)

Copy to:

1. SLDC User/Concerned Entity/Asset Owner
2. All concerned

Format-VII

<Name of the SLDC>

Certificate of successful Trial Run (with electrical load) as per Clause 5.8 of KEGC, 2025

OR

Certificate of successful Trial Run (without electrical load) as per applicable KERC/CERC regulations

Certificate No: **Dated:**

References:

1. Your application dated------------(in Format-I A and I B)
2. SLDC acknowledgment dated ----------------- (in Format-II)
3. Your request and details forwarded on dated in Format III, IIIA, IIIB IIIC and IIID
4. SLDC provisional approval for energization, testing and trial run dated ----------------- (in Format-IV)
5. Real Time Codes______ from <SLDC Name> dated--------------- for energization/trial run.
6. Submission of information and request for issuance of certificate of successful trial run dated --------(in Format-V)
7. Objections raised by <Beneficiary(ies)> dated (in Format-VI)

1) There has been no receipt of any objection raised by any beneficiary in writing to SLDC

OR

The objections raised by the beneficiary (ies) under S.No. 7 have been satisfactorily addressed by the <Name of the User>

2) It is hereby certified that the following power system elements have successfully completed trial run with/without electrical load:

S.No	Name of the Element	Owner of the Element	Date and Time of commencement of trial run with/without electrical load	Date and Time of completion of trial operation with/without electrical load

This certificate is being issued in accordance with Regulation 5.8 (1) and 5.8 (2) of KEGC Regulations, 2025 and amendments thereof to certify successful trial run of power system element with electrical load.

OR

This certificate is being issued in accordance with KERC/CERC Regulations to certify successful trial run of power system element without electrical load i.e. without flow of active power.

Usage of this certificate for any other purpose is prohibited.

(Name and designation of authorized personnel with seal)

Place:

Copy to:

Appendix-1: Requirements for Charging/Energization and Integration of Altered (including modified/replaced/upgraded) Power System Elements

Case	Particulars	CEA-RIO/State EI Clearance	PTCC clearance	Undertaking (to be submitted by asset owner)	VOIP Communication, SCADA & PMU Data Availability	Protection Coordination (to be ensured by owner)	References
1	**Charging/Energization of power system elements after continuous outage/shutdown for more than six months.**	Yes	Not required	Not required	Yes	Confirmation from Licensee that no changes have been carried out which may affect protection coordination	Regulation 45 of CEA (Measures relating to Safety and Electric Supply) Regulations, 2023
2	**Charging/Energization of transmission line/bay after alteration (including modification/ replacement/ upgradation) under Planned/Emergency/Forced outage**						
a	Replacement and/or upgradation of substation equipment: CT, PT, CVT, CB, LA, Isolator and Wave trap	Yes	Not required	Yes (as per **Annexure-B6**)	Yes	Yes (If changes in protection coordination are required as mentioned in Annexure-B6)	CEA clarifications vide meetings held on 10.05.2022 and 03.08.2023
b	Replacement of one phase of a failed Transformer/Reactor with a cold spare unit	Yes	Not required	Yes (as per **Annexure-B6**)	Yes	Yes (If changes in protection coordination are required as mentioned in Annexure-B6)	CEA clarifications vide meetings held on 10.05.2022 and 03.08.2023
c	Replacement of one phase of a failed Transformer/Reactor with a hot spare unit	Not required	Not required	Not required	Yes	Not required	CEA clarifications vide meetings held on 10.05.2022 and 03.08.2023
d	Replacement of failed 3-ph Transformer/ Reactor with new 3-ph Transformer/ Reactor	To be processed as a fresh case for First Time Energization, PTCC clearance not required					
3	**Charging/Energization of transmission line after restoration of damaged/ collapsed towers at the same location**	Yes	Not required	Yes (as per **Annexure-B6**)	Yes	Yes (If changes in protection coordination are required as mentioned in Annexure-B6)	CEA clarifications vide meetings held on 10.05.2022 and 03.08.2023
4	**Restoration and charging /energization of transmission line through Emergency Restoration System towers, Interim bypass arrangement or Restoration and modification of transmission Tower**	Yes	Not required	Yes (as per **Annexure-B7**)	Yes	Yes (If changes in protection coordination are required as mentioned in Annexure-B7)	CEA clarifications vide meetings held on 10.05.2022 and 03.08.2023
5	**Charging/Energization after re-conductoring,re-bundling or similar other alterations invloving change in nature of power flow in the line**	To be processed as a fresh case for First Time Energization. Fresh PTCC Clearance or Suitable Advisory on requirement of fresh PTCC Clearance by CEA to be submitted by transmission licensee.					CEA clarification vide No. PTCC/Misc/200/391-393 dated 06.05.2022
6	**Charging/Energization of transmission line after upgradation/increase in voltage level or line rearrangements including Loop-In-Loop-Out**	To be processed as a fresh case for First Time Energization. Fresh PTCC Clearance or Suitable Advisory on requirement of fresh PTCC Clearance by CEA to be submitted by transmission licensee.					CEA clarification vide No. PTCC/Misc/200/391-393 dated 06.05.2022
7	**Charging/Energization of transmission line after alterations involving change in course of transmission line i.e. in case of railway line/road/river crossing (with or without the use of ERS) and diversion or restoration and modification of transmission line/tower involving crossing of another line.**	Yes	Fresh PTCC Clearance or Suitable Advisory on requirement of fresh PTCC Clearance by CEA to be submitted by transmission licensee. *(Not required for increase in tower height only)*	Yes (as per **Annexure-B7**)	Yes	Yes (If changes in protection coordination are required as mentioned in Annexure-B7)	CEA clarifications vide meetings held on 10.05.2022 and 03.08.2023 CEA clarification vide No. PTCC/Misc/200/391-393 dated 06.05.2022
8	**Anti-theft charging/energization of already commissioned /new transmission line**						
a	Idle charging (for anti-theft) of a section or complete line length of new transmission line which is not terminated at both ends	Not required	Yes	Yes (as per **Annexure-B8**)	Yes	Yes (Relay settings confirmation for safe anti-theft charging)	CEA clarifications dated 23.06.2015 and vide letter to NLDC dated 08.09.2015
b	Charging/Energization of already commissioned transmission line (complete line length or a section) which is under breakdown /outage		Not required				

Section 2:

Procedure for First Time Energization and Integration of In-STS/In-SGS connected conventional generating (Thermal, Gas & Hydro) plants, Bulk Consumers or Load Serving Entities and Combined (Load & Captive) Generation complex

Procedure for First Time Energization and Integration of In-STS/In-SGS connected conventional generating plants (Thermal, Gas & Hydro), Bulk Consumers or Load Serving Entities and Combined (Load and Captive) generation complex

References:

1. KEGC-2025 & amendments thereof
2. KERC (Deviation Settlement Mechanism) Regulation 2025 & amendments thereof
3. KERC (Forecasting scheduling for wind & Solar) regulations-2015 & amendments thereof
4. CEA (Installation of Operation of Meters) Regulation 2006 and Amendments thereof.
5. CEA (Technical standard for Connectivity to the Grid) Regulation, 2007 & amendments thereof
6. CEA (Measures relating to safety & electric supply) Regulations-2023 & amendments thereof
7. Central Electricity Regulatory Commission (Communication System for Inter-State Transmission of Electricity) Regulations,2017 & amendments thereof
8. Central Electricity Regulatory Commission (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022 & amendments thereof
9. Central Electricity Authority (Technical Standards for Communication System in Power System Operation) Regulations, 2020 & amendments thereof
10. Central Electricity Regulatory Commission (Furnishing of Technical Details by the Generating Companies) Regulations, 2009 & amendments thereof
11. Central Electricity Authority (Cyber Security in Power Sector) Regulations & amendments thereof
12. Central Electricity Authority (Flexible Operation of Coal based Thermal Power Generating Units) Regulations, 2023 & amendments thereof
13. CEA Technical standards- plant and line construction

First time charging and issuance of trial operation certificate of In-STS/In-SGS connected conventional generating plants (Thermal, Gas & Hydro), Bulk Consumers or Load Serving Entities and Combined (Load & Captive) generation complex shall be in accordance with Section-1 of this procedure. The formats and annexures (A1-A6, B1-B5(a), C1-C4) mentioned in section-1 need to be submitted to the SLDC in accordance with the mentioned timelines.

Documents Submission to SLDC

The following documents shall be submitted by In-STS/In-SGS connected conventional generating plants (Thermal, Gas & Hydro), Bulk Consumers / Load Serving entities and Combined (load & captive) generation) complex to SLDC before commencement of any startup activities of any unit :

1. **Control Area**: Control Area jurisdiction of Generating station, Bulk Consumers or Load Serving Entities and Combined (Load & Captive) generation complex shall be in accordance with clause 7.3 of Chapter- 7 of KEGC-2023.

2. **Connectivity Details**: As per clause 4.2(1) of KEGC -2025, All Users connected to or seeking connection to the grid shall comply with all the applicable regulations as enacted or amended from time to time as mentioned in clause 4.2(1) of KEGC 2025

3. **User Registration with SLDC & related modalities:**

   a. Generating Station, Bulk Consumers or Load Serving Entities and Combined (Load & Captive) generation complex is required to register as a 'User' of SLDC for commencement of Grid Access as per prevailing Regulation.

4. **Energy Metering:**
   As per clause 7.9(14) of KEGC-2025, The STU shall be responsible for procurement and installation of

Interface Energy Meters (IEMs), at the cost of respective entity, at all the In-STS interface points, points of connections between the intra State entities, Intra state entities and other identified points for recording of actual active and reactive energy interchanged in each time-block through those points. Accordingly, SLDC shall work out the requirement of IEMs in line CEA (Installation & Operation of Meters) Regulation-2006 & subsequent amendments after receipt of the Single Line switching Diagram of generating station indicating proposed path for drawal of start-up power. Subsequent to intimation from SLDC on the requirement of SEMs. Generating station shall coordinate with Regional HQ, STU, for procurement of the IEMs along with Data Collecting Device (DCD).

5. Telemetry & SCADA integration:

As per clause 4.7 of KEGC-2025, All Users shall provide Reliable speech and data communication systems to facilitate necessary communication, data exchange, supervision and control of the grid by the SLDC and SRLDC in accordance with the CERC (Communication System for Inter-State Transmission of Electricity) Regulations, 2017 and the CEA Technical Standards for Communication . The associated communication system to facilitate data flow up to appropriate data collection point on STU's system shall also be established by concerned User, as specified by STU in the connection agreement. All users, STU and participating entities in case of cross-border trade shall provide, in coordination with STU, the required facilities at their respective ends as specified in the connectivity agreement

6. Integration of Bulk Consumers or Load Serving Entities and Combined (Load and Captive) generation complex:

As per KEGC, 2025, 'Bulk Consumer' shall have the same meaning as defined in CEA Technical Standards for Connectivity and 'Captive Generating Plant' shall have the same meaning as defined in the Electricity Act System security to be ensured during the integration of Bulk Consumers or Load Serving Entities and Combined (Load and Captive) generation complex. Electrolyser shall be considered under bulk consumer. Additional requirement to be fulfilled by Bulk Consumers or Load Serving Entities and Combined (Load and Captive) generation complex, other than the information mentioned in this procedure. Notarized Undertaking to be submitted by the owner of above-mentioned entities as per Annexure- 1.

7. Statutory approval & first-time charging

Statutory approval for energization from the Central Electricity Authority; Govt. of India in line with the CEA (Measures relating to safety & electric supply) Regulations-2023 & amendments is to be submitted to SLDC before energization of any Electrical Installation at your end.

First Time Charging and issuance of trial operation certificate of new or modified power system elements shall be in accordance with Section-I of this procedure. The formats and annexures need to be submitted to SLDC in accordance with the mentioned timelines.

8. Notice of Trial Run:

a. As per Clause 5.4 of KEGC, 2025, the generating company proposing its generating station or a unit thereof for trial run or repeat of trial run shall give a notice of not less than seven (7) days to the SLDC, and the beneficiaries of the generating stations, including intermediary procurers, wherever identified

   Provided that in case the repeat trial run is to take place within forty-eight (48) hours of the failed trial run, fresh notice shall not be required.

b. Data to be furnished prior to notice of trial run

   As per clause 5.3(1) of KEGC-2025 "The following details, as applicable, shall be furnished by each intra State entity generating station to the SLDC, RPC and the beneficiaries of the generating station, wherever identified, prior to notice of trial run:"

Description	Units
Installed Capacity of generating station	MW
Installed Capacity of generating station	MVA
MCR	MW
Number x unit size	No x MW
Time required for cold start	Minute
Time required for warm start	Minute
Time required for hot start	Minute
Time required for combined cycle operation under cold conditions	Minute
Time required for combined cycle operation under warm conditions	Minute
Ramping up capability	% per minute
Ramping down capability	% per minute
Minimum turndown level	% of MCR
Minimum turndown level	MW (ex-bus)
Inverter Loading Ratio (DC/AC capacity)	
Name of QCA (where applicable)	
Full reservoir level (FRL)	Metre
Design Head	Metre
Minimum draw down level (MDDL)	Metre
Water released at Design Head	M3/ MW
Unit-wise forbidden zones	MW

9. Start-up power Drawal & Injection of Infirm Power

1. As per clause 5.2(1) of KEGC-2025 "A unit of a generating station including unit of a captive generating plant that has been granted connectivity to the intra-State Transmission System in accordance with applicable Regulations shall be allowed to inter-change power with the grid during the commissioning period, including testing and full load testing before the COD, after obtaining prior permission of the State Load Dispatch Centre".
2. The period for inter-change of power shall be allowed as per clause 5.2(2) and 5.2(3) of KEGC-2025 or amendment thereof.
3. Drawal of start-up power shall be subject to payment of transmission as per regulation 5.2(4) of KEGC 2025 or amendments thereof. The charges for deviation for drawal of startup power or for injection of infirm power shall be as per the DSM Regulations as per regulation 5.2(5) of KEGC 2025 or amendments

thereof.

4. During the period of drawal / injection of infirm power, SLDC Control Room should be intimated in advance, the scheduled pattern of quantum of drawl / infirm injection and tripping and synchronization of the unit.
5. For any switching operation necessary codes have to be taken from SLDC control room

Generating station has to follow the enclosed Procedure attached at Annex-3, before commencement of any activity. All the documents to be submitted as mentioned in the enclosed procedure at **Annexure-2** including the duly filled "Application form seeking start up power" which is the part of procedure.

10. <u>Modelling data for simulation study:</u>

Steady-state and Dynamic Simulation Models (both RMS and EMT) along with detailed model user guide shall be submitted for generating units. The models shall include auxiliary models such as excitation system model, turbine governor model, AVR and PSS model etc.

Annexure-3(A), 3(B), 3(C) and 3(D) may be referred for providing generic RMS modelling data for Thermal, Gas and Hydro Plants respectively.

Further, for the Bulk Consumers / Load Serving entities and Combined (Load + Captive) Generation Complex, RMS and EMT models shall be submitted.

The models shall be submitted as per the model compatibility guidelines specified at **Annexure- 3(D).**

Hydro plants reservoir details such as FRL, MDDL, monthly design energy/10 daily energy, rated cumecs and rated head, energy content of reservoir and water content details to be provided as per **Annexure-4**

11. <u>Submission of final as-built validated model:</u> Within 03 months of issuance of successful trial run certificate, asset owner shall submit a final as built validated simulation model (both EMT and RMS) along-with model validation report of the Generating Station/Load for both steady state and transient conditions. For steady-state validation, real-time PMU data may be used. For transient condition validation, disturbance recorder data or high-resolution data recorded during test by AVR/PSS or DR system at Generating station.

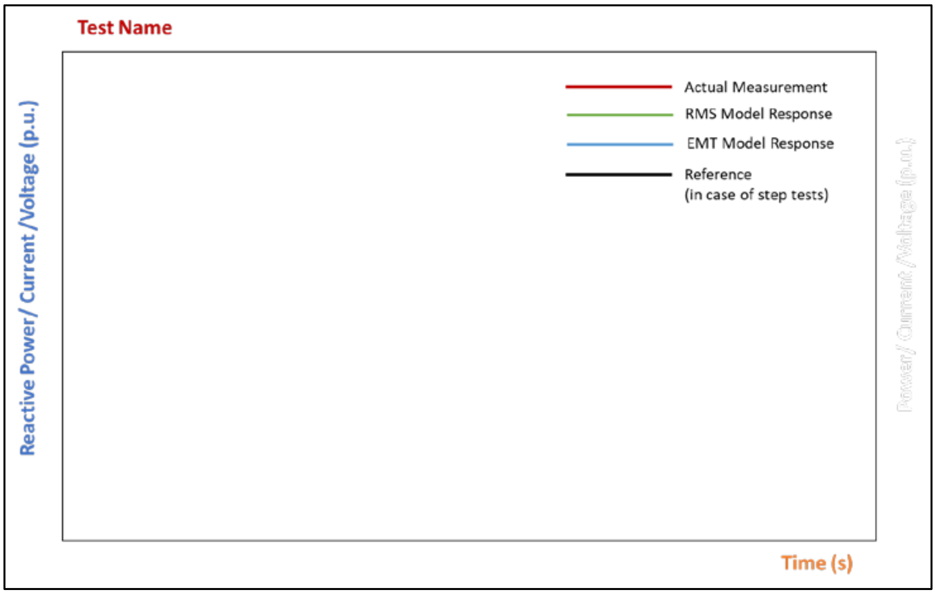
The validation report shall include the following:

1. Model file names of RMS & EMT model.

2. Final simulation model parameters of Generating units/Load entities.

3. The table demonstrating the similarity between simulation model parameters/settings and settings implemented at site (in real-time operation) shall be provided.

4. Comparison of on-site test measurement with simulation results shall be provided as per the format shown below :



5. Along with graphical comparison of field test measurement with simulation results, time series measurements/data of field test and simulation response (of same time resolution) shall also be provided in suitable format (preferably .csv file).

6. Model Validation report shall also provide details of the causes of deviation from simulated behavior and suggest corrective actions.

12. Declaration of Commercial Operation Date (COD)

1. Documents and tests prior to declaration of commercial operation

   As per clause 5.7 (1) of KEGC 2025

   "1. Notwithstanding the requirements in other standards, codes and contracts, for ensuring grid security, the tests as specified in the following clauses shall be scheduled and carried out in coordination with RLDC and the SLDC by the generating company or the transmission licensee, as the case may be, and relevant reports and other documents as specified shall be submitted to RLDC and the SLDC before a certificate of successful trial run is issued to such a generating company or the transmission licensee, as the case may be.

2. All thermal generating stations having a capacity of more than 200 MW and hydro generating stations having a capacity of more than 25 MW shall submit documents confirming the enablement of automatic operation of the plant from the appropriate load dispatch centre by integrating the controls and tele-metering features of their system into the automatic generation control in accordance with the CEA Technical Standards for Construction and the CEA Technical Standards for Connectivity."

3. **Documents and Tests Required for Thermal (coal/lignite) Generating Stations:**

   The generating company shall submit the following OEM documents, namely

(i) startup curve for boiler and turbine including starting time of unit in cold, warm and hot conditions,

(ii) capability curve of generator

(iii) design ramp rate of boiler and turbine

(b) The following tests shall be performed:

(i) Operation at a load of fifty five (55) percent of MCR as per the CEA Technical Standards for Construction for a sustained period of four (4) hours.

(ii) Ramp-up from fifty five (55) percent of MCR to MCR at a ramp rate of at least one (1) percent of MCR per minute, in one step or two steps (with stabilization period of 30 minutes between two steps), and sustained operation at MCR for one (1) hour.

(iii) Demonstrate overload capability with the valve wide open as per the CEA Technical Standards for Construction and sustained operation at that level for at least five (5) minutes.

(iv) Ramp-down from MCR to fifty five(55) percent of MCR at a ramp rate of at least one (1) percent of MCR per minute, in one or two steps (with stabilization period of 30 minutes between two steps).

(v) Primary response through injecting a frequency test signal with a step change of ± 0.1 Hz at 55%, 60%, 75% and 100% load.

(vi) Reactive power capability as per the generator capability curve as provided by OEM considering over-excitation and under-excitation limiter settings and prevailing grid condition.

4. Documents and Tests Required for Hydro Generating Stations including Pumped Storage Hydro Generating Station:

(a) The generating company shall submit OEM documents for the turbine characteristics curve indicating the operating zone(s) and forbidden zone(s). In order to demonstrate the operating flexibility of the generating unit, it shall be operated below and above the forbidden zone(s).

(b) The following tests shall be performed considering the water availability and head:

(i) Primary response through injecting a frequency test signal with a step change of ± 0.1 Hz for various loadings within the operating zone.

(ii) Reactive power capability as per the generator capability curve considering over-excitation and under-excitation limiter settings.

(iii) Black start capability, wherever feasible.

(iv) As per clause 45(10)(a) of KEGC 2025"Optimum Utilization of Hydro Energy: During high inflow and water spillage conditions, for Storage type generating station and Run–of-River Generating Stations with or without Pondage, the declared capacity for the day may be up to the installed capacity plus overload capability (up to 10% or such other limit as certified by the OEM and approved by CEA) minus auxiliary consumption, corrected for the reservoir level. In case, the overload capability of such a station is more than 10% as approved, such a station shall declare the overload capability in advance." Hydro Generating stations shall demonstrate such over load capacity during trial run operation subject to above mentioned provision.

5. **Documents and Test Required for Gas Turbine based Generating Stations:**

(a) The generating company shall submit OEM documents for
(i) starting time of the unit in cold, warm and hot conditions
(ii) design ramp rate.

(b) The following tests shall be performed:

(i) Primary response through injecting a frequency test signal with a step change of ± 0.1 Hz for various loadings within the operating zone.

(ii) Reactive power capability as per the generator capability curve considering over-excitation and under-excitation limiter settings.

(iii) Black start capability up to 100 MW capacity, wherever feasible.

(iv) Operation in synchronous condenser mode wherever designed.

6. COD declaration of units of generating station shall be in line with clause (5.10) of KEGC 2025. Accordingly, after completion of the trial run as per clause (5.5) of KEGC 2025 , details to be forwarded to SLDC along with the CoD declaration letter. Relevant clauses/definitions are given under for ready reference.

1. **KEGC 5.10(1)(a): "Date of Commercial Operation (CoD)(Thermal Generating Station or a unit thereof):** (i) The commercial operation date in the case of a unit of the thermal generation station shall be the date declared by the generating company after a successful trial run at MCR or de-rated capacity as per sub-clause (b) of clause (1) of Regulation 5.5 of these regulations, as the case may be, and submission of a declaration as per clause (1) of Regulation 5.9 of these regulations.
(ii) In the case of the generating station, the COD of the last unit of the generating station shall be considered as the COD of the generating station".

2. **KEGC 5.10(1)(b): "Date of Commercial Operation (CoD)(Hydro Generating Station):**
(i) The commercial operation date in the case of a unit of the hydro generating station including a pumped storage hydro generating station shall be the date declared by the generating station after after a successful trial run at MCR or de-rated capacity as per sub-clause (b) of clause (2) of Regulation 5.5 of these regulations, as the case may be, and submission of a declaration as per clause (2) of Regulation 5.9 of these regulations.
(ii) In the case of the generating station, the COD of the last unit of the generating station shall be considered as the COD of the generating station".

3. **KEGC 5.5(1) & (2): Trial Run** in relation to a thermal Central Generating Station or inter- State Generating Station or a unit thereof shall mean the successful running of the generating station or unit thereof at maximum continuous rating or installed capacity for continuous period of 72 hours in case of unit of a thermal generating station or unit thereof and 12 hours in case of a unit of a hydro generating station or unit thereof.

4. The Generating company shall issue a certificate in compliance to clause 5.9 sub-clause (1)(b) & (2)(b)of KEGC (whichever applicable), signed by CMD/CEO/MD of the company with a copy to Head of the State Load Despatch Centre.

5. As per clause 5.4 (4) of KEGC 2025" A generating station shall be required to undergo a trial run in accordance with Regulation 22 of these regulations after completion of Renovation and Modernization for extension of the useful life of the project as per the Tariff Regulations."

   In line with the above provisions a generating station or a unit thereof shall be required to undergo a trial run while uprating or derating of capacity other than existing MCR or installed capacity.

6. Trial Operation Certificate of conventional generating plants (Thermal, Gas & Hydro) will be issued by SLDC.

13. Periodic Testing

Periodic Testing shall be carried out as per regulation (6.18) of the KEGC, 2025 and amendments thereof. It is desirable to submit report of such tests carried out (at the time of first Time Energization and Integration) while applying for trial run certificates.

Within 03 months of completion of the periodic tests, the owner of the synchronous generator shall submit the final validated model comparing the results of the periodic tests against the model response as specified in section-11 as above. The models shall be submitted as per the model compatibility guidelines specified at Annexure-4(A),4(B),4(C).

14. Confidentiality Obligation

SLDC shall preserve the confidentiality of the information and data related with mathematical models (user defined model, source code etc.) and certification reports submitted to them in fulfilment of the obligations under this procedure and shall use them exclusively for the purpose they have been submitted, notably to verify the compliance of requirements set forth in extant regulations in Indian power system. The data may–be used for the purpose of system studies required for reliable and secure operation of the grid as per the Electricity Act and CEA/CERC regulations.

Note: Further amendment in the procedure can be done in line with KEGC/other CERC & CEA regulations/directive from time to time.

Enclosures.

Annex-1: Undertaking by Bulk Consumers or Load Serving Entities and Combined (Load and Captive) generation complex

Annex-2: Procedure for drawal of start-up power

Annex-3(A): Procedure for Collection of Modelling data from Coal fired

station Annex-3(B): Procedure for Collection of Modelling data from Gas

power station Annex-3(C): Procedure for Collection of Modelling data from

Hydro Power Station

Annexure-3(D): Guidelines for Model Compatibility and Support for Conventional generating (Thermal, Gas,Hydro)

Annex-4: Details of Hydro plant

Annex-1

Undertaking by Bulk Consumers or Load Serving Entities and Combined (Load and Captive) generation complex

This Undertaking is executed by MR. ………. **[Name of authorized personal]** on behalf of M/s ……………. **[Name of company]** having its registered address at………. **[registered address of company]**, in favour of **State Load Dispatch Centre (SLDC)**, **Place**, having its registered address at SLDC Address.

I, ………... **[Name of authorized personal]** working as ……………... **[designation of authorized personal]** at M/s ……………. **[Name of company]** with an ultimate installed capacity of ... **[Installed Capacity]** MW and having connectivity to In-STS at ..**[Name of Station Name, voltage level and Transmission licensee]**, do here by solemnly state and confirm as under:

1. Shall comply the KEGC and all the applicable regulations as enacted or amended from time to time as mentioned in regulation 4.2 (1) of KEGC-25 and amendments thereof.
2. Shall furnish the data required by SLDC to evaluate the short circuit level at the interconnection point.
3. PMU shall be suitably placed to monitor parameters at point of interconnection.
4. Shall ensure that connection to the network does not result in a determined level of distortion or fluctuation of the supply voltage on the network, at the connection point. The level of distortion shall not exceed that mentioned in CEA Technical Standards to the Grid Regulations.
5. Modelling data (both EMT and RMS) along-with model validation report of the Bulk Consumers or Load Serving Entities and Combined (Load and Captive) generation complex for both steady state and transient conditions shall be submitted for simulation studies.

Place:
Date:

Signature:
Name of the authorized personal:
Designation of the authorized person:

Annex-2

<u>Procedure for availing Start up power from the Grid by the Generating Stations under commissioning phase</u>

1. **Pre-conditions for availing Start-up power**:

The Generating Station intending to avail Start-up power shall fulfil the following conditions:

a. It has a valid Connectivity granted by STU as per CERC/KERC Applicable Regulations/orders/Procedure
b. It has signed Connection Agreement as per Regulations/orders/Procedure
c. It has established Connectivity with the In-STS
d. It has commissioned requisite switchyard equipment including Bay/Bus / Line reactor if any as per the reliability criteria & grant of Connectivity and in compliance First Time Energizations and Integration Procedure for Transmission Elements.
e. It has established Data and Voice communication with the SLDC as per clause 4.7 of KEGC 2025.
f. It has put in place necessary system protection in place as specified by SRPC.
g. It shall coordinate Generation Transformer (GT) / Station Transformer (ST) tap positions as per the direction of State Load Despatch Centre (SLDC).

2. **Procedure for applying for Start-up power:**

2.1 **The Generating Station shall submit a request for availing Start-up power to the SLDC at least one month prior to the expected date of availing Start-up power i.e 16 months before the expected date of first synchronisation of the unit.**

2.2 While requesting for start-up power, the Generating Station shall furnish the following details to the SLDC:

(1) Submission of reference documents pertaining to COD of Transmission elements required for availing start Power.
(2) Details of arrangement for drawing start up power,
(3) Single line diagram of the Generating Station
(4) Safety clearance from the Electrical Inspectorate of State (EI) of GT and generating unit.
(5) Details of electrical scheme for drawal of construction power clearly establishing the isolation between the schemes for construction power and start up power.
(6) Details of electrical scheme for drawal of start-up power by various phases of the Generating station.
(7) Unit details like Unit size, MCR, Auxiliaries & their rating etc.
(8) Schedule of activities and their requirement of power in terms of quantity and period etc.
(9) The generating station shall open a revolving and irrevocable LC issued by a scheduled bank equivalent to at least 2 months transmission charges prior to the drawal of start-up power. Start-up power shall be granted by SLDC as per the validity of the LC, the requested start-up power timeline by the generator, or as per the timeline mentioned in Section 5.2(2) of KEGC 2025, whichever is earlier. The validity of the said LC shall be verified by the STU.

2.3 The Generating Station shall submit an undertaking that:

(1) Drawal of power is only for the purpose of start-up power and not for the construction activity.

(2) The onus of proving that the interchange of infirm power from the unit(s) of the generating station is for the purpose of pre-commissioning activities, testing and commissioning, shall rest with the generating station, and the SLDC shall seek such information on each occasion of the interchange of power before COD.

(3) There is no violation of any of the agreements made with the Distribution Licensee or any other agency.

(4) The Generating Station shall indemnify, defend and save the SLDCs/SLDCs harmless from any and all damages, losses, claims and actions including those relating to injury or death of any person or damage to property, demands, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties, arising out of or resulting from this drawal.

(5) The Generating Station shall abide by KEGC and all prevailing Regulations and the directions of SLDC from time to time.

(6) The Generating Station shall reschedule the startu p activities as directed by SLDC due to reasons such as staggering the simultaneous drawal of Start-up power by other Generating Stations.

(7) The Generating Station shall pay the charges for Deviation within due date and comply with KERC Deviation Settlement Regulations, 2025 as amended from time to time or subsequent re-enactment thereof.

(8) The Generating Station shall send the Interface Energy Meter (IEM) data to SLDC as per the provisions of KEGC for energy accounting.

(9) The Generating Station shall pay all incidental charges such as Transmission charges, SLDC Fee & Charges, etc., as applicable, within the due date.

2.4 The Generator shall update the following information during the period of availing the Start-up Power and likely date of first synchronisation of the unit and subsequent program for injection of infirm power:

(1) The generating station shall submit a tentative plan for the quantum and time of injection of infirm power on day ahead basis to the SLDC.

3. **Procedure to be followed by SLDC during the period of availing Startup power:**

3.1 SLDC may permit drawal of Start-up power for one or more units at a time within a generating station keeping grid security in view.

3.2 SLDC will issue suitable directions to the Generating Station on Real time basis for limiting / stopping the drawal of start-up power in case of Network constraint on grounds of threat to system security or frequency or Voltage falling below the limits specified in KEGC. Such direction shall be complied by the Generating Station promptly.

3.3 The generator is entitled to draw the start-up power up to the maximum period of 15 months (Fifteen months prior to expected date of synchronization and twelve months after synchronization) from the date of commencement of drawal of start-up power from the grid. In case startup power is required beyond the specified period, the generator shall approach KERC at least two months in advance of the date up to which permission has been granted as per regulation 5.2 (3) of KEGC.

3.4 SLDC may direct the Generating Station to install under- frequency/under voltage relays to operate below a threshold value with suitable dead bands.

If simultaneous drawal of start-up power by more than one generating station is likely to cause system constraints, SLDC may stagger such drawal among various generators to relieve the constraint.

Application form for seeking Startup power

Reference number:

Date:

Name of the Generating Station:

Unit number(for which start-up power Required):

Unit size:

Details of Connectivity granted:

Details of Startup power requirement:

Sl. No.	Intended From date	Intended To date	Requirement of Power in MW	Details of Activities	Remarks

Enclosures:

- A copy of grant of connectivity approval given by STU
- Connection Agreement signed with STU and other In-STS licensees as the case may be
- Safety clearance report from State Electrical Inspectorate
- Single line diagram of the Generating station
- Details of electrical scheme for drawal of construction power clearly establishing the isolation between the schemes for construction power and start up power
- Details of electrical scheme for drawal of start-up power by various phases of the Generating station clearly establishing the isolation between the schemes for construction power and start-up power
- Unit details like Unit size, MCR, Auxiliaries & their rating, etc as per Annexure - A2 of section –I of this proceure
- Indemnity Bond
- Details of Payment Security submitted to STU for transmission charges

Note: Notarized Non Judicial Stamp paper not less than Rs.100(Rupees Hundred Only)

Undertaking

I___________son of_____________________working as_________________________in __________________________(organisation name) am authorised to sign this undertaking. I hereby undertake that:

- Drawal of power by unit no. of____________________(name of Generating station) is only for the purpose of startup power and not for the construction activity. **(The onus of proving that the drawal of power is for start-up of auxiliaries, testing and commissioning activities and not for Construction Power shall lie with the generating company)**
- There is no violation of any of the agreements made with the Distribution Licensee or any other agency.
- (Organization name) shall indemnify at all times, defend and save the SLDCs/RLDCs harmless from any and all damages, losses, claims and actions including those relating to injury to or death of any person or damage to property, demands, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties, arising out of or resulting from this drawal.
- (Organization name) will reschedule the startup activities as directed by SLDC due to reasons such as staggering the simultaneous drawal of startup power by other Generating Stations

Signature (Name)
Designation

Enclosures: as bove

Copy to: 1)
2)SLDC

Grant of Startup Power by SLDC

Approval number: Date:

To:

____

____

____

Sub: Grant of Startup power through Deviation Settlement Mechanism Sir,

With reference to your application number _______________dated _________, permission is hereby accorded to draw Startup power under Deviation Settlement Mechanism as per following details:

Name of the Generating Station :
Unit number :
Unit size :
Details of Start-up power granted :

Sl. No	From date	To date	Startup Power in MW granted	Remarks

Please note that any request regarding extension/revision beyond the stipulated period of this approval shall be made to SLDC at least two months in advance of the completion of the stipulated period as per clause 5.2(3) of KEGC 2025 and amendments thereof.
Please adhere to all the guidelines regarding drawal of start-up power as prescribed in section 19 of KEGC 2025 and SLDC FTE&I Procedure.

Signature (Name)
Designation

Copy to: 1

2) SLDC

Annex-3(A)

Guidelines for furnishing information for RMS (generic) modelling of Coal fired generation

The guidelines provide the desired information for collection of data for RMS modelling (generic) of coal fired thermal generation

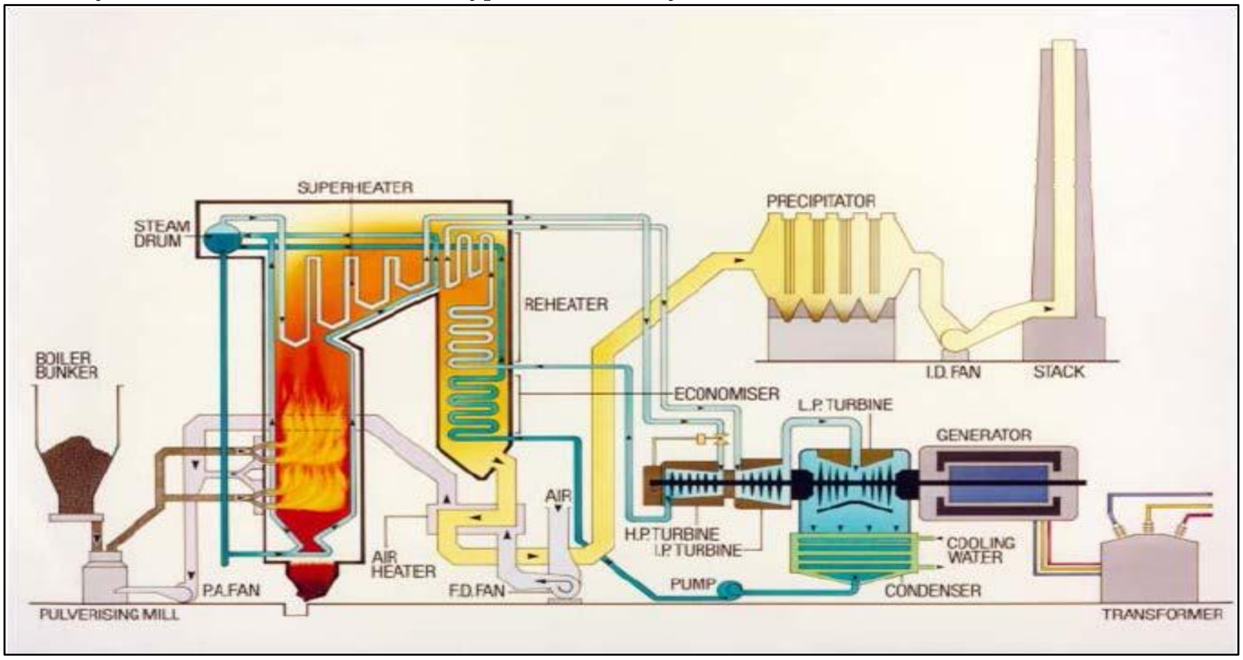
1.0 Coal fired thermal generation technologies:

Coal fired power plants typically burn coal to heat a boiler that produces high-temperature, high- pressure steam that is passed through the turbine to produce mechanical energy (IEEE Power and Energy Society, 2013).

The majority of commercially available coal fired thermal generators use one of the three technologies depending upon the stream pressure within the boiler as listed below:

Technology	Temperature	Pressure
Sub-critical	537 °C / 565 °C	Below 225 kg/cm2
Super-critical	538/565 °C ~ Older units 565/593 °C ~ later commissioned	247kg/cm2
Ultra-supercritical	600/610 °C to 700°C	250-300/cm2

**Figures taken from Standard Technical features of BTG system for subcritical and supercritical units issued by CEA 2013. Above values are typical values only.*



Schematic of a Typical Coal Fired Generator

For Grid-India to have access to verified fit-for-purpose generic RMS models of coal fired thermal generation connected to Indian grid, following information is required:

1. Electrical Single Line Diagram of coal fired thermal station depicting;
   - **For individual generating units:** type of technology, **Complete Generator OEM Technical Datasheet** (which comprises namely generator parameters like impedances & time constants, generator capability curve, V-curve, generator open and short circuit characteristics, excitation system details, inertia of generator & exciter), generator name plate, generator SAT reports including Short circuit and open circuit test results during commissioning/recent overhauling.
   - **Generator step up transformer**: GT name plate/datasheet, details of LV, MV and HV, MVA rating, impedance, tap changer details, vector group, short-circuit parameters (actual positive & zero sequence impedance of GT, NGR nameplate with impedance).
   - **Excitation system: -** Type of excitation system (Direct Current Commutator Exciters (type DC),

AC Excitation (Rotor or brushless excitation) Systems (type AC) and Static Excitation Systems (type ST), Excitation system schematics (Block diagram of AVR system), transfer function block diagram of Excitation system, excitation transformer nameplate, saturation curves of the exciter (I_a versus I_f curve), IEEE standard model of excitation system, IEEE standard model and its parameter of subsystems such as Power system stabilizer (PSS), Under Excitation Limiter (UEL), Over Excitation Limiter (OEL), Voltage per Hz Limiter(V/Hz) control etc. and details thereof, factory acceptance test reports (FAT). Excitation system actual settings to be provided. AVR test report (excitation step response test).

- **Power System Stabilizer (PSS):** Transfer function block diagram of PSS, IEEE Standard Model, Actual PSS software settings, PSS commissioning report and **Recent PSS tuning report**.
- **Turbine-Governor system :** Type of turbine (Tandem/Cross compound), model of turbine and boiler (including details of boiler controls, technology, valves, valve characteristics), model of speed governor and turbine load (if applicable) control system (including details of technology, valves, valves characteristics) , mode of operation and control, ramp rates, **turbine inertia**, IEEE standard model of turbine governor system and its transfer function Block diagram and its parameters, details of control mode (boiler-follow, turbine-follow, or coordinated control), commissioning report of turbine-governor system or recent governor testing report.

3.1 Details of models in PSS/E for modelling coal fired thermal generation:

(a) Synchronous Machine

Category	Parameter Description	Data
Generator Nameplate	Rated apparent power in MVA	
	Rated terminal voltage	
	Rated power factor	
	Rated frequency (in Hz)	
	Rated speed (in RPM)	
	Rated excitation (in Amperes and Volts)	
Type of synchronous machine	Round rotor or salient pole No. of Poles:	
Generator capability curve	The generator capability curve shows the reactive capability of the machine and should include any restrictions on the real or reactive power range like under/over excitation limits, stability limits, etc. Capability curve should have properly labelled axis and legible data	
Generator Open Circuit and Short Circuit Characteristic	Graph of excitation current versus terminal voltage and stator current	
	No load excitation current	
	Excitation current at rated stator current	
Generator vee-curves	Otherwise referred to as "V-curve". A plot of the terminal (armature) current versus the generating unit field voltage.	
Resistance values	Resistance measurements of field winding and stator winding to a known temperature	
	Direct axis synchronous reactance Xd in p.u. (Unsaturated or saturated)	
	Direct axis transient synchronous reactance Xd' in p.u. (Unsaturated or saturated)	
	Direct axis sub-transient synchronous reactance Xd'' in p.u. (Unsaturated or saturated)	
	Stator leakage reactance Xa in p.u. (Unsaturated or saturated)	
	Quadrature axis synchronous reactance Xq in p.u. (Unsaturated or saturated)	
	Quadrature axis transient synchronous reactance Xq' in p.u. (Unsaturated or saturated)	

	Quadrature axis sub-transient synchronous reactance Xq’’ in p.u. (Unsaturated or saturated)	
Generator Data sheet		
	Direct axis open circuit transient time constant Tdo’ in sec	
	Direct axis open circuit sub-transient time constant Tdo’’ in sec	
	Quadrature axis open circuit transient time constant Tqo’ in sec	
	Quadrature axis open circuit sub-transient time constant Tqo’’ in sec	
	Inertia constant of total rotating mass (generator, AVR, turbo-governor set) H in MW. s/MVA	
	Speed Damping D	
	Saturation constant S (1.0) in p.u.	
	Saturation constant S (1.2) in p.u.	

Category	Parameter Description	Data
Generator step up transformer (GSUT)	Nameplate Rating - Rated primary and secondary voltage - Vector group - Impedance - Tap changer details (Number of taps, tap position, tap ratio etc.)	

(b) Site Load

	Low Output			High Output		
	kW	**kvar**	**kVA**	**kW**	**kvar**	**kVA**
Auxiliary Load						

(c) Excitation System

Category	Parameter Description	Data
Type of Automatic Voltage Regulator (AVR)	Manufacturer and product details	
	Type of control system: - Analogue or digital	
	Year of commissioning / Year of manufacture	
	As found settings (obtained either from HMI or downloaded from controller in digital systems)	
Type of excitation system	Static excitation system OR	
	Indirect excitation system (i.e. rotating exciter) - AC exciter, or - DC exciter	
Details of AVR converter	Rated excitation current (converter rating in Amperes)	
	Six pulse thyristor bridge or PWM converter	
Source of excitation supply	Excitation transformer or auxiliary supply (Details thereof)	
	If excitation transformer, nameplate information such as type of transformer, HV and HV winding ratings, positive and zero sequence impedance, tap positions, voltage step per tap is required.	
Schematics	Saturation curves of the exciter (if applicable – see Type AC and DC)	
	Drawings of excitation system, typically prepared and supplied by the OEM	
	Single line diagram (i.e. one-line diagram) for the excitation system	
Excitation limiters	What excitation limiters are commissioned?	
	Under Excitation Limiters settings	
	Over Excitation Limiters settings	
	Voltage/frequency limiter	
	Stator current limiter	
	Minimum excitation current limiter	
PSS	Is the AVR equipped with a PSS?	
	How many input Channels does the PSS have? (speed, real power output or both	

Category	Parameter Description	Data
	If the PSS uses speed, is this a derived speed signal (i.e. synthesized speed signal) or measured directly (i.e. actual rotor speed)?	
	Type of PSS Block Diagram of PSS and as commissioned parameters value (Gain, time constants, filter coefficients, output limits of the PSS)	

(d) Turbine Details

Category	Parameter Description	Data
Manufacturer of turbine	Manufacturer and name plate details Rating of turbine	
Type of Governor	Electro-mechanical governor	
	Digital electric governor	
	Block diagram of the speed governor	
Ramp rates	How fast can the turbine increase and/or decrease load, specified in MW/min	
	Stroke limits of speed changer (values of full stroke, full load and no-load in mm)	
Droop	Droop setting (% on machine base)	
	Frequency influence limiters - Maximum frequency deviation limiter (eg +/-2 Hz) - Maximum influence limiter (eg 10% of rating)	
Dead band	Details of frequency dead band (typically in Hz)	
Steam turbine	**Tandem compound:** all sections on one shaft with a single generator	
	Cross compound: consists of two shafts, each connected to a generator and driven by one or more turbine section	
	Turbine sections: High pressure (HP), intermediate pressure (IP) and low pressure (LP)	
	Reheat or non-reheat: In a reheat, steam upon leaving HP section returns to boiler where it passed through reheater before entering IP section	
	Valves: - Main inlet stop valve (MSV) - Governor control valve (CV) - Reheater stop valve (RSV) - Intercept valves (IV)	
	Turbine control action: - Boiler follow mode - Turbine follow mode - Coordinated control	
	Fast valving /bypass operation	
	Block diagram of the turbine load control	
	Reheater volume (m^3), volume flow (kg/s), and average specific volume (m^3/kg)	

3.2 Generic Models for synchronous machine

There are two typical groups of synchronous machine models, depending upon the type of machine:

- Round rotor machine (2 poles):
  - GENROU – Round rotor machine model with quadratic saturation function
  - GENROE – Round rotor machine model with exponential saturation function
- Salient pole machine (more than two poles):
  - GENSAL – Salient pole machine with quadratic saturation function
  - GENSAE – Salient pole machine with exponential saturation function

Category	Parameter Description	Data
GENERATOR model		
GENROU OR **GENROE**	Direct axis open circuit transient time constant Tdo' in sec	
	Direct axis open circuit sub-transient time constant Tdo'' in sec	
	Quadrature axis open circuit transient time constant Tqo' in sec	
	Quadrature axis open circuit sub-transient time constant Tqo'' in sec	
	Inertia constant of total rotating mass H in MW. s/MVA	
	Speed Damping D	
	Direct axis synchronous reactance Xd in p.u. (Unsaturated or saturated)	
	Quadrature axis synchronous reactance Xq in p.u. (Unsaturated or saturated)	
	Direct axis transient synchronous reactance Xd' in p.u. (Unsaturated or saturated)	
	Quadrature axis transient synchronous reactance Xq' in p.u. (Unsaturated or saturated)	
	Direct axis sub-transient synchronous reactance Xd'' in p.u. (Unsaturated or saturated) = Quadrature axis sub-transient synchronous reactance Xq'' in p.u. (Unsaturated or saturated)	
	Stator leakage reactance Xl in p.u.	
	Saturation constant S (1.0) in p.u.	
	Saturation constant S (1.2) in p.u.	
GENSAE OR **GENSAL**	Direct axis open circuit transient time constant Tdo' in sec	
	Direct axis open circuit sub-transient time constant Tdo'' in sec	
	Quadrature axis open circuit sub-transient time constant Tqo'' in sec	
	Inertia constant of total rotating mass H in MW. s/MVA	
	Speed Damping D	
	Direct axis synchronous reactance Xd in p.u. (Unsaturated or saturated)	
	Quadrature axis synchronous reactance Xq in p.u. (Unsaturated or saturated)	
	Direct axis transient synchronous reactance Xd' in p.u. (Unsaturated or saturated)	
	Direct axis sub-transient synchronous reactance Xd'' in p.u. (Unsaturated or saturated) = Quadrature axis sub-transient synchronous reactance Xq'' in p.u. (Unsaturated or saturated)	
	Stator leakage reactance Xl in p.u.	
	Saturation constant S (1.0) in p.u.	
	Saturation constant S (1.2) in p.u.	

While entering the values in above table, following relationship must be kept:

Xd>Xq>Xq'≥Xd'>Xq"≥Xd''

Tdo'>Td'>Tdo''>Td''

Tqo''>Tq'>Tqo''>Tq''

3.3 Excitation system model:

If a generic model is used, the first step must be to identify what type of exciter is present in the excitation system. The IEEE Std 421.5 (IEEE Recommended Practice for Excitation System Models for Power System Stability Studies published on 26th Aug 2016) has published several generic models, which are classified into three groups:

- Type DC: for excitation systems with a DC exciter
- Type AC: for excitation systems with an AC exciter
- Type ST: for excitation systems with a static exciter

The following table shows the types of models separated into their respective groups.

DC exciter	AC exciter	Static excitation system
Type DC1A	Type AC1A	Type ST1A
Type DC2A	Type AC2A	Type ST2A
Type DC3A	Type AC4A	Type ST3A
Type DC4B	Type AC5A	Type ST4B
	Type AC6A	Type ST5B
	Type AC7B	Type ST6B
	Type AC8B	Type ST7B

Category	Parameter Description	Data
DC Exciter		
ESDC1 A OR ESDC2 A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	TB (s), lag time constant	
	TC (s), lead time constant	
	VRMAX (pu) regulator output maximum limit or Zero	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF1 (> 0) rate feedback time constant (sec)	
	Switch	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
ESDC3A	TR regulator input filter time constant (sec)	
	KV (pu) limit on fast raise/lower contact setting	
	VRMAX (pu) regulator output maximum limit or Zero	
	VRMIN (pu) regulator output minimum limit	
	TRH (> 0) Rheostat motor travel time (sec)	
	TE (> 0) exciter time-constant (sec)	
	KE (pu) exciter constant related to self-excited field	
	VEMIN (pu) exciter minimum limit	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
DC Exciter		
ESDC4B	TR regulator input filter time constant (sec)	
	KP (pu) (> 0) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	KD (pu) voltage regulator derivative gain	
	TD voltage regulator derivative channel time constant (sec)	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KA (> 0) (pu) voltage regulator gain	
	TA voltage regulator time constant (sec)	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	VEMIN (pu) minimum exciter voltage output	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
AC Exciter		
ESAC1A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	

Category	Parameter Description	Data
AC Exciter		
ESAC2A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KB, Second stage regulator gain	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VFEMAX, parameter of VEMAX, exciter field maximum output	
	KH, Exciter field current feedback gain	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
ESAC3A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VEMIN (pu) minimum exciter voltage output	
	KR (>0), Constant associated with regulator and alternator field power supply	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KN, Exciter feedback gain	
	EFDN, A parameter defining for which value of UF the feedback gain shall change from KF to KN	
	KC, rectifier regulation factor (pu)	
	KD, exciter regulation factor (pu)	
	KE (pu) exciter constant related to self-excited field	
	VFEMAX, parameter of VEMAX, exciter field maximum output	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
ESAC4A	TR regulator input filter time constant (sec)	
	VIMAX, Maximum value of limitation of the integrator signal VI in p. u	
	VIMIN, Minimum value of limitation of the signal VI in p.u.	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC, rectifier regulation factor (pu)	
ESAC5A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF1 (sec), Regulator stabilizing circuit time constant in seconds	
	TF2 (sec), Regulator stabilizing circuit time constant in seconds	
	TF3 (sec), Regulator stabilizing circuit time constant in seconds	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
AC6A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	TK (sec), Lead time constant	
	TB (s), lag time constant	
	TC (s), lead time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VFELIM, Exciter field current limit reference	
	KH, Damping module gain	
	VHMAX, damping module limiter	
	TH (sec), damping module lag time constant	
	TJ (sec), damping module lead time constant	
	KC, rectifier regulation factor (pu)	
	KD, exciter regulation factor (pu)	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
AC7B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	KDR (pu) regulator derivative gain	
	TDR (sec) regulator derivative block time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KPA (pu) voltage regulator proportional gain	
	KIA (pu) voltage regulator integral gain	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KP (pu)	
	KL (pu)	
	KF1 (pu)	
	KF2 (pu)	
	KF3 (pu)	
	TF3 (sec) time constant (> 0)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	VFEMAX (pu) exciter field current limit (> 0)	
	VEMIN (pu)	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
AC8B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	KDR (pu) regulator derivative gain	
	TDR (sec) regulator derivative block time constant	
	VPIDMAX (pu) PID maximum limit	
	VPIDMIN (pu) PID minimum limit	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	VFEMAX (pu) max exciter field current limit (> 0)	
	VEMIN (pu),	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
Static Exciter		
ST1A	TR (sec) regulator input filter time constant	
	VIMAX, Controller Input Maximum	
	VIMIN, Controller Input Minimum	
	TC (s), Filter 1st Derivative Time Constant	
	TB (s), l Filter 1st Delay Time Constant	
	TC1 (s), Filter 2nd Derivative Time Constant	
	TB1 (s), Filter 2nd Delay Time Constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KLR, Current Input Factor	
	ILR, Current Input Reference	

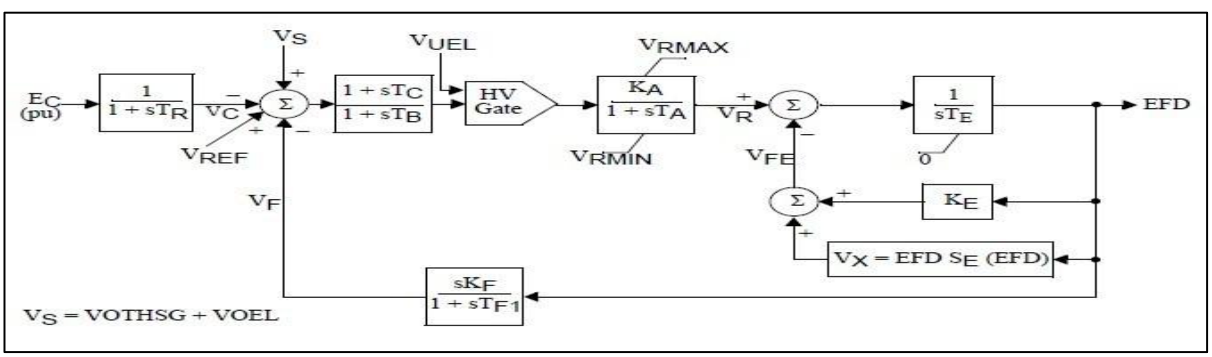
Category	Parameter Description	Data
Static Exciter		
ST2A	TR (sec) regulator input filter time constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	EFDMAX	
ST3A	TR (sec) regulator input filter time constant	
	VIMAX, Maximum value of limitation of the signal VI in p.u.	
	VIMIN, Minimum value of limitation of the signal VI in p.u.	
	KM, Forward gain constant of the inner loop field regulator	
	TC (s), lag time constant	
	TB (s), lead time constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KG, Feedback gain constant of the inner loop field regulator	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	VBMAX, Maximum value of limitation of the signal VB in p.u.	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	XL, Reactance associated with potential source	
	VGMAX, Maximum value of limitation of the signal VG in p. u	
	Θ_P (degrees)	
	TM (sec), Forward time constant of the inner loop field regulator	
	VMMAX, Maximum value of limitation of the signal VM in p. u	
	VMMIN, Minimum value of limitation of the signal VM in p.u.	

Category	Parameter Description	Data
Static Exciter		
ST4B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TA (sec) voltage regulator time constant	
	KPM, Regulator gain	
	KIM, Regulator gain	
	VMMAX, Maximum value of limitation of the signal in p.u.	
	VMMIN, Minimum value of limitation of the signal in p.u.	
	KG	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	VBMAX	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	XL	
	Θ_P (degrees)	
ST5B	TR regulator input filter time constant (sec)	
	TC1 lead time constant of first lead-lag block (voltage regulator channel) (sec)	
	TB1 lag time constant of first lead-lag block (voltage regulator channel) (sec)	
	TC2 lead time constant of second lead-lag block (voltage regulator channel) (sec)	
	TB2 lag time constant of second lead-lag block (voltage regulator channel) (sec)	
	KR (>0) (pu) voltage regulator gain	
	VRMAX (pu) voltage regulator maximum limit	
	VRMIN (pu) voltage regulator minimum limit	
	T1 voltage regulator time constant (sec)	
	KC (pu)	
	TUC1 lead time constant of first lead-lag block (under-excitation channel) (sec)	
	TUB1 lag time constant of first lead-lag block (under-excitation channel) (sec)	
	TUC2 lead time constant of second lead-lag block (under-excitation channel) (sec)	
	TUB2 lag time constant of second lead-lag block (under-excitation channel) (sec)	
	TOC1 lead time constant of first lead-lag block (over-excitation channel) (sec)	
	TOB1 lag time constant of first lead-lag block (over-excitation channel) (sec)	
	TOC2 lead time constant of second lead-lag block (over-excitation channel) (sec)	
	TOB2 lag time constant of second lead-lag block (over-excitation channel) (sec)	

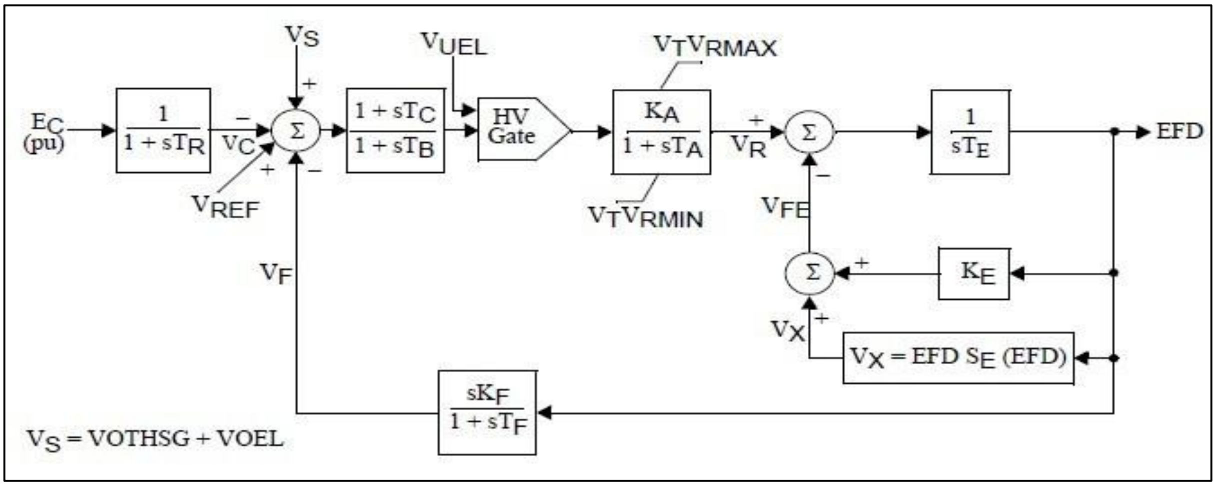
Category	Parameter Description	Data
Static Exciter		
ST6B	TR regulator input filter time constant (sec)	
	KPA (pu) (> 0) voltage regulator proportional gain	
	KIA (pu) voltage regulator integral gain	
	KDA (pu) voltage regulator derivative gain	
	TDA voltage regulator derivative channel time constant (sec)	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KFF (pu) pre-control gain of the inner loop field regulator	
	KM (pu) forward gain of the inner loop field regulator	
	KCI (pu) exciter output current limit adjustment gain	
	KLR (pu) exciter output current limiter gain	
	ILR (pu) exciter current limit reference	
	VRMAX (pu) voltage regulator output maximum limit	
	VRMIN (pu) voltage regulator output minimum limit	
	KG (pu) feedback gain of the inner loop field voltage regulator	
	TG (> 0) feedback time constant of the inner loop field voltage regulator (sec)	
ST7B	TR regulator input filter time constant (sec)	
	TG lead time constant of voltage input (sec)	
	TF lag time constant of voltage input (sec)	
	Vmax (pu) voltage reference maximum limit	
	Vmin (pu) voltage reference minimum limit	
	KPA (pu) (>0) voltage regulator gain	
	VRMAX (pu) voltage regulator output maximum limit	
	VRMIN (pu) voltage regulator output minimum limit	
	KH (pu) feedback gain	
	KL (pu) feedback gain	
	TC lead time constant of voltage regulator (sec)	
	TB lag time constant of voltage regulator (sec)	
	KIA (pu) (>0) gain of the first order feedback block	
	TIA (>0) time constant of the first order feedback block (sec)	

(i) DC Exciters Generic model:

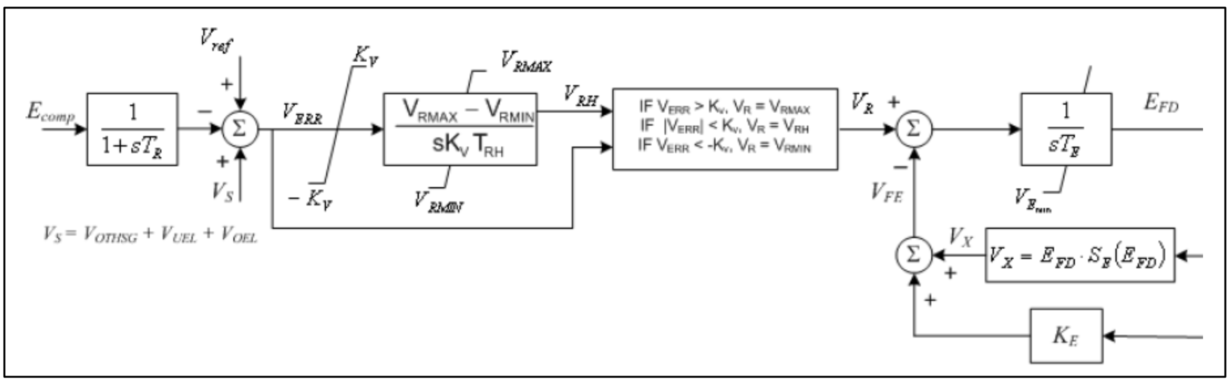
- **Type DC1A: 1992 IEEE type DC1A excitation system model**



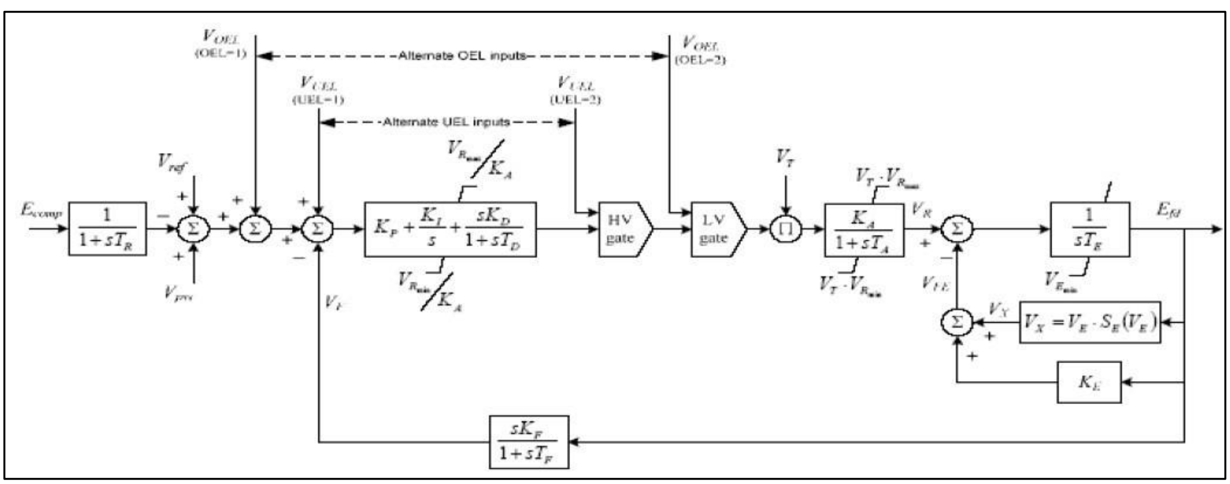
- **Type DC2A: 1992 IEEE type DC2A excitation system model**



- **Type DC3A: IEEE 421.5 2005 DC3A excitation system**

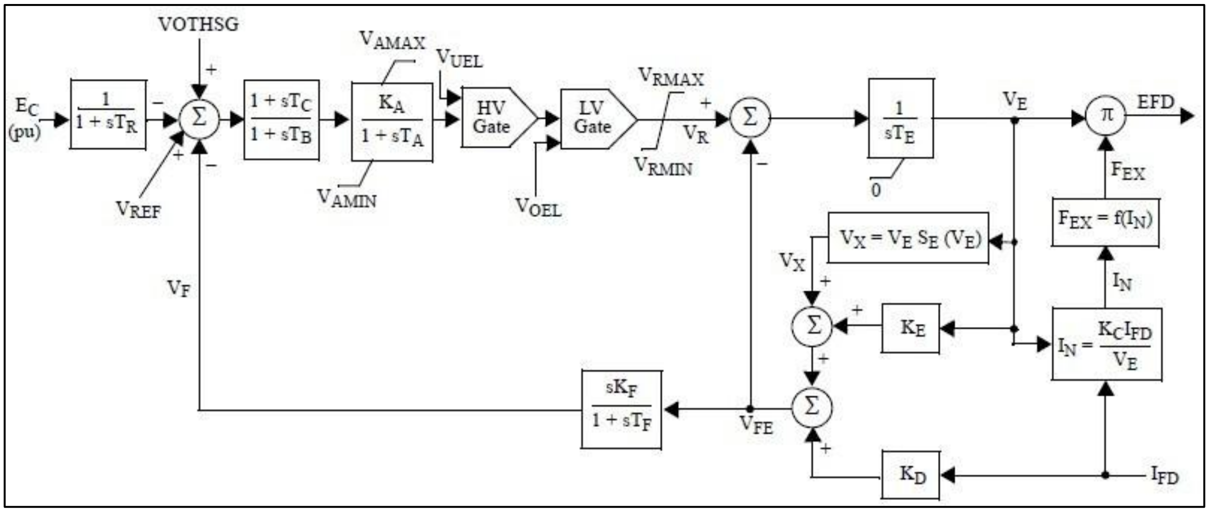


- **Type DC4B: IEEE 421.5 2005 DC4B excitation system**



(ii) **AC Exciters Generic Models:**

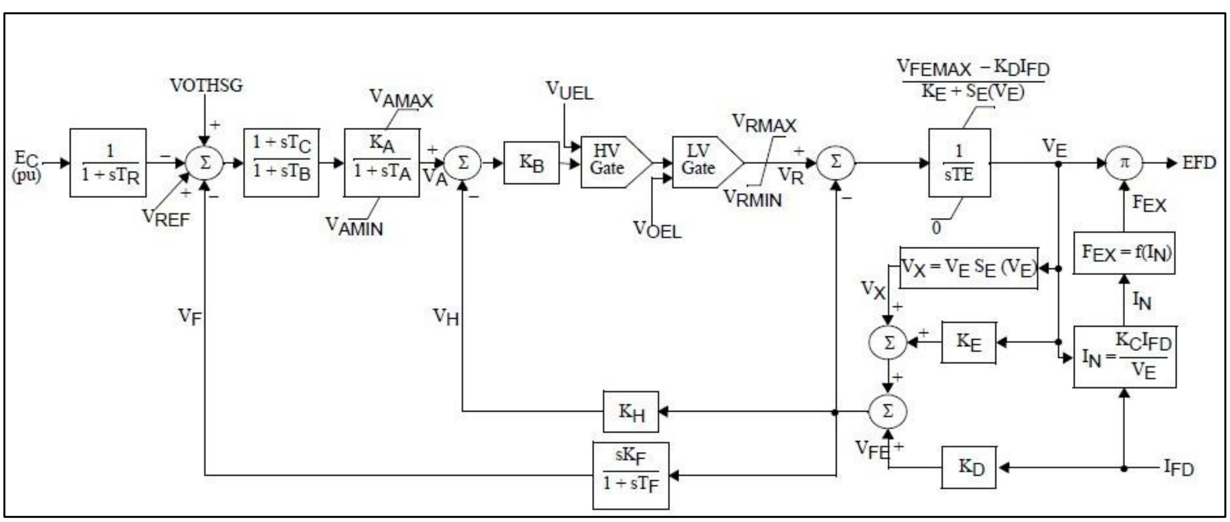
- **Type AC1A: 1992 IEEE type AC1A excitation system model**



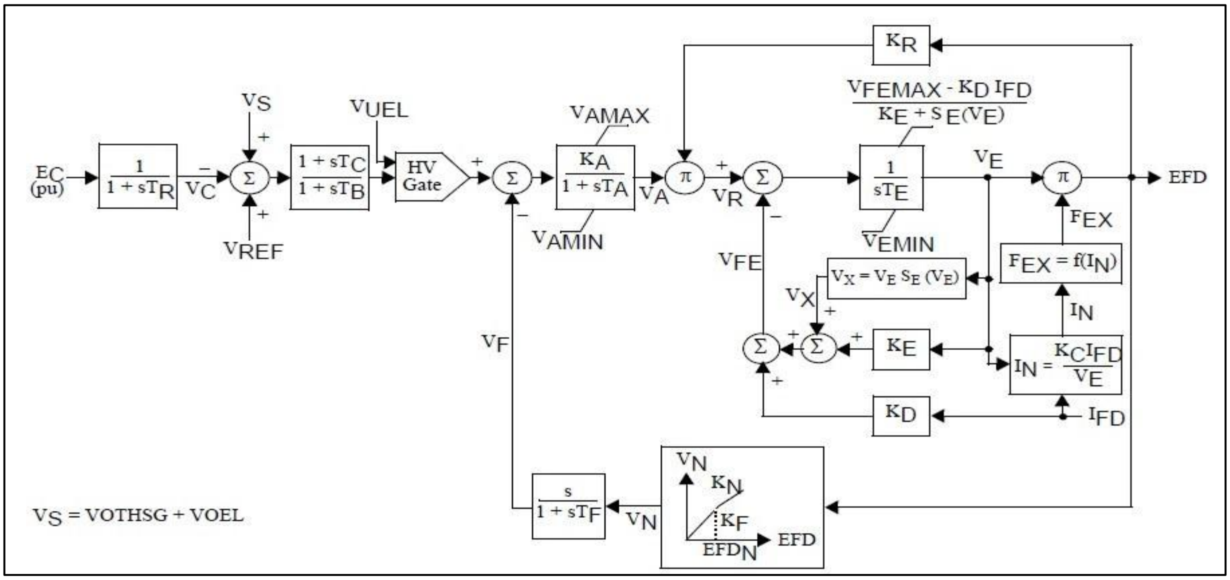
If $I_N \le 0$	$F_{EX} = 1$
If $I_N \le 0.433$	$F_{EX} = 1 - 0.577\ I_N$
If $0.433 < I_N < 0.75$	$F_{EX} = \sqrt{0.75 - I_N^2}$
If $I_N \ge 0.75$	$F_{EX} = 1.732(1 - I_N)$
If $I_N > 1$	$F_{EX} = 0$

$I_N \rightarrow$ (box above) $\rightarrow F_{EX}$

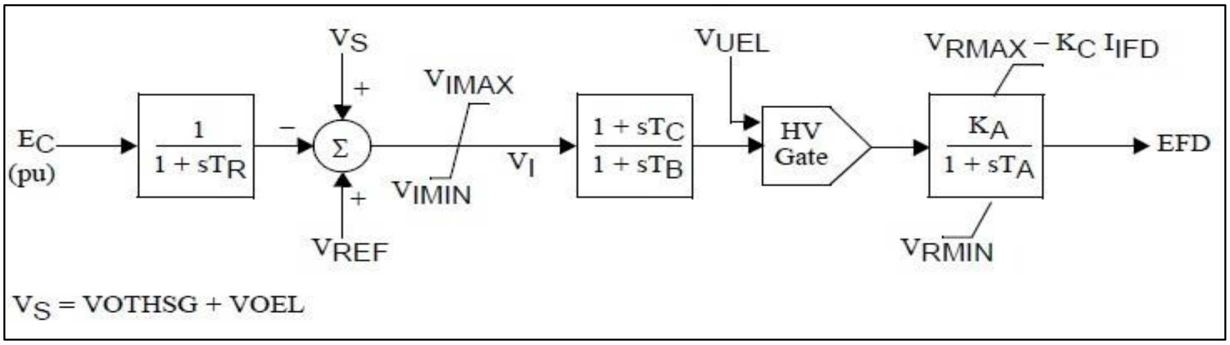
- **Type AC2A: 1992 IEEE type AC2A excitation system model**



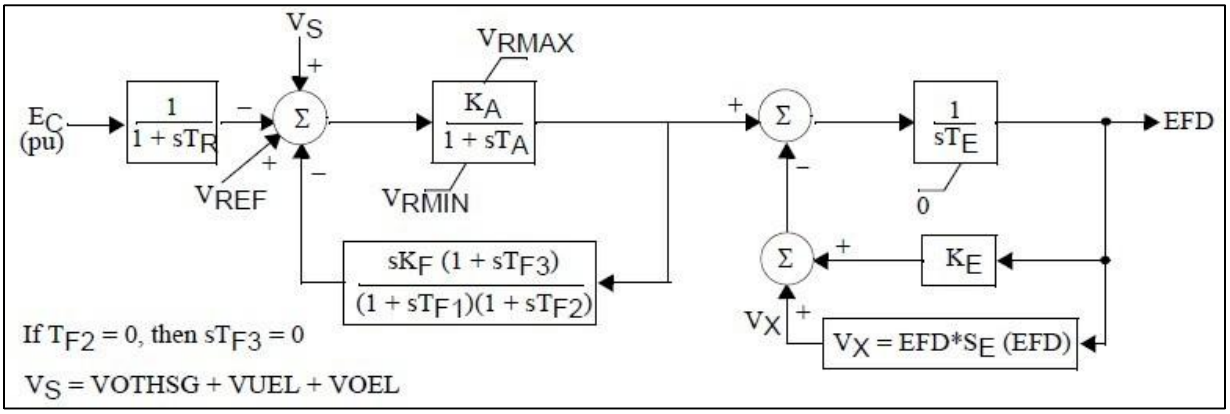
- **Type AC3A: 1992 IEEE type AC3A excitation system model**



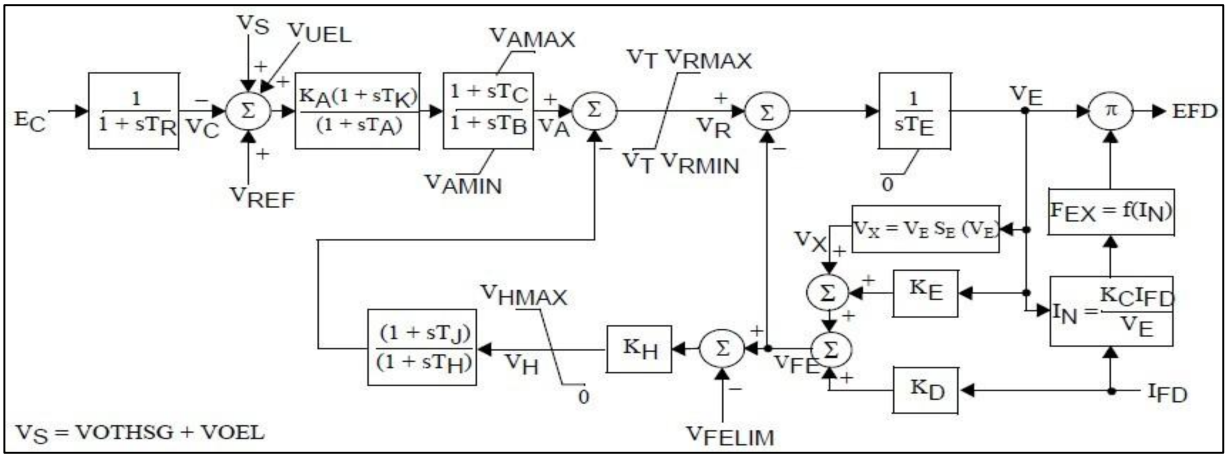
- **Type AC4A: 1992 IEEE type AC4A excitation system model**



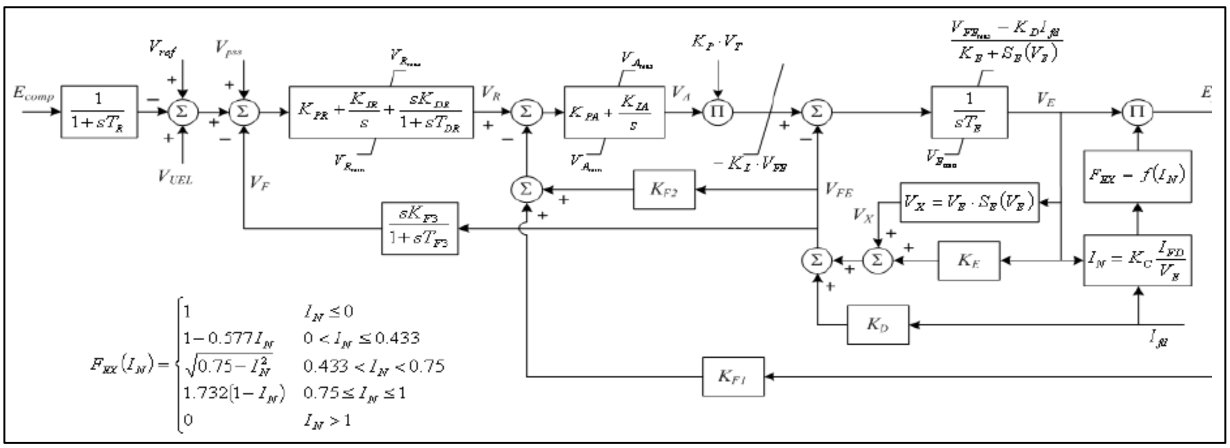
- **Type AC5A: 1992 IEEE type AC5A excitation system model**



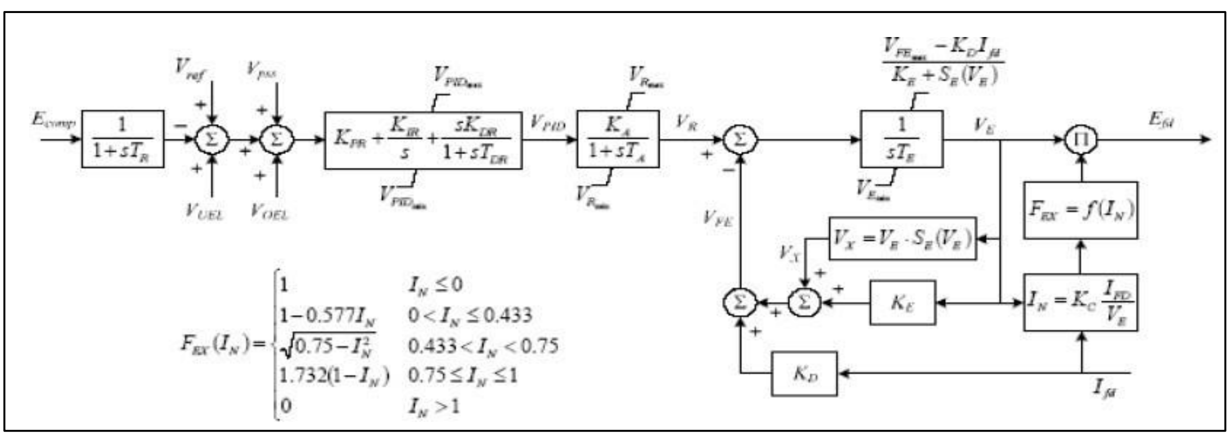
- **Type AC6A: IEEE 421.5 excitation system model**



- **Type AC7B: IEEE 421.5 2005 AC7B excitation system**

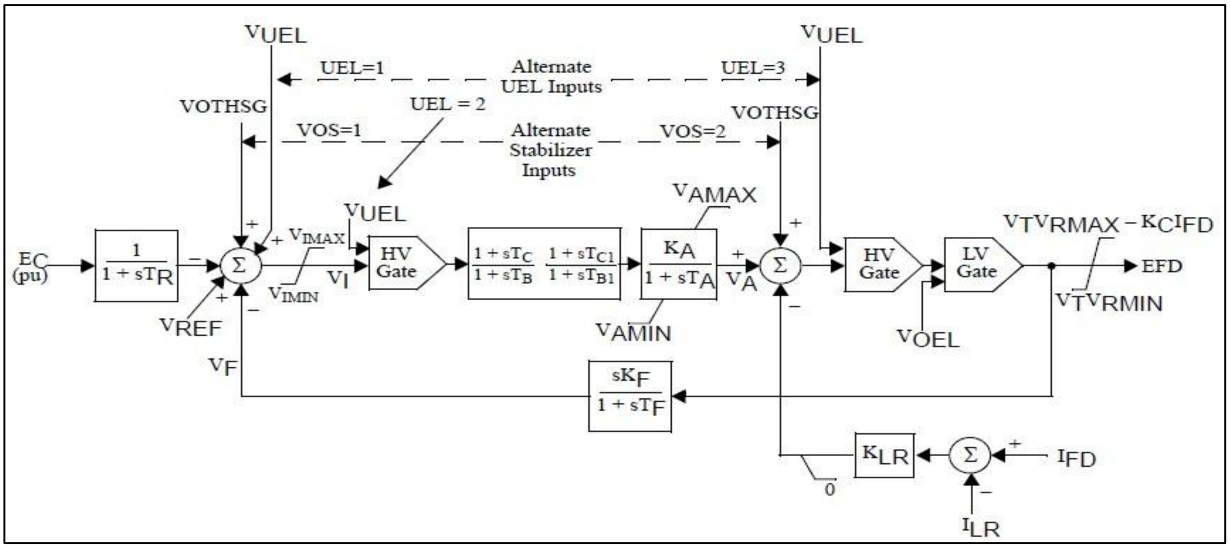


- **Type AC8B: IEEE 421.5 2005 AC8B excitation system**

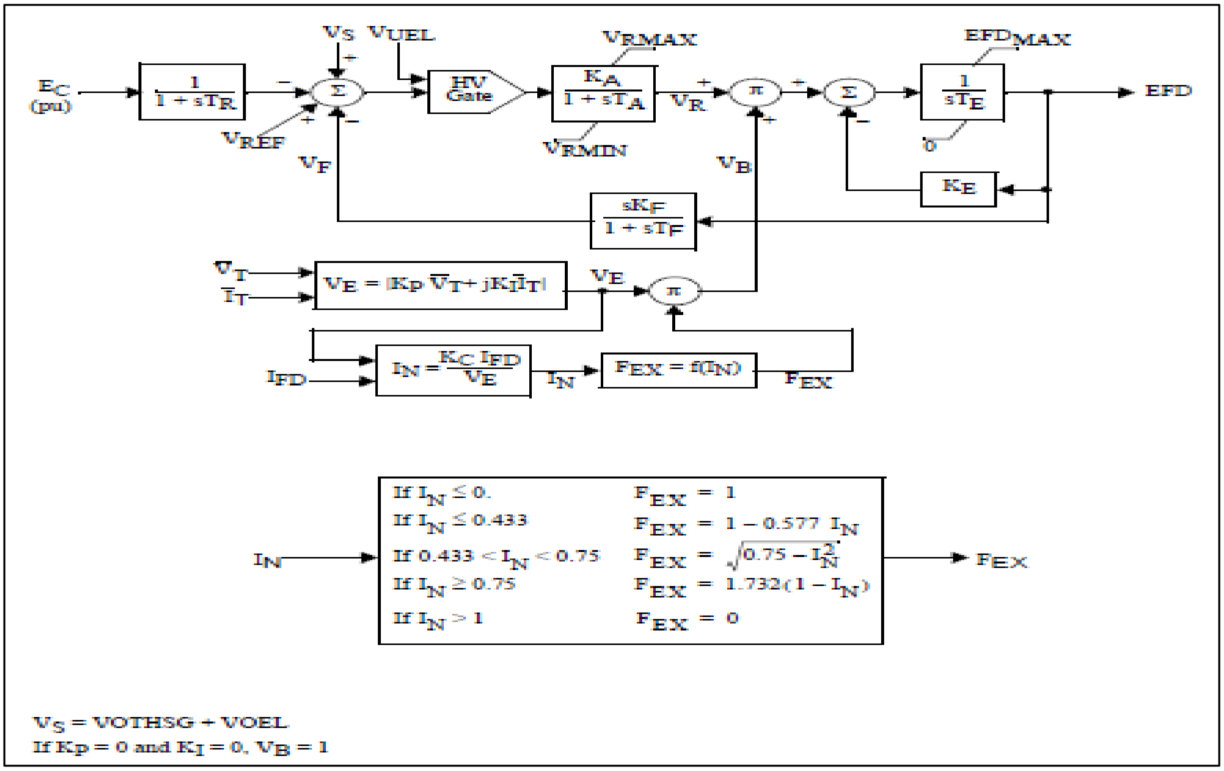


(iii) **Commonly Used Static Exciters Generic Models block diagrams:**

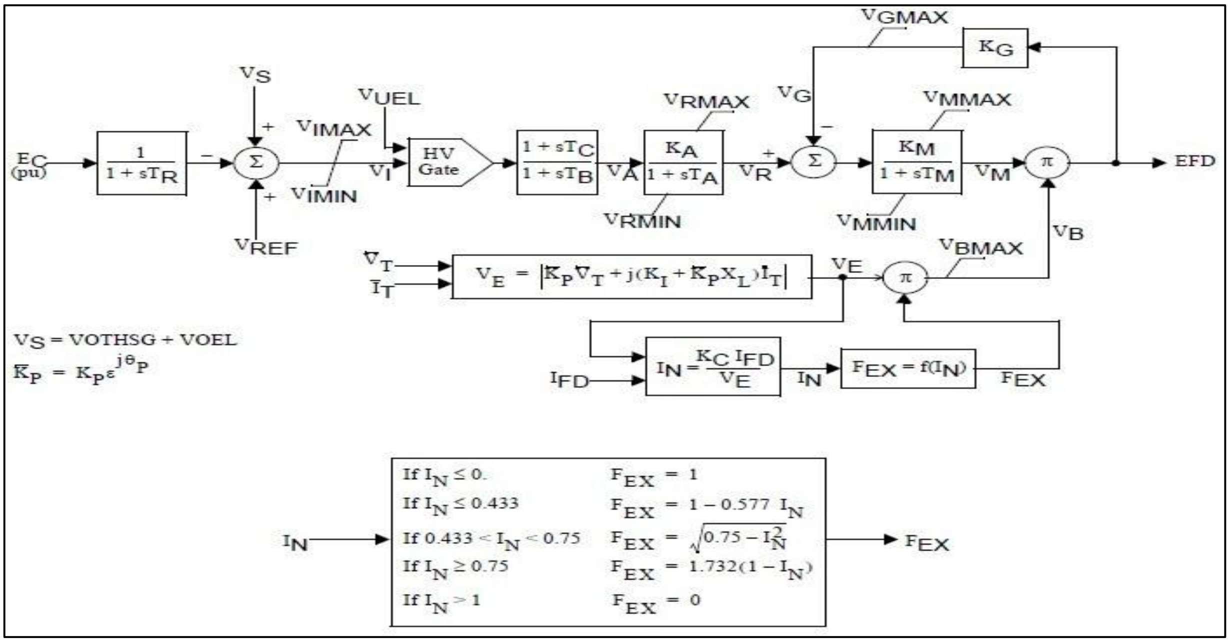
- **Type ST1A: 1992 IEEE type ST1A excitation system model**



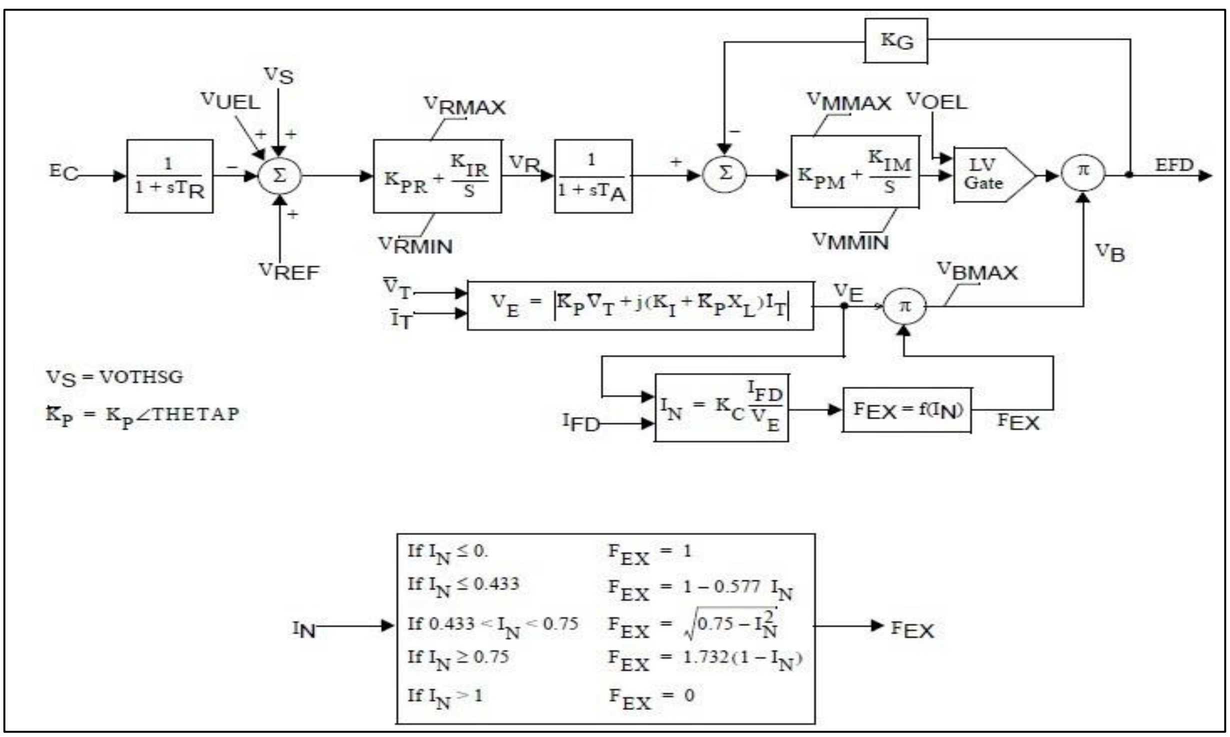
- **Type ST2A: 1992 IEEE type ST2A excitation system model**



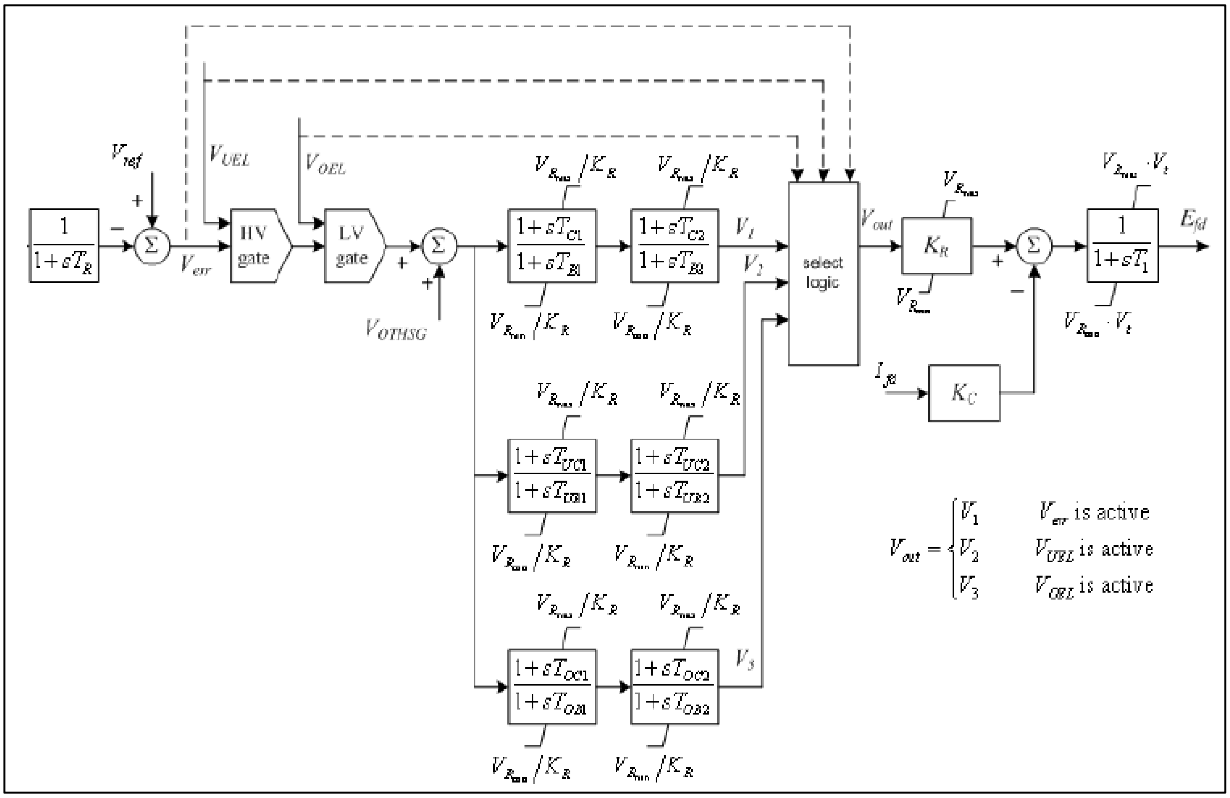
- **Type ST3A: 1992 IEEE type ST3A excitation system model**



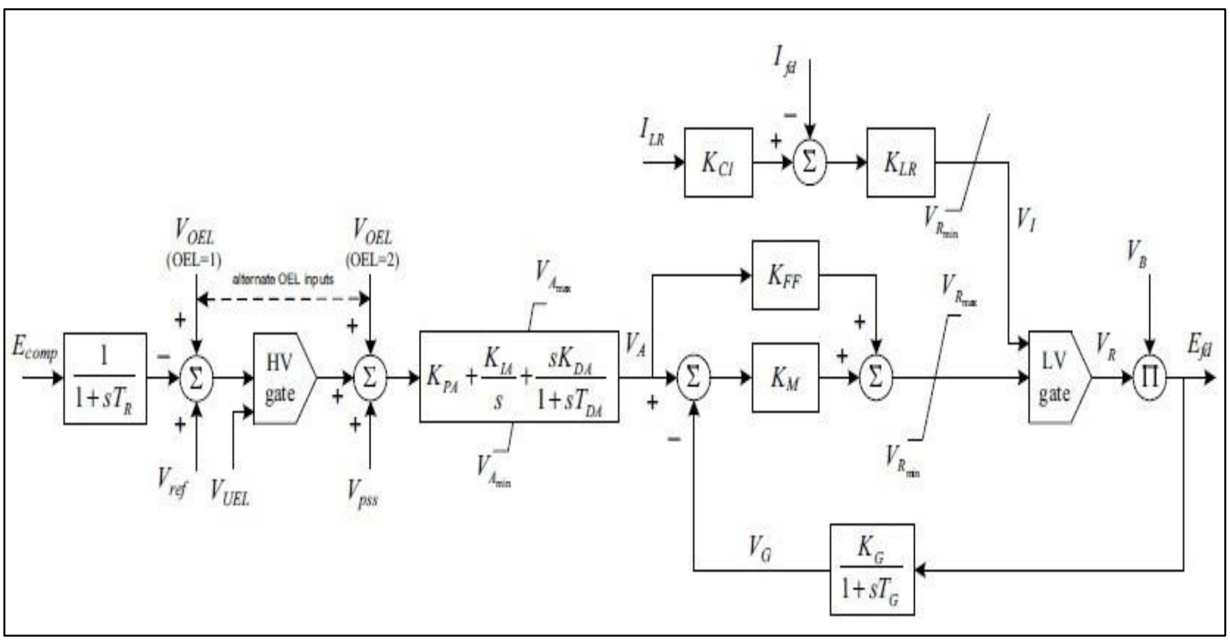
- **Type ST4B: IEEE type ST4B potential or compounded source-controlled rectifier exciter**



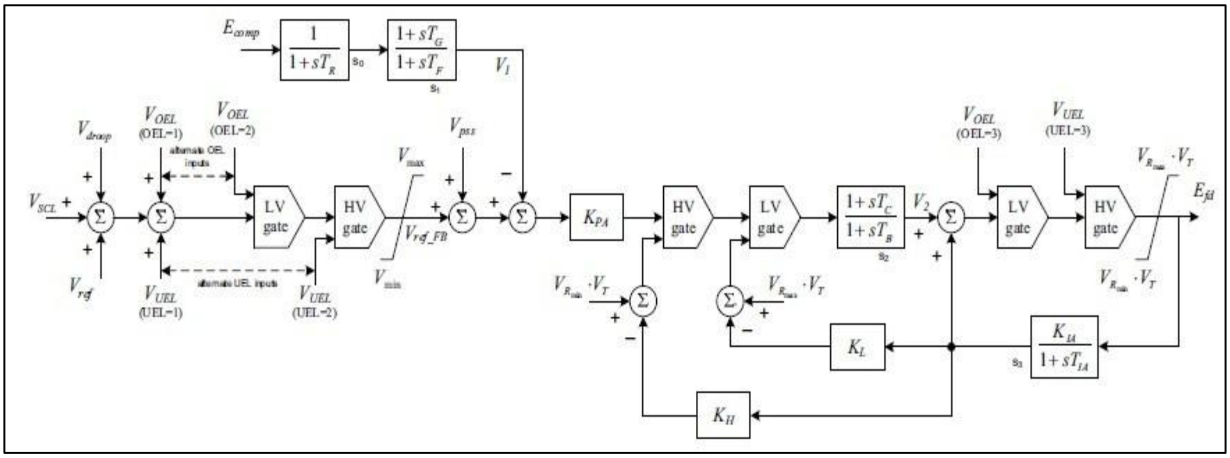
- **Type ST5B: IEEE 421.5 2005 ST5B excitation system**



- **Type ST6B: IEEE 421.5 2005 ST6B excitation system**



- **Type ST7B: IEEE 421.5 2005 ST7B excitation system**



Source-PSSE Model Library

3.4 Power system stabilizer:

The function of the PSS is to add to the unit's characteristic electromechanical oscillations. This is achieved by modulating excitation to develop a component in electrical torque in phase with rotor speed deviations.

The most important aspect when considering a PSS model is the number of inputs. The following table shows the type of models separated based on the inputs:

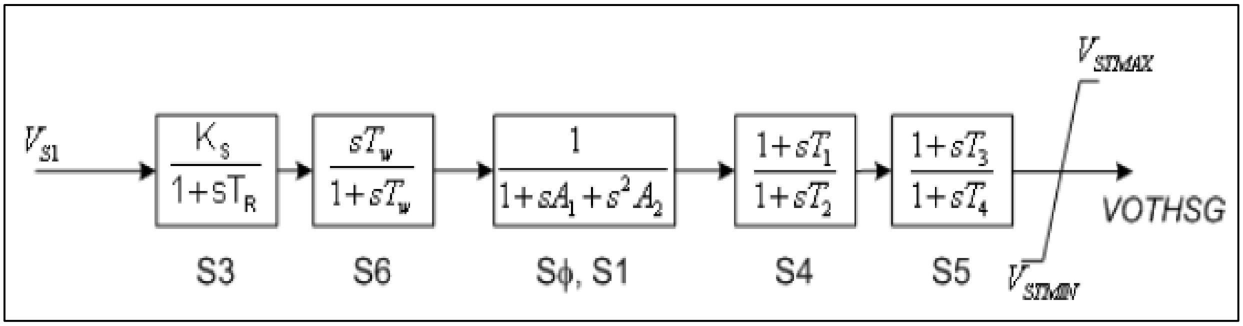
Type	Inputs	Remarks
PSS1A	Single input	Two lead-lags Input can either be speed, frequency or power
PSS2B	Dual input	Integral of accelerating power Speed and Power Most common type Supersedes PSS2A (three versus two lead lags)
PSS3B	Dual input	Power and rotor angular frequency deviation Stabilising signal is a vector sum of processed signals Not very common

Category	Parameter Description	Data
Stabilizer Models		
PSS1A	A1, Filter coefficient	
	A2, Filter coefficient	
	TR, transducer time constant	
	0	
	0	
	0	
	T1, 1st Lead-Lag Derivative Time Constant	
	T2, 1st Lead-Lag Delay Time Constant	
	T3, 2nd Lead-Lag Derivative Time Constant	
	T4, 2nd Lead-Lag Delay Time Constant	
	Tw, Washout Time Constant	
	Tw, Washout Time Constant	
	Ks, input channel gain	
	VSTMAX, Controller maximum output	
	VSTMAX, Controller minimum output	
	0	
	0	

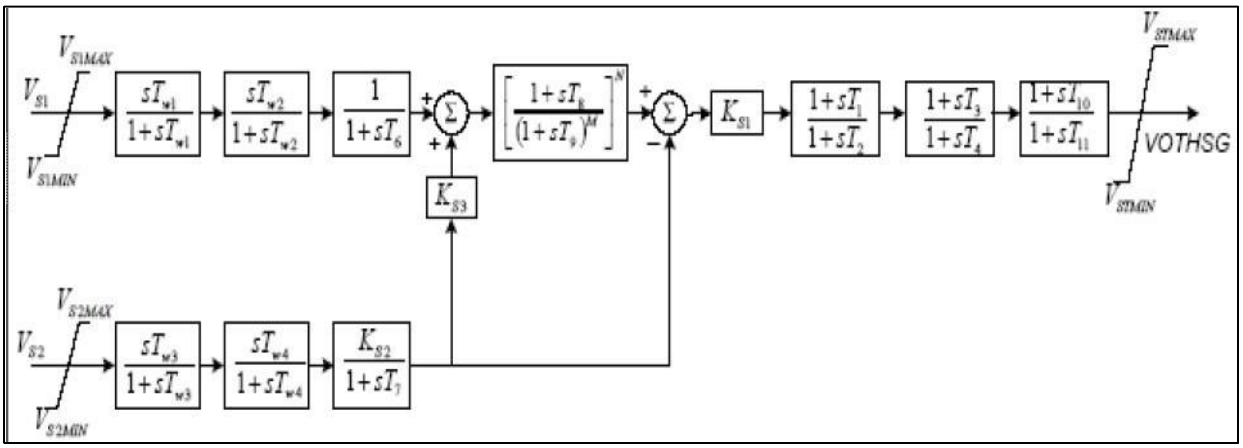
Category	Parameter Description	Data
Stabilizer Models		
PSS2B	TW1, 1st Washout 1th Time Constant	
	TW2, 1st Washout 2th Time Constant	
	T6, 1st Signal Transducer Time Constant	
	TW3, 2nd Washout 1th Time Constant	
	TW4, 2nd Washout 2th Time Constant	
	T7, 2nd Signal Transducer Time Constant	
	KS2, 2nd Signal Transducer Factor	
	KS3, Washouts Coupling Factor	
	T8, Ramp Tracking Filter Deriv. Time Constant	
	T9, Ramp Tracking Filter Delay Time Constant	
	KS1, PSS Gain	
	T1, 1st Lead-Lag Derivative Time Constant	
	T2, 1st Lead-Lag Delay Time Constant	
	T3, 2nd Lead-Lag Derivative Time Constant	
	T4, 2nd Lead-Lag Delay Time Constant	
	T10, 3rd Lead-Lag Derivative Time Constant	
	T11, 3rd Lead-Lag Delay Time Constant	
	VS1MAX, Input 1 Maximum limit	
	VS1MIN, Input 1 Minimum limit	
	VS2MAX, Input 2 Maximum limit	
	VS2MIN, Input 2 Minimum limit	
	VSTMAX, Controller Maximum Output	
	VSTMIN, Controller Minimum Output	
PSS3B	KS1 (pu) (≠0), input channel #1 gain	
	T1 input channel #1 transducer time constant (sec)	
	Tw1 input channel #1 washout time constant (sec)	
	KS2 (pu) (0), inputchannel #2 gain	
	T2 input channel #2 transducer time constant (sec)	
	Tw2 input channel #2 washout time constant (sec)	
	Tw3 (0), main washout time constant (sec)	
	A1, Filter coefficient	
	A2, Filter coefficient	
	A3, Filter coefficient	
	A4, Filter coefficient	
	A5, Filter coefficient	
	A6, Filter coefficient	
	A7, Filter coefficient	
	A8, Filter coefficient	
	VSTMAX, Controller maximum output	
	VSTMAX, Controller minimum output	

Commonly Used Power System Stabilizer generic models block diagrams:

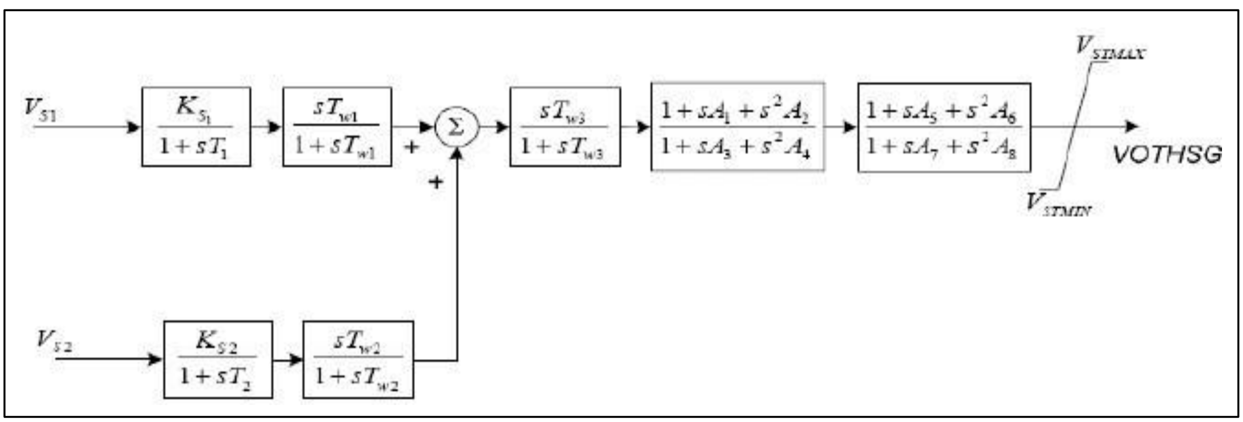
- **PSS1A: IEEE Std. 421.5-2005 PSS1A Single-Input Stabilizer model**



- **PSS2B: IEEE 421.5 2005 PSS2B IEEE dual-input stabilizer model**



- **PSS3B: IEEE Std. 421.5 2005 PSS3B IEEE dual-input stabilizer model**



Source-PSSE Model Library

3.5 Generic models for turbine-governor:

The following table is a list for generic models of steam turbines:

Type	Name	Remarks
BBGOV1	Brown-Boveri turbine governor model	Mainly used for steam turbine with electrical damping feedback
TGOV1	Steam-turbine governor	Mainly used for steam turbine with reheater
CRCMGV	Cross-compound turbine	-
IEEEG1	IEEE type 1 Speed-Governor Model	Used to represent non-reheat, tandem compound, and cross compound types.
IEEEG2	IEEE Type 2 Speed-Governing Model	Linearized model for representing a hydro turbine-governor and penstock dynamics
IEEEG3	IEEE type 3 turbine-governor model	Includes a more complex representation of the governor controls than IEEEG2 does
IEESGO	IEEE Standard Model	Simple model of reheat steam turbine
TGOV2	Steam –turbine governor with fast valving	Fast valving model of steam turbine
TGOV3	Modified IEEE Type 1 Speed-Governing Model with fast valving	Modification of IEEEG! For fast valving studies
TGOV4	Modified IEEE Type 1 Speed-Governing Model with PLU and EVA	Model of steam turbine and boiler, explicit action for both control valve (CV) and inlet valve (IV), main reheat and LP steam effects, and boiler
TGOV5	IEEE Type 1 Speed-Governor Model Modified to Include Boiler Controls	Most common type of governor model, based on TGOV1 with boiler controls
TURCZT	Czech hydro or steam turbine governor model	General-purpose hydro and thermal turbine-governor model. Penstock dynamic is not included in the model

Source: PSSE Model Library, for models other than the above list refer to

https://w3.usa.siemens.com/smartgrid/us/en/transmission-grid/products/grid-analysis-tools/transmission-system-planning/transmission-system-planning-tab/pages/user-support.aspx

Category	Parameter Description	Data
TURBINE GOVERNOR model		
BBGOV1	fcut (>=0) (pu), cut off frequency	
	KS, frequency gain	
	KLS (> 0)	
	KG	
	KP, power regulator gain	
	TN (sec) (> 0)	
	KD, damping gain	
	TD (sec) (> 0), damping time constant	
	T4 (sec), high pressure time constant	
	K2, intermediate pressure time constant	
	T5 (sec), intermediate re-heater time constant	
	K3, high pressure time constant	
	T6 (sec), re-heater time constant	
	T1 (sec), measuring transducer time constant	
	SWITCH	
	PMAX, maximum power output limiter	
	PMIN, minimum power output limiter	
TGOV1	R, Permanent Droop	
	T1 (>0) (sec), Steam bowl time constant	
	VMAX, Maximum valve position	
	VMIN, Minimum valve position	
	T2 (sec), Time constant	
	T3 (>0) (sec), reheater time constant	
	Dt, Turbine damping coefficient	
	VMAX, VMIN, Dt and R, are in per unit on generator MVA base. T2/T3 = high-pressure fraction.	
CRCMGV	PMAX (HP)1, maximum HP value position (on generator base)	
	R (HP), HP governor droop	
	T1 (HP) (>0), HP governor time constant	
	T3 (HP) (>0), HP turbine time constant	
	T4 (HP) (>0), HP turbine time constant	
	T5 (HP) (>0), HP reheater time constant	
	F (HP), fraction of HP power ahead of reheater	
	DH (HP), HP damping factor (on generator base)	
	PMAX (LP), maximum LP value position (on generator base)	
	R (LP), LP governor droop	
	T1 (LP) (>0), LP governor time constant	
	T3 (LP) (>0), LP turbine time constant	
	T4 (LP) (>0), LP turbine time constant	
	T5 (LP) (>0), LP turbine time constant	
	F (LP), fraction of LP power ahead of reheater	
	DH (LP), LP damping factor (on generator base)	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
IEEEG1	K, Governor gain, (1/droop) pu	
	T1 (sec), Lag time constant (sec)	
	T2 (sec), Lead time constant (sec)	
	T3 (> 0) (sec), valve position time constant	
	Uo (pu/sec), maximum valve opening rate	
	Uc (< 0) (pu/sec), maximum valve closing rate	
	PMAX (pu on machine MVA rating)	
	PMIN (pu on machine MVA rating)	
	T4 (sec), time constant for steam inlet	
	K1, HP fraction	
	K2, LP fraction	
	T5 (sec), Time Constant for Second Boiler Pass [s]	
	K3, HP Fraction	
	K4, LP fraction	
	T6 (sec), Time Constant for Third Boiler Pass [s]	
	K5, HP Fraction	
	K6, LP fraction	
	T7 (sec), Time Constant for Fourth Boiler Pass [s]	
	K7, HP Fraction	
	K8, LP fraction	
IEEEG2	K, Governor gain	
	T1 (sec), Governor lag time constant	
	T2 (sec), Governor lead time constant	
	T3 (>0) (sec), Gate actuator time constant	
	PMAX (pu on machine MVA rating), gate maximum	
	PMIN (pu on machine MVA rating), gate minimum	
	T4 (>0) (sec), water starting time	
IEEEG3	TG, (>0) (sec), gate servomotor time constant	
	TP (>0) (sec), pilot value time constant	
	Uo (pu per sec), opening gate rate limit	
	Uc (pu per sec), closing gate rate limit (< 0)	
	PMAX maximum gate position (pu on machine MVA rating)	
	PMIN minimum gate position (pu on machine MVA rating)	
	σ, permanent speed droop coefficient	
	δ, transient speed droop coefficient	
	TR, (>0) (sec), Dashpot time constant	
	TW (>0) (sec), water starting time	
	a11 (>0), Turbine coefficient	
	a13, Turbine coefficient	
	a21, Turbine coefficient	
	a23 (>0), Turbine coefficient	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
IEESGO	T1, Controller Lag	
	T2, Controller Lead Compensation	
	T3, Governor Lag (> 0)	
	T4, Delay Due to Steam Inlet Volumes	
	T5, Reheater Delay	
	T6, Turbine, pipe, hood Delay	
	K1, 1/Per Unit Regulation	
	K2, Fraction	
	K3, fraction	
	PMAX, Upper Power Limit	
	PMIN, Lower Power Limit	
TGOV2	R (pu), permanent droop	
	T1 (>0) (sec), Steam bowl time constant	
	VMAX (pu), Maximum valve position	
	VMIN (pu), Minimum valve position	
	K (pu), Governor gain	
	T3 (>0) (sec), Time constant	
	Dt (pu), Turbine damping coefficient	
	Tt (>0) (sec), Valve time constant	
	TA, Valve position at time 2 (fully closed after fast valving initialization)	
	TB, Valve position at time 3 (start to reopen after fast valving initialization)	
	TC, Valve position at time 4 (again fully open after fast valving initializations)	
TGOV3	K, Governor gain	
	T1 (sec), Governor lead time constant	
	T2 (sec), Governor lag time constant	
	T3 (>0) (sec), Valve positioner time constant	
	Uo, Maximum valve opening velocity	
	Uc (< 0), Maximum valve closing velocity	
	PMAX, Maximum valve opening	
	PMIN, Minimum valve opening	
	T4 (sec), Inlet piping/steam bowl time constant	
	K1, Fraction of turbine power developed after first boiler pass	
	T5 (> 0) (sec), Time constant of second boiler pass	
	K2, Fraction of turbine power developed after second boiler pass	
	T6 (sec), Time constant of crossover or third boiler pass	
	K3, Fraction of hp turbine power developed after crossover or third boiler pass	
	TA (sec), Valve position at time 2 (fully closed after fast valving initializations)	
	TB (sec), Valve position at time 3 (start to reopen after fast valving initializations)	
	TC (sec), Valve position at time 4 (again fully open after fast valving initializations)	
	PRMAX (pu), Max. pressure in reheater	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
TGOV4	K, The inverse of the governor speed droop	
	T1 (sec), The governor controller lag time constant	
	T2 (sec), The governor controller lead time constant	
	T3 (>0) (sec), The valve servomotor time constant for the control valves	
	Uo, The control valve open rate limit	
	Uc (<0), The control valve close rate limit	
	KCAL	
	T4 (sec), The steam flow time constant	
	K1	
	T5 (> 0) (sec)	
	K2	
	T6 (sec)	
	PRMAX	
	KP	
	KI	
	TFuel (sec)	
	TFD1 (sec)	
	TFD2 (sec)	
	Kb	
	Cb (> 0) (sec)	
	TIV (> 0) (sec)	
	UOIV	
	UCIV	
	R (>0)	
	Offset	
	CV position demand characteristic	
	CV #2 offset	
	CV #3 offset	
	CV #4 offset	
	IV position demand characteristic	
	IV #2 offset	
	CV valve characteristic	
	IV valve characteristic	
	CV starting time for valve closing (sec)	
	CV closing rate (pu/sec)	
	Time closed for CV #1 (sec)	
	Time closed for CV #2	
	Time closed for CV #3	
	Time closed for CV #4	
	IV starting time for valve closing (sec)	

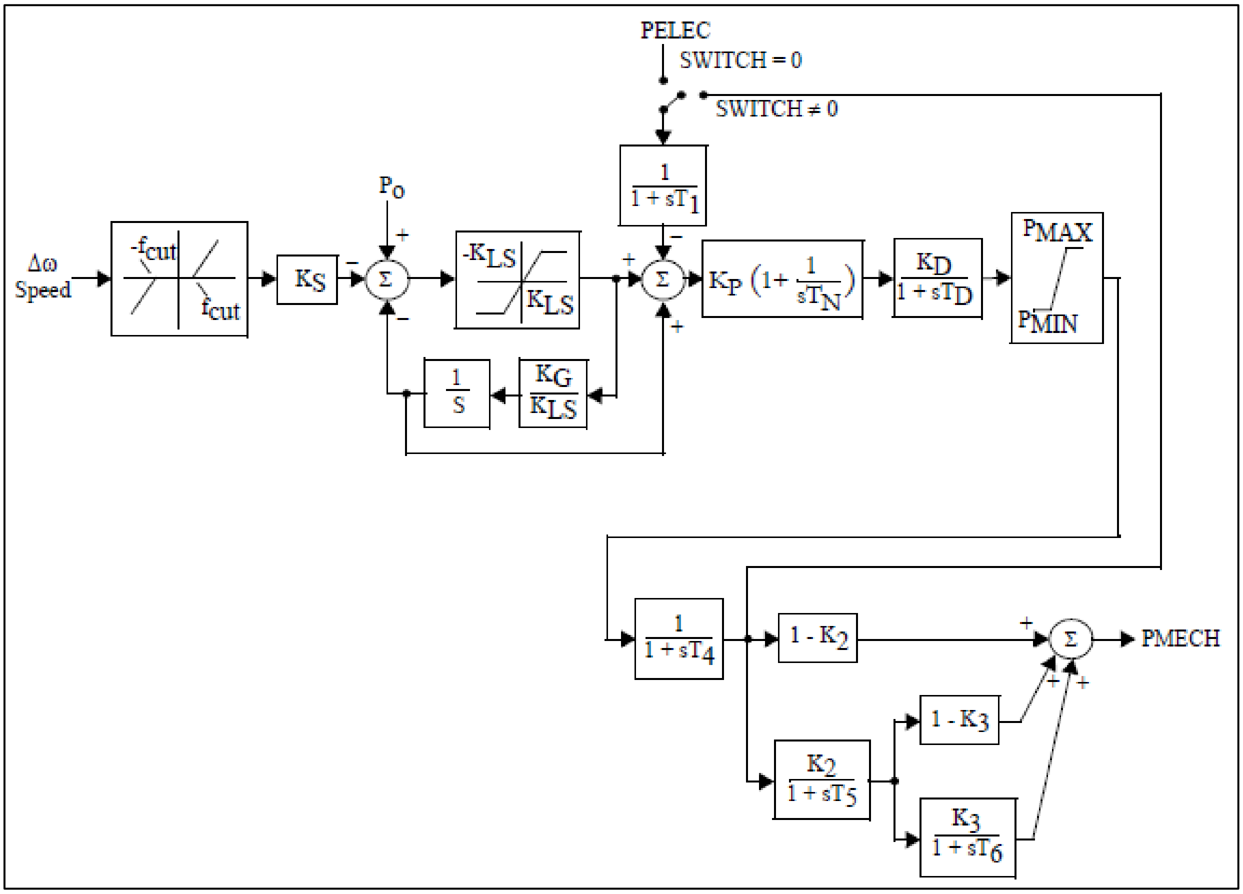
Category	Parameter Description	Data
TURBINE GOVERNOR model		
TGOV4	IV closing rate (pu/sec)	
	Time closed for IV #1 (sec)	
	Time closed for IV #2 (sec)	
	TRPLU (>0) (sec)	
	PLU rate level	
	Timer	
	PLU unbalance level	
	TREVA (>0) (sec)	
	EVA rate level	
	EVA unbalance level	
	Minimum load reference (pu)	
	Load reference ramp rate (pu/sec)	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
TGOV5	K, The inverse of the governor speed droop	
	T1 (sec), The governor controller lag time constant	
	T2 (sec), The governor controller lead time constant	
	T3 (>0) (sec), The valve servomotor time constant for the control valves	
	Uo, The control valve open rate limit	
	Uc (<0), The control valve close rate limit	
	VMAX, The maximum valve area	
	VMIN, The minimum valve area	
	T4 (sec), The steam flow time constant	
	K1, The fractions of the HP	
	K2, fractions of the LP	
	T5 (sec), The first reheater time constant	
	K3, The fractions of the HP	
	K4, fractions of the LP	
	T6 (sec), second reheater time constant	
	K5, The fractions of the HP	
	K6, fractions of the LP	
	T7 (sec), crossover time constant	
	K7, The fractions of the HP	
	K8, fractions of the LP	
	K9, The adjustment to the pressure drop coefficient as a function of drum pressure	
	K10, The gain of anticipation signal from main stream flow	
	K11, The gain of anticipation signal from load demand	
	K12, The gain for pressure error bias	
	K13, The gain between MW demand and pressure set point	
	K14, Inverse of load reference servomotor time constant (= 0.0 if load reference does not change).	
	RMAX, The load reference positive rate of change limit	
	RMIN, The load reference negative rate of change limit	
	LMAX, The maximum load reference	
	LMIN, The minimum load reference	
	C1, The pressure drop coefficient	
	C2, The gain for the pressure error bias	
	C3, The adjustment to the pressure set point	
	B, The frequency bias for load reference control	
	CB (>0) (sec), The boiler storage time constant	
	KI, The controller integral gain	
	TI (sec), The controller proportional lead time constant	
	TR (sec), The controller rate lead time constant	
	TR1 (sec), The inherent lag associated with lead TR (usually about TR/10)	
	CMAX, The maximum controller output	

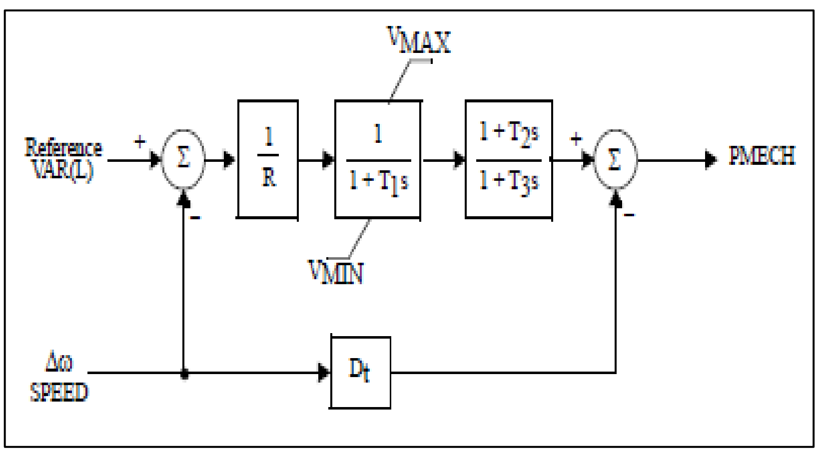
Category	Parameter Description	Data
TURBINE GOVERNOR model		
TGOV5	CMIN, The minimum controller output	
	TD (sec), The time delay in the fuel supply system	
	TF (sec), The fuel and air system time constant	
	TW (sec), The water wall time constant	
	Psp (initial) (>0), The initial throttle pressure set point	
	TMW (sec), The MW transducer time constant	
	KL (0.0 or 1.0), The feedback gain from the load reference	
	KMW (0.0 or 1.0), The gain of the MW transducer	
	DPE (pu pressure), The dead band in the pressure error signal for load reference control	
	• *The fractions of the HP unit's mechanical power developed by the various turbine stages. The sum of K1, K3, K5 andK7 constants should be one for a non-cross-compound unit.* • *Similarly fractions of the LP unit's mechanical power should be zero for a non-cross-compound unit. For a cross-compound unit, the sum of K1 through K8 should equal one.*	
TURCZT	fDEAD (pu), Frequency Dead Band	
	fMIN (pu), Frequency Minimum Deviation	
	fMAX (pu), Frequency Maximum Deviation	
	KKOR (pu), Frequency Gain	
	KM > 0 (pu), Power Measurement Gain	
	KP (pu), Regulator Proportional Gain	
	SDEAD (pu), Speed Dead Band	
	KSTAT (pu), Speed Gain	
	KHP (pu), High Pressure Constant	
	TC (sec), Measuring transducer time constant	
	T 1 (sec), Regulator Integrator Time Constant	
	TEHP (sec), Hydro Converter Time Constant	
	TV > 0 (sec), Regulation Valve Time Constant	
	THP (sec), High Pressure Time Constant	
	TR (sec), Reheater time constant	
	TW (sec), Water Time Constant	
	NTMAX (pu), Power Regulator-Integrator Maximum Limiter	
	NTMIN (pu), Power Regulator-Integrator Minimum Limiter	
	GMAX (pu), Valve Maximum Open	
	GMIN (pu), Valve Minimum Open	
	VMIN (pu/sec), Valve Maximum Speed Close	
	VMAX (pu/sec), Valve Maximum Speed Open	

Commonly Used Steam Turbine Generic Models Block Diagrams:

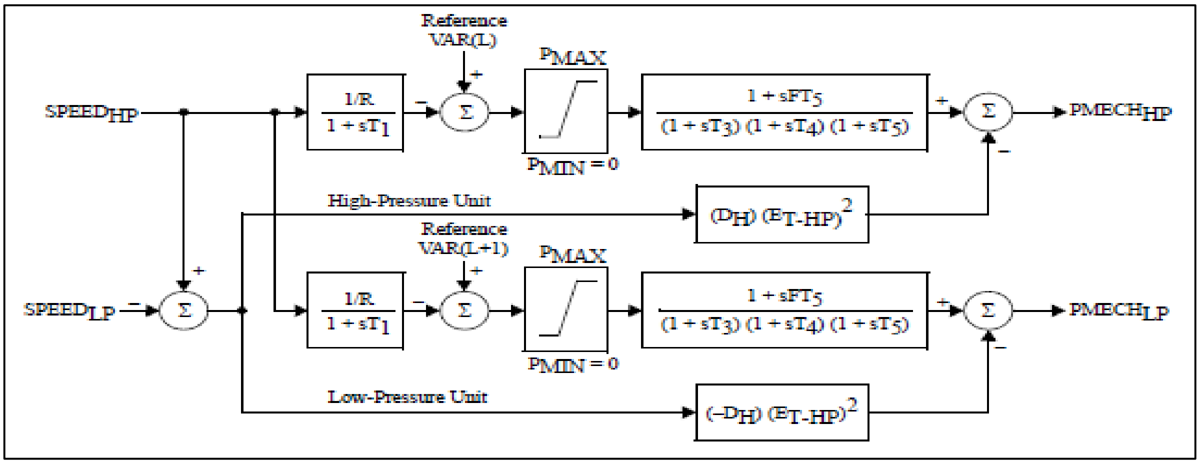
- **BBGOV1: Brown-Boveri turbine-governor model**



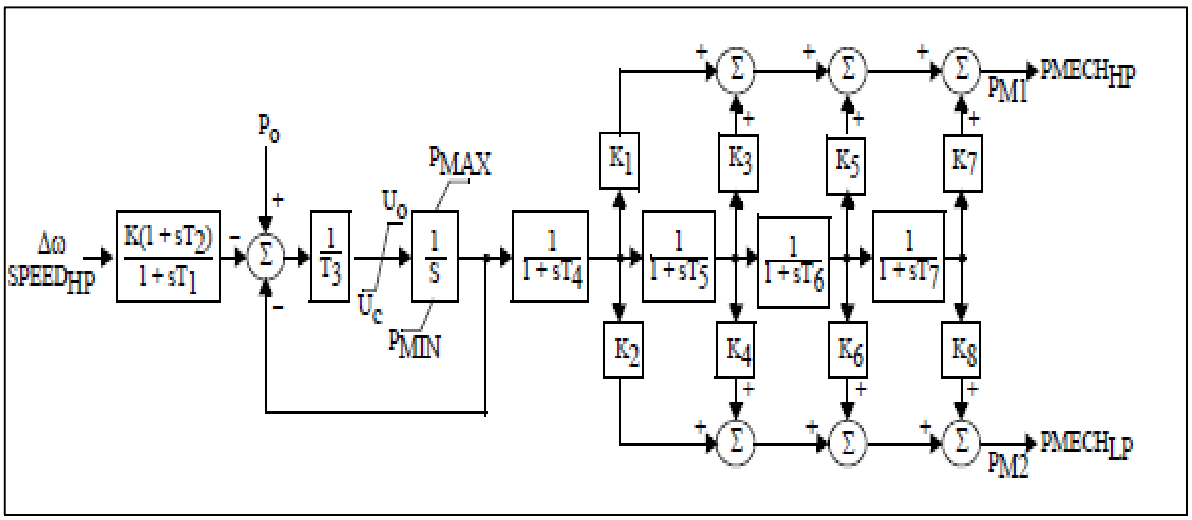
- **TGOV1: Steam turbine-governor model**



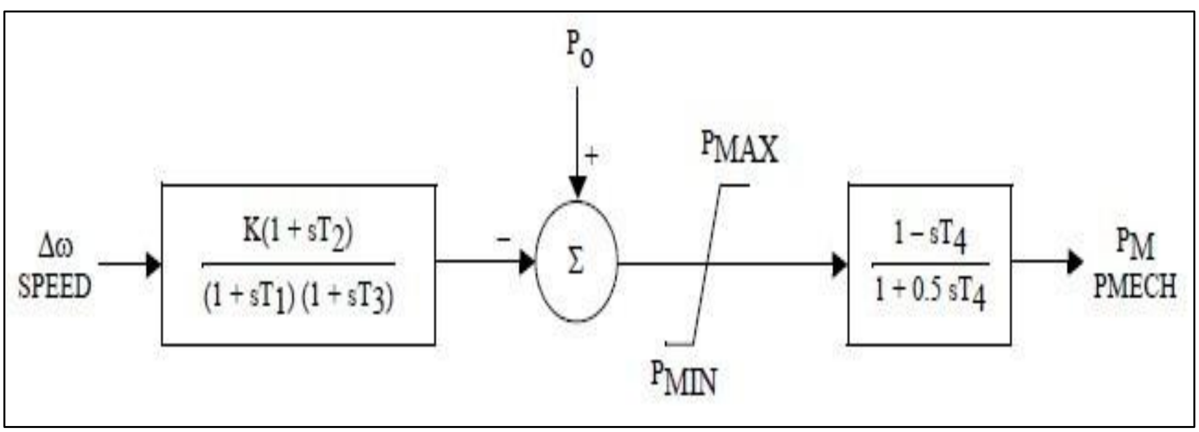
- **CRCMGV: Cross compound turbine-governor model**



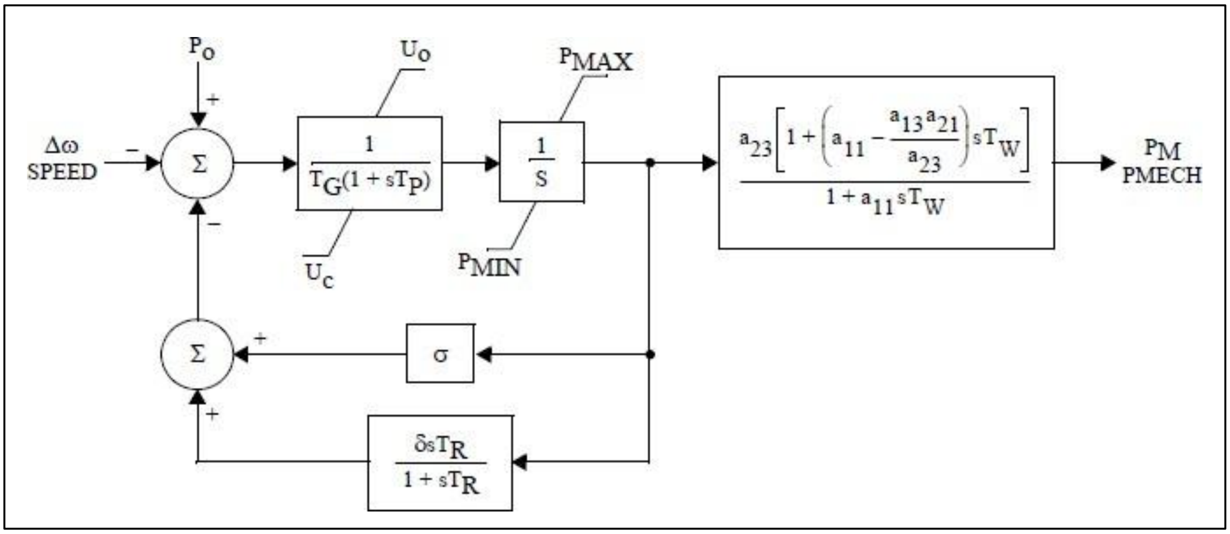
- **IEEEG1: 1981 IEEE type 1 turbine-governor model**



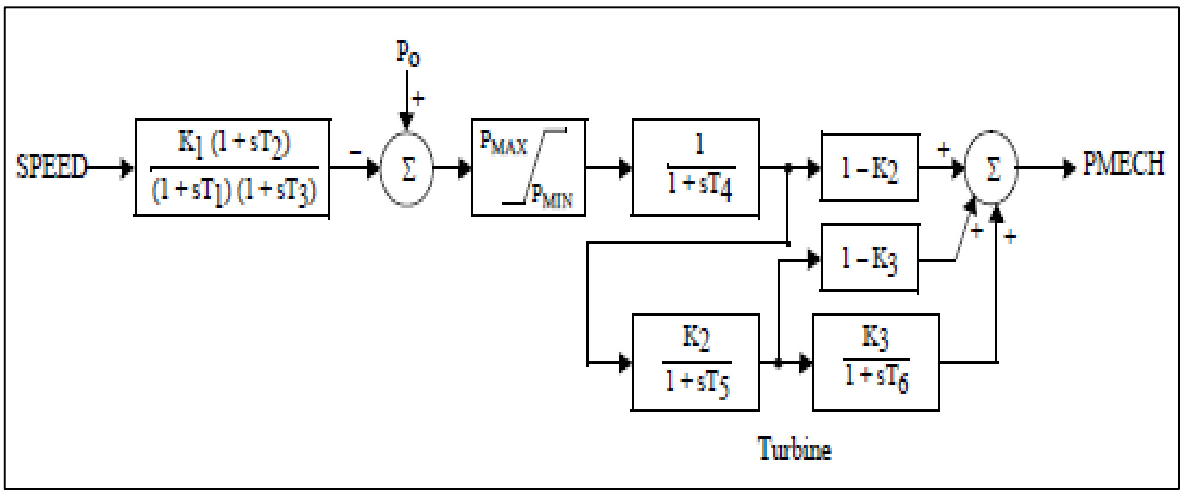
- **IEEEG2: 1981 IEEE Type 2 Speed-Governing Model**



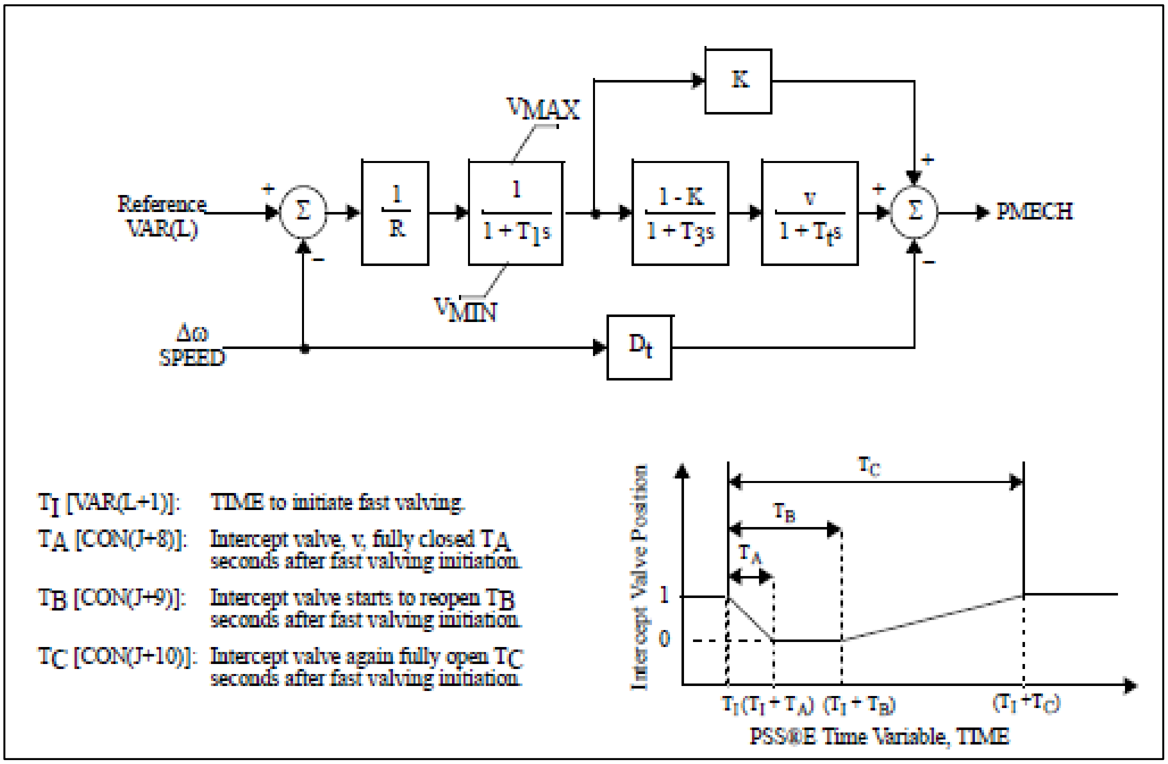
- **IEEEG3: 1981 IEEE Type 3 Speed-Governing Model**



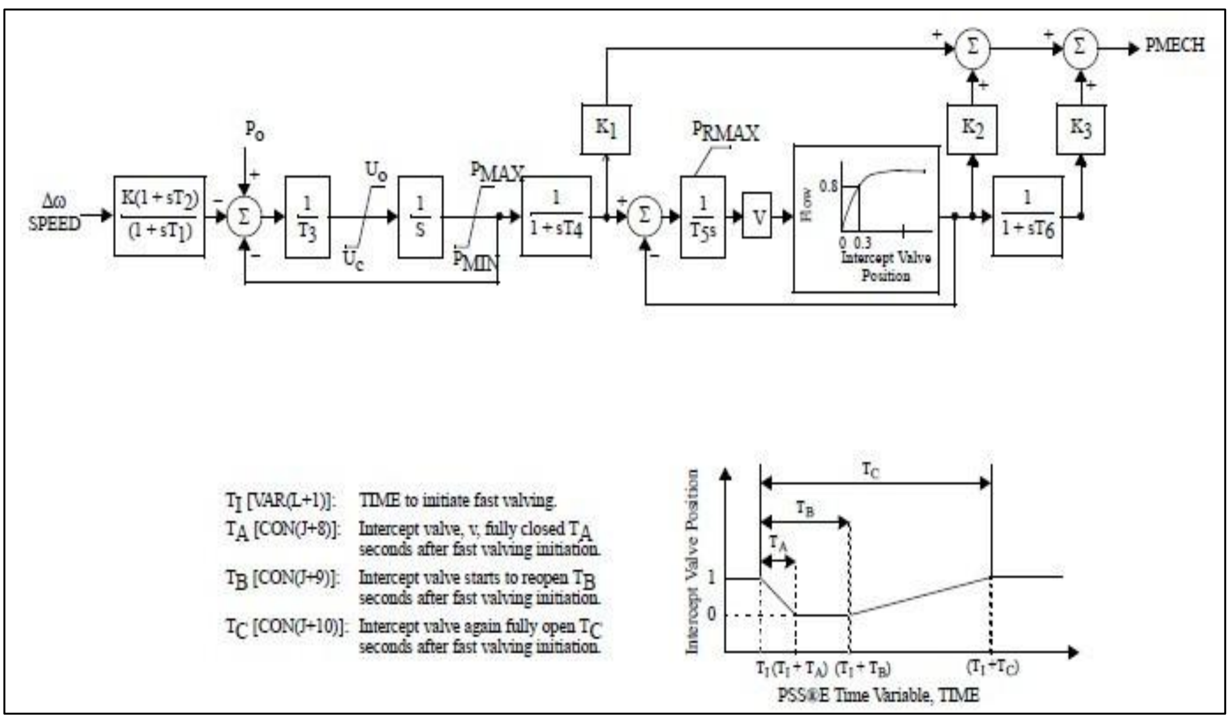
- **IEESGO: 1973 IEEE standard turbine-governor model**



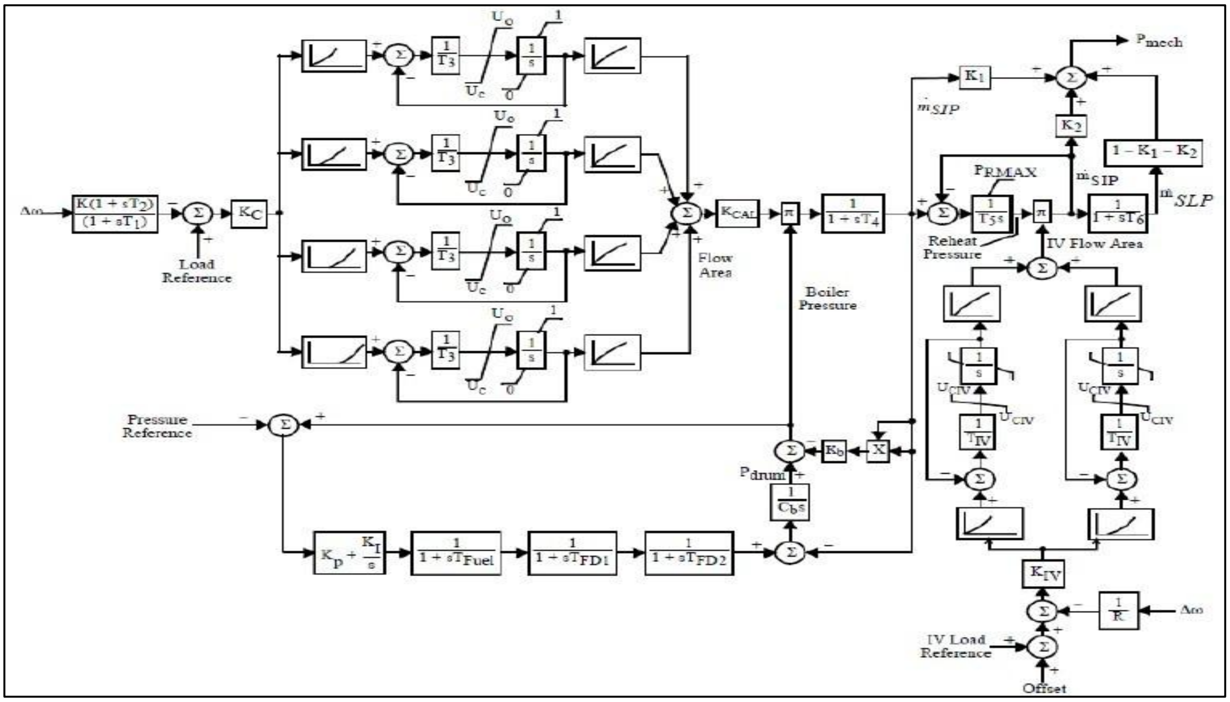
- **TGOV2: Steam turbine-governor model with fast valving**



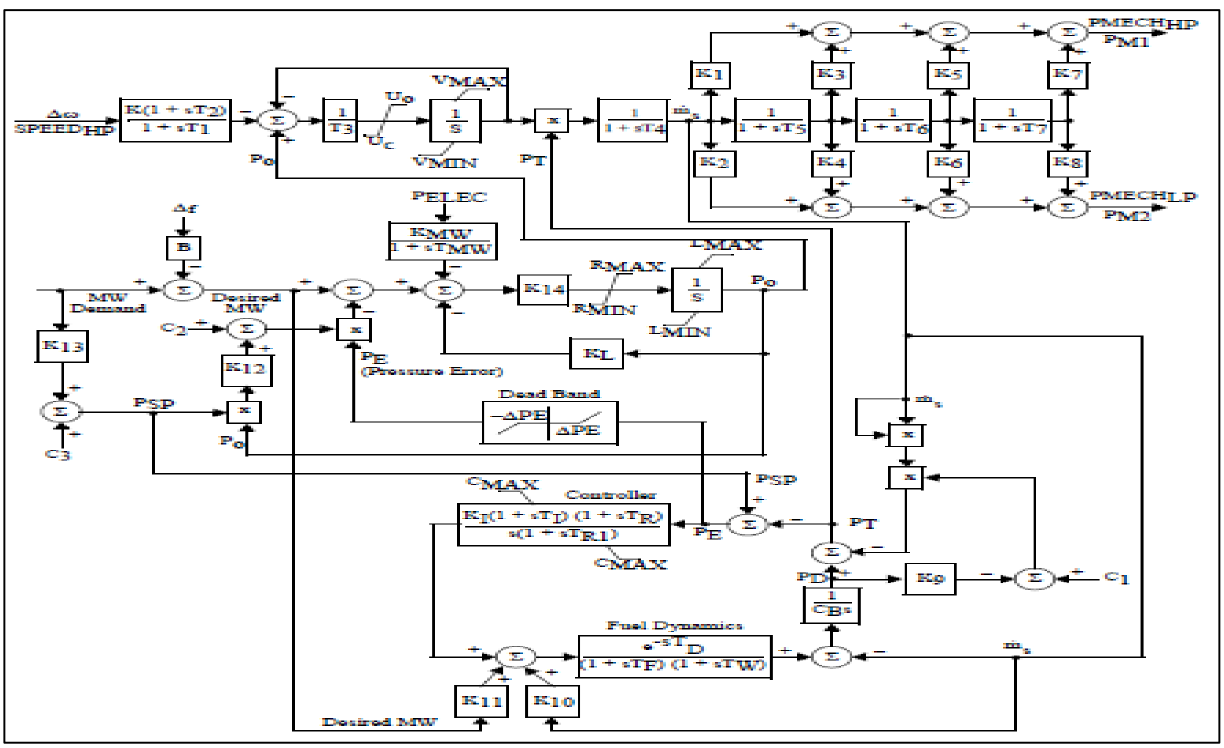
- **TGOV3: Modified IEEE type 1 turbine-governor model with fast valving**



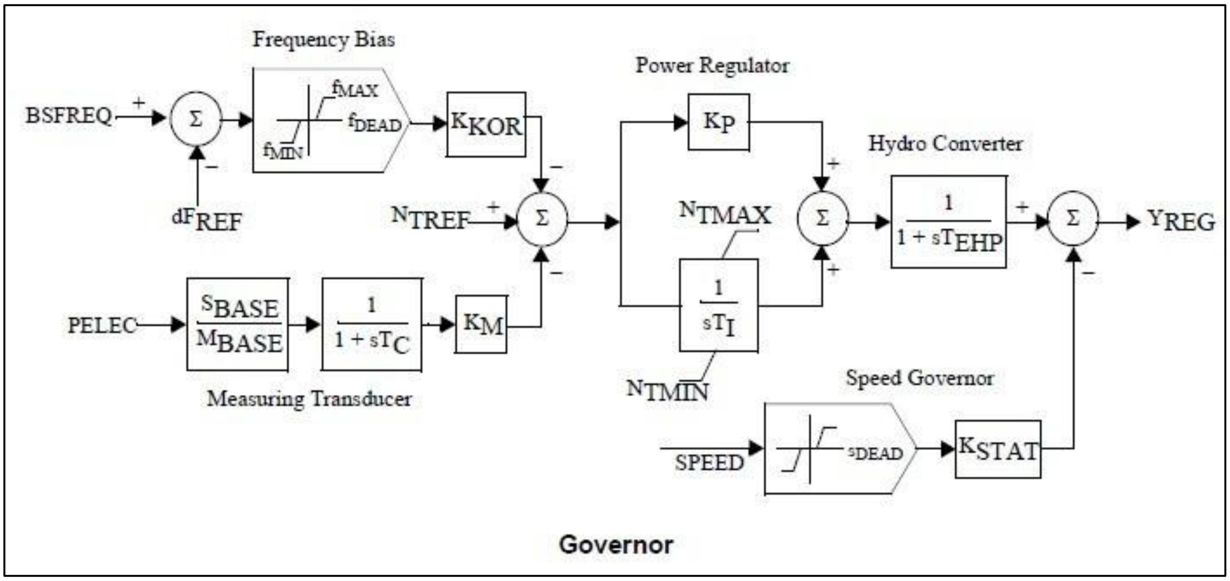
- **TGOV4: Modified IEEE type 1 speed governing model with PLU and EVA**

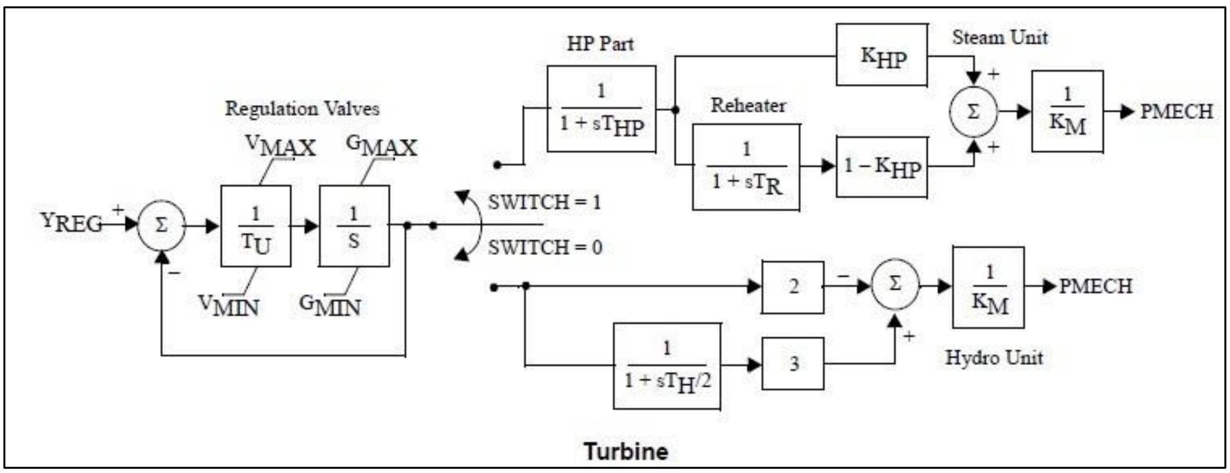


- **TGOV5: Modified IEEE type 1 turbine-governor model with boiler controls**



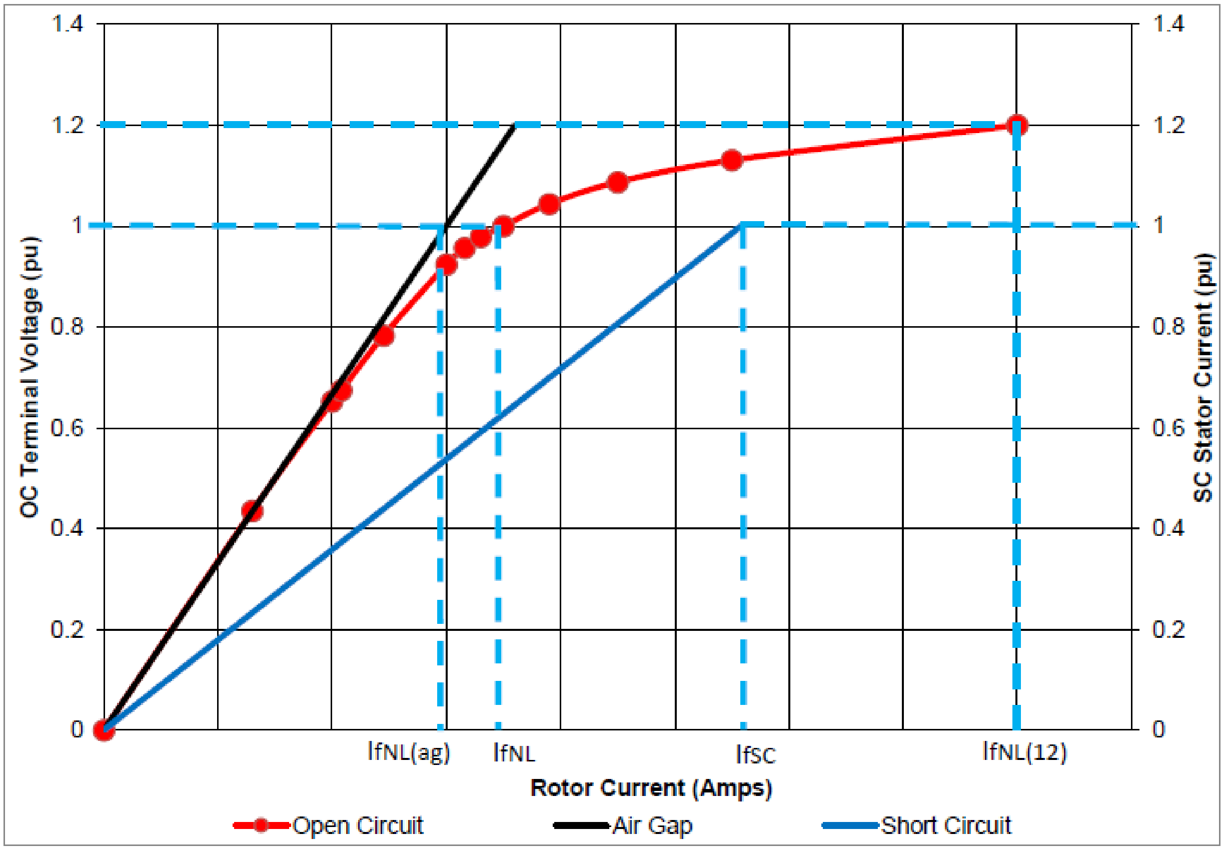
- **TURCZT: Czech Hydro and Steam Governor**





Source-PSSE Model Library

Calculation of saturation parameters:



Open and short circuit characteristics

The saturation can be calculated using the following calculation:

$$S(1.0) = \frac{If_{NL} - If_{NL(AG)}}{If_{NL(AG)}}$$

$$S(1.2) = \frac{If_{NL(12)} - 1.2 \times If_{NL(AG)}}{1.2 \times If_{NL(AG)}}$$

Annex-3(B)

Guideline for furnishing information for RMS (generic) modelling of Gas-fired generation

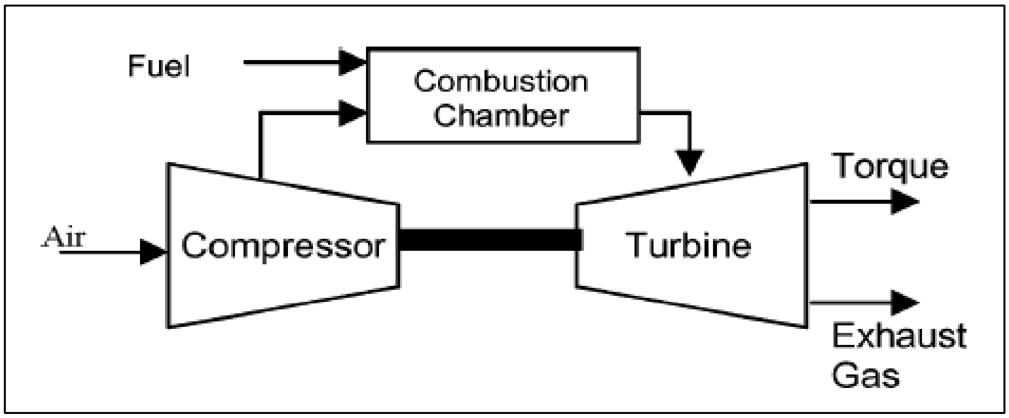
The guidelines present the desired information for collection of data for RMS modelling (generic) of Gas-fired power generators

2.1 Gas Power Plant Classification:

The gas turbine power plants which are used in electric power industry are classified into two main groups as per the cycle of operation and configuration:

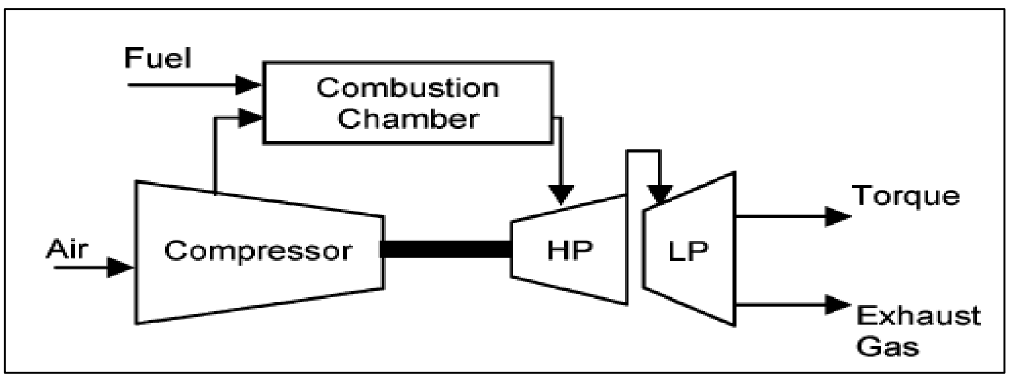
a. **Open cycle gas turbine (OCGT):**

In open cycle, air at the ambient condition is drawn into the compressor (either an axial-flow or centrifugal compressor) where its temperature and pressure are raised. The high-pressure air proceeds into the combustion chamber, where the fuel is burnt at constant pressure. The high temperature gases then enter into the turbine where they expand to the atmospheric pressure while producing power output. The exhaust gases leaving the turbine are thrown out (not recirculated), causing the cycle to be classified as open cycle. All masses are typically on the same shaft (the compressor, combustion chamber, and turbine). This is also referred to as a "single-shaft" gas turbine.



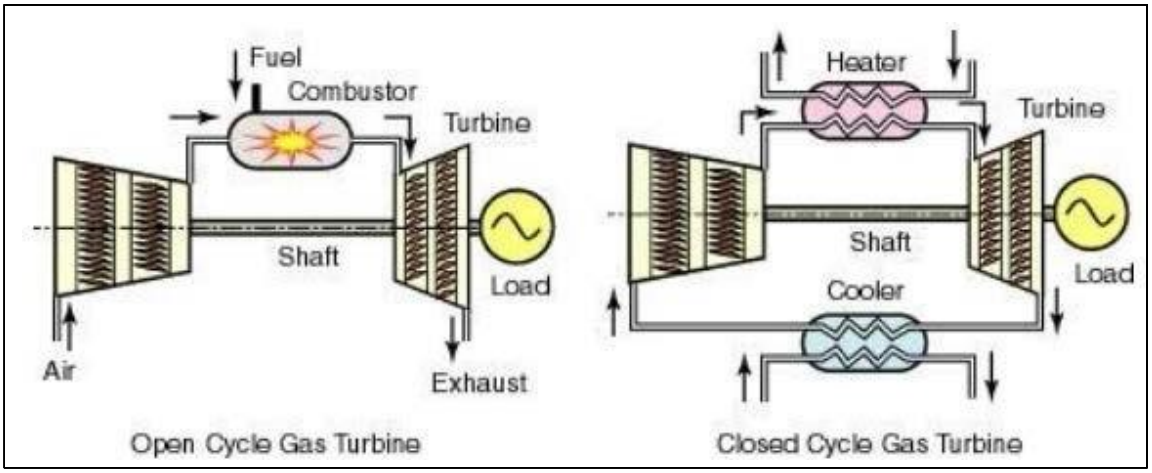
Single Shaft Gas Turbine

In aero-derivative type turbines, the gas generator (compressor and compressor turbine) are mechanically separated from the power turbine. The compressor can have different speed settings to achieve higher efficiency. However, the inertia will be lower than a "single-shaft" gas turbine.



Aero-derivative Gas Turbine

b. **Closed cycle gas turbine (CCGT):**
In a closed cycle gas turbine, working fluid does not come in contact with atmospheric air. The compression and expansion process remain the same but the combustion process is replaced by constant pressure heat addition process from an external source. The exhaust process is replaced by constant pressure heat rejection process to the ambient air. The exhaust gases leaving the turbine are cooled in heat exchanger called sink where it rejects heat. Therefore, in this cycle, same working fluid is recirculated, causing the cycle to be classified as close cycle.



Typical Open and Close cycle Gas Turbine

For SLDC to have access to verified fit-for-purpose models of gas power generator connected to Indian grid, following information is required:

1. Electrical Single Line Diagram of gas power station depicting;
   - For individual generating units: type of technology, Complete Generator OEM Technical Datasheet (which comprises namely generator parameters like impedances & time constants, generator capability curve, V-curve, generator open and short circuit characteristics, excitation system details, inertia of generator & exciter), generator name plate, generator SAT report including Short circuit and open circuit test results during commissioning/recent overhauling.
   - **Generator step up transformer**: GT name plate/datasheet, details of LV, MV and HV, MVA rating, impedance, tap changer details, vector group, short-circuit parameters (actual positive & zero sequence impedance of GT, NGR nameplate with impedance).
   - **Excitation system :-** Type of excitation system (Direct Current Commutator Exciters (type DC), AC Excitation (Rotor or brushless excitation) Systems (type AC) and Static Excitation Systems (type ST), Excitation system schematics (Block diagram of AVR system), transfer function block diagram of Excitation system, excitation transformer nameplate, saturation curves of the exciter (E_{fd} versus I_f curve), IEEE standard model of excitation system, IEEE standard model and its parameter of subsystems such as Power system stabilizer (PSS), Under Excitation Limiter (UEL), Over Excitation Limiter (OEL), Voltage per Hz Limiter(V/Hz) control etc. and details thereof, factory acceptance test reports (FAT). Excitation system actual settings to be provided. AVR test report (excitation step response test).

- **Power System Stabilizer (PSS):** Transfer function block diagram of PSS, IEEE Standard Model, Actual PSS software settings, PSS commissioning report and recent PSS tuning report.
- **Turbine-Governor system :-** Type of prime mover (open cycle, aero-derivative gas turbine or close cycle), droop and dead-band setting, characteristic of active power versus fuel valve position (or fuel stroke reference), size of steam turbine (ST), frequency control of ST, time lag and relationship of GT and ST, model of governor control system (including details of technology, valves, valves characteristics) , inlet guide vane (IGV) characteristic, ramp rates, base load/frequency control, details of heat recovery generator-HRSG (Block diagram, GT output vs heat relationship, Drum time constant, Pressure loss due to friction in boiler tubes), , turbine inertia, IEEE standard model of turbine governor system and its transfer function Block diagram and its parameters, details of control mode (boiler-follow, turbine-follow, or coordinated control), commissioning report of turbine-governor system or recent governor testing report.

3.1 Details of models in PSS/E for modelling gas power generator:

(a) Synchronous Machine – To be filled separately for Gas turbine (GT) and steam turbine (ST)

Category	Parameter Description	Data
Generator Nameplate	Rated apparent power in MVA	
	Rated terminal voltage	
	Rated power factor	
	Rated speed (in RPM)	
	Rated frequency (in Hz)	
	Rated excitation (in Amperes and Volts)	
Type of synchronous machine	Round rotor or salient pole No. of poles	
Generator capability curve	The generator capability curve shows the reactive capability of the machine and should include any restrictions on the real or reactive power range like under/over excitation limits, stability limits, etc. Capability curve should have properly labelled axis and legible data	
Generator Open Circuit and Short Circuit Characteristic	Graph of excitation current versus terminal voltage and stator current	
	No load excitation current – used to derive per unit values	
	Excitation current at rated stator current	
Generator vee-curves	Otherwise referred to as "V-curve". A plot of the terminal (armature) current versus the generating unit field voltage.	
Resistance values	Resistance measurements of field winding and stator winding to a known temperature	
Generator Data sheet	Direct axis synchronous reactance Xd in p.u. (Unsaturated or saturated)	
	Direct axis transient synchronous reactance Xd' in p.u. (Unsaturated or saturated)	
	Direct axis sub-transient synchronous reactance Xd'' in p.u. (Unsaturated or saturated)	
	Stator leakage reactance Xa in p.u. (Unsaturated or saturated)	
	Quadrature axis synchronous reactance Xq in p.u. (Unsaturated or saturated)	
	Quadrature axis transient synchronous reactance Xq' in p.u. (Unsaturated or saturated)	
	Quadrature axis sub-transient synchronous reactance Xq'' in p.u. (Unsaturated or saturated)	
	Direct axis open circuit transient time constant Tdo' in sec	
	Direct axis open circuit sub-transient time constant Tdo'' in sec	
	Quadrature axis open circuit transient time constant Tqo' in sec	
	Quadrature axis open circuit sub-transient time constant Tqo'' in sec	
	Inertia constant of total rotating mass (generator, AVR, turbo-governor set) H in MW. s/MVA	
	Speed Damping D	
	Saturation constant S (1.0) in p.u.	
	Saturation constant S (1.2) in p.u.	

Category	Parameter Description	Data
Generator step up transformer (GSUT)	Nameplate Rating - Rated primary and secondary voltage - Vector group - Impedance - Tap changer details (Number of taps, tap position, tap ratio etc.)	
Auxiliary power (i.e. active and reactive auxiliary load)	Value of auxiliary load (MW and Mvar) at rated power of the generating unit. Whether or not the load trips if the generating unit trips.	
Test Reports	Factory acceptance test (FAT) reports	

(b) Site Load

	Low Output			High Output		
	kW	kvar	kVA	kW	kvar	kVA
Auxiliary Load						

(c) Excitation System

Category	Parameter Description	Data
Type of Automatic Voltage Regulator (AVR)	Manufacturer and product details (for example ABB UNITROL or GE EX2100e)	
	Type of control system: - Analogue or digital	
	Year of commissioning / Year of manufacture	
	As found settings (obtained either from HMI or downloaded from controller in digital systems)	
Type of excitation system	Static excitation system OR	
	Indirect excitation system (i.e. rotating exciter) - AC exciter, or - DC exciter	
Details of AVR converter	Rated excitation current (converter rating in Amperes)	
	Six pulse thyristor bridge or PWM converter	
Source of excitation supply	Excitation transformer or auxiliary supply (Details thereof)	
	If excitation transformer, nameplate information required	
Schematics	Saturation curves of the exciter (if applicable – see Type AC and DC)	
	Drawings of excitation system, typically prepared and supplied by the OEM	
	Single line diagram (i.e. one-line diagram) for the excitation system	
Excitation limiters	What excitation limiters are commissioned?	
	Under Excitation Limiters settings	
	Over Excitation Limiters settings	
	Voltage/frequency limiter	
	Stator current limiter	
	Minimum excitation current limiter	

Category	Parameter Description	Data
PSS	Is the AVR equipped with a PSS?	
	How many input Channels does the PSS have? (speed, real power output or both	
	If the PSS uses speed, is this a derived speed signal (i.e. synthesized speed signal) or measured directly (i.e. actual rotor speed)?	
	Type of PSS Block Diagram of PSS and as commissioned parameters value (Gain, time constants, filter coefficients, output limits of the PSS)	
Test Reports	Factory acceptance test (FAT) reports	

(d) Turbine Details (to be filled in for the GT and ST separately)

Category	Parameter Description	Data
Type of prime mover	- Open cycle gas turbine - Aero-derivative (twin shaft) gas turbine - Combined cycle plant (closed cycle gas turbine)	
Manufacturer of turbine	Manufacturer and name plate details	
Governor	Electro-mechanical governor (including settings and drawings)	
	Digital electric governor (including settings and drawings)	
Ramp rates	How fast can the turbine increase and/or decrease load, specified in MW/min Guide vane/wicket gate characteristic, including opening, closing rates/times and limits	
Droop	Droop setting (% on machine base)	
	Frequency influence limiters - Maximum frequency deviation limiter (eg +/-2 Hz) - Maximum influence limiter (eg 10% of rating)	
Dead band	Details of frequency dead band (typically in Hz or RPM)	
Technology	- Open cycle - Close cycle	
Gas turbine	Does turbine operate in dual fuel (gas and liquid fuel)	
	Inlet guide vane (IGV) characteristic	
	Limit for exhaust gas temperature (EGT)	
	Base load/frequency control	
	Power output versus ambient temperature	
	No load fuel flow and turbine gain (determined by relationship of active power versus fuel valve position or fuel stroke reference)	

Category	Parameter Description	Data
Combine cycle plant	Details on heat recovery steam generator (HRSG) - Block diagram - GT output vs heat relationship (look up table) - Drum time constant - Pressure loss due to friction in boiler tubes	
	Size of steam turbine	
	Frequency control of ST	
	Time lag and relationship of GT and ST	
	Is the combined cycle plant a single shaft plant – i.e. the gas and steam turbine are on same shaft and drive same generator	

3.2 Generic Models for synchronous machine

Gas turbine (GT) or steam turbines (ST) are generally round rotor machines however, salient pole Gas turbine (aero-derivative) with synchronous machine having four poles has also been installed at some of the places. Depending upon the saturation characteristic of the machine they are classified further:

- **Round rotor machine (2 poles):**
    - GENROU – Round rotor machine model with quadratic saturation function
    - GENROE – Round rotor machine model with exponential saturation function
- **Salient pole machine (more than two poles):**
    - GENSAL – Salient pole machine with quadratic saturation function
    - GENSAE – Salient pole machine with exponential saturation function

Category	Parameter Description	Data
GENERATOR model		
GENROU OR **GENROE**	Direct axis open circuit transient time constant Tdo’ in sec	
	Direct axis open circuit sub-transient time constant Tdo’’ in sec	
	Quadrature axis open circuit transient time constant Tqo’ in sec	
	Quadrature axis open circuit sub-transient time constant Tqo’’ in sec	
	Inertia constant of total rotating mass H in MW. s/MVA	
	Speed Damping D	
	Direct axis synchronous reactance Xd in p.u. (Unsaturated or saturated)	
	Quadrature axis synchronous reactance Xq in p.u. (Unsaturated or saturated)	
	Direct axis transient synchronous reactance Xd’ in p.u. (Unsaturated or saturated)	
	Quadrature axis transient synchronous reactance Xq’ in p.u. (Unsaturated or saturated)	
	Direct axis sub-transient synchronous reactance Xd’’ in p.u. (Unsaturated or saturated) = Quadrature axis sub-transient synchronous reactance Xq’’ in p.u. (Unsaturated or saturated)	
	Stator leakage reactance Xl in p.u.	
	Saturation constant S (1.0) in p.u.	
	Saturation constant S (1.2) in p.u.	
GENSAE OR **GENSAL**	Direct axis open circuit transient time constant Tdo’ in sec	
	Direct axis open circuit sub-transient time constant Tdo’’ in sec	
	Quadrature axis open circuit sub-transient time constant Tqo’’ in sec	
	Inertia constant of total rotating mass H in MW. s/MVA	
	Speed Damping D	
	Direct axis synchronous reactance Xd in p.u. (Unsaturated or saturated)	
	Quadrature axis synchronous reactance Xq in p.u. (Unsaturated or saturated)	
	Direct axis transient synchronous reactance Xd’ in p.u. (Unsaturated or saturated)	
	Direct axis sub-transient synchronous reactance Xd’’ in p.u. (Unsaturated or saturated) = Quadrature axis sub-transient synchronous reactance Xq’’ in p.u. (Unsaturated or saturated)	
	Stator leakage reactance Xl in p.u.	
	Saturation constant S (1.0) in p.u.	
	Saturation constant S (1.2) in p.u.	

While entering the values in above table, following relationship must be kept:

Xd>Xq>Xq'≥Xd'>Xq"≥Xd''

Tdo'>Td'>Tdo''>Td''

Tqo''>Tq'>Tqo''>Tq''

3.3 Excitation system model:

If a generic model is used, the first step must be to identify what type of exciter is present in the excitation system. The IEEE Std 421.5 (IEEE Recommended Practice for Excitation System Models for Power System Stability Studies published on 26th Aug 2016) has published several generic models, which are classified into three groups:

- Type DC: for excitation systems with a DC exciter
- Type AC: for excitation systems with an AC exciter
- Type ST: for excitation systems with a static exciter

The following table shows the types of models separated into their respective groups.

DC exciter	AC exciter	Static excitation system
Type DC1A	Type AC1A	Type ST1A
Type DC2A	Type AC2A	Type ST2A
Type DC3A	Type AC4A	Type ST3A
Type DC4B	Type AC5A	Type ST4B
	Type AC6A	Type ST5B
	Type AC7B	Type ST6B
	Type AC8B	Type ST7B

Category	Parameter Description	Data
DC Exciter		
ESDC1 A OR ESDC2 A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	TB (s), lag time constant	
	TC (s), lead time constant	
	VRMAX (pu) regulator output maximum limit or Zero	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF1 (> 0) rate feedback time constant (sec)	
	Switch	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
ESDC3A	TR regulator input filter time constant (sec)	
	KV (pu) limit on fast raise/lower contact setting	
	VRMAX (pu) regulator output maximum limit or Zero	
	VRMIN (pu) regulator output minimum limit	
	TRH (> 0) Rheostat motor travel time (sec)	
	TE (> 0) exciter time-constant (sec)	
	KE (pu) exciter constant related to self-excited field	
	VEMIN (pu) exciter minimum limit	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
DC Exciter		
ESDC4B	TR regulator input filter time constant (sec)	
	KP (pu) (> 0) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	KD (pu) voltage regulator derivative gain	
	TD voltage regulator derivative channel time constant (sec)	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KA (> 0) (pu) voltage regulator gain	
	TA voltage regulator time constant (sec)	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	VEMIN (pu) minimum exciter voltage output	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
ESAC1A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	

Category	Parameter Description	Data
DC Exciter		
ESAC2A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KB, Second stage regulator gain	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VFEMAX, parameter of VEMAX, exciter field maximum output	
	KH, Exciter field current feedback gain	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
ESAC3A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VEMIN (pu) minimum exciter voltage output	
	KR (>0), Constant associated with regulator and alternator field power supply	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KN, Exciter feedback gain	
	EFDN, A parameter defining for which value of UF the feedback gain shall change from KF to KN	
	KC, rectifier regulation factor (pu)	
	KD, exciter regulation factor (pu)	
	KE (pu) exciter constant related to self-excited field	
	VFEMAX, parameter of VEMAX, exciter field maximum output	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
ESAC4A	TR regulator input filter time constant (sec)	
	VIMAX, Maximum value of limitation of the integrator signal VI in p.u	
	VIMIN, Minimum value of limitation of the signal VI in p.u.	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC, rectifier regulation factor (pu)	

Category	Parameter Description	Data
AC Exciter		
ESAC5A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF1 (sec), Regulator stabilizing circuit time constant in seconds	
	TF2 (sec), Regulator stabilizing circuit time constant in seconds	
	TF3 (sec), Regulator stabilizing circuit time constant in seconds	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
AC6A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	TK (sec), Lead time constant	
	TB (s), lag time constant	
	TC (s), lead time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VFELIM, Exciter field current limit reference	
	KH, Damping module gain	
	VHMAX, damping module limiter	
	TH (sec), damping module lag time constant	
	TJ (sec), damping module lead time constant	
	KC, rectifier regulation factor (pu)	
	KD, exciter regulation factor (pu)	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
AC7B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	KDR (pu) regulator derivative gain	
	TDR (sec) regulator derivative block time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KPA (pu) voltage regulator proportional gain	
	KIA (pu) voltage regulator integral gain	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KP (pu)	
	KL (pu)	
	KF1 (pu)	
	KF2 (pu)	
	KF3 (pu)	
	TF3 (sec) time constant (> 0)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	VFEMAX (pu) exciter field current limit (> 0)	
	VEMIN (pu)	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
AC8B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	KDR (pu) regulator derivative gain	
	TDR (sec) regulator derivative block time constant	
	VPIDMAX (pu) PID maximum limit	
	VPIDMIN (pu) PID minimum limit	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	VFEMAX (pu) max exciter field current limit (> 0)	
	VEMIN (pu),	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
Static Exciter		
ST1A	TR (sec) regulator input filter time constant	
	VIMAX, Controller Input Maximum	
	VIMIN, Controller Input Minimum	
	TC (s), Filter 1st Derivative Time Constant	
	TB (s), l Filter 1st Delay Time Constant	
	TC1 (s), Filter 2nd Derivative Time Constant	
	TB1 (s), Filter 2nd Delay Time Constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KLR, Current Input Factor	
	ILR, Current Input Reference	

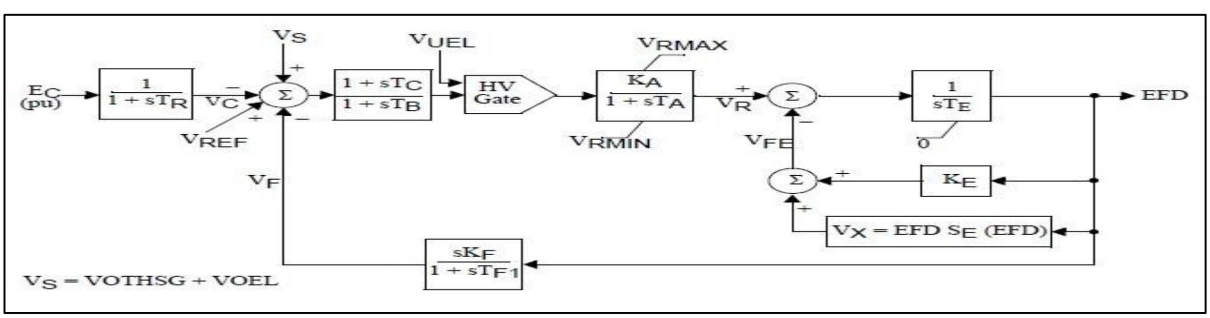
Category	Parameter Description	Data
Static Exciter		
ST2A	TR (sec) regulator input filter time constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	EFDMAX	
ST3A	TR (sec) regulator input filter time constant	
	VIMAX, Maximum value of limitation of the signal VI in p.u.	
	VIMIN, Minimum value of limitation of the signal VI in p.u.	
	KM, Forward gain constant of the inner loop field regulator	
	TC (s), lag time constant	
	TB (s), lead time constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KG, Feedback gain constant of the inner loop field regulator	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	VBMAX, Maximum value of limitation of the signal VB in p.u.	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	XL, Reactance associated with potential source	
	VGMAX, Maximum value of limitation of the signal VG in p. u	
	Θ_P (degrees)	
	TM (sec), Forward time constant of the inner loop field regulator	
	VMMAX, Maximum value of limitation of the signal VM in p. u	
	VMMIN, Minimum value of limitation of the signal VM in p.u.	

Category	Parameter Description	Data
Static Exciter		
ST4B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TA (sec) voltage regulator time constant	
	KPM, Regulator gain	
	KIM, Regulator gain	
	VMMAX, Maximum value of limitation of the signal in p.u.	
	VMMIN, Minimum value of limitation of the signal in p.u.	
	KG	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	VBMAX	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	XL	
	Θ_P (degrees)	
ST5B	TR regulator input filter time constant (sec)	
	TC1 lead time constant of first lead-lag block (voltage regulator channel) (sec)	
	TB1 lag time constant of first lead-lag block (voltage regulator channel) (sec)	
	TC2 lead time constant of second lead-lag block (voltage regulator channel) (sec)	
	TB2 lag time constant of second lead-lag block (voltage regulator channel) (sec)	
	KR (>0) (pu) voltage regulator gain	
	VRMAX (pu) voltage regulator maximum limit	
	VRMIN (pu) voltage regulator minimum limit	
	T1 voltage regulator time constant (sec)	
	KC (pu)	
	TUC1 lead time constant of first lead-lag block (under-excitation channel) (sec)	
	TUB1 lag time constant of first lead-lag block (under-excitation channel) (sec)	
	TUC2 lead time constant of second lead-lag block (under-excitation channel) (sec)	
	TUB2 lag time constant of second lead-lag block (under-excitation channel) (sec)	
	TOC1 lead time constant of first lead-lag block (over-excitation channel) (sec)	
	TOB1 lag time constant of first lead-lag block (over-excitation channel) (sec)	
	TOC2 lead time constant of second lead-lag block (over-excitation channel) (sec)	
	TOB2 lag time constant of second lead-lag block (over-excitation channel) (sec)	

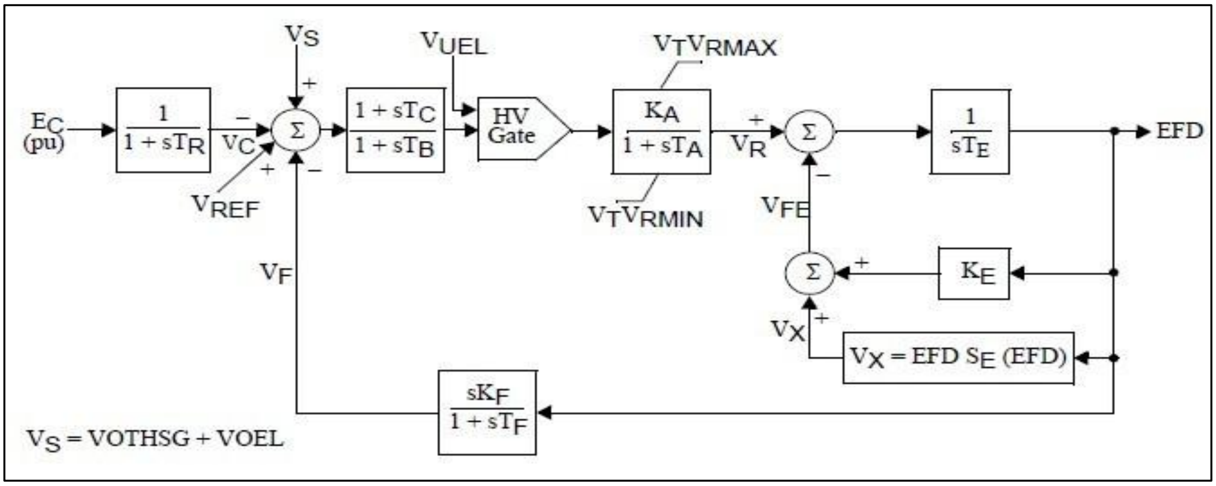
Category	Parameter Description	Data
Static Exciter		
ST6B	TR regulator input filter time constant (sec)	
	KPA (pu) (> 0) voltage regulator proportional gain	
	KIA (pu) voltage regulator integral gain	
	KDA (pu) voltage regulator derivative gain	
	TDA voltage regulator derivative channel time constant (sec)	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KFF (pu) pre-control gain of the inner loop field regulator	
	KM (pu) forward gain of the inner loop field regulator	
	KCI (pu) exciter output current limit adjustment gain	
	KLR (pu) exciter output current limiter gain	
	ILR (pu) exciter current limit reference	
	VRMAX (pu) voltage regulator output maximum limit	
	VRMIN (pu) voltage regulator output minimum limit	
	KG (pu) feedback gain of the inner loop field voltage regulator	
	TG (> 0) feedback time constant of the inner loop field voltage regulator (sec)	
ST7B	TR regulator input filter time constant (sec)	
	TG lead time constant of voltage input (sec)	
	TF lag time constant of voltage input (sec)	
	Vmax (pu) voltage reference maximum limit	
	Vmin (pu) voltage reference minimum limit	
	KPA (pu) (>0) voltage regulator gain	
	VRMAX (pu) voltage regulator output maximum limit	
	VRMIN (pu) voltage regulator output minimum limit	
	KH (pu) feedback gain	
	KL (pu) feedback gain	
	TC lead time constant of voltage regulator (sec)	
	TB lag time constant of voltage regulator (sec)	
	KIA (pu) (>0) gain of the first order feedback block	
	TIA (>0) time constant of the first order feedback block (sec)	

(i) DC Exciters Generic model:

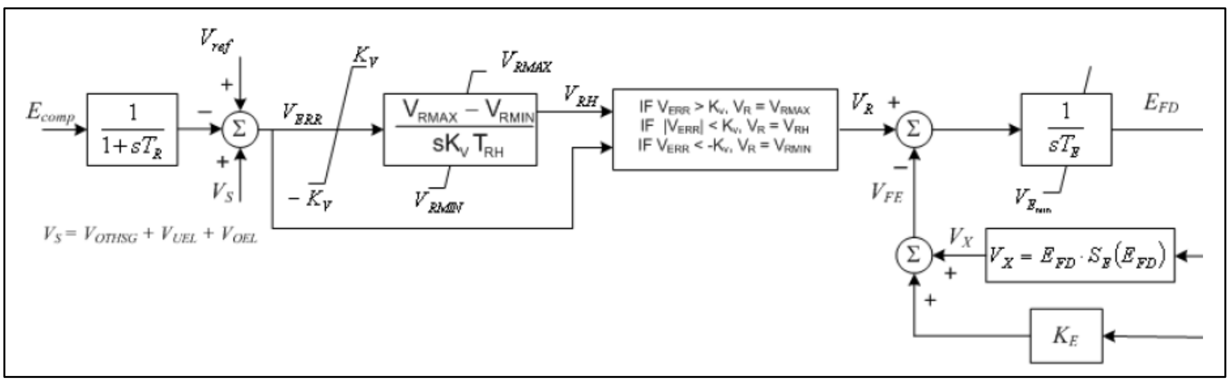
- **Type DC1A: 1992 IEEE type DC1A excitation system model**



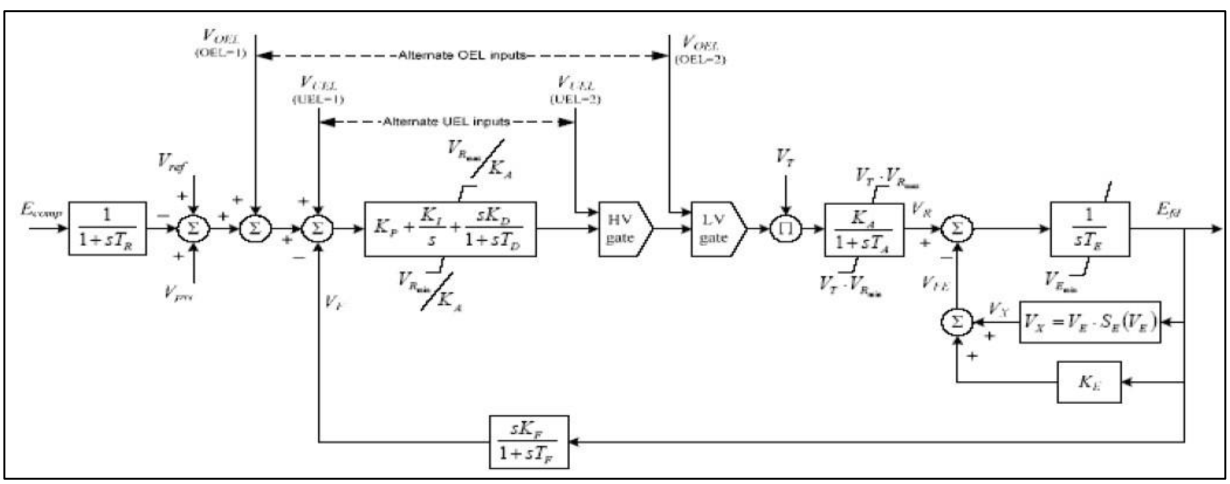
- **Type DC2A: 1992 IEEE type DC2A excitation system model**



- **Type DC3A: IEEE 421.5 2005 DC3A excitation system**

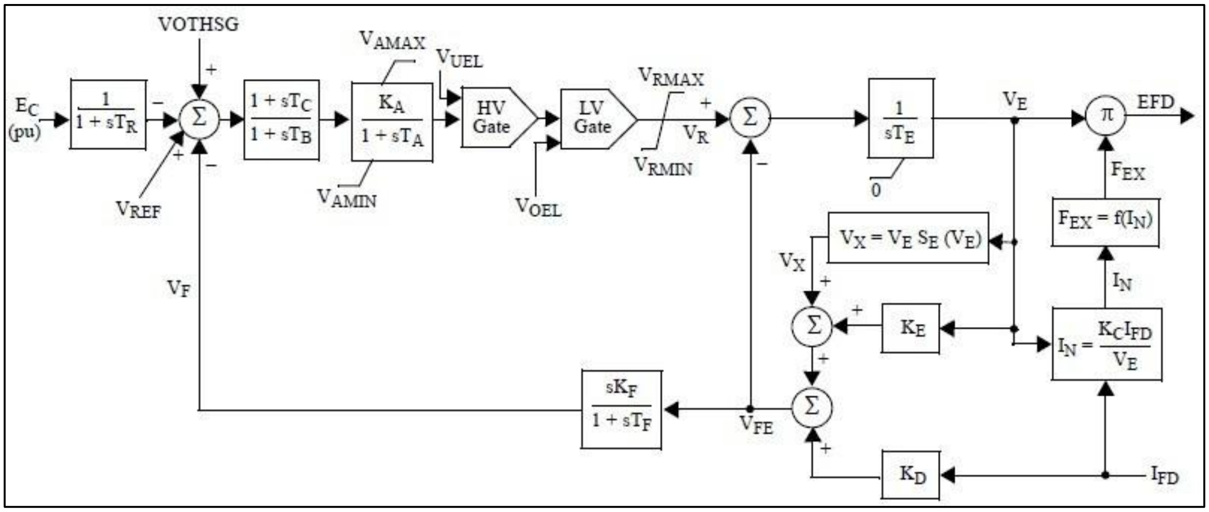


- **Type DC4B: IEEE 421.5 2005 DC4B excitation system**



(ii) AC Exciters Generic Models:

- **Type AC1A: 1992 IEEE type AC1A excitation system model**

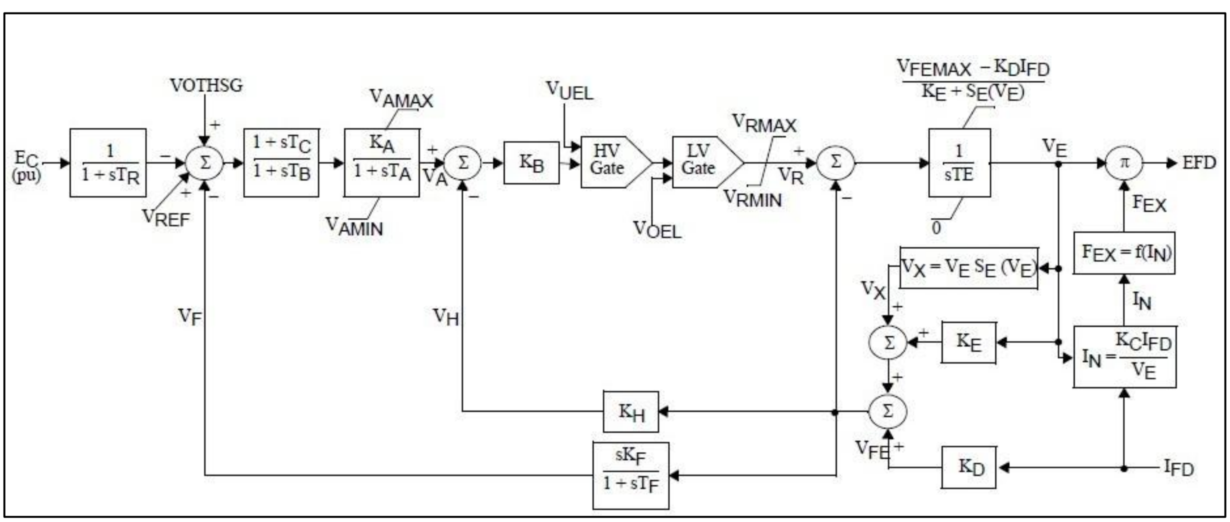


$I_N \rightarrow$

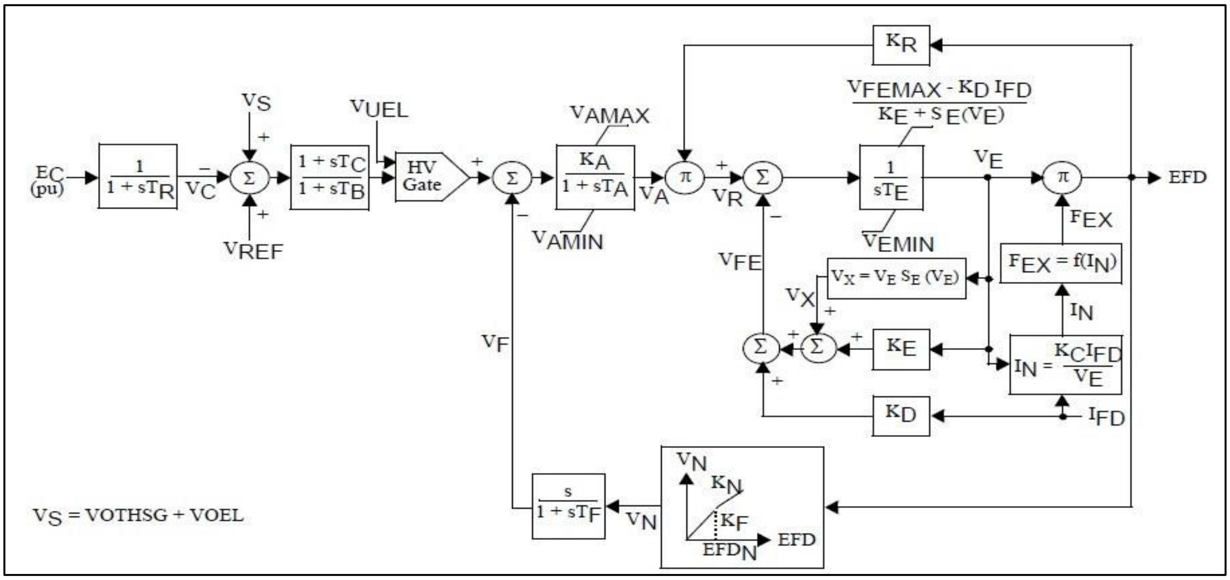
- If $I_N \le 0$: $F_{EX} = 1$
- If $I_N \le 0.433$: $F_{EX} = 1 - 0.577\, I_N$
- If $0.433 < I_N < 0.75$: $F_{EX} = \sqrt{0.75 - I_N^2}$
- If $I_N \ge 0.75$: $F_{EX} = 1.732(1 - I_N)$
- If $I_N > 1$: $F_{EX} = 0$

$\rightarrow F_{EX}$

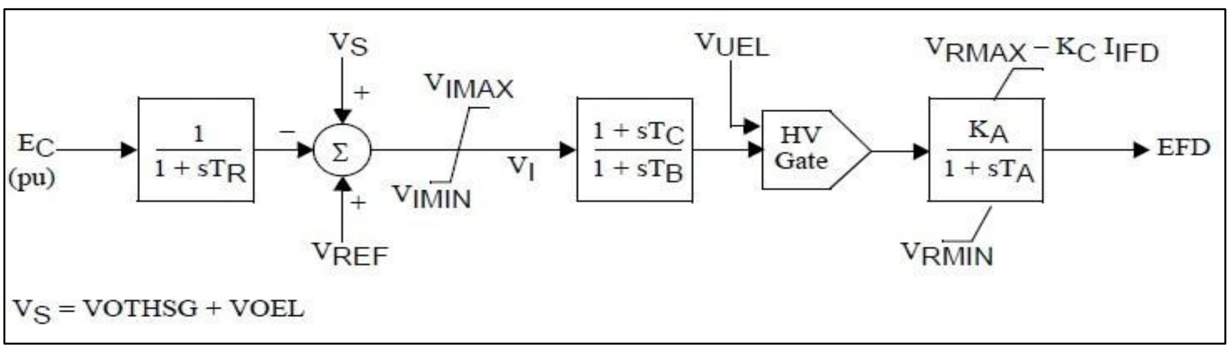
- **Type AC2A: 1992 IEEE type AC2A excitation system model**



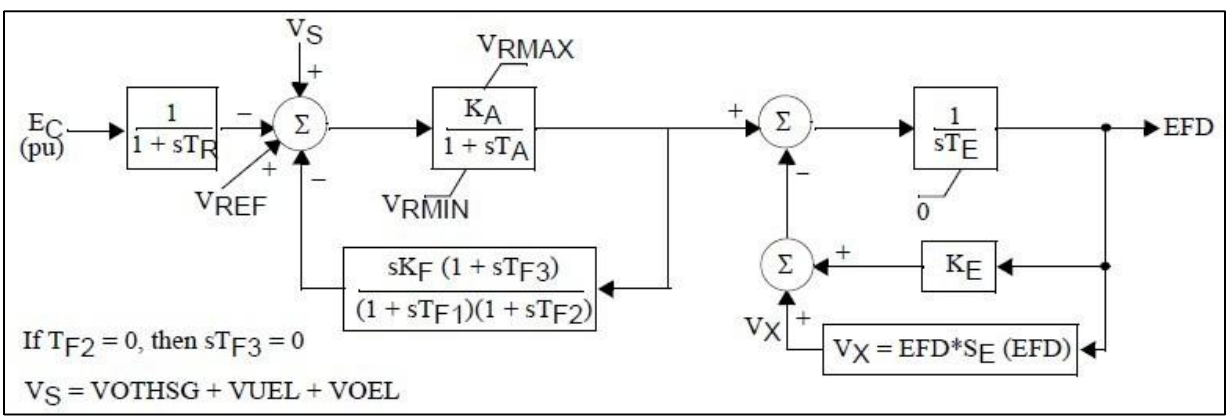
➢ **Type AC3A: 1992 IEEE type AC3A excitation system model**



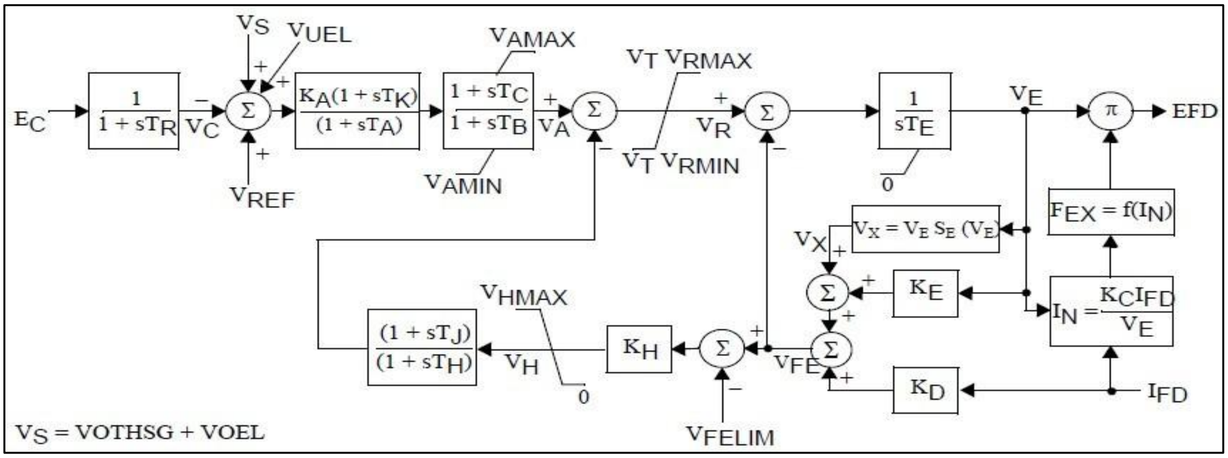
➢ **Type AC4A: 1992 IEEE type AC4A excitation system model**



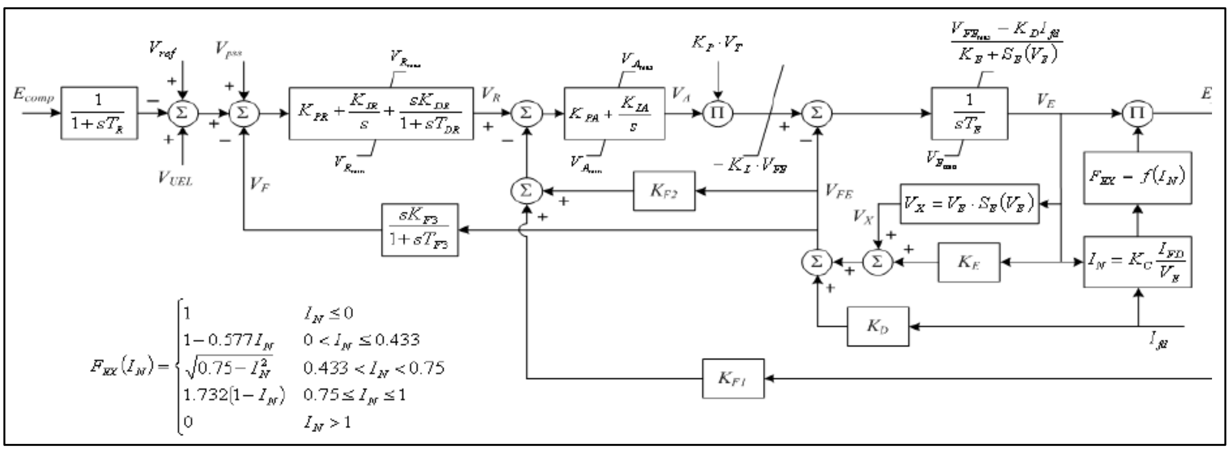
➢ **Type AC5A: 1992 IEEE type AC5A excitation system model**



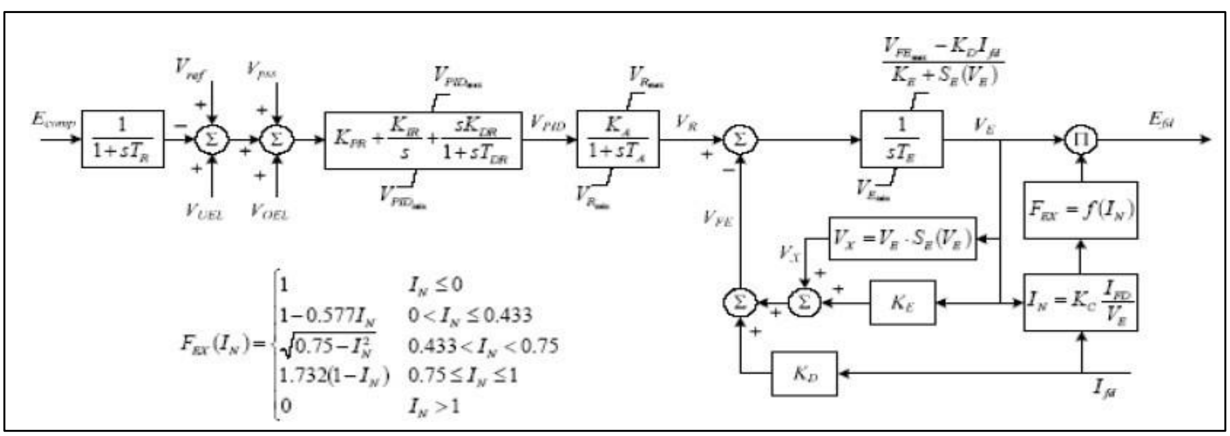
- **Type AC6A: IEEE 421.5 excitation system model**



- **Type AC7B: IEEE 421.5 2005 AC7B excitation system**

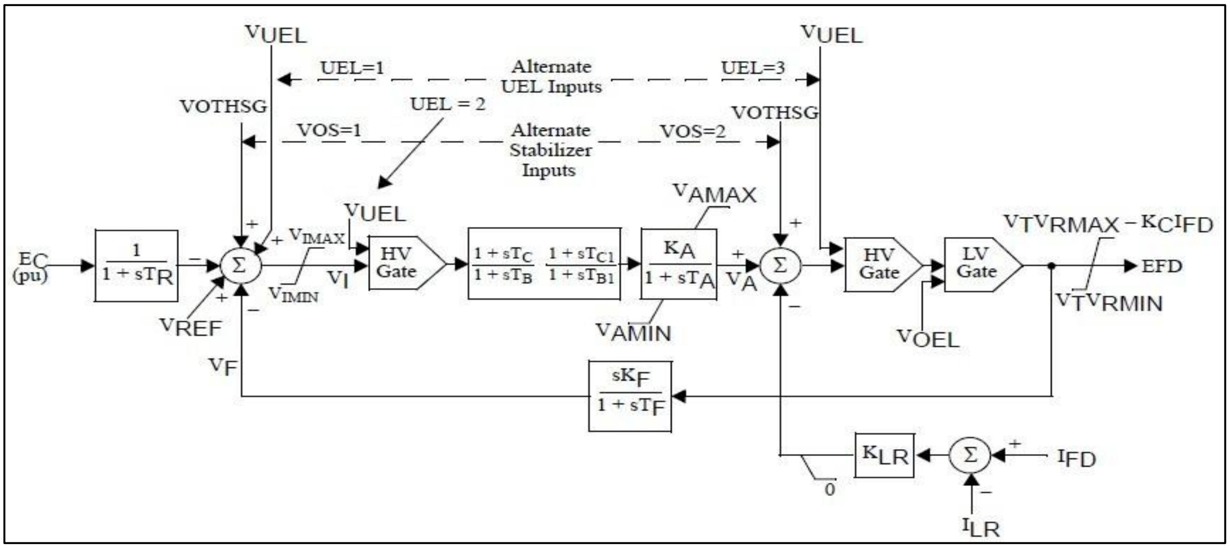


- **Type AC8B: IEEE 421.5 2005 AC8B excitation system**

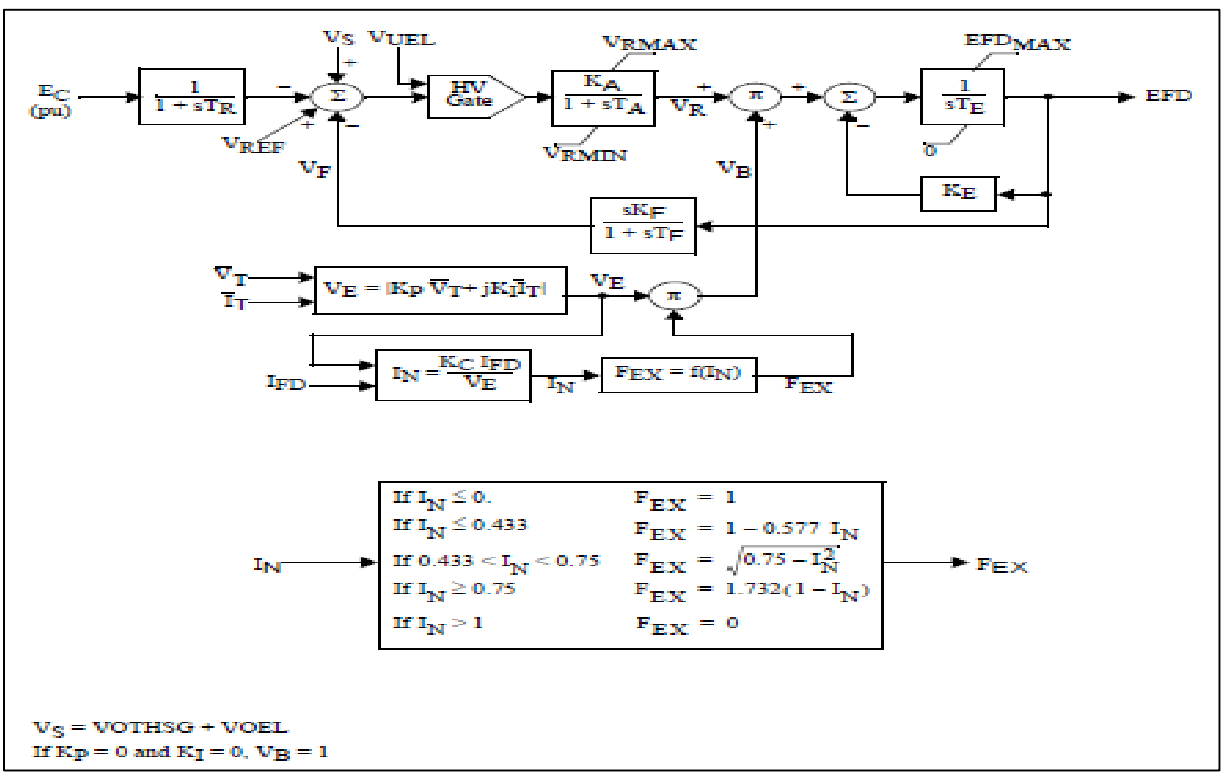


(iii) Commonly Used Static Exciters Generic Models block diagrams:

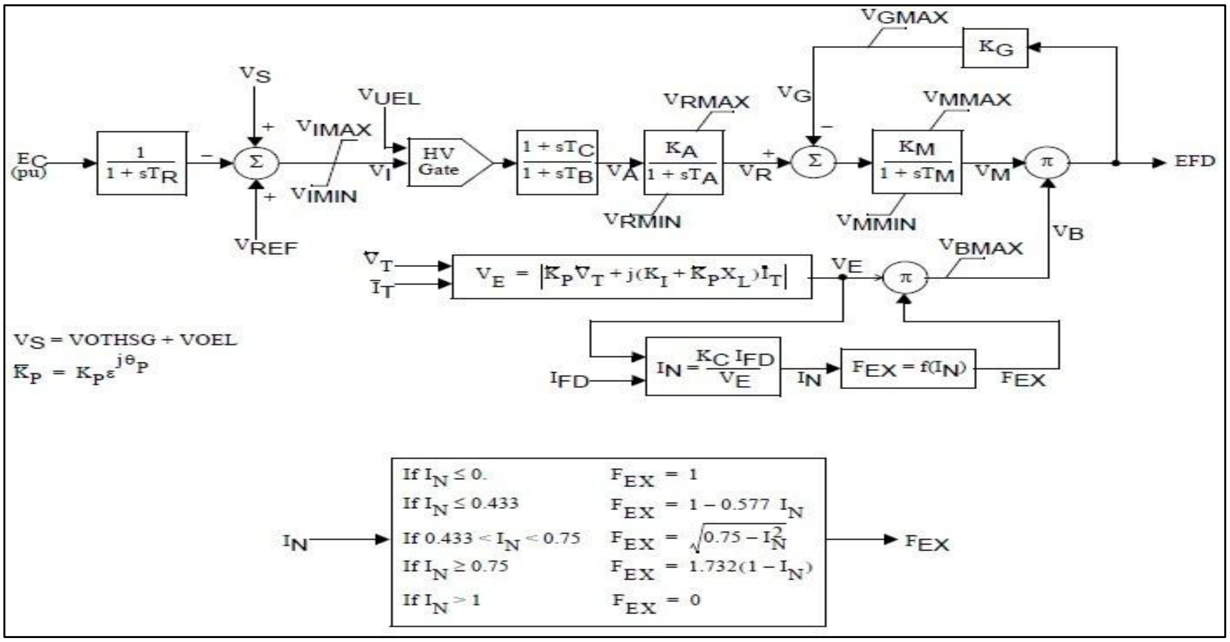
- **Type ST1A: 1992 IEEE type ST1A excitation system model**



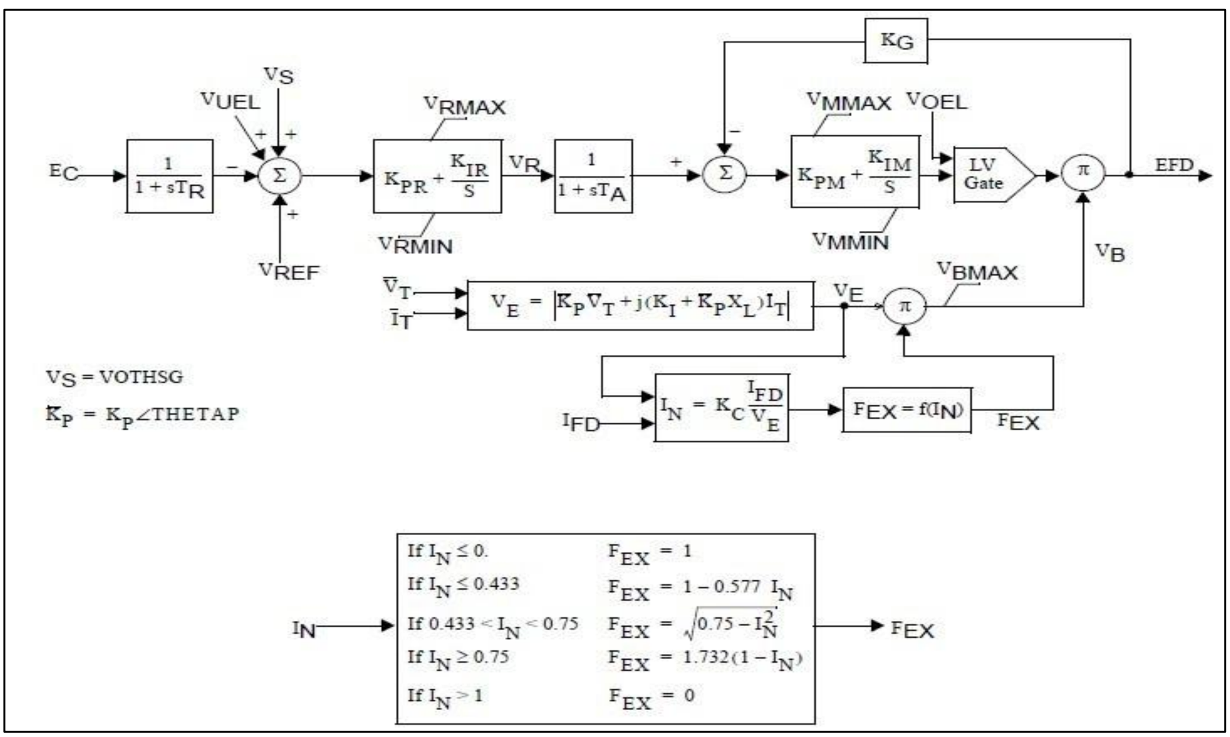
- **Type ST2A: 1992 IEEE type ST2A excitation system model**



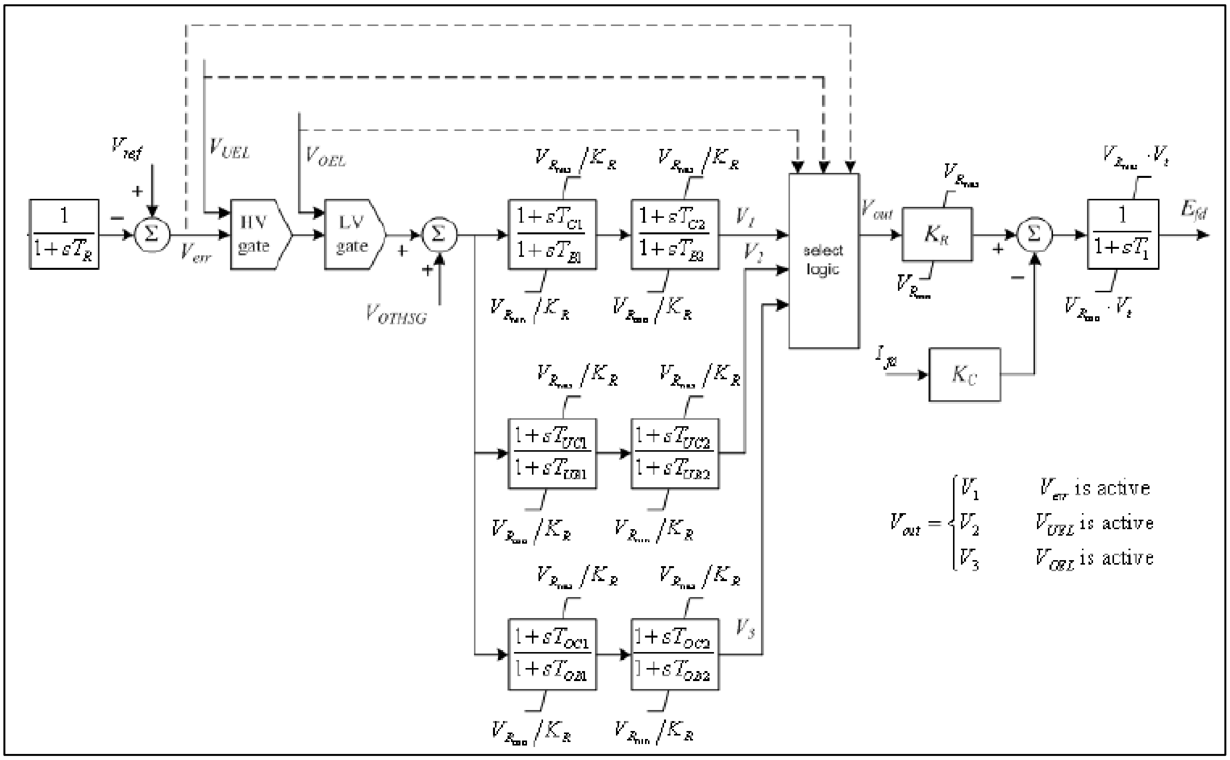
- **Type ST3A: 1992 IEEE type ST3A excitation system model**



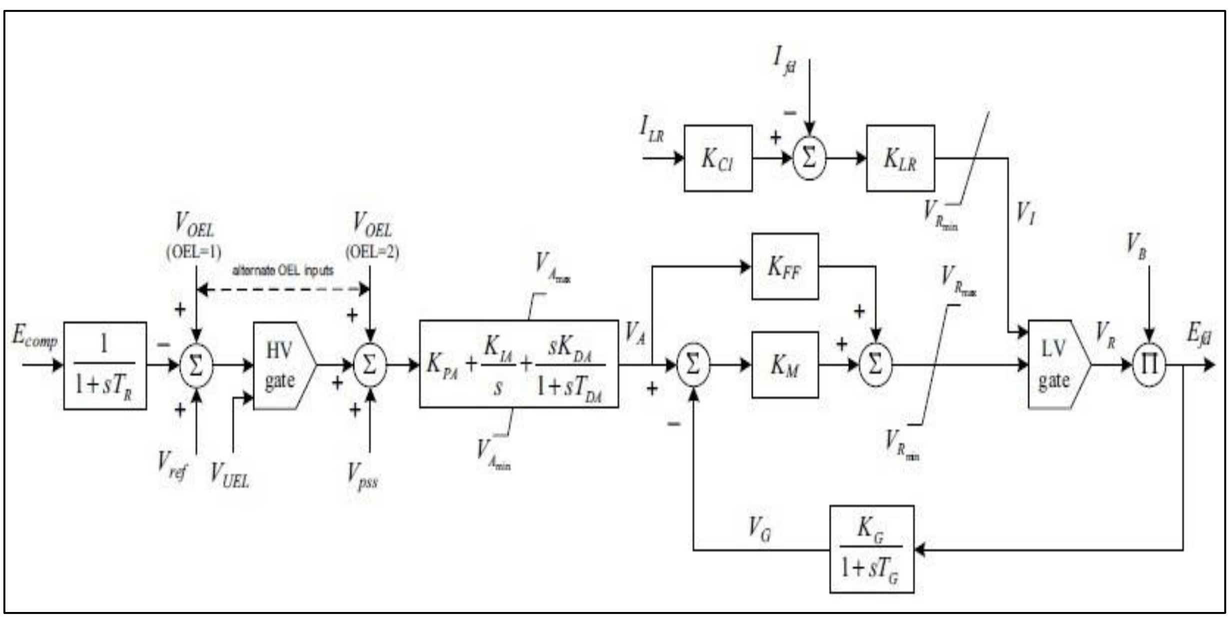
- **Type ST4B: IEEE type ST4B potential or compounded source-controlled rectifier exciter**



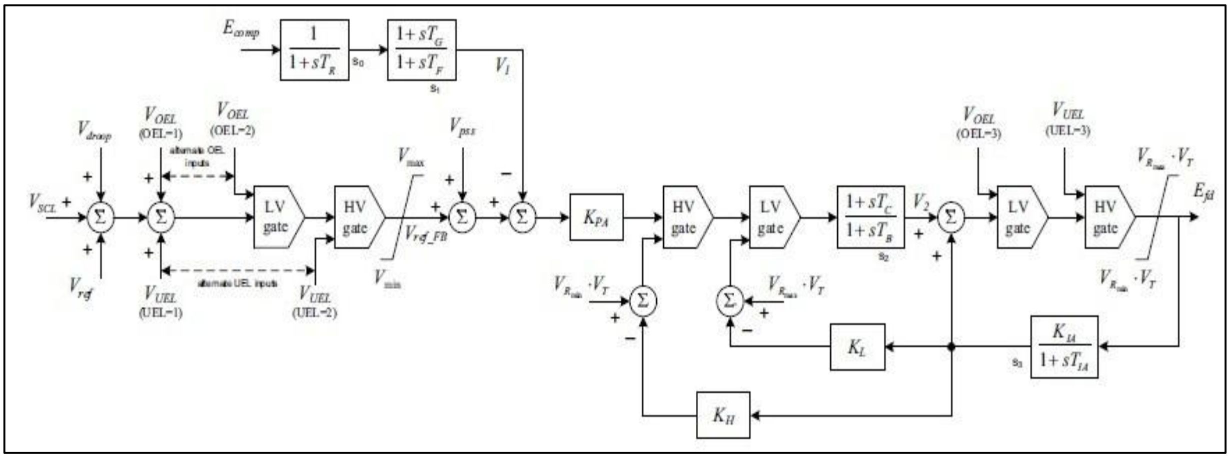
- **Type ST5B: IEEE 421.5 2005 ST5B excitation system**



- **Type ST6B: IEEE 421.5 2005 ST6B excitation system**



➢ **Type ST7B: IEEE 421.5 2005 ST7B excitation system**



Source-PSSE Model Library

3.4 Power system stabilizer:

The function of the PSS is to add to the unit's characteristic electromechanical oscillations. This is achieved by modulating excitation to develop a component in electrical torque in phase with rotor speed deviations.

The most important aspect when considering a PSS model is the number of inputs. The following table shows the type of models separated based on the inputs:

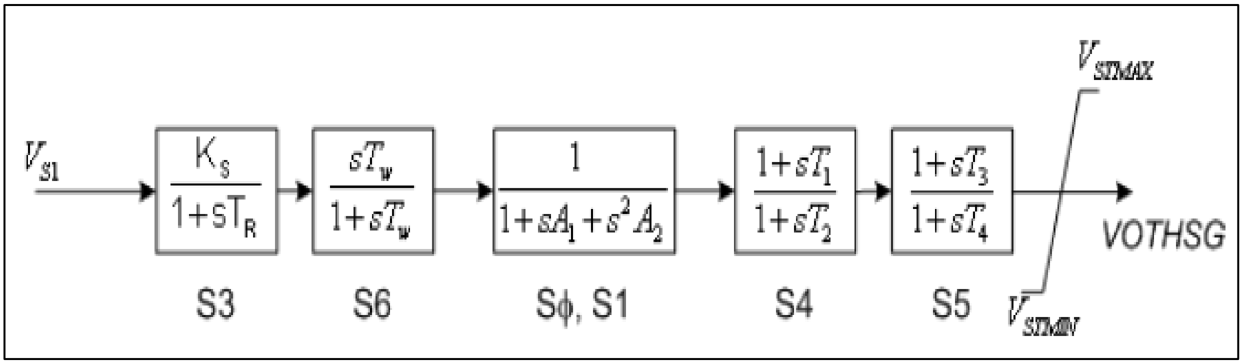
Type	Inputs	Remarks
PSS1A	Single input	Two lead-lags Input can either be speed, frequency or power
PSS2B	Dual input	Integral of accelerating power type stabiliser Speed and Power Most common type Supersedes PSS2A (three versus two lead lags)
PSS3B	Dual input	Power and rotor angular frequency deviation Stabilising signal is a vector sum of processed signals Not very common

Category	Parameter Description	Data
	Stabilizer Models	
PSS1A	A1, Filter coefficient	
	A2, Filter coefficient	
	TR, transducer time constant	
	0	
	0	
	0	
	T1, 1st Lead-Lag Derivative Time Constant	
	T2, 1st Lead-Lag Delay Time Constant	
	T3, 2nd Lead-Lag Derivative Time Constant	
	T4, 2nd Lead-Lag Delay Time Constant	
	Tw, Washout Time Constant	
	Tw, Washout Time Constant	
	Ks, input channel gain	
	VSTMAX, Controller maximum output	
	VSTMAX, Controller minimum output	
	0	
	0	
PSS2B	TW1, 1st Washout 1th Time Constant	
	TW2, 1st Washout 2th Time Constant	
	T6, 1st Signal Transducer Time Constant	
	TW3, 2nd Washout 1th Time Constant	
	TW4, 2nd Washout 2th Time Constant	
	T7, 2nd Signal Transducer Time Constant	
	KS2, 2nd Signal Transducer Factor	
	KS3, Washouts Coupling Factor	
	T8, Ramp Tracking Filter Deriv. Time Constant	
	T9, Ramp Tracking Filter Delay Time Constant	
	KS1, PSS Gain	
	T1, 1st Lead-Lag Derivative Time Constant	
	T2, 1st Lead-Lag Delay Time Constant	
	T3, 2nd Lead-Lag Derivative Time Constant	
	T4, 2nd Lead-Lag Delay Time Constant	
	T10, 3rd Lead-Lag Derivative Time Constant	
	T11, 3rd Lead-Lag Delay Time Constant	
	VS1MAX, Input 1 Maximum limit	
	VS1MIN, Input 1 Minimum limit	
	VS2MAX, Input 2 Maximum limit	
	VS2MIN, Input 2 Minimum limit	
	VSTMAX, Controller Maximum Output	
	VSTMIN, Controller Minimum Output	

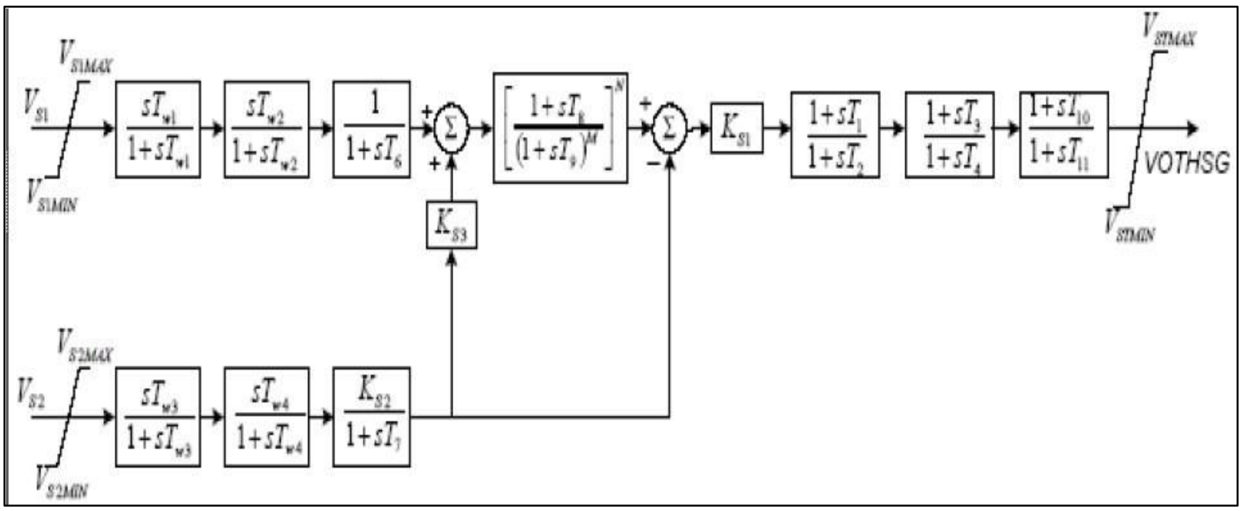
Category	Parameter Description	Data
Stabilizer Models		
PSS3B	KS1 (pu) (≠0), input channel #1 gain	
	T1 input channel #1 transducer time constant (sec)	
	Tw1 input channel #1 washout time constant (sec)	
	KS2 (pu) inputchannel #2 gain	
	T2 input channel #2 transducer time constant (sec)	
	Tw2 input channel #2 washout time constant (sec)	
	Tw3 (0), main washout time constant (sec)	
	A1, Filter coefficient	
	A2, Filter coefficient	
	A3, Filter coefficient	
	A4, Filter coefficient	
	A5, Filter coefficient	
	A6, Filter coefficient	
	A7, Filter coefficient	
	A8, Filter coefficient	
	VSTMAX, Controller maximum output	
	VSTMAX, Controller minimum output	

Commonly Used Power System Stabilizer generic models block diagrams:

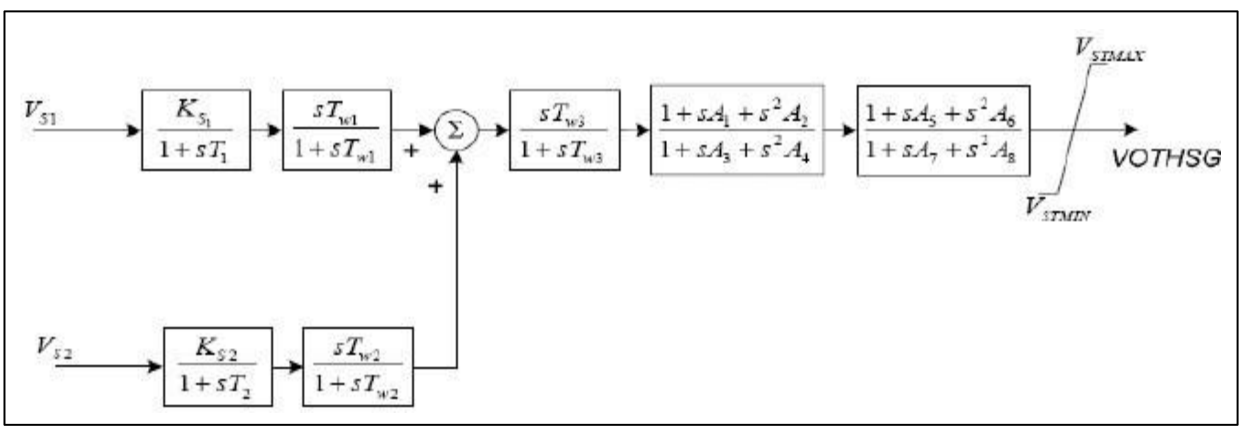
- **PSS1A: IEEE Std. 421.5-2005 PSS1A Single-Input Stabilizer model**



- **PSS2B: IEEE 421.5 2005 PSS2B IEEE dual-input stabilizer model**



- **PSS3B: IEEE Std. 421.5 2005 PSS3B IEEE dual-input stabilizer model**



Source-PSSE Model Library

3.5 Generic models for gas turbine-governor:

The following table is a list for common generic models of gas turbines:

Type	Name	Remarks
GAST	Gas turbine governor	Simplified model for industrial gas turbine (i.e. OCGT)
GAST2A	Gas turbine governor	More detailed GT from GAST. Governor can be configured for droop or isochronous control. Includes temperature control
GASTWD	Woodward Gas Turbine-Governor model	Same detail of turbine dynamics as GAST2A but with a Woodward governor controls
WESGOV	Westinghouse Digital governor for Gas Turbine	Westinghouse 501 combination turbine governor
GGOV1	GE General Governor/Turbine model	General purpose GE GT model (neglects ICV control)
PWTBD1	Pratt & Whitney Turboden turbine-Governor	Turbine load PI control with valve and look-up Table
URCSCT	Combined cycle, single shaft turbine-governor model	
URGS3T	WECC gas turbine governor	

Source: PSSE Model Library, for models other than the above list refer to

https://w3.usa.siemens.com/smartgrid/us/en/transmission-grid/products/grid-analysis-tools/transmission-system-planning/transmission-system-planning-tab/pages/user-support.aspx

Category	Parameter Description	Data
TURBINE GOVERNOR model		
GAST	R, permanent droop	
	T1 (>0) (sec), Governor mechanism time constant	
	T2 (>0) (sec), Turbine power time constant	
	T3 (>0) (sec), Turbine exhaust temperature time constant	
	Ambient temperature load limit, AT	
	KT, Temperature limiter gain	
	VMAX, Maximum turbine power	
	VMIN, Minimum turbine power	
	Dturb, Turbine damping factor	
GAST2A	W, governor gain (1/droop) (on turbine rating)	
	X (sec) governor lead time constant	
	Y (sec) (> 0) governor lag time constant	
	Z, governor mode:1 Droop or 0 ISO	
	ETD (sec), Turbine exhausts time constant	
	TCD (sec), Gas turbine dynamic time constant	
	TRATE turbine rating (MW)	
	T (sec), Fuel control time constant	
	MAX (pu) limit (on turbine rating)	
	MIN (pu) limit (on turbine rating)	
	ECR (sec), Combustor time constant	
	K3, Fuel control gain	
	a (> 0) valve positioner	
	b (sec) (> 0) valve positioner	
	c valve positioner	
	Tf (sec) (> 0), Fuel system time constant	
	Kf, feedback gain	
	K5, Radiation shield	
	K4, Radiation shield	
	T3 (sec) (> 0), Radiation shield time constant	
	T4 (sec) (> 0), Thermocouple time constant, seconds	
	Tt (> 0), Temperature control time constant	
	T5 (sec) (> 0), Temperature control time constant	
	af1, describes the turbine characteristic	
	bf1, describes the turbine characteristic	
	af2, describes the turbine characteristic	
	bf2, describes the turbine characteristic	
	cf2, describes the turbine characteristic	
	TR (degree), Rated temperature	
	K6 (pu), Minimum fuel flow	
	TC (degree), Temperature control	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
GASTWD	KDROOP (on turbine rating)	
	KP, Proportional gain	
	KI, Integral gain	
	KD, Derivative gain	
	ETD (sec), Turbine exhaust time constant	
	TCD (sec), Gas turbine dynamic time constant	
	TRATE turbine rating (MW)	
	T (sec), Fuel control time constant	
	MAX (pu) limit (on turbine rating)	
	MIN (pu) limit (on turbine rating)	
	ECR (sec), Combustor time constant	
	K3, Fuel control gain	
	a (> 0) valve positioner	
	b (sec) (> 0) valve positioner	
	c valve positioner	
	tf (sec) (> 0), Fuel system time constant	
	Kf, feedback gain	
	K5, Radiation shield	
	K4, Radiation shield	
	T3 (sec) (> 0), Radiation shield time constant	
	T4 (sec) (> 0), Thermocouple time constant, seconds	
	tt (> 0), Temperature control time constant	
	T5 (sec) (> 0), Temperature control time constant	
	af1, describes the turbine characteristic	
	bf1, describes the turbine characteristic	
	af2, describes the turbine characteristic	
	bf2 (>0), describes the turbine characteristic	
	cf2, describes the turbine characteristic	
	TR (degree), Rated temperature1	
	K6 (pu), Minimum fuel flow	
	TC (degree), Temperature control1	
	TD (sec) (> 0), Power transducer	
WESGOV	ΔTC (sec), Δt sample for controls	
	ΔTP (sec), Δt sample for PE	
	Power Droop	
	Kp, Trubine proportional gain	
	TI (> 0) (sec), Integral time constant	
	T1 (sec), Constant time	
	T2 (sec), Constant time	
	ALIM	
	Tpe (sec), Power time constant	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
	R, Permanent droop, pu	
	Tpelec, Electrical power transducer time constant, sec	
	maxerr, Maximum value for speed error signal	
	minerr, Minimum value for speed error signal	
	Kpgov, Governor proportional gain	
	Kigov, Governor integral gain	
	Kdgov, Governor derivative gain	
	Tdgov, Governor derivative controller time constant, sec	
	vmax, Maximum valve position limit	
	vmin, Minimum valve position limit	
	Tact, Actuator time constant, sec	
	Kturb, Turbine gain	
	Wfnl, No load fuel flow, pu	
	Tb, Turbine lag time constant, sec	
	Tc, Turbine lead time constant, sec	
	Teng, Transport lag time constant for diesel engine, sec	
GGOV1	Tfload, Load Limiter time constant, sec	
	Kpload, Load limiter proportional gain for PI controller	
	Kiload, Load limiter integral gain for PI controller	
	Ldref, Load limiter reference value pu	
	Dm, Mechanical damping coefficient, pu	
	Ropen, Maximum valve opening rate, pu/sec	
	Rclose, Maximum valve closing rate, pu/sec	
	Kimw, Power controller (reset) gain	
	Aset, Acceleration limiter setpoint, pu/sec	
	Ka, Acceleration limiter gain	
	Ta, Acceleration limiter time constant, sec (> 0)	
	Trate, Turbine rating (MW)1	
	db, Speed governor deadband	
	Tsa, Temperature detection lead time constant, sec	
	Tsb, Temperature detection lag time constant, sec	
	Rup, Maximum rate of load limit increase	
	Rdown, Maximum rate of load limit decrease	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
PWTBD1	Trate (MW), Turbine rating (MW)	
	K (pu), Proportional gain	
	Ki (pu), Integral gain	
	Vrmax (pu), Upper Limit of PI controller	
	Vrmin (pu), Lower Limit of PI controller	
	Tv (s) (>0), Control valve Time Constant	
	Lo (pu/sec) (>0), Control valve open rate limit	
	Lc (pu/sec) (>0), Control valve close rate limit	
	Vmax (pu), Maximum valve position	
	Vmin (pu), Minimum valve position	
	Tb1 (s), steam buffer time constant	
	Tb2 (s), steam buffer time constant	
	v1 (pu), valve position 1	
	p1 (pu), power output for valve position v1	
	v2 (pu), valve position 2	
	p2 (pu), power output for valve position v2	
	v3 (pu), valve position 3	
	p3 (pu), power output for valve position v3	
	v4 (pu), valve position 4	
	p4 (pu), power output for valve position v4	
	v5 (pu), valve position 5	
	p5 (pu), power output for valve position v5	
	v6 (pu), valve position 6	
	p6 (pu), power output for valve position v6	
	v7 (pu), valve position 7	
	p7 (pu), power output for valve position v7	
	v8 (pu), valve position 8	
	p8 (pu), power output for valve position v8	
	v9 (pu), valve position 9	
	p9 (pu), power output for valve position v9	
	v10 (pu), valve position 10	
	p11 (pu), power output for valve position v11	
	v11 (pu), valve position 11	
	p11 (pu), power output for valve position v11	

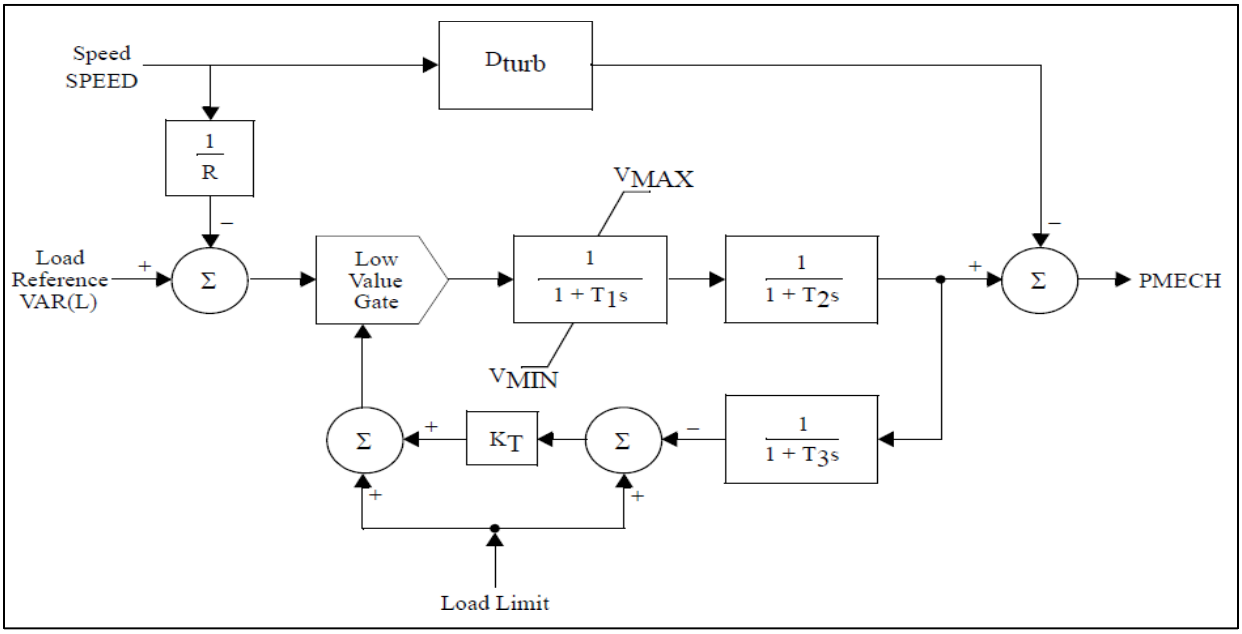
Category	Parameter Description	Data
TURBINE GOVERNOR model		
URCSCT	W, governor gain (1/droop) (on turbine rating)	
	X (sec) governor lead time constant	
	Y (sec) (> 0) governor lag time constant	
	Z, governor mode:1 Droop or 0 ISO	
	ETD (sec), Turbine exhausts time constant	
	TCD (sec), Gas turbine dynamic time constant	
	TRATE turbine rating (MW)	
	T (sec), Fuel control time constant	
	MAX (pu) limit (on turbine rating)	
	MIN (pu) limit (on turbine rating)	
	ECR (sec), Combustor time constant	
	K3, Fuel control gain	
	a (> 0) valve positioner	
	b (sec) (> 0) valve positioner	
	c valve positioner	
	Tf (sec) (> 0), Fuel system time constant	
	Kf, feedback gain	
	K5, Radiation shield	
	K4, Radiation shield	
	T3 (sec) (> 0), Radiation shield time constant	
	T4 (sec) (> 0), Thermocouple time constant, seconds	
	Tt (> 0), Temperature control time constant	
	T5 (sec) (> 0), Temperature control time constant	
	af1, describes the turbine characteristic	
	bf1, describes the turbine characteristic	
	af2, describes the turbine characteristic	
	bf2, describes the turbine characteristic	
	cf2, describes the turbine characteristic	
	TR (degree), Rated temperature	
	K6 (pu), Minimum fuel flow	
	TC (degree), Temperature control	
	K, Governor gain, (1/droop) pu	
	T1 (sec), Lag time constant (sec)	
	T2 (sec), Lead time constant (sec)	
	T3 (> 0) (sec), valve position time constant	
	Uo (pu/sec), maximum valve opening rate	
	Uc (< 0) (pu/sec), maximum valve closing rate	
	PMAX (pu on machine MVA rating)	
	PMIN (pu on machine MVA rating)	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
URSCT (continued)	T4 (sec), time constant for steam inlet	
	K1, HP fraction	
	K2, LP fraction	
	T5 (sec), Time Constant for Second Boiler Pass [s]	
	K3, HP Fraction	
	K4, LP fraction	
	T6 (sec), Time Constant for Third Boiler Pass [s]	
	K5, HP Fraction	
	K6, LP fraction	
	T7 (sec), Time Constant for Fourth Boiler Pass [s]	
	K7, HP Fraction	
	K8, LP fraction	
	ST Rating, Steam turbine rating (MW)	
	POUT A, Plant total, point A (MW)	
	STOUT A, Steam turbine output, point A (MW)	
	POUT B, Plant total, point B (MW)	
	STOUT B, Steam turbine output, point B (MW)	
	POUT C, Plant total, point C (MW)	
	STOUT C, Steam turbine output, point C (MW)	
URGS3T	R	
	T1 (> 0) (sec)	
	T2 (> 0) (sec)	
	T3 (> 0) (sec)	
	Lmax	
	Kt	
	Vmax	
	Vmin	
	Dturb	
	Fidle	
	Rmax	
	Linc (> 0)	
	Tltr (>0) (sec)	
	Ltrat	
	A	
	b (> 0)	
	db1, dead band width (p.u.)	
	Err, deadband hysteresis (p.u.)	
	db2, dead band width (p.u.)	
	GV1, coordinate of power-gate look-up table (p.u. gate)	

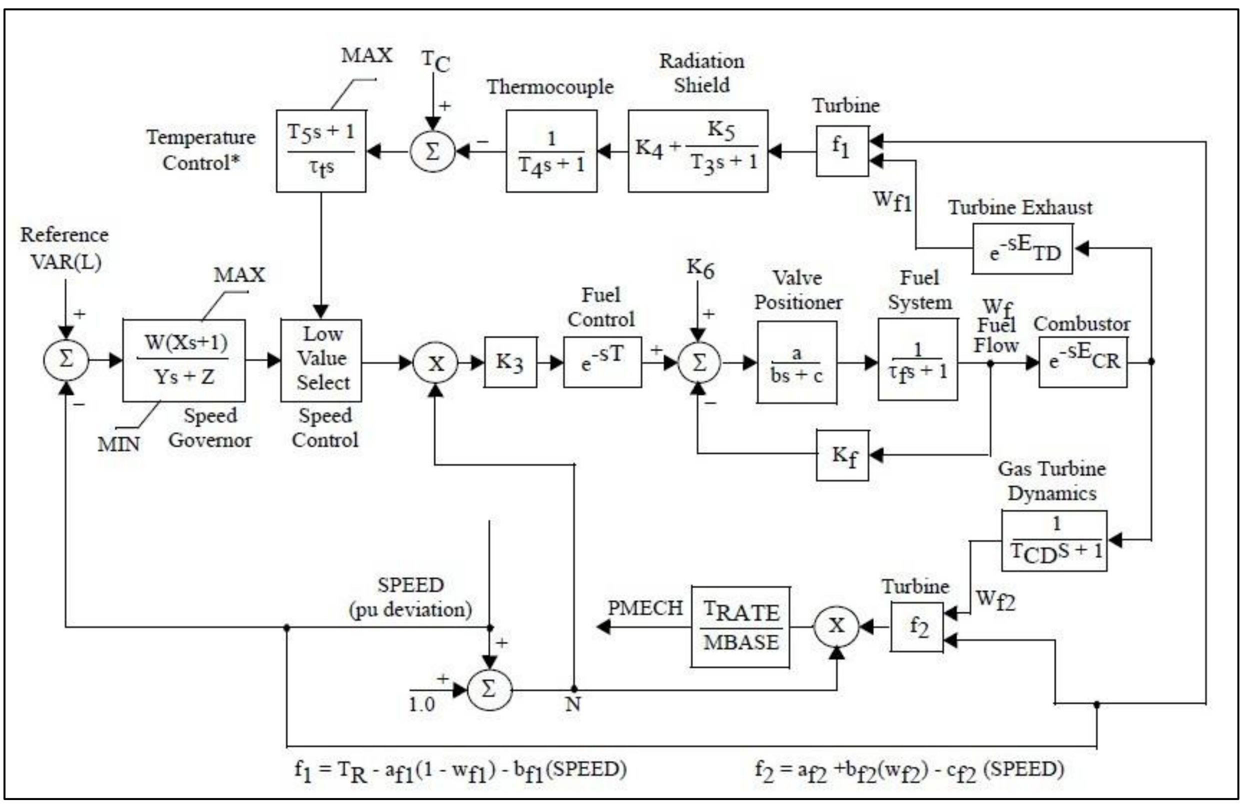
URGS3T (CONTINUED)	PGV1, coordinate of power-gate look-up table (p.u. power)	
	GV2, coordinate of power-gate look-up table (p.u. gate)	
	PGV2, coordinate of power-gate look-up table (p.u. power)	
	GV3, coordinate of power-gate look-up table (p.u. gate)	
	PGV3, coordinate of power-gate look-up table (p.u. power)	
	GV4, coordinate of power-gate look-up table (p.u. gate)	
	PGV4, coordinate of power-gate look-up table (p.u. power)	
	GV5, coordinate of power-gate look-up table (p.u. gate)	
	PGV5, coordinate of power-gate look-up table (p.u. power)	
	Ka	
	T4	
	T5	
	MWCAP	

Commonly Used Gas Turbine Generic Models Block Diagrams:

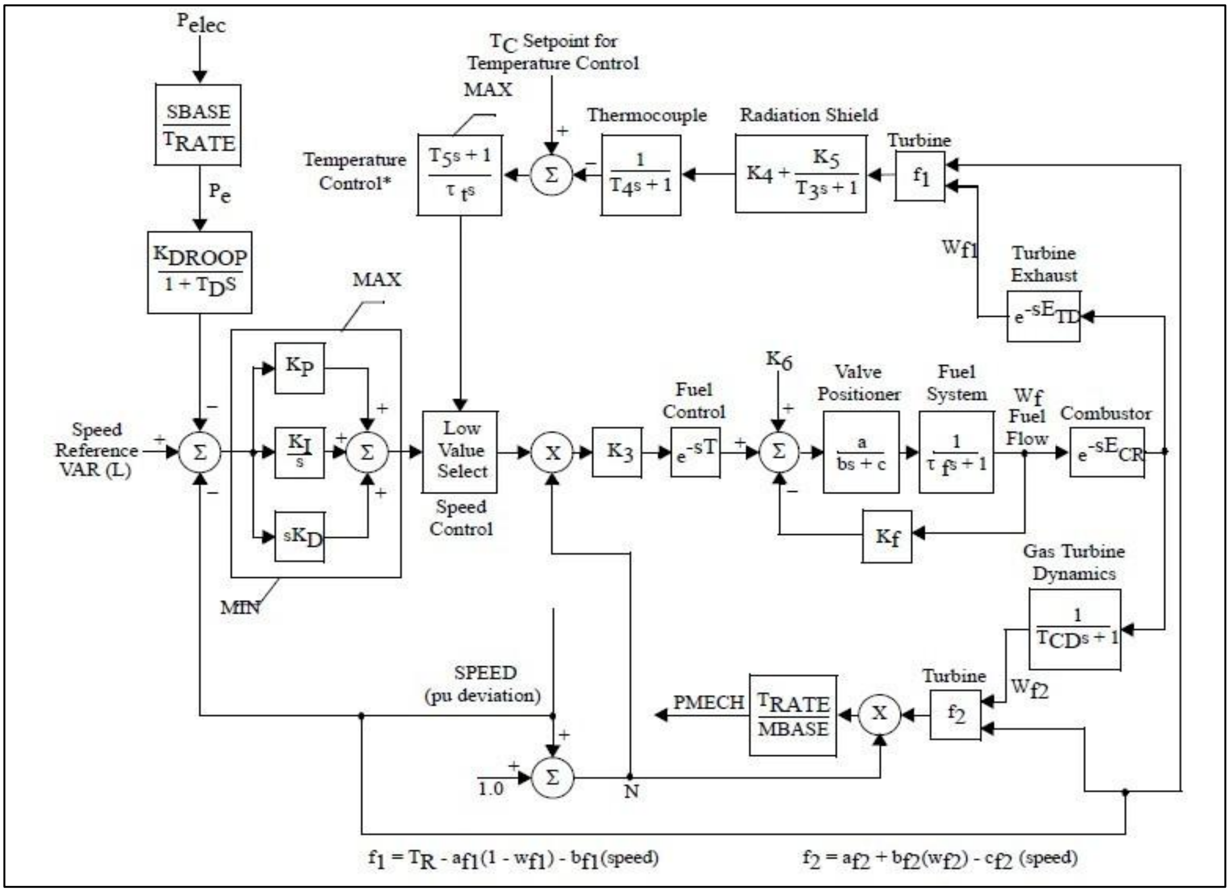
- **GAST: Gas Turbine-Governor**



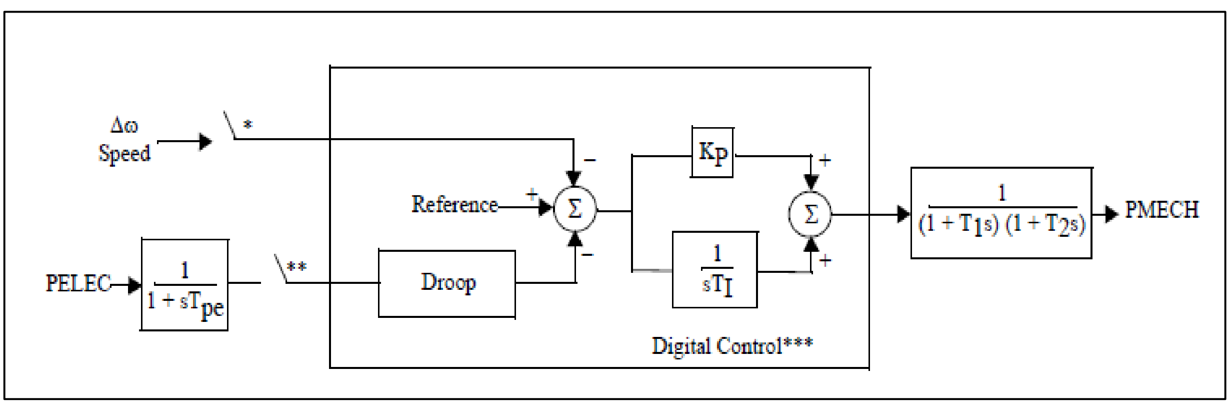
- **GAST2A: Hydro Turbine-Governor**



➢ **GASTWD: Woodward Gas Turbine-Governor Model**



➢ **WESGOV: Westinghouse Digital Governor for Gas Turbine**

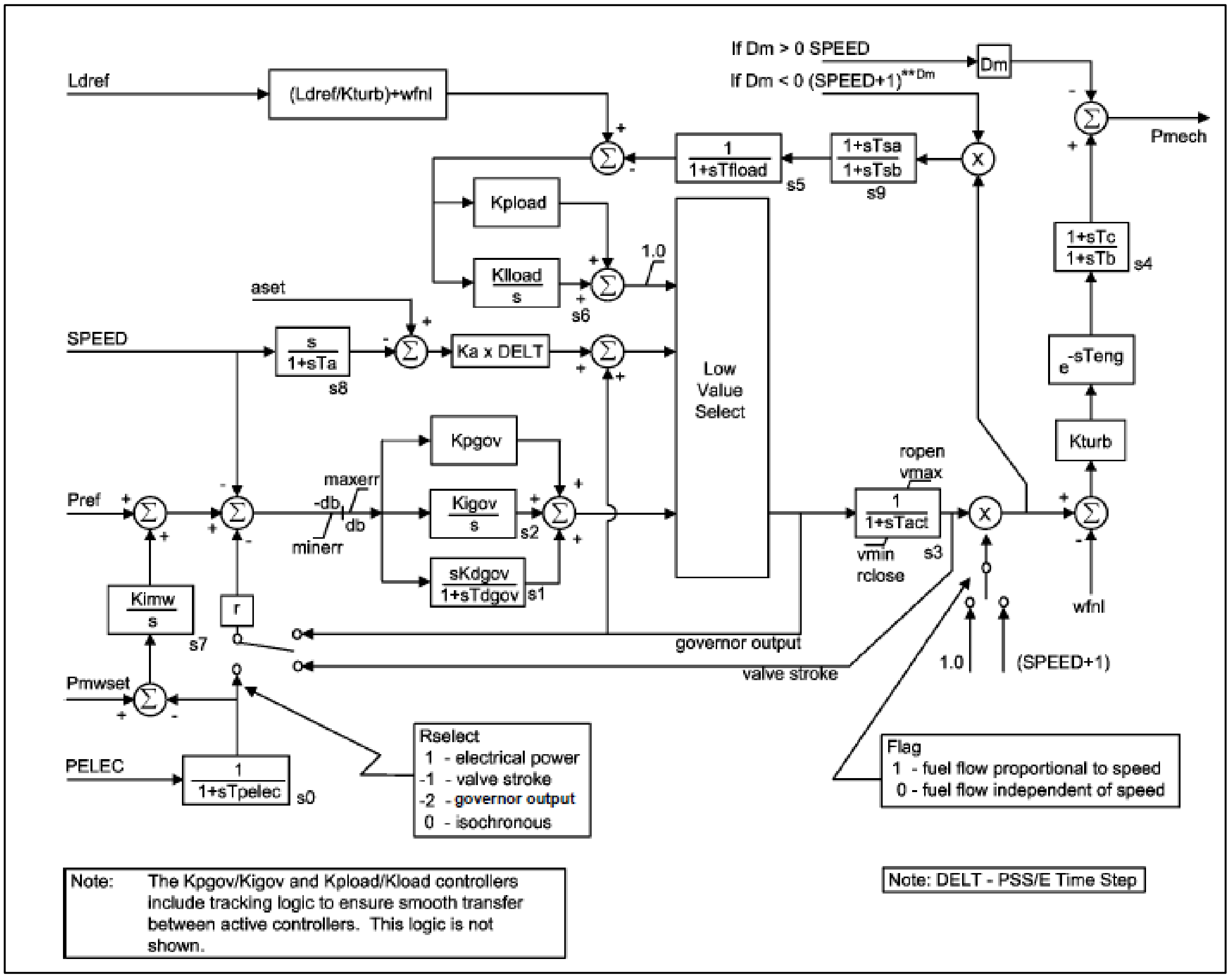


*Sample hold with sample period defined by ΔTC.

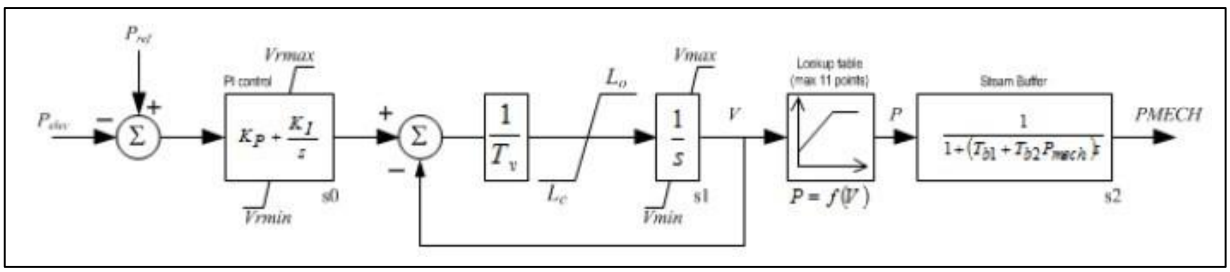
**Sample hold with sample period defined by ΔTP.

***Maximum change is limited to ALIM between sampling times.

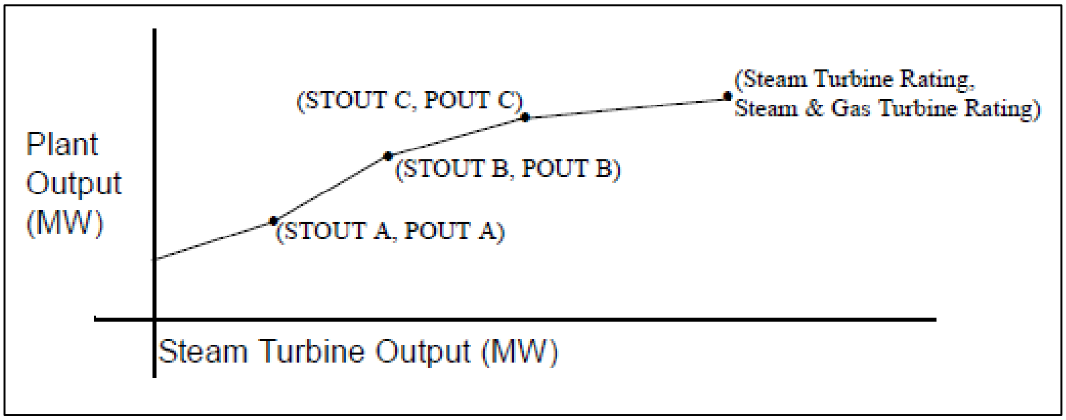
➢ **GGOV1: GE General Governor/Turbine Model**



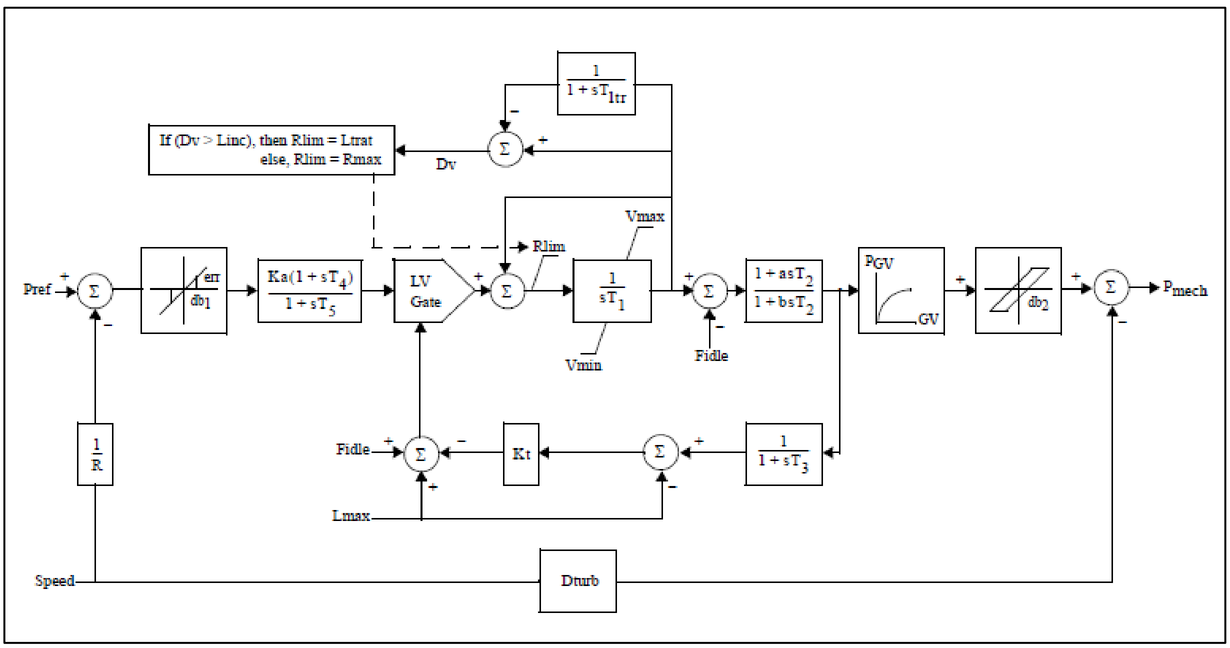
➢ **PWTBD1: Pratt & Whitney Turboden Turbine-Governor Model**



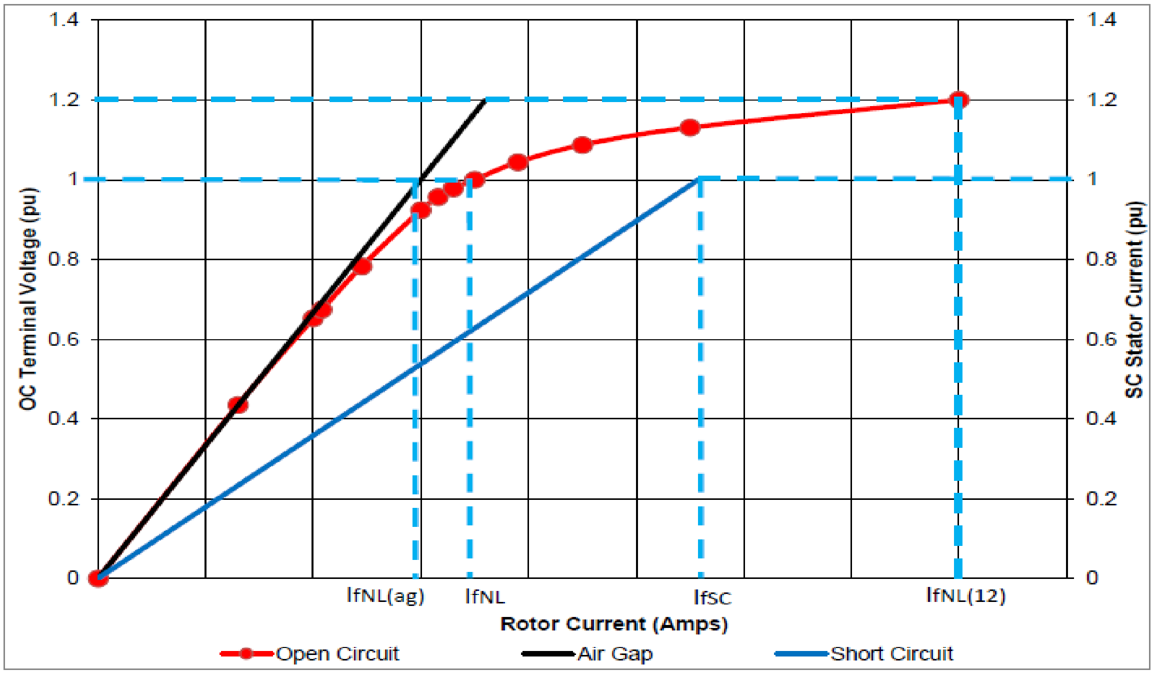
➢ **URCSCT: Combined Cycle on Single Shaft**



➢ **URGS3T: WECC Gas Turbine Model**



Source-PSSE Model Library

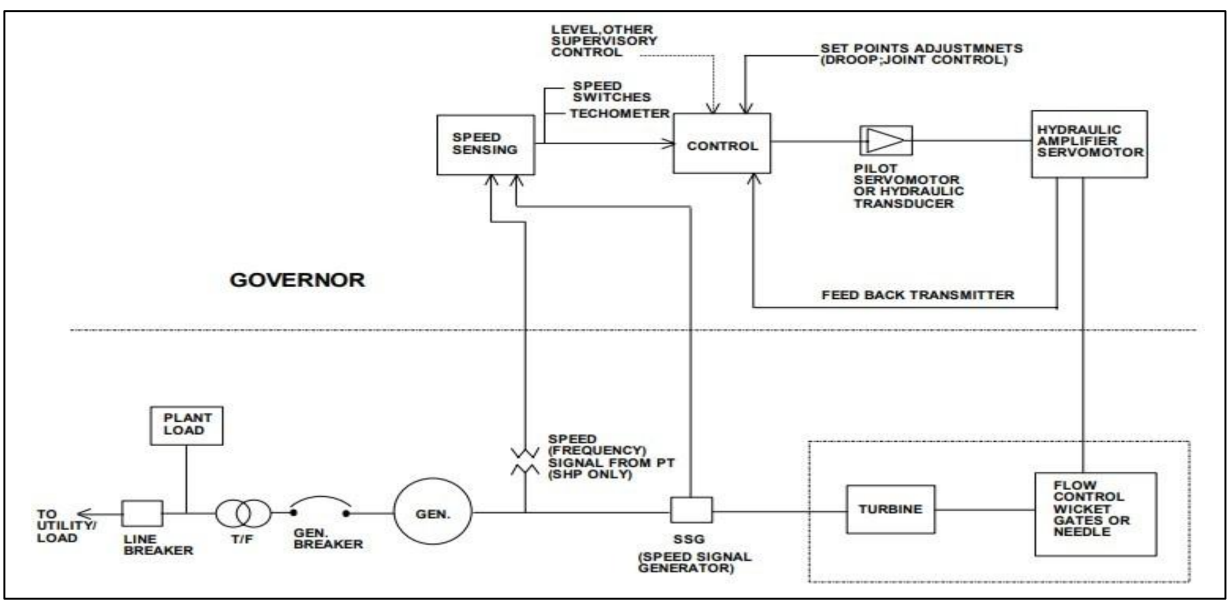


Open and short circuit characteristics

The saturation can be calculated using the following calculation:

$$S(1.0) = \frac{If_{NL} - If_{NL(AG)}}{If_{NL(AG)}}$$

$$S(1.2) = \frac{If_{NL(12)} - 1.2 \times If_{NL(AG)}}{1.2 \times If_{NL(AG)}}$$



Governing system - Block Diagram (Typical) as per IEEE std. -75

Guidelines for furnishing information for RMS (generic) modelling of Hydro Generation

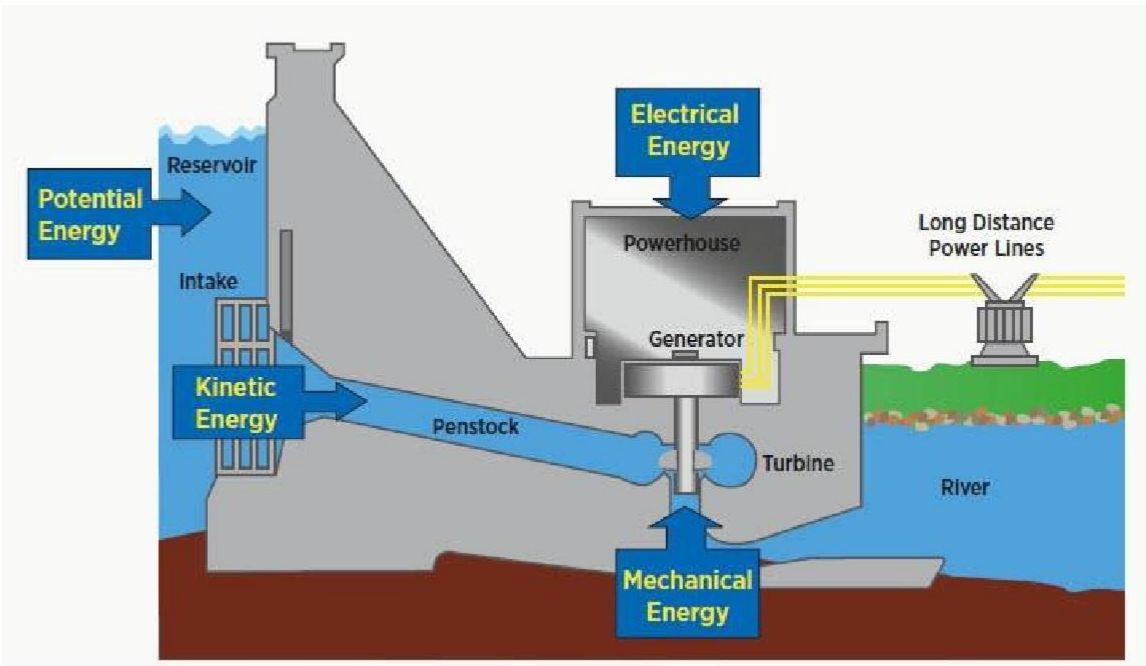
The guidelines provide the desired information for collection of data for RMS modelling (generic) of hydro power generation.

2.1 Hydro Power Plant Classification:

a. **Run-of-river:**
Run of river hydropower projects have no, or very little, storage capacity behind the dam and generations dependent on the timing and size of river flows.

b. **Reservoir (HPP):**
Reservoir based hydropower schemes have the ability to store water behind the dam in a reservoir in order to de-couple generation from hydro inflows. A hydroelectric reservoir makes use of potential energy of water for generating electricity. Water is held back by the dam, and released through a turbine, which in turn produces electricity. Reservoir capacities can be small or very large, depending on the characteristics of the site and the economics of dam construction.

c. Pumped storage (PSP):
Pumped storage hydropower schemes use off-peak electricity to pump water from a reservoir located after the tailrace to the top of the reservoir, so that the pumped storage plant can generate electricity at peak times and provide grid stability and flexibility services



Typical "LOW HEAD" Hydro Power Plant with storage

Types of hydraulic turbines in regional grid:

The conventional hydroelectric generator can be classified broadly into three categories based on the hydraulic turbine type given as under:

1) Pelton wheel turbine
2) Kaplan Turbine

3) Francis Turbine
4) Bulb and other types of turbines

Pelton wheel turbine is an impulse turbine for high head and low discharges (flow rate) conditions. Kaplan wheel turbine is a reaction type turbine suitable for low head and high discharge (flow rate) conditions. Francis turbine is mix type of turbine that operates at medium head and flow rate.

Among the hydro generators the Francis turbine generators are characterized by unstable operation zone over a certain range of generation (typically 10-70%) where it experiences vibration due to cavitation. Cavitation is the resulting vibration caused by bubbles formed in water column due to pressure change and this causes loss of head and turbine efficiency. The Pelton wheel turbines on the other hand do have better load following characteristics and are capable of extended part load operation since they don't have any such forbidden zones.

For SLDC to have access to verified fit-for-purpose models of hydro power generator connected to Indian grid, following information is required:

1. Electrical Single Line Diagram of coal fired thermal station depicting;
   - **For individual generating units:** type of technology, **Complete Generator OEM Technical Datasheet** (which comprises namely generator parameters like impedances & time constants, generator capability curve, V-curve, generator open and short circuit characteristics, excitation system details, inertia of generator & exciter), generator name plate, generator SAT report including short circuit and open circuit test results during commissioning/recent overhauling.
   - **Generator step up transformer**: GT name plate/datasheet, details of LV, MV and HV, MVA rating, impedance, tap changer details, vector group, short-circuit parameters (actual positive & zero sequence impedance of GT, NGR nameplate with impedance).
   - **Excitation system :-** Type of excitation system (Direct Current Commutator Exciters (type DC), AC Excitation (Rotor or brushless excitation) Systems (type AC) and Static Excitation Systems (type ST), Excitation system schematics (Block diagram of AVR system), transfer function block diagram of Excitation system, excitation transformer nameplate, saturation curves of the exciter (I_a versus I_f curve), IEEE standard model of excitation system, IEEE standard model and its parameter of subsystems such as Power system stabilizer (PSS), Under Excitation Limiter (UEL), Over Excitation Limiter (OEL), Voltage per Hz Limiter(V/Hz) control etc. and details thereof, factory acceptance test reports (FAT). Excitation system actual settings to be provided. AVR test report (excitation step response test).

- **Power System Stabilizer (PSS):** Transfer function block diagram of PSS, IEEE Standard Model, Actual PSS software settings, PSS commissioning report and **Recent PSS tuning report**.
- **Turbine-Governor system :-** Type of prime mover (hydro-electric or pumped storage), type of hydro turbine (impulse or reaction turbine) and details of head, model of turbine (including details of technology, valves, valve characteristics), model of governor control system (including details of technology, valves, valves characteristics) , penstock details (length, area, diameter, thickness, elastic or non-elastic, no of penstock supplied through common tunnel and flow of water through turbine) , mode of operation (hydro, pump storage or synchronous condenser) and control, surge tank details (height, diameter and restricted inlet orifice), pump characteristic (Active power Vs head) ramp rates, losses in case of synchronous condenser operation (Mechanical loss and copper loss as a function of MVAr output), Block diagram of turbine- governor system, IEEE standard model of turbine governor system and its transfer function diagram and its parameters, Turbine inertia, commissioning report of turbine-governor system or recent governor testing report.

3.1 Details of models in PSS/E for modelling hydro power generator:

(a) Synchronous Machine – HPP and PSP types

Category	Parameter Description	Data
Generator Nameplate	Rated apparent power in MVA	
	Rated terminal voltage	
	Rated power factor	
	Rated speed (in RPM)	
	Rated frequency (in Hz)	
	Rated excitation (in Amperes and Volts)	
Type of synchronous machine	Round rotor or salient pole No. of poles	
Generator capability curve	The generator capability curve shows the reactive capability of the machine and should include any restrictions on the real or reactive power range like under/over excitation limits, stability limits, etc. Capability curve should have properly labelled axis and legible data	
Generator Open Circuit and Short Circuit Characteristic	Graph of excitation current versus terminal voltage and stator current	
	No load excitation current – used to derive per unit values	
	Excitation current at rated stator current	
Generator vee-curves	Otherwise referred to as "V-curve". A plot of the terminal (armature) current versus the generating unit field voltage.	
Resistance values	Resistance measurements of field winding and stator winding to a known temperature	
Generator Data sheet	Direct axis synchronous reactance Xd in p.u. (Unsaturated or saturated)	
	Direct axis transient synchronous reactance Xd' in p.u. (Unsaturated or saturated)	
	Direct axis sub-transient synchronous reactance Xd'' in p.u. (Unsaturated or saturated)	
	Stator leakage reactance Xa in p.u. (Unsaturated or saturated)	

Generator Data sheet	Quadrature axis synchronous reactance Xq in p.u. (Unsaturated or saturated)	
	Quadrature axis transient synchronous reactance Xq’ in p.u. (Unsaturated or saturated)	
	Quadrature axis sub-transient synchronous reactance Xq’’ in p.u. (Unsaturated or saturated)	
	Direct axis open circuit transient time constant Tdo’ in sec	
	Direct axis open circuit sub-transient time constant Tdo’’ in sec	
	Quadrature axis open circuit transient time constant Tqo’ in sec	
	Quadrature axis open circuit sub-transient time constant Tqo’’ in sec	
	Inertia constant of total rotating mass (generator, AVR, turbo-governor set) H in MW. s/MVA	
	Speed Damping D	
	Saturation constant S (1.0) in p.u.	
	Saturation constant S (1.2) in p.u.	

Category	Parameter Description	Data
Generator step up transformer (GSUT)	Nameplate Rating - Rated primary and secondary voltage - Vector group - Impedance	
Auxiliary power (i.e. active and reactive auxiliary load)	Value of auxiliary load (MW and Mvar) at rated power of the generating unit. Whether or not the load trips if the generating unit trips.	
Test Reports	Factory acceptance test (FAT) reports	

(b) Site Load

	Low Output			High Output		
	kW	kvar	kVA	kW	kvar	kVA
Auxiliary Load						

(c) Excitation System

Category	Parameter Description	Data
Type of Automatic Voltage Regulator (AVR)	Manufacturer and product details (for example ABB UNITROL)	
	Type of control system: - Analogue or digital	
	Year of commissioning / Year of manufacture	
	As found settings (obtained either from HMI or downloaded from controller in digital systems)	
Type of excitation system	Static excitation system OR	
	Indirect excitation system (i.e. rotating exciter) - AC exciter, or - DC exciter	
Details of AVR converter	Rated excitation current (converter rating in Amperes)	
	Six pulse thyristor bridge or PWM converter	
Source of excitation supply	Excitation transformer or auxiliary supply (Details thereof)	
	If excitation transformer, nameplate information required	
Schematics	Saturation curves of the exciter (if applicable – see Type AC and DC)	
	Drawings of excitation system, typically prepared and supplied by the OEM	
	Single line diagram (i.e. one-line diagram) for the excitation system	
Excitation limiters	What excitation limiters are commissioned?	
	Under Excitation Limiters settings	
	Over Excitation Limiters settings	
	Voltage/frequency limiter	
	Stator current limiter	
	Minimum excitation current limiter	

Category	Parameter Description	Data
PSS	Is the AVR equipped with a PSS?	
	How many input Channels does the PSS have? (speed, real power output or both	
	If the PSS uses speed, is this a derived speed signal (i.e. synthesized speed signal) or measured directly (i.e. actual rotor speed)?	
	Type of PSS Block Diagram of PSS and as commissioned parameters value (Gain, time constants, filter coefficients, output limits of the PSS)	
Test Reports	Factory acceptance test (FAT) reports	

(d) Turbine Details (to be filled in for the HPP and PSP separately)

Category	Parameter Description	Data
Type of prime mover	Hydro-electric turbine Other (Pumped storage)	
Manufacturer of turbine	Manufacturer and name plate details	
Modes of operation	Type of modes of operation capable: - Generator - Pump storage - Synchronous condenser	
Governor	- Electro-mechanical governor (including settings and drawings) - Digital electric governor (including settings and drawings) - PID governor details and settings - Transient droop (dashpot) governor details and settings - Tacho-accelerometric governor details and settings - Input transducer details - Transfer function data	
	Digital electric governor	
Ramp rates	How fast can the turbine increase and/or decrease load, specified in MW/min Guide vane/wicket gate characteristic, including opening, closing rates/times and limits	
Droop	Droop setting (% on machine base)	
	Frequency influence limiters - Maximum frequency deviation limiter (eg +/-2 Hz) - Maximum influence limiter (eg 10% of rating)	
Dead band	Details of frequency dead band (typically in Hz or RPM)	
Hydro-electric turbine	Type of hydro turbine	
	- Impulse turbines : typical with high head plants (Pelton wheel)	
	Reaction turbine : typical with low and medium head plants (such as Francis and Kaplan turbine	
	Head, water flow, velocity and pressure (e.g. intake and outtake/draft tube)	

Penstock	Length (m)	
	Area (m^2)	
	Internal penstock diameter	
	Pipe thickness, material or other characteristics (such as tapering)	
	Non-elastic or elastic	
	Linear or non-linear model (with or without relief valve) or Kaplan model	
	Flow of water through turbine (m^3/s) – with gates fully open	
	Number of penstocks supplied from common tunnel	
Pressure relief valve	Drawings/schematics	
	Settings	
	Operational descriptions	
Surge tank, reservoir and tail water (i.e. head)	Vertical distance between the upper reservoir and level of turbine (in meters)	
	Head at turbine admission (lake head minus tailrace head) – (in meters)	
	Head loss due to friction in conduit (in meters)	
	Surge tank height, diameter and other characteristics (e.g. restricted inlet orifice)	
Pump characteristics	Active power draw vs head (table)	
	PSS status when pumping (on/off/not used)	
Synchronous condenser	Dewatered when operating as Syncon (yes/no)	
	Losses when operating as Syncon: • Mechanical loss (0 Mvar): …… MW • Copper loss (table) MW loss as a function of MVar output	
Other	Details of protection schemes that could influence dynamics (if any)	
	Details of resonance chamber for pipes (if any)	
	Temperature (e.g. water, ambient, unit)	
	Characteristic curve of blade versus gate (from 0MW to maximum MW)	

3.2 Generic Models for synchronous machine

Hydro machines are multi-pole machines and depending upon the saturation characteristic of the machine they are classified in two groups:

- GENSAL – Salient pole machine with quadratic saturation function
- GENSAE – Salient pole machine with exponential saturation function

Category	Parameter Description	Data
GENERATOR model		
GENSAE OR **GENSAL**	Direct axis open circuit transient time constant Tdo' in sec	
	Direct axis open circuit sub-transient time constant Tdo'' in sec	
	Quadrature axis open circuit sub-transient time constant Tqo'' in sec	
	Inertia constant of total rotating mass H in MW. s/MVA	
	Speed Damping D	
	Direct axis synchronous reactance Xd in p.u. (Unsaturated or saturated)	
	Quadrature axis synchronous reactance Xq in p.u. (Unsaturated or saturated)	
	Direct axis transient synchronous reactance Xd' in p.u. (Unsaturated or saturated)	
	Direct axis sub-transient synchronous reactance Xd'' in p.u. (Unsaturated or saturated) = Quadrature axis sub-transient synchronous reactance Xq'' in p.u. (Unsaturated or saturated)	
	Stator leakage reactance Xl	
	Saturation constant S (1.0) in p.u.	
	Saturation constant S (1.2) in p.u.	

While entering the values in above table, following relationship must be kept:

Xd>Xq>Xq'≥Xd'>Xq" ≥Xd''

Tdo'>Td'>Tdo''>Td''

Tqo''>Tq'>Tqo''>Tq''

3.3 Excitation system model:

If a generic model is used, the first step must be to identify what type of exciter is present in the excitation system. The IEEE Std 421.5 (IEEE Recommended Practice for Excitation System Models for Power System Stability Studies published on 26th Aug 2016) has published several generic models, which are classified into three groups:

- Type DC: for excitation systems with a DC exciter
- Type AC: for excitation systems with an AC exciter
- Type ST: for excitation systems with a static exciter

The following table shows the types of models separated into their respective groups.

DC exciter	AC exciter	Static excitation system
Type DC1A	Type AC1A	Type ST1A
Type DC2A	Type AC2A	Type ST2A
Type DC3A	Type AC4A	Type ST3A
Type DC4B	Type AC5A	Type ST4B
	Type AC6A	Type ST5B
	Type AC7B	Type ST6B
	Type AC8B	Type ST7B

Category	Parameter Description	Data
DC Exciter		
ESDC1 A OR ESDC2 A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	TB (s), lag time constant	
	TC (s), lead time constant	
	VRMAX (pu) regulator output maximum limit or Zero	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF1 (> 0) rate feedback time constant (sec)	
	Switch	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
DC Exciter		
ESDC3A	TR regulator input filter time constant (sec)	
	KV (pu) limit on fast raise/lower contact setting	
	VRMAX (pu) regulator output maximum limit or Zero	
	VRMIN (pu) regulator output minimum limit	
	TRH (> 0) Rheostat motor travel time (sec)	
	TE (> 0) exciter time-constant (sec)	
	KE (pu) exciter constant related to self-excited field	
	VEMIN (pu) exciter minimum limit	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
ESDC4B	TR regulator input filter time constant (sec)	
	KP (pu) (> 0) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	KD (pu) voltage regulator derivative gain	
	TD voltage regulator derivative channel time constant (sec)	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KA (> 0) (pu) voltage regulator gain	
	TA voltage regulator time constant (sec)	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	VEMIN (pu) minimum exciter voltage output	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
ESAC1A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
ESAC2A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KB, Second stage regulator gain	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VFEMAX, parameter of VEMAX, exciter field maximum output	
	KH, Exciter field current feedback gain	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
ESAC3A	TR regulator input filter time constant (sec)	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VEMIN (pu) minimum exciter voltage output	
	KR (>0), Constant associated with regulator and alternator field power supply	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KN, Exciter feedback gain	
	EFDN, A parameter defining for which value of UF the feedback gain shall change from KF to KN	
	KC, rectifier regulation factor (pu)	
	KD, exciter regulation factor (pu)	
	KE (pu) exciter constant related to self-excited field	
	VFEMAX, parameter of VEMAX, exciter field maximum output	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
ESAC4A	TR regulator input filter time constant (sec)	
	VIMAX, Maximum value of limitation of the integrator signal VI in p. u	
	VIMIN, Minimum value of limitation of the signal VI in p.u.	
	TB (s), lag time constant	
	TC (s), lead time constant	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC, rectifier regulation factor (pu)	

Category	Parameter Description	Data
AC Exciter		
ESAC5A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (> 0) rotating exciter time constant (sec)	
	KF (pu) rate feedback gain	
	TF1 (sec), Regulator stabilizing circuit time constant in seconds	
	TF2 (sec), Regulator stabilizing circuit time constant in seconds	
	TF3 (sec), Regulator stabilizing circuit time constant in seconds	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
AC6A	TR regulator input filter time constant (sec)	
	KA (> 0) (pu) voltage regulator gain	
	TA (s), voltage regulator time constant	
	TK (sec), Lead time constant	
	TB (s), lag time constant	
	TC (s), lead time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TE (> 0) rotating exciter time constant (sec)	
	VFELIM, Exciter field current limit reference	
	KH, Damping module gain	
	VHMAX, damping module limiter	
	TH (sec), damping module lag time constant	
	TJ (sec), damping module lead time constant	
	KC, rectifier regulation factor (pu)	
	KD, exciter regulation factor (pu)	
	KE (pu) exciter constant related to self-excited field	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
AC7B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	KDR (pu) regulator derivative gain	
	TDR (sec) regulator derivative block time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KPA (pu) voltage regulator proportional gain	
	KIA (pu) voltage regulator integral gain	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KP (pu)	
	KL (pu)	
	KF1 (pu)	
	KF2 (pu)	
	KF3 (pu)	
	TF3 (sec) time constant (> 0)	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	VFEMAX (pu) exciter field current limit (> 0)	
	VEMIN (pu)	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	

Category	Parameter Description	Data
AC Exciter		
AC8B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	KDR (pu) regulator derivative gain	
	TDR (sec) regulator derivative block time constant	
	VPIDMAX (pu) PID maximum limit	
	VPIDMIN (pu) PID minimum limit	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KD (pu) demagnetizing factor, function of AC exciter reactance	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	VFEMAX (pu) max exciter field current limit (> 0)	
	VEMIN (pu),	
	E1, exciter flux at knee of curve (pu)	
	SE(E1), saturation factor at knee of curve	
	E2, maximum exciter flux (pu)	
	SE(E2), saturation factor at maximum exciter flux (pu)	
Static Exciter		
ST1A	TR (sec) regulator input filter time constant	
	VIMAX, Controller Input Maximum	
	VIMIN, Controller Input Minimum	
	TC (s), Filter 1st Derivative Time Constant	
	TB (s), l Filter 1st Delay Time Constant	
	TC1 (s), Filter 2nd Derivative Time Constant	
	TB1 (s), Filter 2nd Delay Time Constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KLR, Current Input Factor	
	ILR, Current Input Reference	

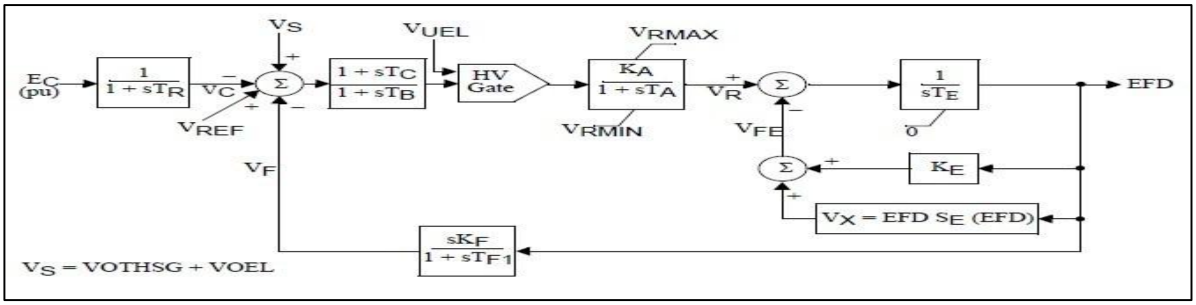
Category	Parameter Description	Data
Static Exciter		
ST2A	TR (sec) regulator input filter time constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KE (pu) exciter constant related to self-excited field	
	TE (pu) exciter time constant (>0)	
	KF (pu) rate feedback gain	
	TF (> 0) rate feedback time constant (sec)	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	EFDMAX	
ST3A	TR (sec) regulator input filter time constant	
	VIMAX, Maximum value of limitation of the signal VI in p.u.	
	VIMIN, Minimum value of limitation of the signal VI in p.u.	
	KM, Forward gain constant of the inner loop field regulator	
	TC (s), lag time constant	
	TB (s), lead time constant	
	KA (pu) voltage regulator proportional gain	
	TA (sec) voltage regulator time constant	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	KG, Feedback gain constant of the inner loop field regulator	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	VBMAX, Maximum value of limitation of the signal VB in p.u.	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	XL, Reactance associated with potential source	
	VGMAX, Maximum value of limitation of the signal VG in p. u	
	Θ_P (degrees)	
	TM (sec), Forward time constant of the inner loop field regulator	
	VMMAX, Maximum value of limitation of the signal VM in p. u	
	VMMIN, Minimum value of limitation of the signal VM in p.u.	

Category	Parameter Description	Data
Static Exciter		
ST4B	TR (sec) regulator input filter time constant	
	KPR (pu) regulator proportional gain	
	KIR (pu) regulator integral gain	
	VRMAX (pu) regulator output maximum limit	
	VRMIN (pu) regulator output minimum limit	
	TA (sec) voltage regulator time constant	
	KPM, Regulator gain	
	KIM, Regulator gain	
	VMMAX, Maximum value of limitation of the signal in p.u.	
	VMMIN, Minimum value of limitation of the signal in p.u.	
	KG	
	KP (pu) voltage regulator proportional gain	
	KI (pu) voltage regulator integral gain	
	VBMAX	
	KC (pu) rectifier loading factor proportional to commutating reactance	
	XL	
	Θ_P (degrees)	
ST5B	TR regulator input filter time constant (sec)	
	TC1 lead time constant of first lead-lag block (voltage regulator channel) (sec)	
	TB1 lag time constant of first lead-lag block (voltage regulator channel) (sec)	
	TC2 lead time constant of second lead-lag block (voltage regulator channel) (sec)	
	TB2 lag time constant of second lead-lag block (voltage regulator channel) (sec)	
	KR (>0) (pu) voltage regulator gain	
	VRMAX (pu) voltage regulator maximum limit	
	VRMIN (pu) voltage regulator minimum limit	
	T1 voltage regulator time constant (sec)	
	KC (pu)	
	TUC1 lead time constant of first lead-lag block (under-excitation channel) (sec)	
	TUB1 lag time constant of first lead-lag block (under-excitation channel) (sec)	
	TUC2 lead time constant of second lead-lag block (under-excitation channel) (sec)	
	TUB2 lag time constant of second lead-lag block (under-excitation channel) (sec)	
	TOC1 lead time constant of first lead-lag block (over-excitation channel) (sec)	
	TOB1 lag time constant of first lead-lag block (over-excitation channel) (sec)	
	TOC2 lead time constant of second lead-lag block (over-excitation channel) (sec)	
	TOB2 lag time constant of second lead-lag block (over-excitation channel) (sec)	

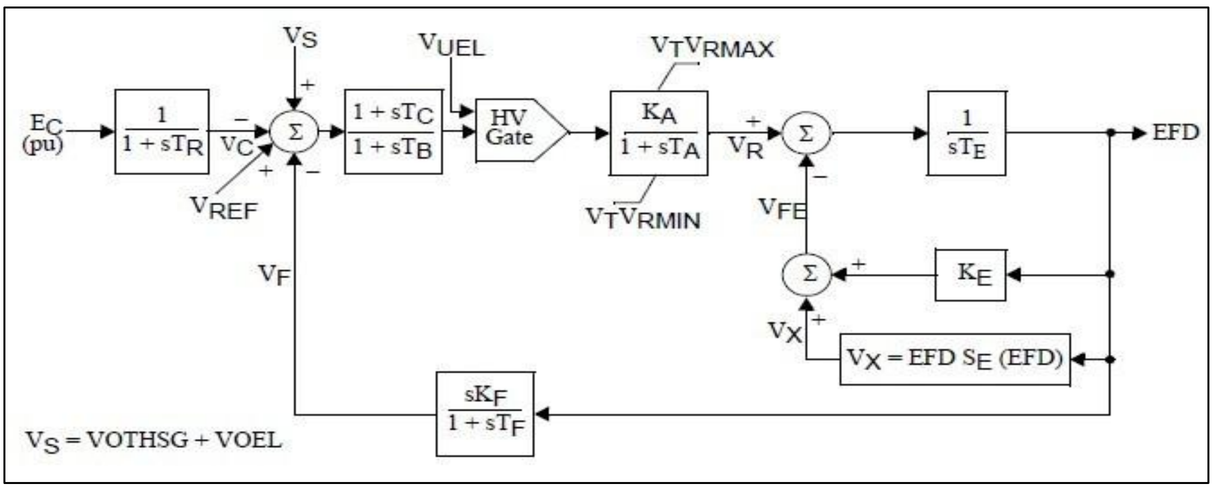
Category	Parameter Description	Data
Static Exciter		
ST6B	TR regulator input filter time constant (sec)	
	KPA (pu) (> 0) voltage regulator proportional gain	
	KIA (pu) voltage regulator integral gain	
	KDA (pu) voltage regulator derivative gain	
	TDA voltage regulator derivative channel time constant (sec)	
	VAMAX (pu) regulator output maximum limit	
	VAMIN (pu) regulator output minimum limit	
	KFF (pu) pre-control gain of the inner loop field regulator	
	KM (pu) forward gain of the inner loop field regulator	
	KCI (pu) exciter output current limit adjustment gain	
	KLR (pu) exciter output current limiter gain	
	ILR (pu) exciter current limit reference	
	VRMAX (pu) voltage regulator output maximum limit	
	VRMIN (pu) voltage regulator output minimum limit	
	KG (pu) feedback gain of the inner loop field voltage regulator	
	TG (> 0) feedback time constant of the inner loop field voltage regulator (sec)	
ST7B	TR regulator input filter time constant (sec)	
	TG lead time constant of voltage input (sec)	
	TF lag time constant of voltage input (sec)	
	Vmax (pu) voltage reference maximum limit	
	Vmin (pu) voltage reference minimum limit	
	KPA (pu) (>0) voltage regulator gain	
	VRMAX (pu) voltage regulator output maximum limit	
	VRMIN (pu) voltage regulator output minimum limit	
	KH (pu) feedback gain	
	KL (pu) feedback gain	
	TC lead time constant of voltage regulator (sec)	
	TB lag time constant of voltage regulator (sec)	
	KIA (pu) (>0) gain of the first order feedback block	
	TIA (>0) time constant of the first order feedback block (sec)	

(i) DC Exciters Generic model:

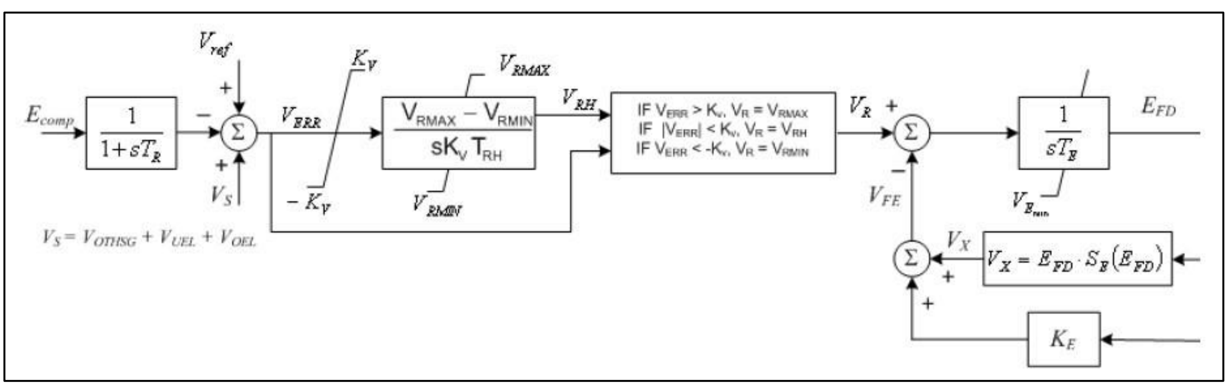
- **Type DC1A: 1992 IEEE type DC1A excitation system model**



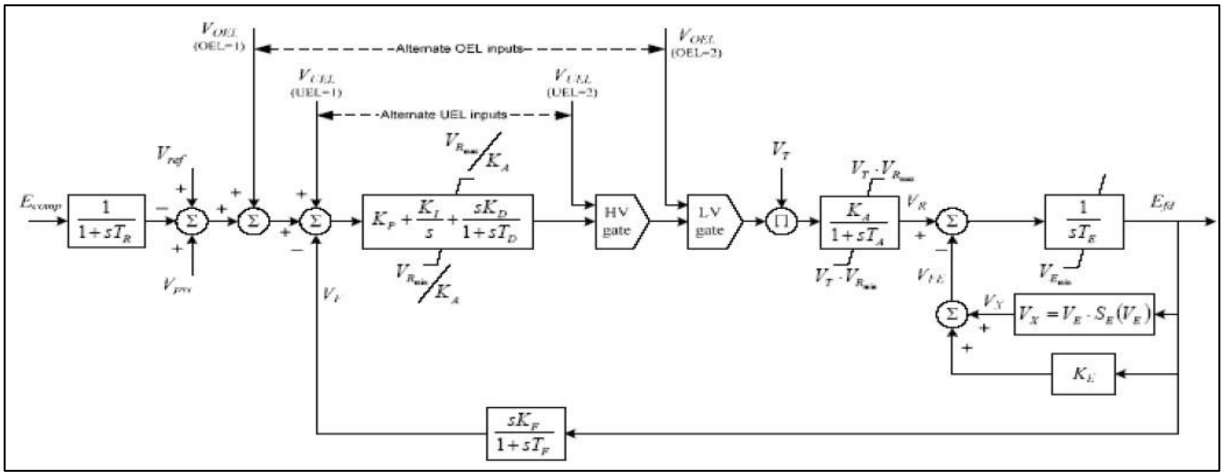
- **Type DC2A: 1992 IEEE type DC2A excitation system model**



- **Type DC3A: IEEE 421.5 2005 DC3A excitation system**

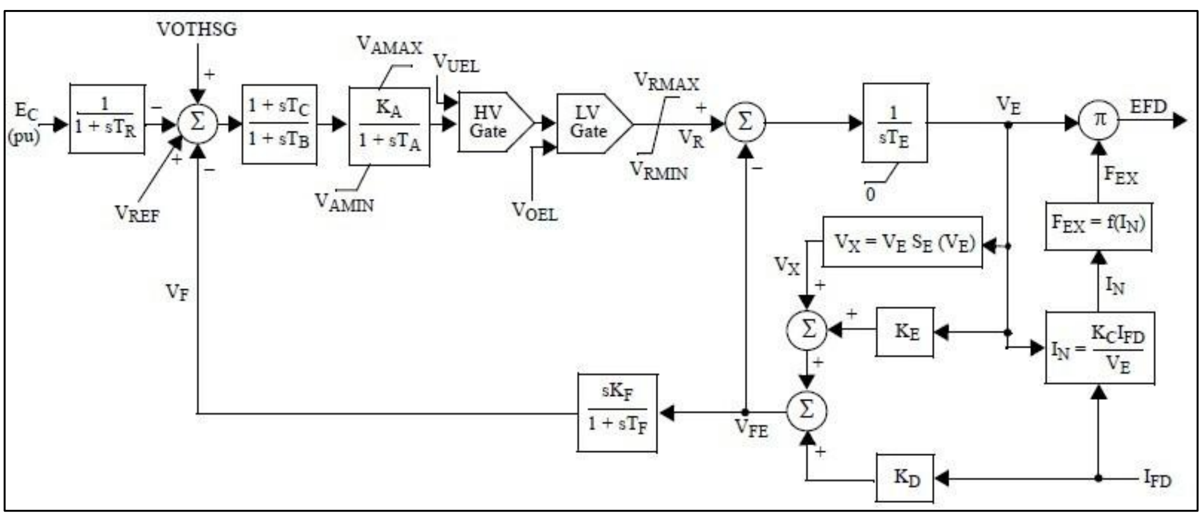


- **Type DC4B: IEEE 421.5 2005 DC4B excitation system**



(ii) AC Exciters Generic Models:

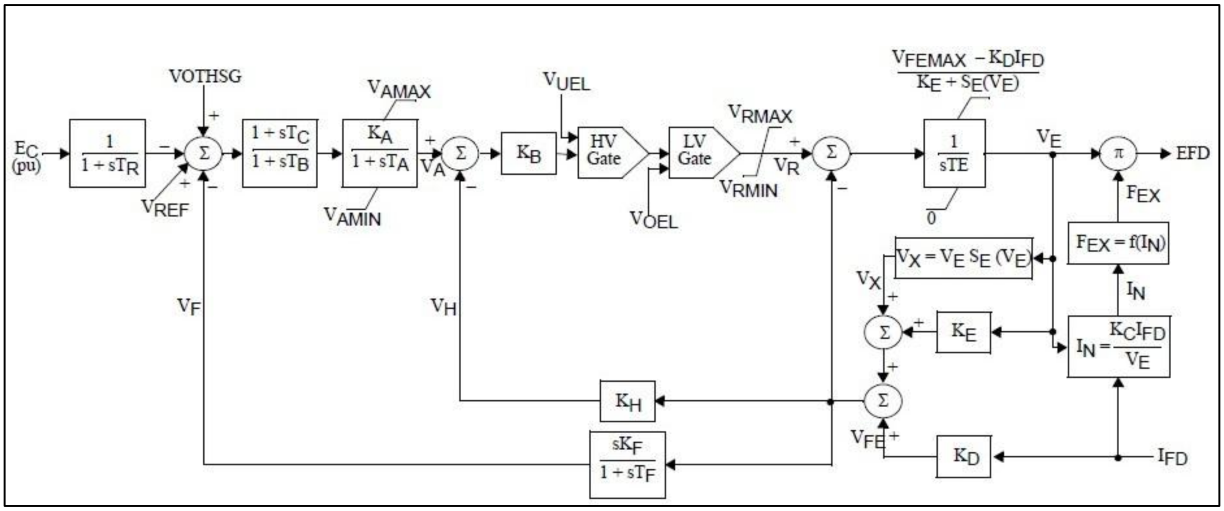
- **Type AC1A: 1992 IEEE type AC1A excitation system model**



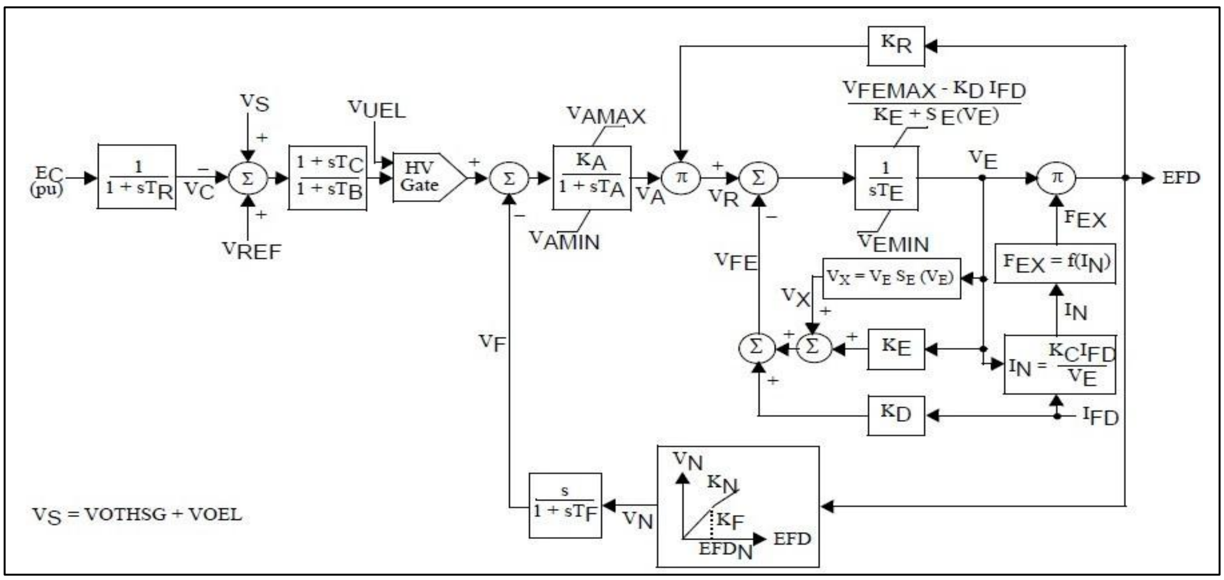
Input: I_N → Output: F_{EX}

If $I_N \le 0$	$F_{EX} = 1$
If $I_N \le 0.433$	$F_{EX} = 1 - 0.577\ I_N$
If $0.433 < I_N < 0.75$	$F_{EX} = \sqrt{0.75 - I_N^2}$
If $I_N \ge 0.75$	$F_{EX} = 1.732(1 - I_N)$
If $I_N > 1$	$F_{EX} = 0$

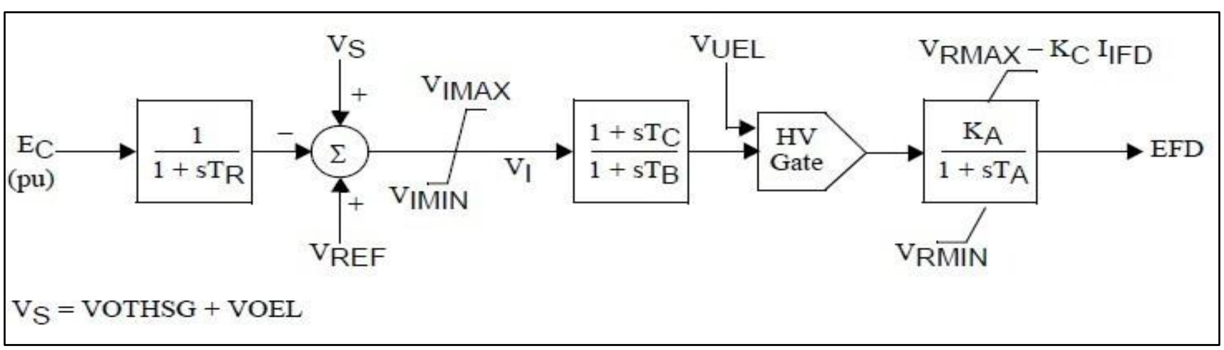
- **Type AC2A: 1992 IEEE type AC2A excitation system model**



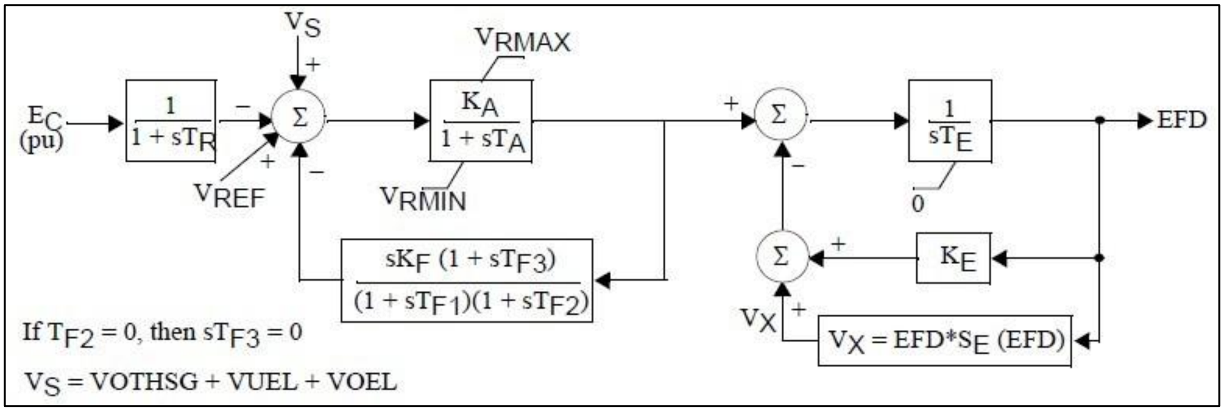
- **Type AC3A: 1992 IEEE type AC3A excitation system model**



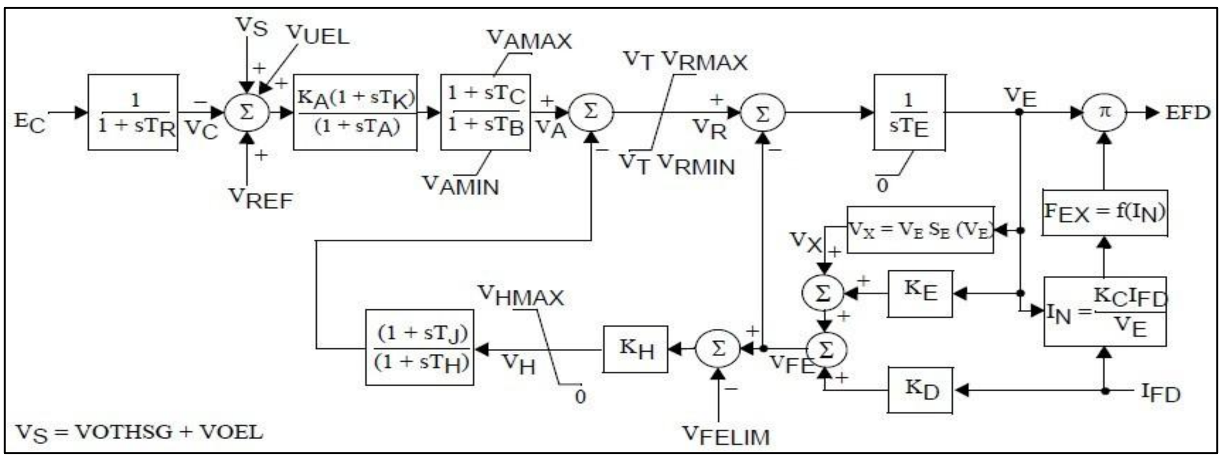
- **Type AC4A: 1992 IEEE type AC4A excitation system model**



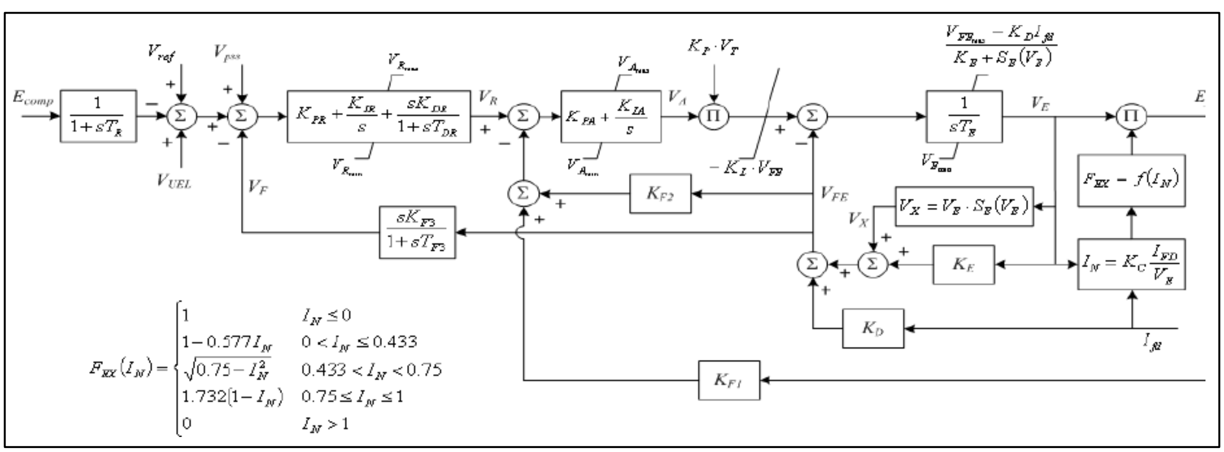
- **Type AC5A: 1992 IEEE type AC5A excitation system model**



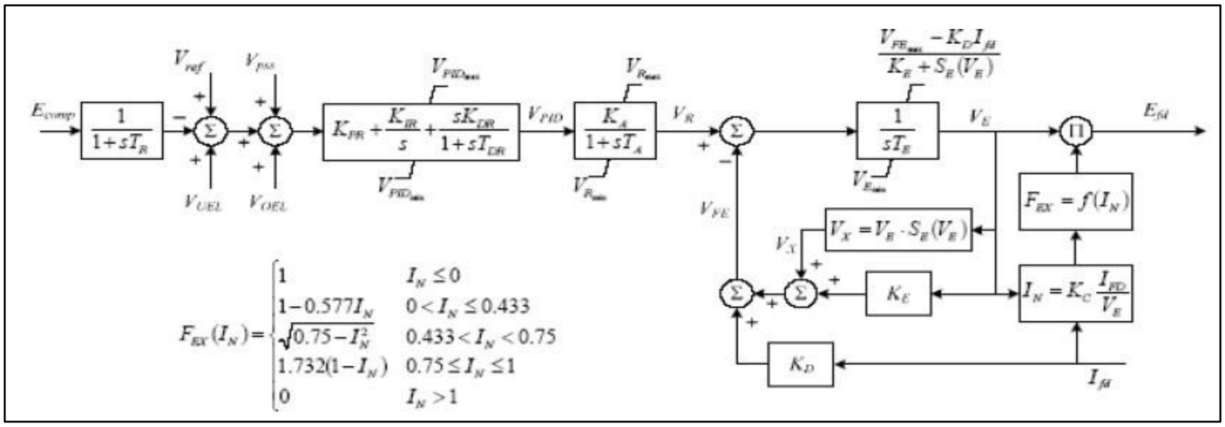
- **Type AC6A: IEEE 421.5 excitation system model**



- **Type AC7B: IEEE 421.5 2005 AC7B excitation system**

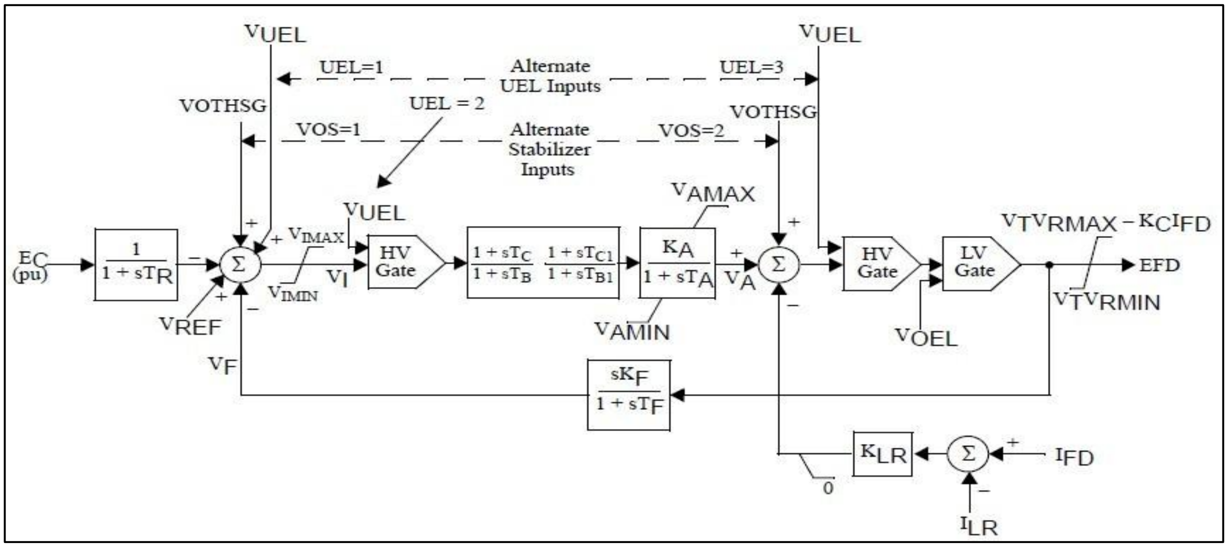


➢ **Type AC8B: IEEE 421.5 2005 AC8B excitation system**

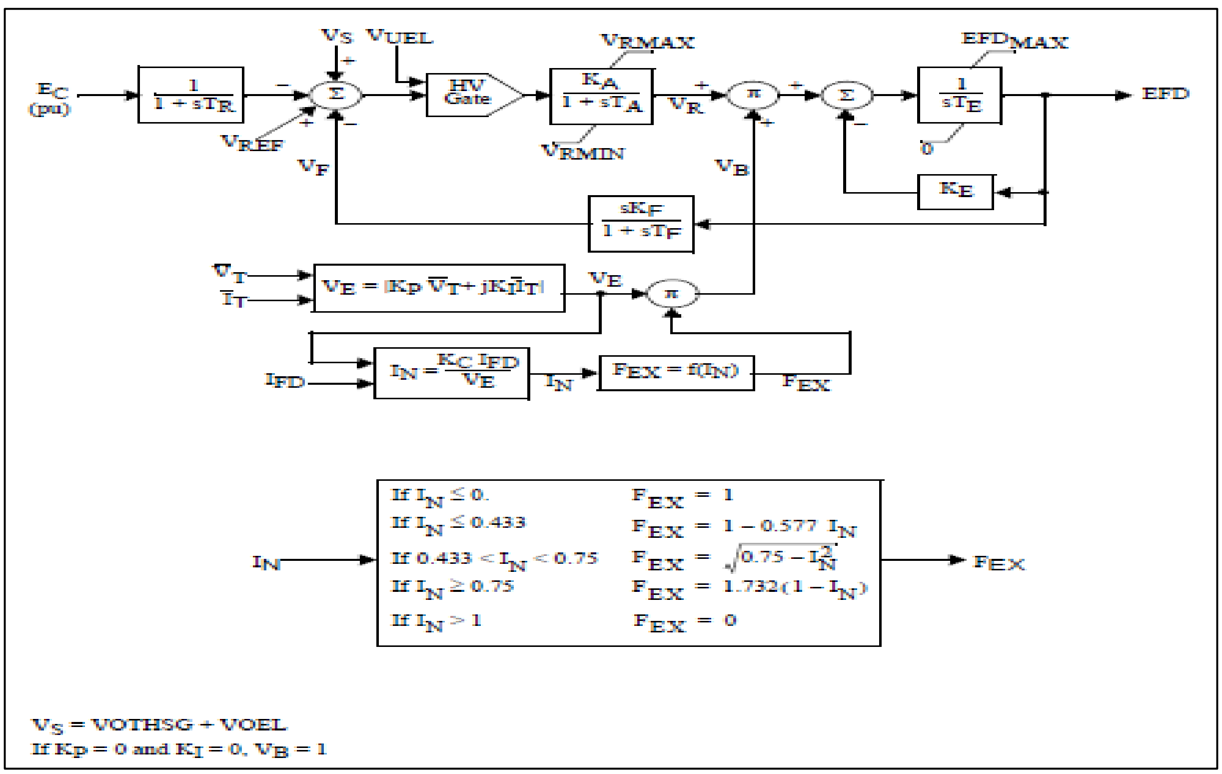


(iii) **Commonly Used Static Exciters Generic Models block diagrams:**

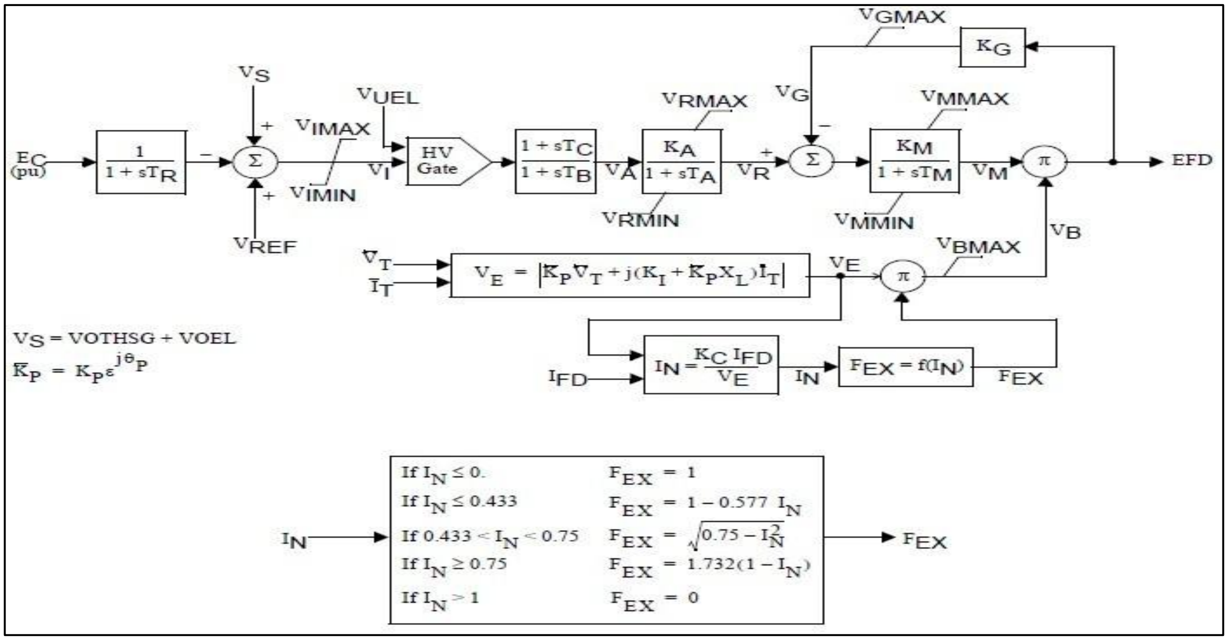
- **Type ST1A: 1992 IEEE type ST1A excitation system model**



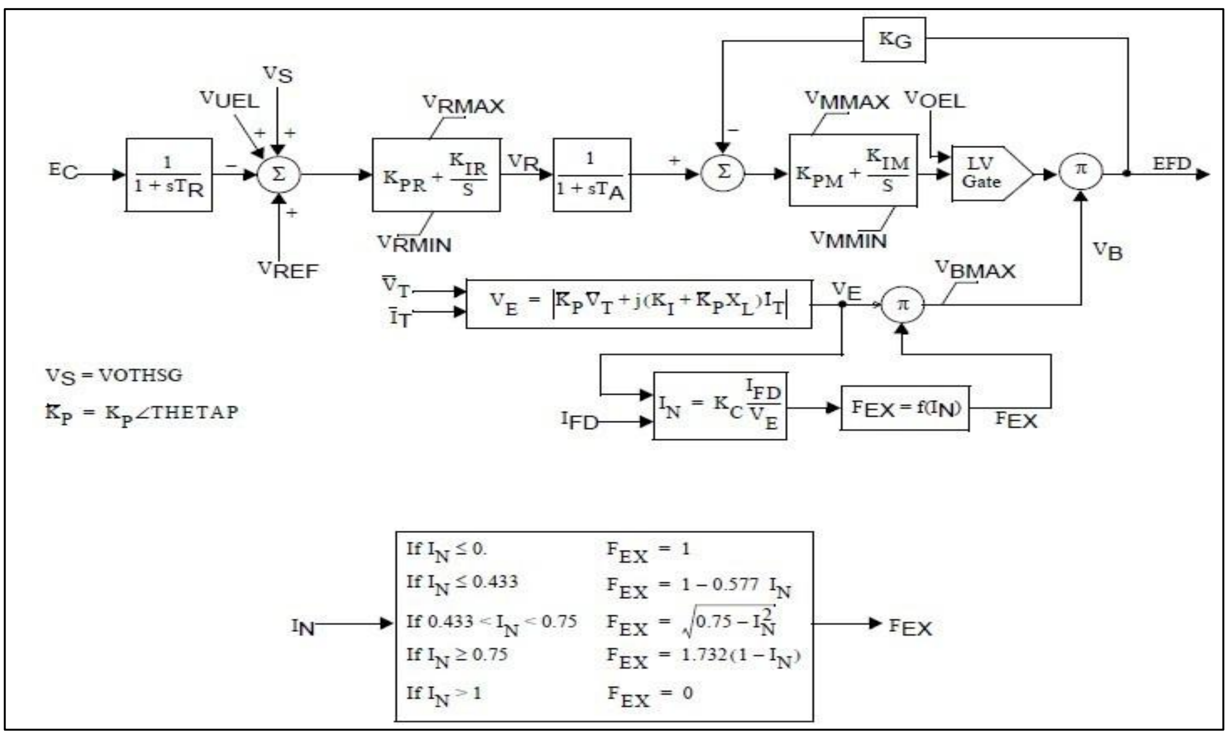
- **Type ST2A: 1992 IEEE type ST2A excitation system model**



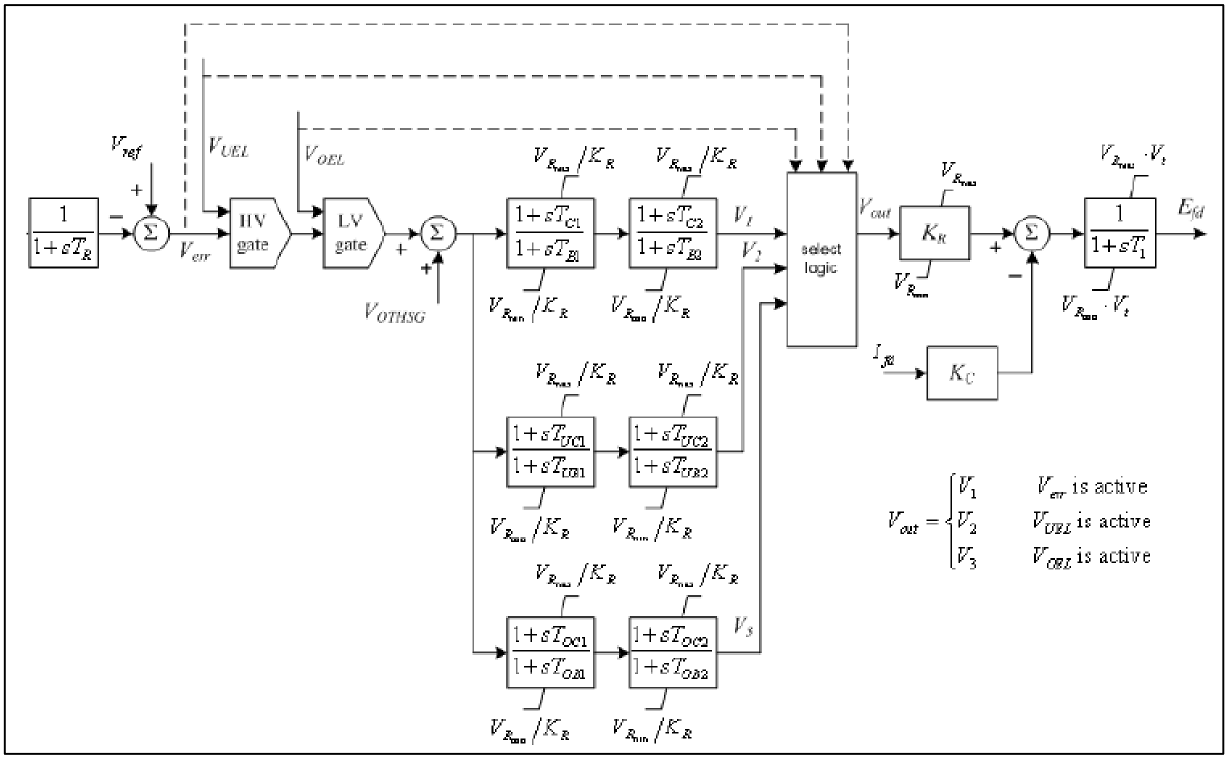
- **Type ST3A: 1992 IEEE type ST3A excitation system model**



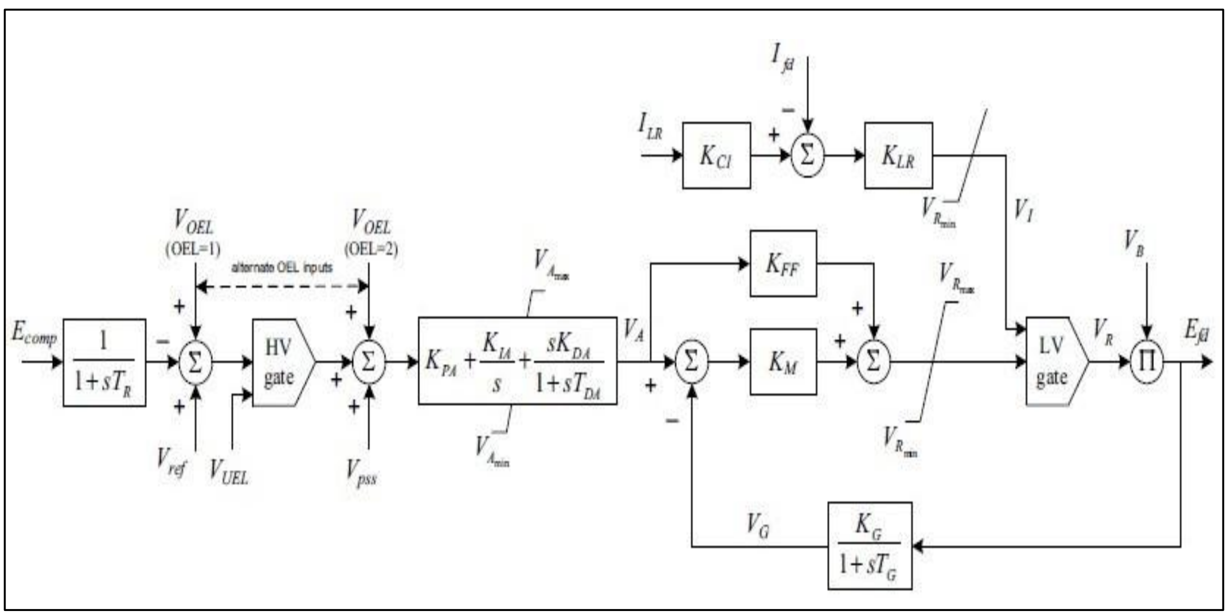
- **Type ST4B: IEEE type ST4B potential or compounded source-controlled rectifier exciter**



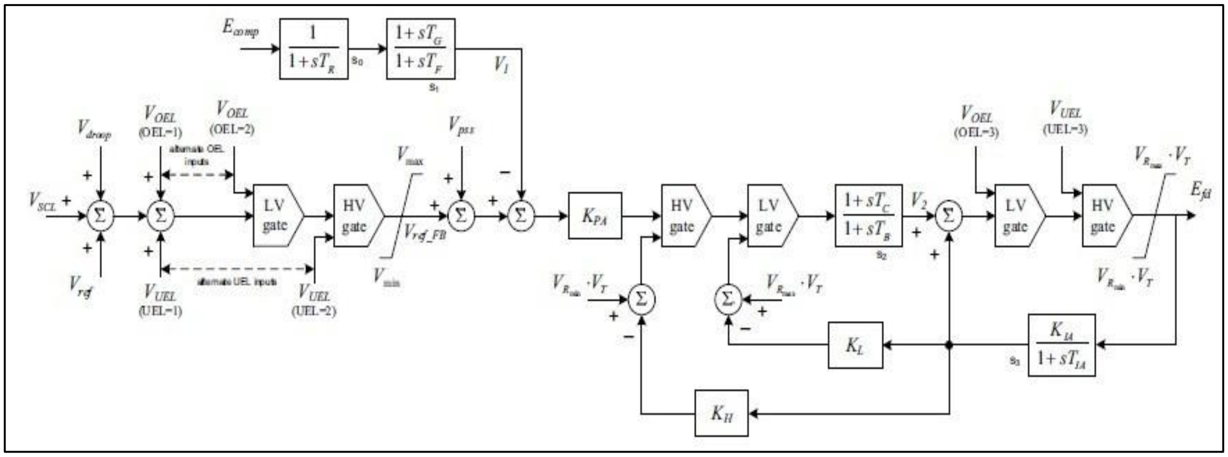
- **Type ST5B: IEEE 421.5 2005 ST5B excitation system**



- **Type ST6B: IEEE 421.5 2005 ST6B excitation system**



- **Type ST7B: IEEE 421.5 2005 ST7B excitation system**



Source-PSSE Model Library

3.4 Power system stabilizer:

The function of the PSS is to add to the unit's characteristic electromechanical oscillations. This is achieved by modulating excitation to develop a component in electrical torque in phase with rotor speed deviations.

The most important aspect when considering a PSS model is the number of inputs. The following table shows the type of models separated based on the inputs:

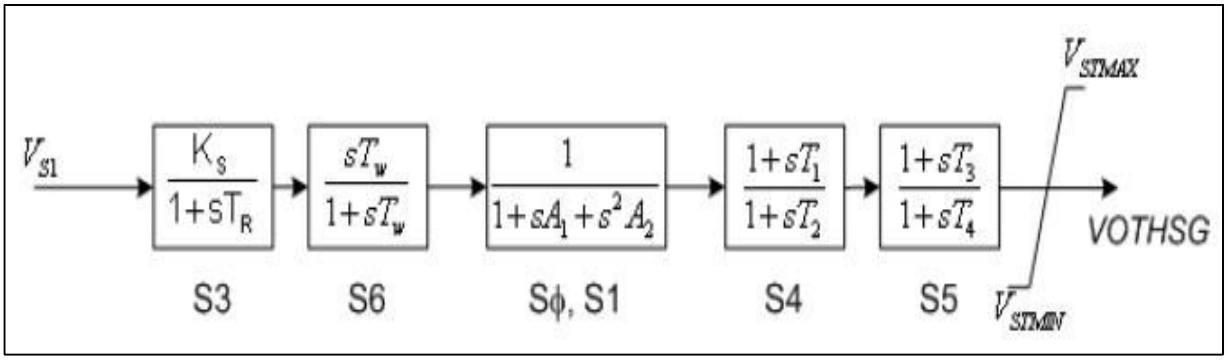
Type	Inputs	Remarks
PSS1A	Single input	Two lead-lags Input can either be speed, frequency or power
PSS2B	Dual input	Integral of accelerating power type stabiliser Speed and Power Most common type Supersedes PSS2A (three versus two lead lags)
PSS3B	Dual input	Power and rotor angular frequency deviation Stabilising signal is a vector sum of processed signals Not very common

Category	Parameter Description	Data
Stabilizer Models		
PSS1A	A1, Filter coefficient	
	A2, Filter coefficient	
	TR, transducer time constant	
	0	
	0	
	0	
	T1, 1st Lead-Lag Derivative Time Constant	
	T2, 1st Lead-Lag Delay Time Constant	
	T3, 2nd Lead-Lag Derivative Time Constant	
	T4, 2nd Lead-Lag Delay Time Constant	
	Tw, Washout Time Constant	
	Tw, Washout Time Constant	
	Ks, input channel gain	
	VSTMAX, Controller maximum output	
	VSTMAX, Controller minimum output	
	0	
	0	
PSS2B	TW1, 1st Washout 1th Time Constant	
	TW2, 1st Washout 2th Time Constant	
	T6, 1st Signal Transducer Time Constant	
	TW3, 2nd Washout 1th Time Constant	
	TW4, 2nd Washout 2th Time Constant	
	T7, 2nd Signal Transducer Time Constant	
	KS2, 2nd Signal Transducer Factor	
	KS3, Washouts Coupling Factor	
	T8, Ramp Tracking Filter Deriv. Time Constant	
	T9, Ramp Tracking Filter Delay Time Constant	
	KS1, PSS Gain	
	T1, 1st Lead-Lag Derivative Time Constant	
	T2, 1st Lead-Lag Delay Time Constant	
	T3, 2nd Lead-Lag Derivative Time Constant	
	T4, 2nd Lead-Lag Delay Time Constant	
	T10, 3rd Lead-Lag Derivative Time Constant	
	T11, 3rd Lead-Lag Delay Time Constant	
	VS1MAX, Input 1 Maximum limit	
	VS1MIN, Input 1 Minimum limit	
	VS2MAX, Input 2 Maximum limit	
	VS2MIN, Input 2 Minimum limit	
	VSTMAX, Controller Maximum Output	
	VSTMIN, Controller Minimum Output	

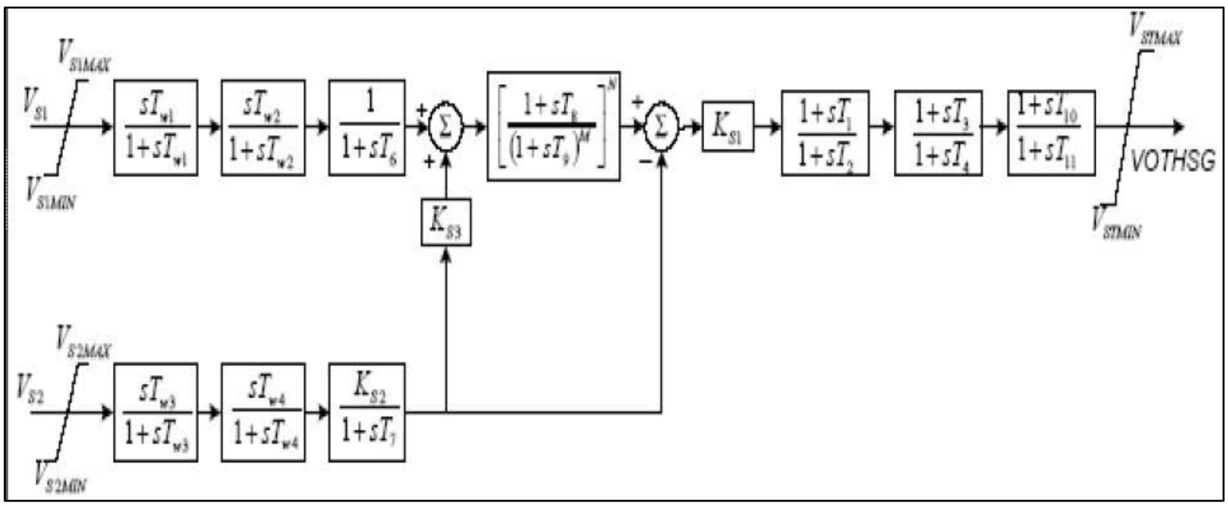
Category	Parameter Description	Data
	Stabilizer Models	
PSS3B	KS1 (pu) (≠0), input channel #1 gain	
	T1 input channel #1 transducer time constant (sec)	
	Tw1 input channel #1 washout time constant (sec)	
	KS2 (pu) (□0), input channel #2 gain	
	T2 input channel #2 transducer time constant (sec)	
	Tw2 input channel #2 washout time constant (sec)	
	Tw3 (0), main washout time constant (sec)	
	A1, Filter coefficient	
	A2, Filter coefficient	
	A3, Filter coefficient	
	A4, Filter coefficient	
	A5, Filter coefficient	
	A6, Filter coefficient	
	A7, Filter coefficient	
	A8, Filter coefficient	
	VSTMAX, Controller maximum output	
	VSTMAX, Controller minimum output	

Commonly Used Power System Stabilizer generic models block diagrams:

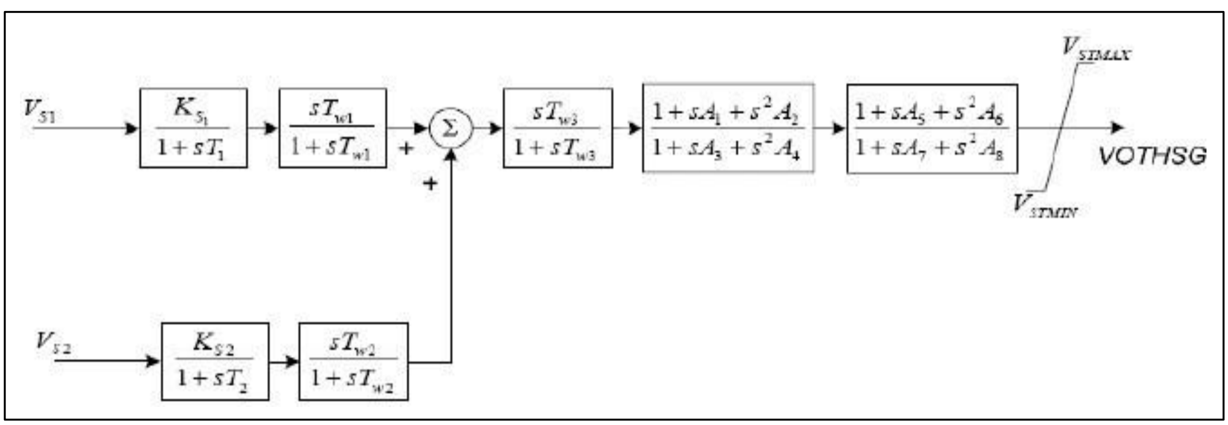
- **PSS1A: IEEE Std. 421.5-2005 PSS1A Single-Input Stabilizer model**



- **PSS2B: IEEE 421.5 2005 PSS2B IEEE dual-input stabilizer model**



- **PSS3B: IEEE Std. 421.5 2005 PSS3B IEEE dual-input stabilizer model**



Source-PSSE Model Library

3.5 Generic models for turbine-governor:

The following table is a list for common generic models of hydro turbines:

Type	Name	Remarks
HYGOV	Hydro-turbine Governor	Simple hydro model with unrestricted head race and tail race, no surge tank
HYGOVDU	Hydro turbine-governor model with speed dead band	Added asymmetrical deal band
HYGOVM	Hydro-Turbine Governor	Includes detailed representation of surge chamber
WEHGOV	Woodward Electric Hydro Governor Model	Woodward hydro governor with non-linear model for penstock dynamics
HYGOVT	Hydro Turbine-Governor traveling wave Model	Travelling-wave solution applied to penstock and Tunnel
PIDGOV	Hydro Turbine Governor	Straight forward penstock configuration with PID governor
HYGOVR1	Fourth order lead-lag hydro-turbine	for a unit with digital controls, allows a nonlinear relationship between the gate position and power
TURCZT	Czech hydro or steam turbine governor model	General-purpose hydro and thermal turbine-governor model. Penstock dynamic is not included in the model
TWDM1T	Tail water depression hydro governor model 1	same basic permanent and transient droop elements as the HYGOV model, but it adds a representation for a tail water depression protection system
TWDM2T	Tail water depression hydro governor model 2	Same as TWDM1T and uses a governor proportional-integral-derivative (PID) controller
WPIDHY	Woodward PID hydro governor model	includes governor controls representing a Woodward PID hydro governor. The model includes a nonlinear gate/power relationship and a linearized turbine/penstock model.
WSHYDD	WECC double derivative hydro governor model	Double-derivative hydro turbine-governor mode. Includes two dead band, also includes a nonlinear gate/power relationship and a linearized turbine/ penstock model
WSHYGP	WECC GP hydro governor plus turbine model	WECC GP hydro turbine-governor model with a PID controller, penstock dynamics are similar to those of the WECC WSHYDD

Source: PSSE Model Library, for models other than the above list refer to

https://w3.usa.siemens.com/smartgrid/us/en/transmission-grid/products/grid-analysis-tools/transmission-system- planning/transmission-system-planning-tab/pages/user-support.aspx

Category	Parameter Description	Data
TURBINE GOVERNOR model		
HYGOV	R, permanent droop	
	r, temporary droop	
	Tr (>0) governor time constant	
	Tf (>0) filter time constant	
	Tg (>0) servo time constant	
	+ VELM, gate velocity limit	
	GMAX, maximum gate limit	
	GMIN, minimum gate limit	
	TW (>0) water time constant	
	At, turbine gain	
	Dturb, turbine damping	
	qNL, no power flow	
HYGOVDU	R, permanent droop	
	r, temporary droop	
	Tr (>0) governor time constant	
	Tf (>0) filter time constant	
	Tg (>0) servo time constant	
	+ VELM, gate velocity limit	
	GMAX, maximum gate limit	
	GMIN, minimum gate limit	
	TW (>0) water time constant	
	At, turbine gain	
	Dturb, turbine damping	
	qNL, no power flow	
	DBH (pu), droop for over-speed, (> 0)	
	DBL (pu), droop for under-speed, (< 0)	
	TRate (MW), turbine rating, if zero, then MBASE used	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
	Prated, rated turbine power (MW	
	Qrated, rated turbine flow (cfs or cms)	
	Hrated, rated turbine head (ft or m)	
	Grated, gate position at rated conditions (pu)	
	QNL, no power flow (pu of Qrated)	
	R, permanent droop (pu)	
	r, temporary droop (pu)	
	Tr, governor time constant (> 0) (sec)	
	Tf, filter time constant (> 0) (sec)	
	Tg, servo time constant (> 0) (sec)	
	MXGTOR, maximum gate opening rate (pu/sec)	
	MXGTCR, maximum gate closing rate (< 0) (pu/sec)	
	MXBGOR, maximum buffered gate opening rate (pu/sec)	
	MXBGCR, maximum buffered gate closing rate (< 0) (pu/sec)	
	BUFLIM, buffer upper limit (pu)	
	GMAX, maximum gate limit (pu)	
	GMIN, minimum gate limit (pu)	
HYGOVM	RVLVCR, relief valve closing rate (< 0) (pu/sec) or MXJDOR, maximum jet deflector opening rate (pu/sec)	
	RVLMAX, maximum relief valve limit (pu) or MXJDCR, maximum jet deflector closing rate (< 0) (pu/sec)	
	HLAKE, lake head (ft or m)	
	HTAIL, tail head (ft or m)	
	PENL/A, summation of penstock, scroll case and draft tube lengths/ cross sections (> 0) (1/ft or 1/m)	
	PENLOS, penstock head loss coefficient (ft/cfs2 or m/cms2)	
	TUNL/A, summation of tunnel lengths/cross sections (>0) (1/ft or 1/m)	
	TUNLOS, tunnel head loss coefficient (ft/cfs^2 or m/cms^2)	
	SCHARE, surge chamber effective cross section (>0) (ft^2 or m^2)	
	SCHMAX, maximum water level in surge chamber (ft or m)	
	SCHMIN, minimum water level in surge chamber (ft or m)	
	SCHLOS, surge chamber orifice head loss coefficient (ft/cfs^2 or m/cms^2)	
	DAMP1, turbine damping under RPM1	
	RPM1, over speed (pu)	
	DAMP2, turbine damping above RPM2	
	RPM2, over speed (pu)	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
WEHGOV	R-PERM-GATE (Feedback settings)	
	R-PERM-PE (Feedback settings)	
	TPE (sec), Power time constant	
	Kp, Proportional gain	
	KI, Integral gain	
	KD, Derivative gain	
	TD (sec), Derivative time constant	
	TP (sec), Gate servo time constant	
	TDV (sec), Time constant	
	Tg (sec), Gate servo time constant	
	GTMXOP (>0), Max gate opening velocity	
	GTMXCL (<0), Max gate closing velocity	
	GMAX, Maximum governor output	
	GMIN, Minimum governor output	
	DTURB, Turbine damping factor	
	TW (sec), Water inertia time constant	
	Speed Dead Band (DBAND)	
	DPV, Governor limit factor	
	DICN, Gate limiter modifier	
	GATE 1	
	GATE 2	
	GATE 3	
	GATE 4	
	GATE 5	
	FLOW G1	
	FLOW G2	
	FLOW G3	
	FLOW G4	
	FLOW G5	
	FLOW P1	
	FLOW P2	
	FLOW P3	
	FLOW P4	
	FLOW P5	
	FLOW P6	
	FLOW P7	
	FLOW P8	
	FLOW P9	
	FLOW P10	
	PMECH1	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
WEHGOV	PMECH2	
	PMECH3	
	PMECH4	
	PMECH5	
	PMECH6	
	PMECH7	
	PMECH8	
	PMECH9	
	PMECH10	
HYGOVT	Prated, rated turbine power (MW)	
	Qrated, rated turbine flow (cfs or cms)	
	Hrated, rated turbine head (ft or m)	
	Grated, gate position at rated conditions (pu)	
	QNL, no power flow (pu of Qrated)	
	R, permanent droop	
	r, temporary droop (pu)	
	Tr, governor time constant (> 0) (sec)	
	Tf, filter time constant (> 0) (sec)	
	Tg, servo time constant (> 0) (sec)	
	MXGTOR, maximum gate opening rate (pu/sec)	
	MXGTCR, maximum gate closing rate (< 0) (pu/sec)	
	MXBGOR, maximum buffered gate opening rate (pu/sec)	
	MXBGCR, maximum buffered gate closing rate (< 0) (pu/sec)	
	BUFLIM, buffer upper limit (pu)	
	GMAX, maximum gate limit (pu)	
	GMIN, minimum gate limit (pu)	
	RVLVCR, relief valve closing rate (< 0) (pu/sec) or MXJDOR, maximum jet deflector opening rate (pu/sec)	
	RVLMAX, maximum relief valve limit (pu) or MXJDCR, maximum jet deflector closing rate (< 0) (pu/sec)	
	HLAKE, lake head (ft or m)	
	HTAIL, tail head (ft or m)	
	PENLGTH, penstock length (ft or m)	
	PENLOS, penstock head loss coefficient (ft/cfs2 or m/cms2)	
	TUNLGTH, tunnel length (ft or m)	
	TUNLOS, tunnel head loss coefficient (ft/cfs2 or m/cms2)	
	SCHARE, surge chamber effective cross section (>0) (ft2 or m2)	
	SCHMAX, maximum water level in surge chamber (ft or m)	
	SCHMIN, minimum water level in surge chamber (ft or m)	
	SCHLOS, surge chamber orifice head loss coefficient (ft/cfs2 or m/cms2)	
	DAMP1, turbine damping under RPM1	
	RPM1, overspeed (pu)	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
HYGOVT	DAMP2, turbine damping above RPM2	
	RPM2, overspeed (pu)	
	PENSPD, penstock wave velocity (>0) (ft/sec or m/sec)	
	PENARE, penstock cross section (>0) (ft2 or m2)	
	TUNSPD, tunnel wave velocity (>0) (ft/sec or m/sec)	
	TUNARE, tunnel cross section (>0) (ft2 or m2)	
PIDGOV	Rperm, permanent drop, pu	
	Treg (sec), speed detector time constant	
	Kp, proportional gain, pu/sec	
	Ki, reset gain, pu/sec	
	Kd, derivative gain, pu	
	Ta (sec) > 0, controller time constant	
	Tb (sec) > 0, gate servo time constant	
	Dturb, turbine damping factor, pu	
	G0, gate opening at speed no load, pu	
	G1, intermediate gate opening, pu	
	P1, power at gate opening G1, pu	
	G2, intermediate gate opening, pu	
	P2, power at gate opening G2, pu	
	P3, power at full opened gate, pu	
	Gmax, maximum gate opening, pu	
	Gmin, minimum gate opening, pu	
	Atw > 0, factor multiplying Tw, pu	
	Tw (sec) > 0, water inertia time constant	
	Velmax, minimum gate opening velocity, pu/sec	
	Velmin < 0, minimum gate closing velocity, pu/sec	
HYGOVR1	db1, Intentional dead band width, Hz	
	Err, deadband hysteresis (p.u.)	
	Td (sec), Input filter time constant, s	
	T1 (sec), Lead time constant 1, s	
	T2 (sec) q, Lag time constant 1, s	
	T3 (sec), Lead time constant 2, s	
	T4 (sec), Lag time constant 2, s	
	T5 (sec), Lead time constant 3, s	
	T6 (sec), Lag time constant 3, s	
	T7 (sec), Lead time constant 4, s	
	T8 (sec), Lag time constant 4, s	
	KP, proportional gain	
	R, Steady-state droop, p.u.	
	Tt, Power feedback time constant, s	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
HYGOVR1	KG, Gate servo gain, p.u.	
	TP (sec), Gate servo time constant, s	
	VELOPEN, Maximum gate opening velocity, p.u./s	
	VELCLOSE, Maximum gate closing velocity, p.u./s (<0)	
	PMAX, Maximum gate opening, p.u. of mwcap	
	PMIN, Minimum gate opening, p.u. of mwcap	
	db2, Unintentional deadband, MW	
	TW (>0) water time constant	
	At, turbine gain	
	Dturb, turbine damping	
	qNL, no power flow	
	Trate (Turbine MW rating)	
TURCZT	fDEAD (pu), Frequency Dead Band	
	fMIN (pu), Frequency Minimum Deviation	
	fMAX (pu), Frequency Maximum Deviation	
	KKOR (pu), Frequency Gain	
	KM > 0 (pu), Power Measurement Gain	
	KP (pu), Regulator Proportional Gain	
	SDEAD (pu), Speed Dead Band	
	KSTAT (pu), Speed Gain	
	KHP (pu), High Pressure Constant	
	TC (sec), Measuring transducer time constant	
	T 1 (sec), Regulator Integrator Time Constant	
	TEHP (sec), Hydro Converter Time Constant	
	TV > 0 (sec), Regulation Valve Time Constant	
	THP (sec), High Pressure Time Constant	
	TR (sec), Reheater time constant	
	TW (sec), Water Time Constant	
	NTMAX (pu), Power Regulator-Integrator Maximum Limiter	
	NTMIN (pu), Power Regulator-Integrator Minimum Limiter	
	GMAX (pu), Valve Maximum Open	
	GMIN (pu), Valve Minimum Open	
	VMIN (pu/sec), Valve Maximum Speed Close	
	VMAX (pu/sec), Valve Maximum Speed Open	
TWDM1T	R, permanent droop	
	r, temporary droop	
	Tr, governor time constant (>0)	
	Tf, filter time constant (>0)	
	Tg, servo time constant (>0)	
	VELMX, open gate velocity limit (pu/sec)	

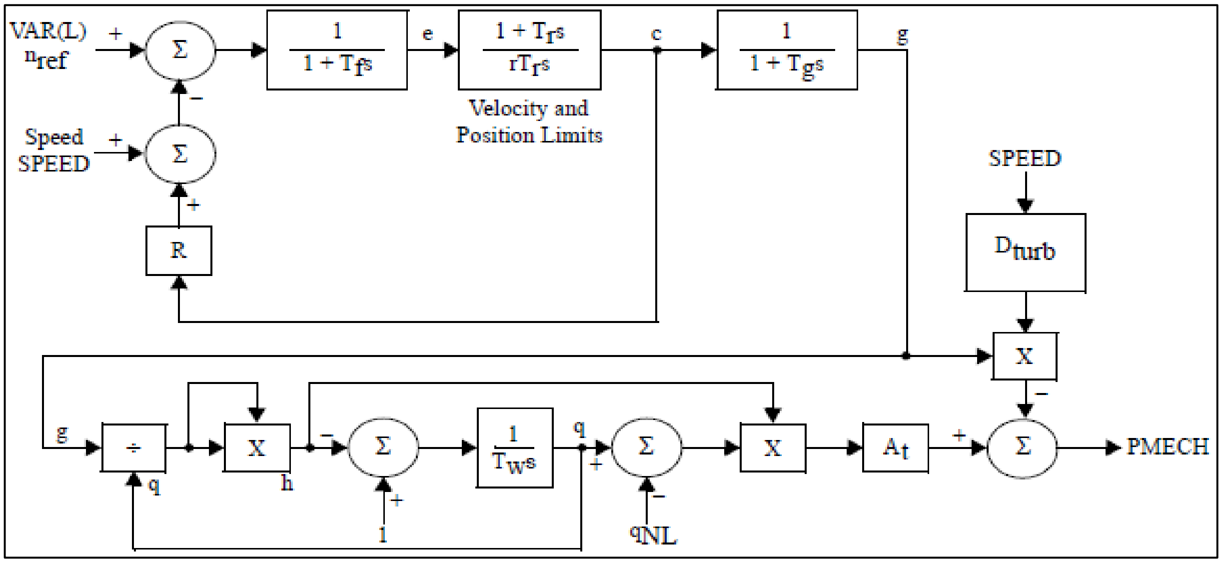
Category	Parameter Description	Data
TURBINE GOVERNOR model		
TWDM1	VELMN, close gate velocity limit (pu/sec) (<0)	
	GMAX, maximum gate limit	
	GMIN, minimum gate limit	
	TW, water time constant (sec) (>0)	
	At, turbine gain	
	Dturb, turbine damping	
	qNL, no power flow	
	F1, frequency deviation (pu)	
	TF1, time delay (sec)	
	F2, frequency deviation (pu)	
	sF2, frequency (pu/sec)	
	TF2, time delay (sec)	
	GMXRT, rate with which GMAX changes when TWD is tripped (pu/sec)	
	NREF, setpoint frequency deviation (pu)	
	Tft, frequency filter time constant (>0	
TWDM2	TREG (sec), governor time constant (s)	
	Reg, permanent droop (p.u. on generator MVA rating)	
	KP, controller proportional gain (p.u.)	
	KI, controller integral gain (p.u./s)	
	KD, controller derivative gain (p.u.-s)	
	TA (sec) (> 0), controller time constant (s)	
	TB (sec) (> 0), controller time constant (s)	
	VELMX (pu/sec), open gate velocity limit (p.u./s)	
	VELMN (pu/sec) (> 0), close gate velocity limit (p.u./s)	
	GATMX (pu), maximum gate limit (p.u.)	
	GATMN (pu), minimum gate limit (p.u.)	
	TW (sec) (> 0), water time constant (s)	
	At, turbine gain	
	qNL, flow rate at no load (p.u.)	
	Dturb, turbine damping factor	
	F1, frequency deviation (pu)	
	TF1, time delay (sec)	
	F2, frequency deviation (pu)	
	sF2, frequency (pu/sec)	
	TF2, time delay (sec)	
	PREF, power reference (pu)	
	Tft, frequency filter time constant (sec) (>0)	

Category	Parameter Description	Data
TURBINE GOVERNOR model		
WPIDHY	TREG (sec), governor time constant (s)	
	REG1, permanent droop (p.u. on generator MVA base)	
	KP, controller proportional gain (p.u.)	
	KI, controller integral gain (p.u./s)	
	KD, controller derivative gain (p.u./s)	
	TA (>0) (sec), controller time constant (s)	
	TB (>0) (sec), controller time constant (s)	
	VELMX (>0), open gate velocity limit (p.u./s)	
	VELMN (<0), close gate velocity limit (p.u./s)	
	GATMX, maximum gate limit (p.u.)	
	GATMN, minimum gate limit (p.u.)	
	TW (>0) (sec), water time constant (s)	
	PMAX, maximum gate position (p.u.)	
	PMIN, minimum gate position (p.u.)	
	D	
	G0, gate position at no load (p.u.)	
	G1, first gate intermediate position (p.u.)	
	P1, power at gate position G1 (p.u. on generator MVA rating)	
	G2, second gate intermediate position (p.u.)	
	P2, power at gate position G2 (p.u. on generator MVA rating)	
	P3, power at fully open gate (p.u. on generator MVA rating)	
WSHYDD	db1, deadband width (p.u.)	
	Err, deadband hysteresis (p.u.)	
	Td (sec), input filter time constant (s)	
	K1, derivative gain (p.u.)	
	Tf (sec), derivative time constant (s)	
	KD, double derivative gain (p.u.)	
	KP, integral gain (p.u.)	
	R, droop (p.u. on Trate)	
	Tt, power feedback time constant (s)	
	KG, gate servo gain (p.u.)	
	TP (sec), gate servo time constant (s)	
	VELOPEN (>0), maximum gate opening rate (p.u./s)	
	VELCLOSE (>0), maximum gate closing rate (p.u./s)	
	PMAX, maximum gate opening (p.u.)	
	PMIN, minimum gate opening (p.u.)	
	db2, deadband (p.u.)	
	GV1, coordinate of power-gate look-up table (p.u. gate)	
	PGV1, coordinate of power-gate look-up table (p.u. power)	
	GV2, coordinate of power-gate look-up table (p.u. gate)	

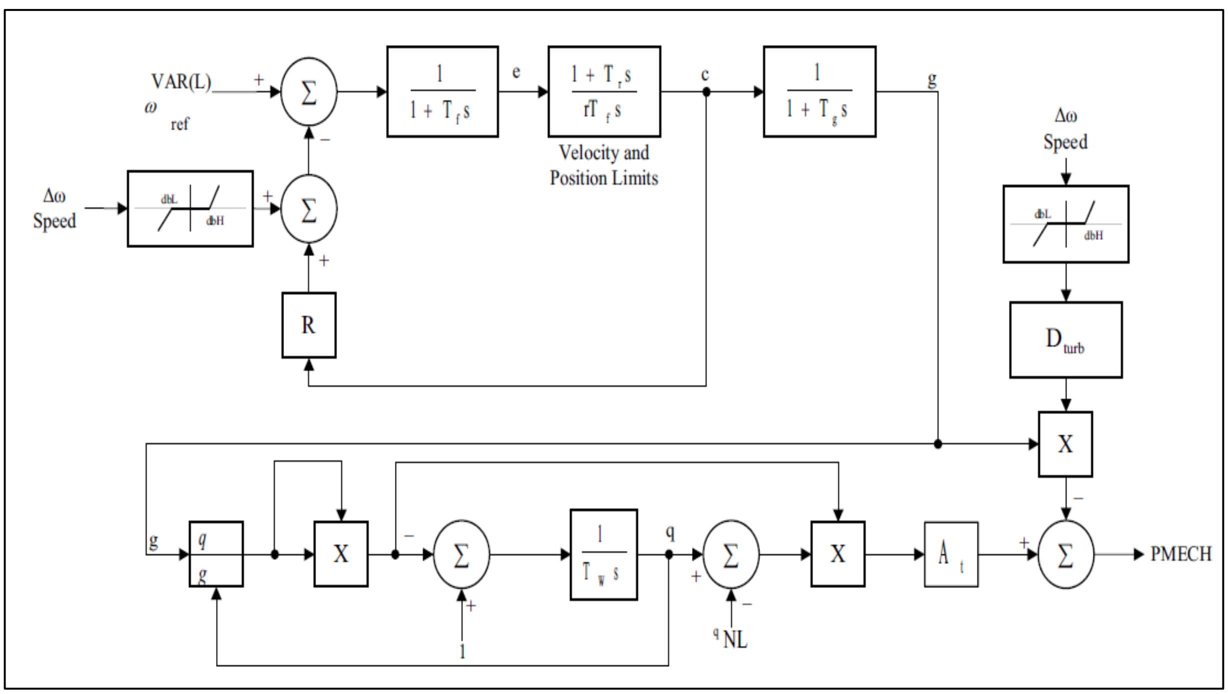
Category	Parameter Description	Data
TURBINE GOVERNOR model		
WSHYDD	PGV2, coordinate of power-gate look-up table (p.u. power)	
	GV3, coordinate of power-gate look-up table (p.u. gate)	
	PGV3, coordinate of power-gate look-up table (p.u. power)	
	GV4, coordinate of power-gate look-up table (p.u. gate)	
	PGV4, coordinate of power-gate look-up table (p.u. power)	
	GV5, coordinate of power-gate look-up table (p.u. gate)	
	PGV5, coordinate of power-gate look-up table (p.u. power)	
	Aturb, turbine lead time constant multiplier	
	Bturb (> 0), turbine lag time constant multiplier	
	Tturb (> 0) (sec), turbine time constant (s)	
	Trate, turbine rating (MW)	
WSHYGP	db1, deadband width (p.u.)	
	Err, deadband hysteresis (p.u.)	
	Td (sec), input filter time constant (s)	
	K1, derivative gain (p.u.)	
	Tf (sec), derivative time constant (s)	
	KD, double derivative gain (p.u.)	
	KP, integral gain (p.u.)	
	R, droop (p.u. on Trate)	
	Tt, power feedback time constant (s)	
	KG, gate servo gain (p.u.)	
	TP (sec), gate servo time constant (s)	
	VELOPEN (>0), maximum gate opening rate (p.u./s)	
	VELCLOSE (>0), maximum gate closing rate (p.u./s)	
	PMAX, maximum gate opening (p.u.)	
	PMIN, minimum gate opening (p.u.)	
	db2, deadband (p.u.)	
	GV1, coordinate of power-gate look-up table (p.u. gate)	
	PGV1, coordinate of power-gate look-up table (p.u. power)	
	GV2, coordinate of power-gate look-up table (p.u. gate)	
	PGV2, coordinate of power-gate look-up table (p.u. power)	
	GV3, coordinate of power-gate look-up table (p.u. gate)	
	PGV3, coordinate of power-gate look-up table (p.u. power)	
	GV4, coordinate of power-gate look-up table (p.u. gate)	
	PGV4, coordinate of power-gate look-up table (p.u. power)	
	GV5, coordinate of power-gate look-up table (p.u. gate)	
	PGV5, coordinate of power-gate look-up table (p.u. power)	
	Aturb, turbine lead time constant multiplier	
	Bturb (> 0), turbine lag time constant multiplier	
	Tturb (> 0) (sec), turbine time constant (s)	
	Trate, turbine rating (MW)	

Commonly Used Hydro Turbine Generic Models Block Diagrams:

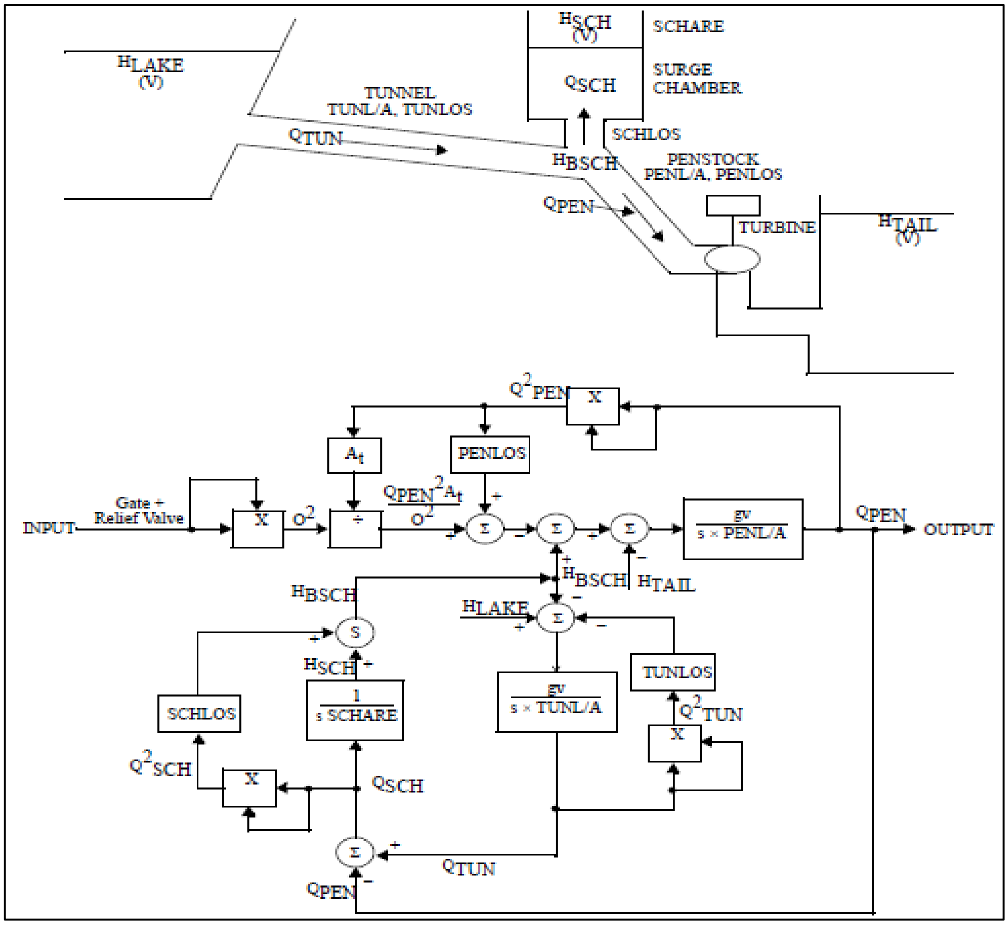
- **HYGOV: Hydro Turbine-Governor**



- **HYGOVDU: Hydro Turbine-Governor**

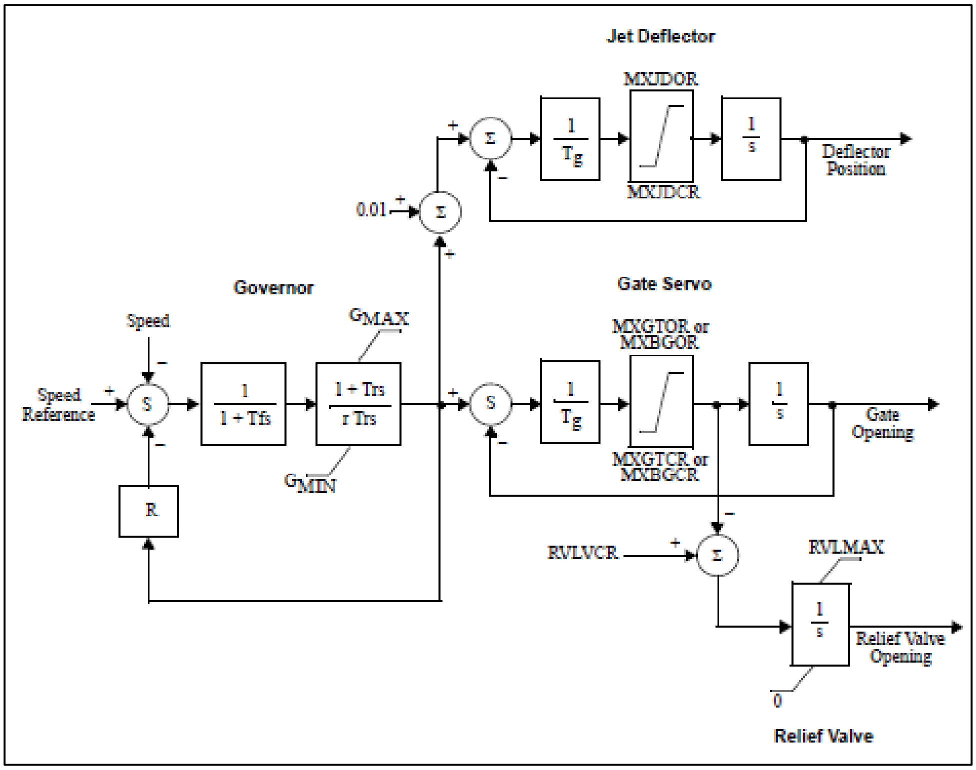


- **HYGOVM: Hydro Turbine-Governor Lumped Parameter Model**

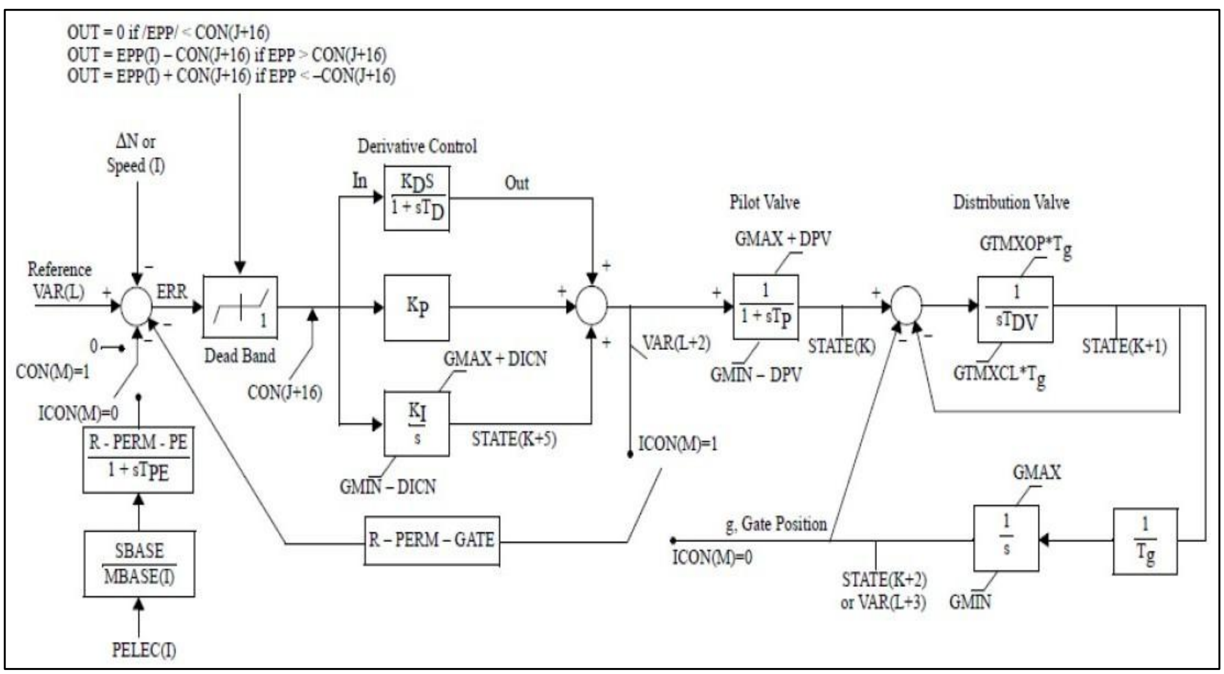


gv	Gravitational acceleration	A_t	Turbine flow gain
TUNL/A	Summation of length/cross section of tunnel	O	Gate + relief valve opening
SCHARE	Surge chamber cross section	HSCH	Water level in surge chamber
PENLOS	Penstock head loss coefficient	QPEN	Penstock flow
TUNLOS	Tunnel head loss coefficient	QTUN	Tunnel flow
FSCH	Surge chamber orifice head loss coefficient	QSCH	Surge chamber flow
PENL/A	Summation of length/cross section of penstock, scroll case and draft tube		

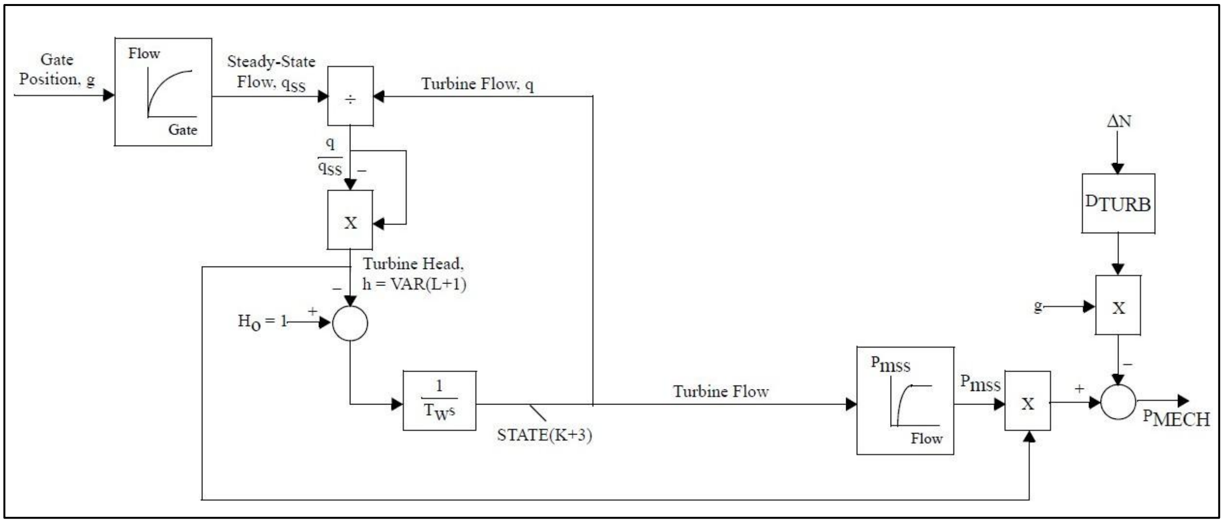
➢ WEHGOV: Woodward Electric Hydro Governor Model



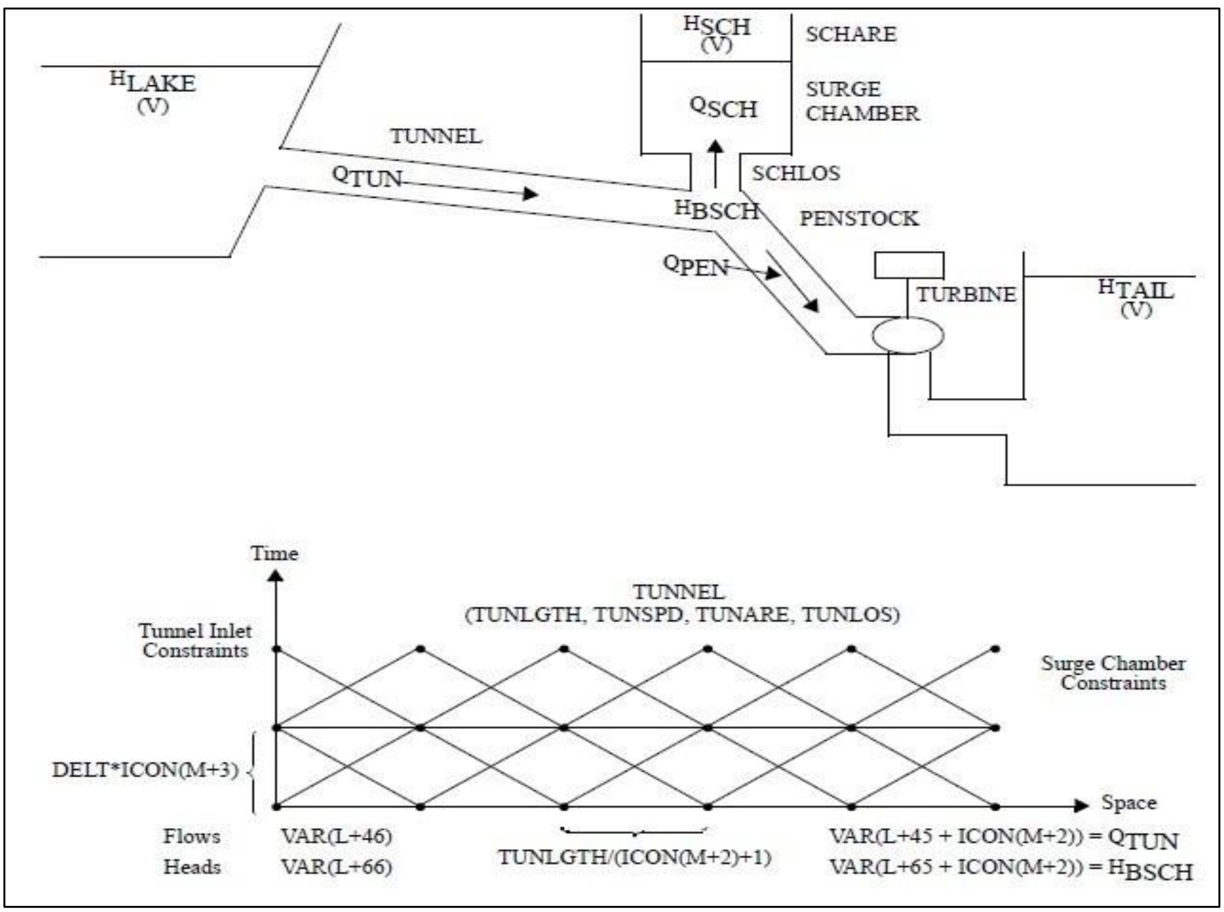
Governor and Hydraulic Actuators

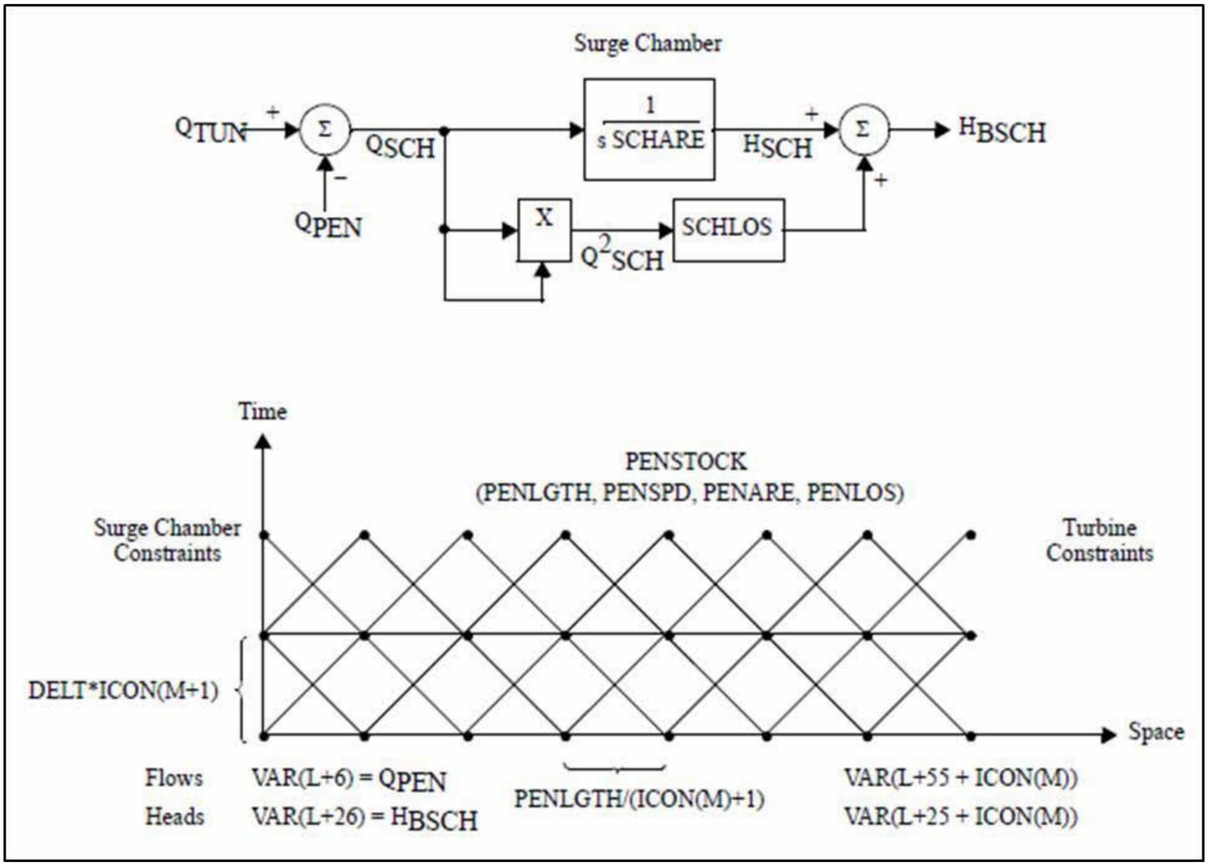


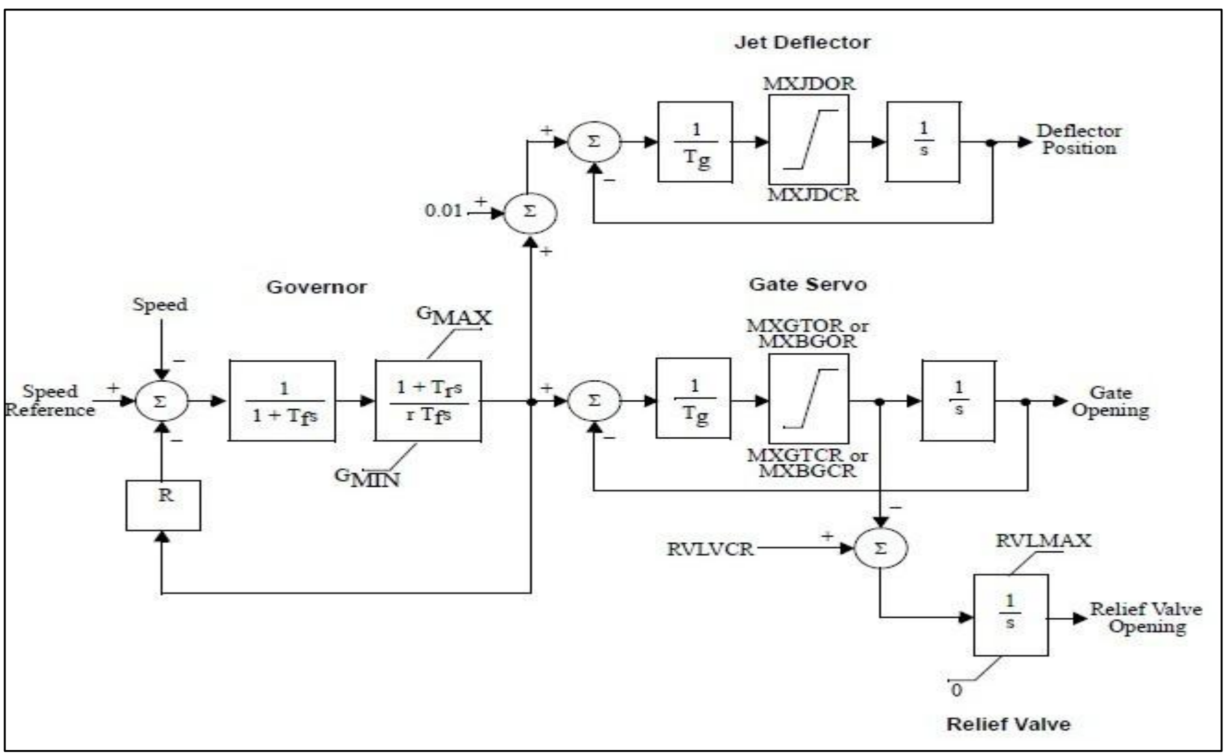
Turbine Dynamics



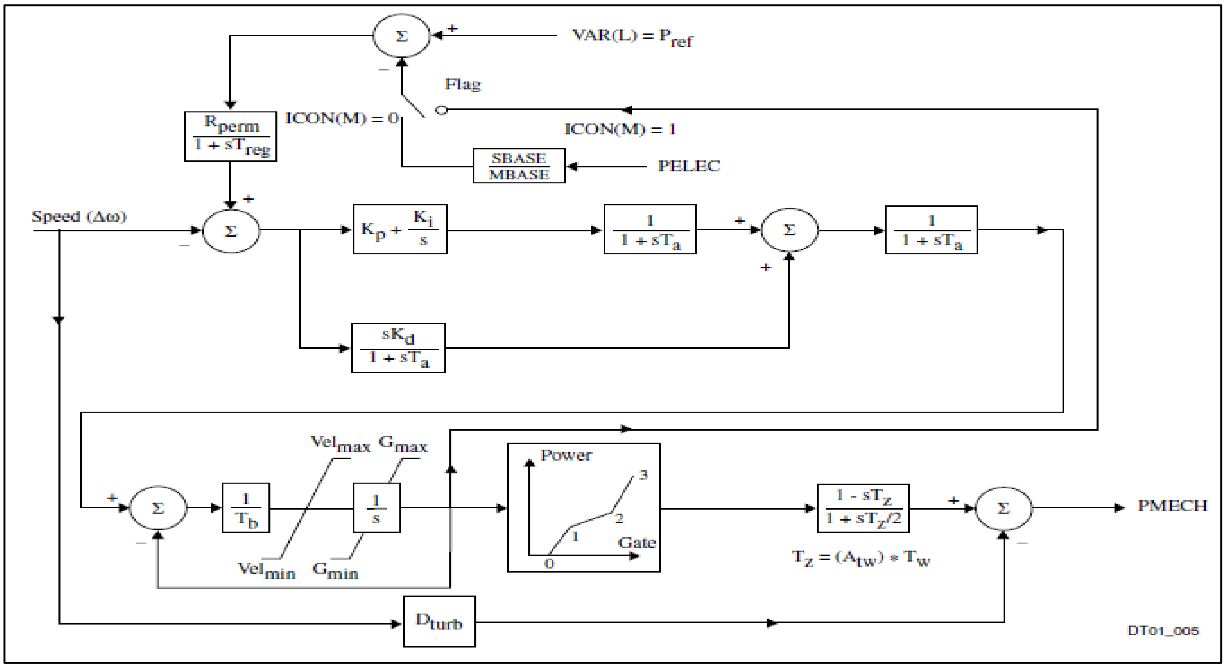
➢ **HYGOVT: Hydro Turbine-Governor Traveling Wave Model**



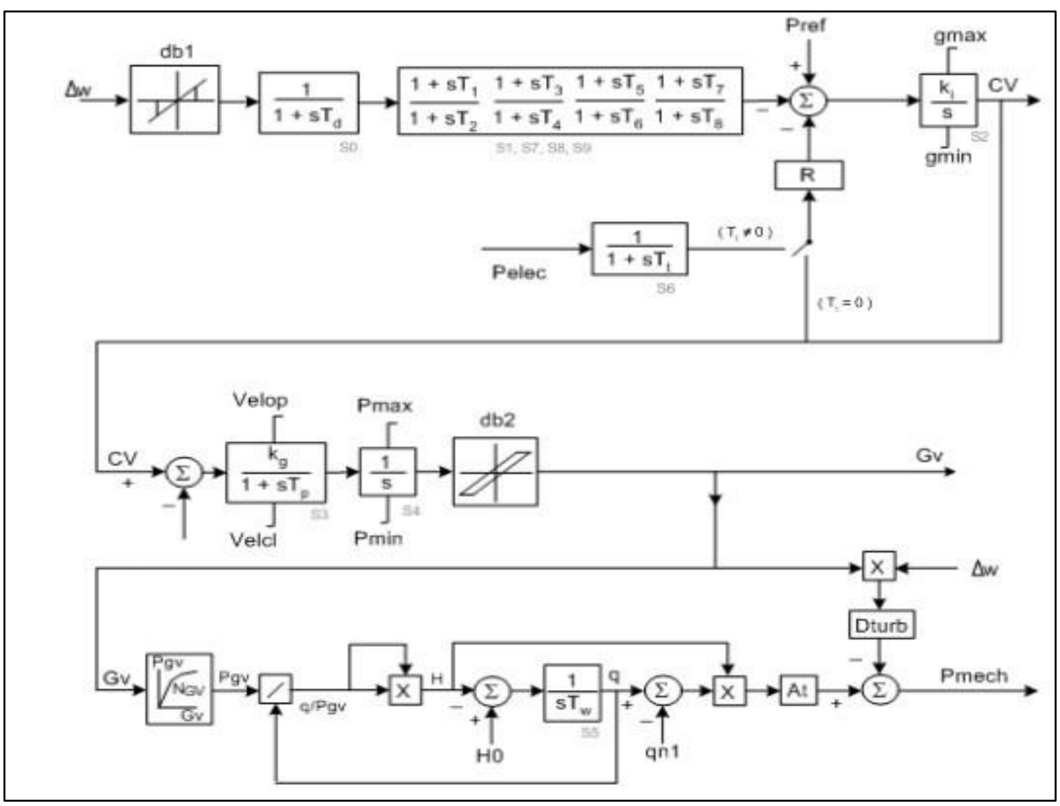

Surge Chamber
QTUN
QPEN
QSCH
1
s SCHARE
HSCH
HBSCH
X
Q2SCH
SCHLOS
Time
PENSTOCK
(PENLGTH, PENSPD, PENARE, PENLOS)
Surge Chamber Constraints
Turbine Constraints
DELT*ICON(M+1)
Space
Flows VAR(L+6) = QPEN
Heads VAR(L+26) = HBSCH
PENLGTH/(ICON(M)+1)
VAR(L+55 + ICON(M))
VAR(L+25 + ICON(M))


Jet Deflector
MXJDOR
MXJDCR
1
Tg
1
s
Deflector Position
0.01
Governor
Speed
Speed Reference
1
1 + Tfs
1 + Trs
r Tfs
GMAX
GMIN
R
Gate Servo
MXGTOR or MXBGOR
MXGTCR or MXBGCR
Gate Opening
RVLVCR
RVLMAX
Relief Valve Opening
0
Relief Valve

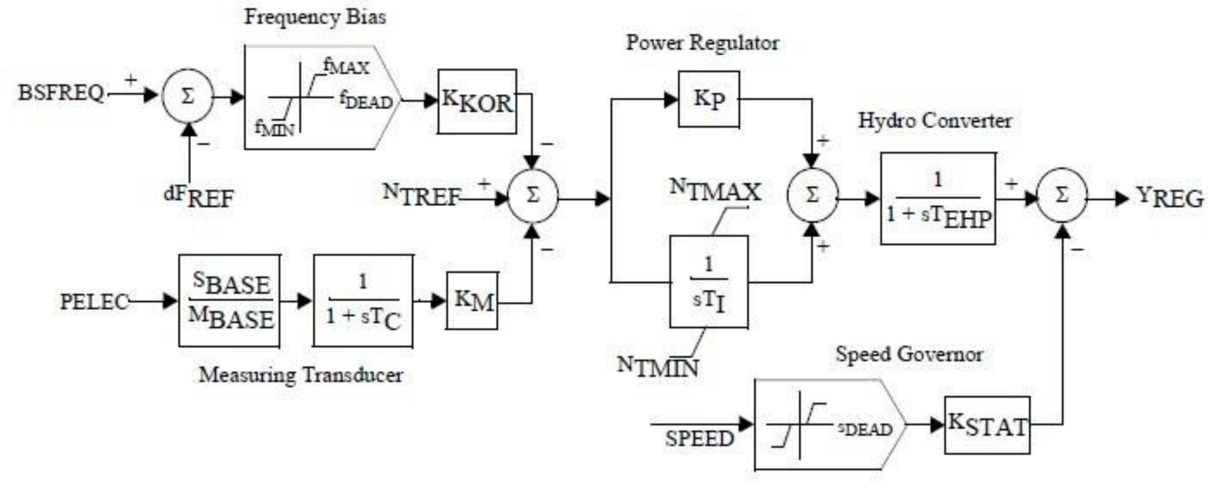
➢ **PIDGOV: Hydro Turbine-Governor**



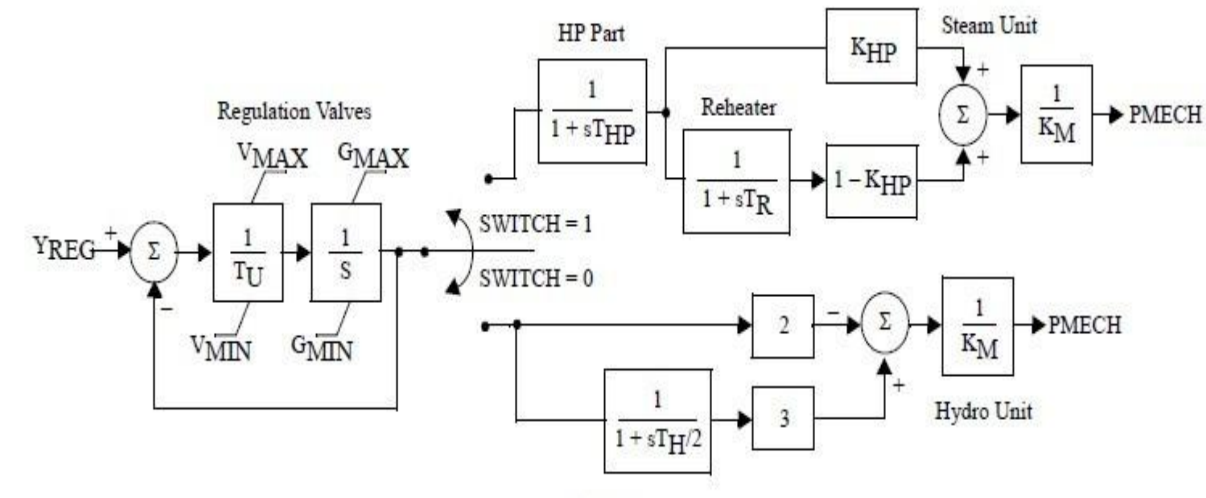
➢ **HYGOVR1: Fourth order lead-lag hydro-turbine**



➢ **TURCZT: Czech Hydro and Steam Governor**

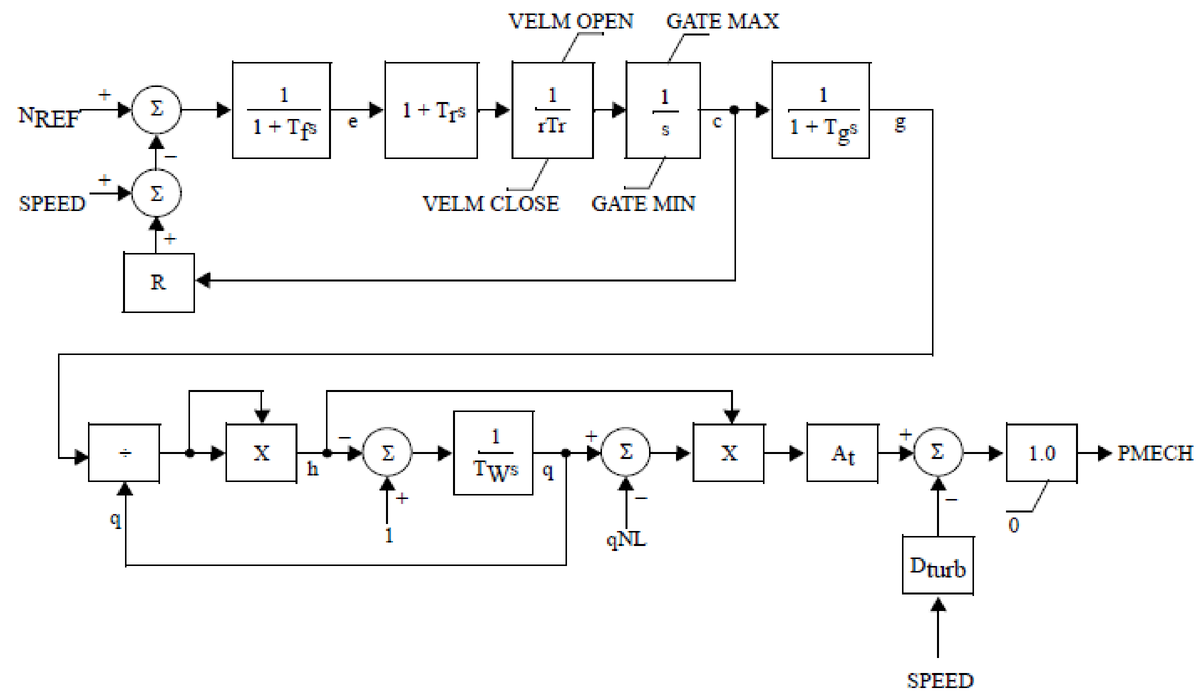


Governor

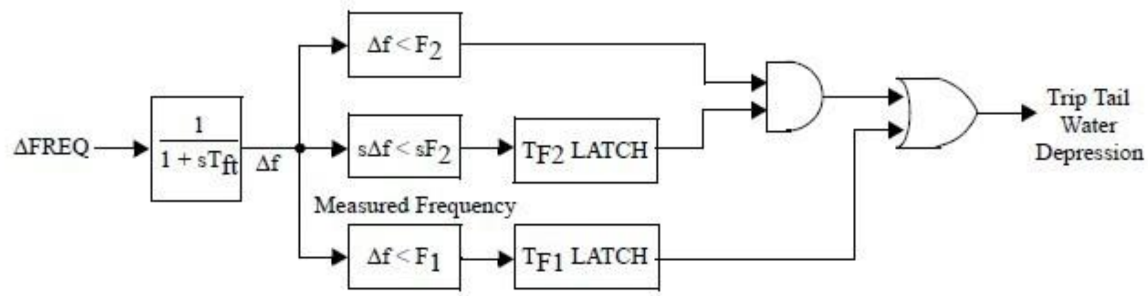


Turbine

- **TWDM1T: Tail Water Depression Hydro Governor Model 1**

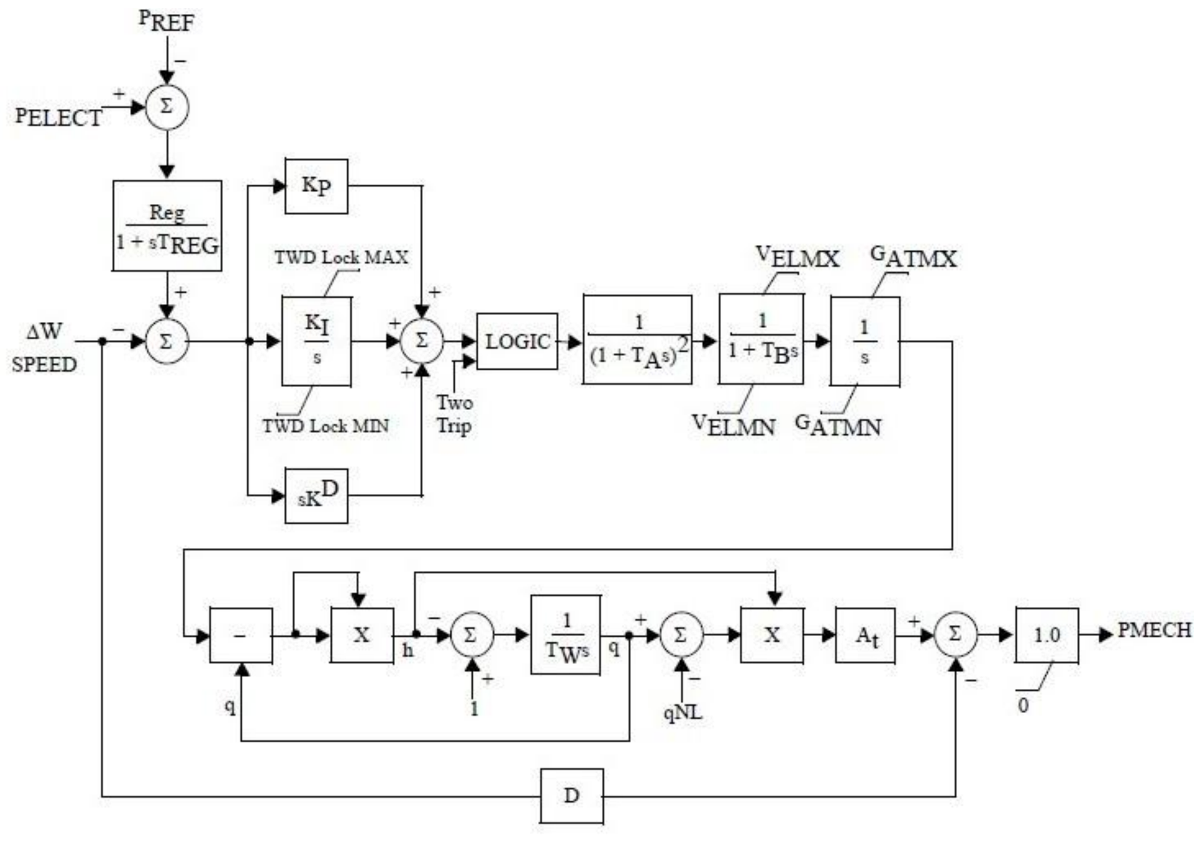


Tail Water Depression Model 1

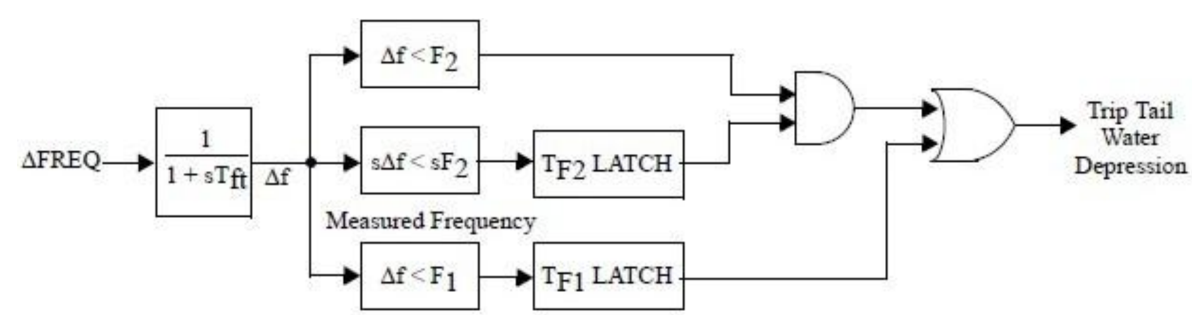


Tail Water Depression Trip Model

- **TWDM2T: Tail Water Depression Hydro Governor Model 2**

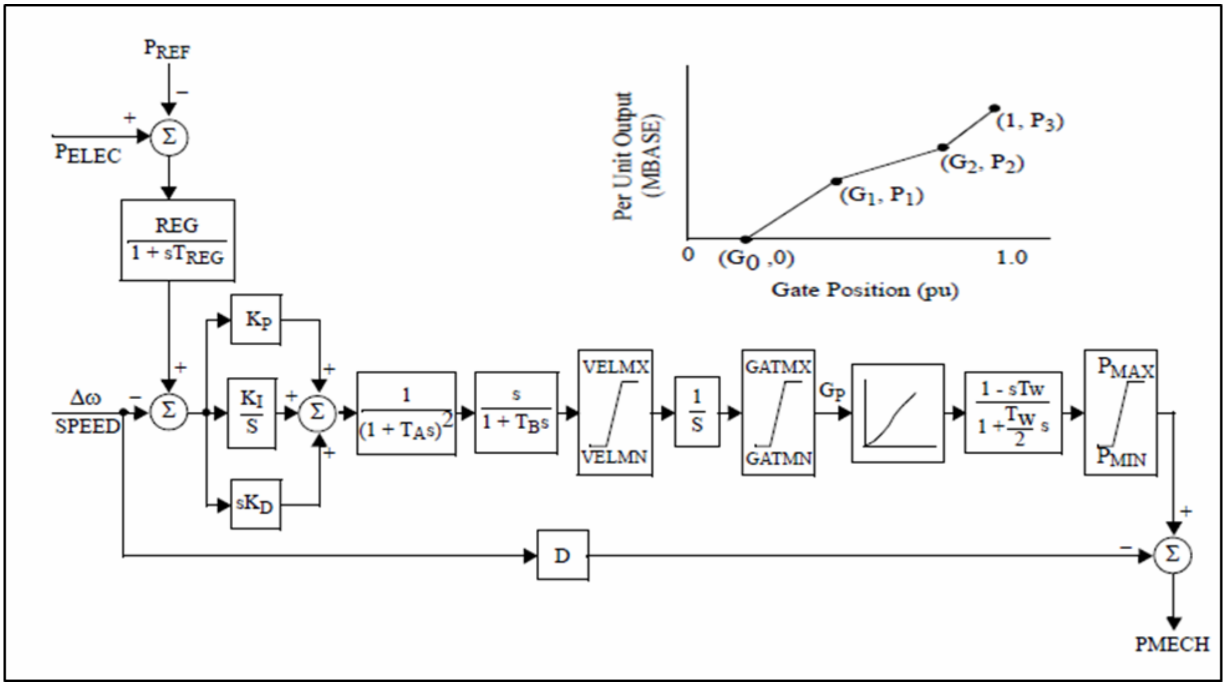


Tail Water Depression Model 2

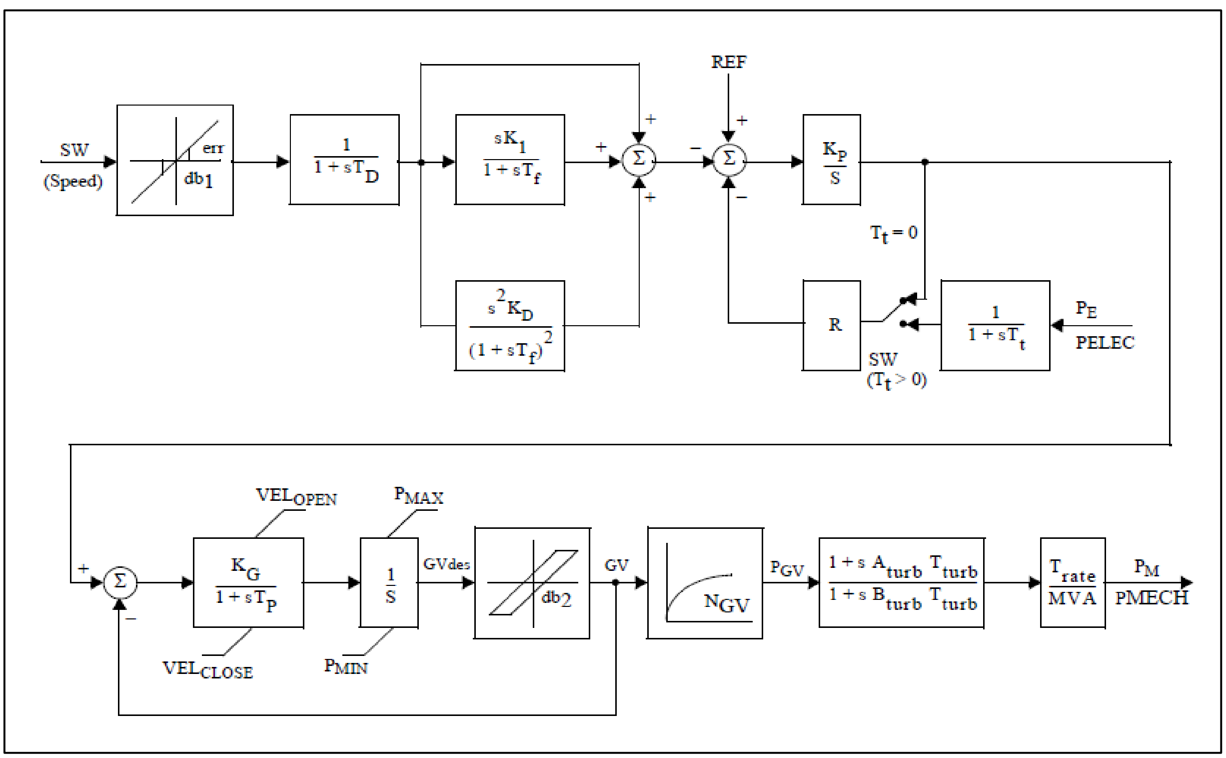


Tail Water Depression Trip Model

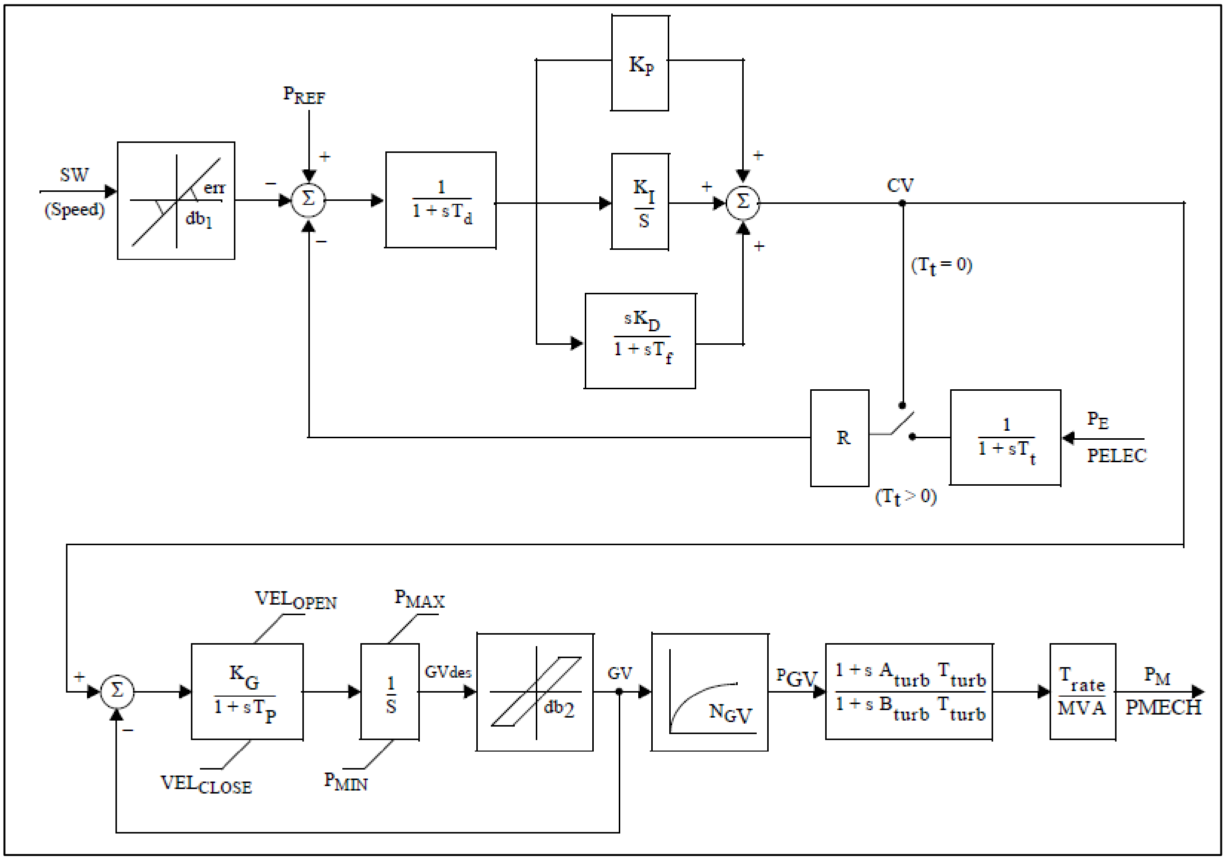
- **WPIDHY: Woodward PID Hydro Governor**



- **WSHYDD: WECC Double-Derivative Hydro Governor**

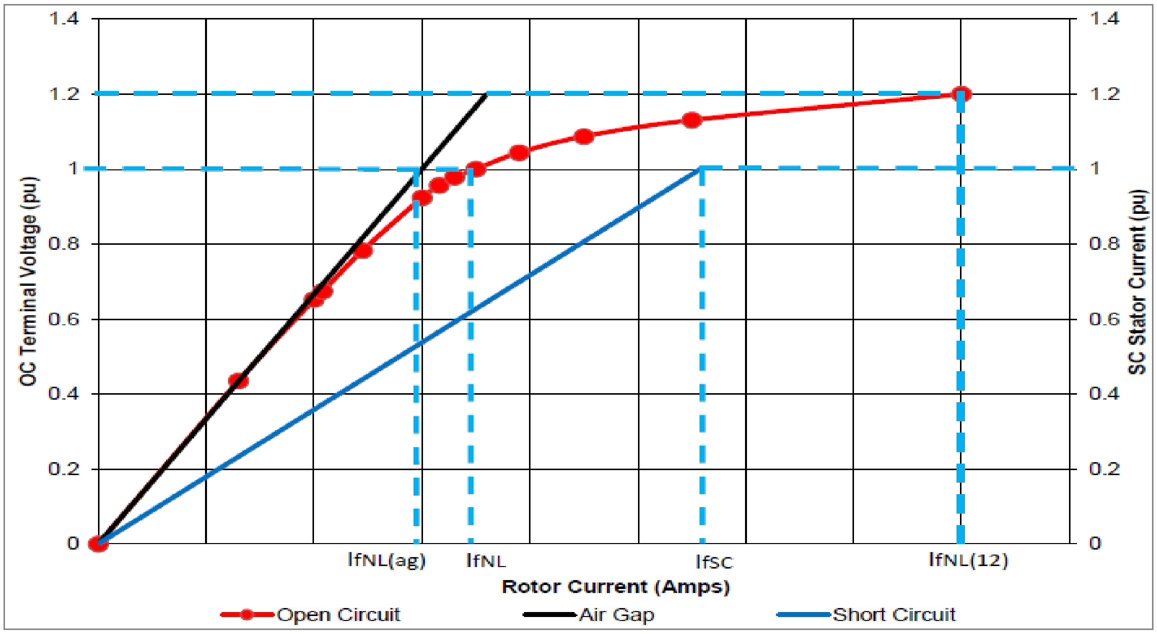


➢ **WSHYGP: WECC GP Hydro Governor Plus Turbine**



Source-PSSE Model Library

Calculation of saturation parameters:

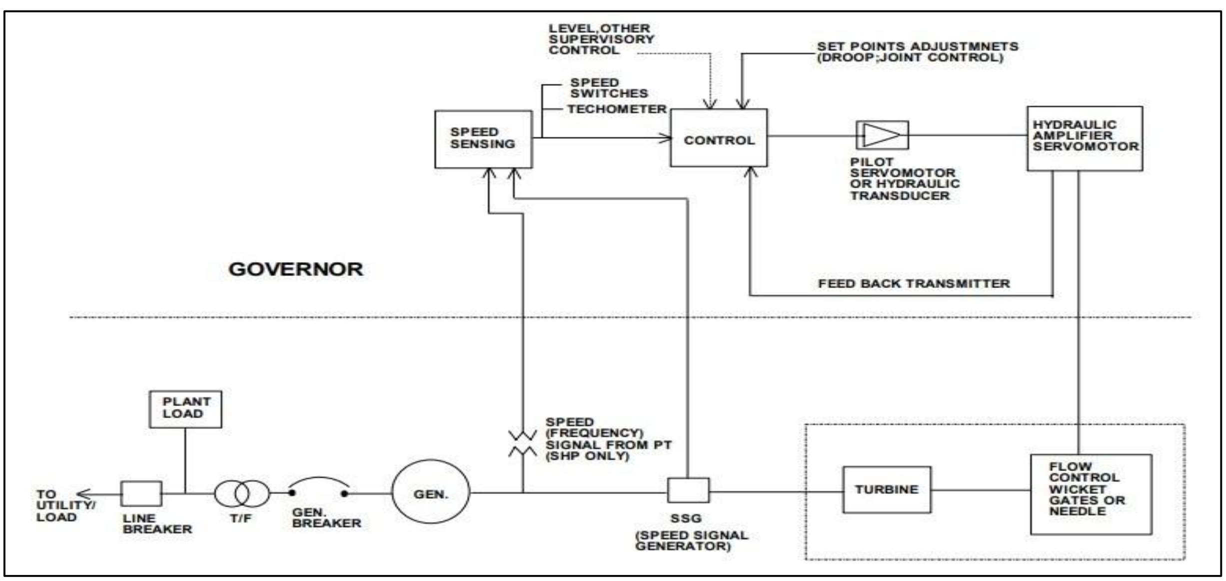


Open and short circuit characteristics

The saturation can be calculated using the following calculation:

$$S(1.0) = \frac{If_{NL} - If_{NL(AG)}}{If_{NL(AG)}}$$

$$S(1.2) = \frac{If_{NL(12)} - 1.2 \times If_{NL(AG)}}{1.2 \times If_{NL(AG)}}$$



Governing system - Block Diagram (Typical) as per IEEE std. -75

Annexure-3(D): Guidelines for Model Compatibility and Support for Conventional generating (Thermal, Gas & Hydro) plants, Bulk Consumers or Load Serving Entities and Combined (Load and Captive) Generation Complex

1. Model Compatibility and Support Guidelines

i. Both RMS and EMT models for conventional generating stations and Bulk Consumers / Load Serving Entities and Combined (Load + Captive) Generation Complex shall be submitted. The model shall include auxiliary models such as excitation system model, turbine governor model, AVR and PSS model etc.

ii. The models shall be compatible with the power system software simulation products as specified by SLDC below: -

a) RMS models shall be compatible with **PSS/E version 35** and above.

Provided that the SLDC may accept the model compatible with version 34 also under special circumstances. The decision in this regard will be at the discretion of the SLDC only.

The RMS models are required to be **generic** [1]models and shall not contain any encrypted or compiled parts, as the system operator must be able to maintain the same without the restrictions of software updates etc.

If there is significant difference in the actual performance of the element vis-à-vis the response of the generic model, then **user defined model (UDM)** shall also be submitted in addition to the generic RMS models.

In case of submission of User Defined Models (UDMs), the submission of the **source code and compiling procedure** along with the model is mandatory.

Further, a comparison report highlighting the difference between the simulation response obtained from the generic model and UDM shall be submitted.

a) EMT models shall be compatible with PSCAD version 4.6.3 and above with the following –

i. Intel 15 Update 5 and newer (32-bit) and Visual Studio 2015 and newer
ii. Intel 15 Update 5 and newer (64-bit) and Visual Studio 2015 and newer

[1] **Annexure-3(A), 3(B) and 3(C)** may be referred for submitting generic RMS modelling data of Thermal, Gas and Hydro Plants respectively

iii. Model works across a range of time steps and does not require a specific time step

These models must not be dependent on a specific Intel Visual FORTRAN version and should not have dependencies on additional external commercial software.

iii. The simulation models (applicable for generic and UDMs) shall:

a) Be submitted in the form of generating units/load connected to the representation of the Grid (Thevenin-equivalent) SMIB (Single Machine Infinite Bus) model.

b) Be supported by model descriptions that, as a minimum, shall include Laplace domain transfer functions (for RMS models), and function descriptions of the arithmetical, logical and sequence-controlled modules used in the simulation model.

c) Include descriptions of the individual model components and related parameters including saturation, non-linearity, dead band, time delays and constraint functions (non-wind-up/anti wind-up) etc.

d) Include descriptions of the set-up of the simulation model as well as any limitations to the application hereof. There shall be no initialization errors for the dynamic models. The warning messages shall be reviewed and resolution or explanation shall be provided.

e) Work for a range of dynamic simulation solution parameters rather than for specific settings only.

iv) Any model validity limitations due to system impedance or strength or any other reason shall be clearly defined.

v) Models shall not show any characteristics that are not present in the actual HVDC response.

vi) **Model user guide** including model setup procedure, RMS & EMT software version, compiler, visual studio version etc. shall be submitted along with the model.

vii) Model limitations, maximum solution time step etc. to be included in user guide

viii) EMT model shall not contain any dependent libraries. The submitted workspace file (.pswx) must not load any PSCAD library (.pslx) files apart from the PSCAD master library. The model shall be capable of running with no extra steps aside from clicking “Run” option in PSCAD.

Annex-4

Hydro Plant Details	
	Project/Plant details
1	Company/SLDC name:
2	Owner of the power station:
3	Project name and location:
4	Contact Number & Name of the Nodal person: Mr./ Ms.
5	Total Installed Capacity (MW): (e.g.2x100MW):
6	Turbine type: Francis /Kaplan / Pelton/Bulb/Any other
7	Intake River & Diversion dam:
8	Hydro station type - ROR/ ROR with poundage/Storage type:
9	In case of RoR generating station with pondage, what is the time period for which all the units can run at their MCR using the available water stored in the pondage (considering full pondage
	Reservoir details
1	Power station- Underground/Surface:
2	Full Reservoir Level (FRL),Minimum Draw Down Level (MDDL) in meters,Energy content at FRL and Target energy for financial year
3	Monthly design energy/10 daily energy:
4	Water usage (other than electricity production)- Irrigation/Flood control/ Bilateral treaty/ hydrology:
5	Which are the riparian States?
6	Is the Station part of the tandem hydro system? If yes then what are the constraints in operating the station?
7	Which is next hydro station (with pondage /reservoir) on the upstream and downstream side?
8	What is the accounting period for total water inflows and releases from the station?
9	Monthly pattern of release of water (over the day too)
10	What are the tools for forecasting the inflow silt etc. how much early (from the generation time) inflow forecasting is available? Is there any tool for forecasting of generation from the plant? If yes,
11	If the reservoir water level and inflow being monitored in real time? Whether these parameters are being recorded manually or automatically by a sensor? Also, Is the historical reservoir water level and inflow is
	Beneficiaries of Plant
12	Who owns the Station and Who operates the Hydro Electric Station?
13	Which are the entities having entitlement on the power generated from the Station?
	Control/Direction
14	Which agency assesses the water inflows for the river basin on which the hydro station is built?
15	Which are the sectors/ entities that are entitled for water usage from the reservoir?
16	Who decides the allocation of water available for different usage such as drinking water, irrigation, industrial use, tourism, power generation?
17	Is the Station operation governed under some water sharing treaty?
18	In case the hydro station has multiple beneficiaries- Who coordinate the scheduling?
19	Who manages the water releases? Who decides the quantum of water available for powergeneration?
20	Where is the offtake for water for irrigation/drinking water- From the upstream from the reservoir or downstream of the tail race? What is the operating domain for the plant operator with respect to the water

21	What is the philosophy for despatching the station - (managing peak demand / load following / ramping / deviation control / other)
22	How is the station compensated for the energy generated? Is the tariff multi-part or single part?
	Pumped mode operation
23	Pumped Storage Capability available (Y/N), If yes operational since when? /Reason for Not utilized
24	In case of a pumped storage station, can the water be released when the lower reservoir is full?
	Scheduling aspects
25	Is the Station given a day-ahead schedule? If yes, can the schedule be revised in real- time?
26	What are the considerations/aspects to be taken care while revising day-ahead injection schedule?
	Operations
27	Unit wise lower and upper limit of Vibration zone or Forbidden zone in MW. Specify the operating range of each unit.
28	Does the station have overload capacity (Yes/No)? If yes, how much?
29	Time required for synchronizing the unit and Time from synchronization to full load.
30	Is the station capable of operating in condenser mode? If yes, has it ever operated in this mode?
31	Is the station capable of black start (Yes/No) & AGC (Yes/No).Specify the capacity of DG set?
32	Who assesses the performance of the station? What are the indices for measuring the performance of the station?
33	What is the periodicity of assessing the performance and any incentive scheme?
34	Whether units are capable of accepting simulated frequency signals for third party Primary Frequency Response (PFR) Testing
35	Operational constraint
36	Regarding speed governor : a. What is the minimum speed droop setting possible? b. Whether the ripple filter is programmed at previously sampled frequency or 50 Hz? eg. If frequency change from 50.02 Hz to 50.05 Hz is observed by the governor, whether response shall be provided or not? c. What is the sampling rate for monitoring and data recording in speed governor system and AVR system? d. What is the maximum period of storage of generator data in Data Acquisition System (DAS)? e.g. 1 year, 3 year, 5 year, etc.?

Section-3

Procedure for First Time Energization of Solar, Wind, BESS or Hybrid (Wind/Solar/BESS) Power Plants/Parks and Issuance of Certificate of Successful Trial Run

Procedure for First Time Energization of Solar, Wind, BESS or Hybrid (Wind/Solar/BESS) Power Plants/Parks and Issuance of Certificate of Successful Trial Operation

First time charging and issuance of trial operation certificate of new Wind, Solar, BESS and Hybrid (Wind/Solar/BESS) plants/parks shall be in accordance with **Section-1** of this procedure. The formats and annexures (A1-A6, B1-B5 (a) and C1-C5) mentioned in section-1 need to be submitted to the SLDC in accordance with the mentioned timelines.

Further, apart from the requirements mentioned in section-1, following guidelines shall be followed for the first-time energization of Wind, Solar, BESS and Hybrid (Wind/Solar/BESS) plants/parks:

1. Common Technical Data - Simulation Model, Reports and Certificate Submission to STU and SLDC

1.1. Pre-Commissioning Data Submission

i) The Wind, Solar, BESS[1] and Hybrid (Wind/Solar/BESS) plant/park developer shall submit the **technical connection data** mentioned at points (a) and (b) below to STU **at least 12 months** prior to the physical interconnection of the RE plant with the Grid. STU shall share the submitted data and models with SLDC. Both STU & SLDC shall, in parallel, examine the submitted data.

The joint observations on the submitted data, if any, shall be conveyed by STU to the RE developer[2] within one month of the receipt of complete technical data.

a) **Simulation Model Submission:** The steady-state and dynamic simulation models (RMS[3] , EMT and Power Quality Assessment model) shall be submitted at least **12 months** prior to the physical interconnection of the Wind, Solar, BESS and Hybrid (Wind/Solar/BESS) plant/park with the grid. The models shall be submitted as per the model compatibility guidelines specified at **S. No. 1 of Annexure – I (E)(a)**.

b) **Test Reports, Simulation Reports and Certificates Submission:** Following report and certificates demonstrating compliance to CEA's "Technical Standards for

[1] **Battery Energy Storage System -** Real time telemetry and other technical requirement for BESS are provided in **Annexure-I (G)**. Same shall be followed while submitting the data.

[2] In case of multiple Solar / Wind / BESS / Hybrid plants in a single power park, the park developer shall be responsible for overall coordination with individual developers for submission of modelling data and other details.

[3] **Annexure-I(C)** (Guidelines for Exchange of data for modelling wind farms) and **Annexure-I(D)** (Guidelines for Exchange of data for modelling Solar farms) and shall be referred for RMS modelling (Generic)

Connectivity to the Grid, 2007" and subsequent amendments shall be submitted for each make IBR[4] in a Generating Station:

For providing certification details of the IBR unit, following documents shall be submitted for each make of IBR in a Generating station.

i. Statement of compliance (SOC) to applicable CEA standards from an Accredited Agency.
ii. Evaluation report[5]
iii. Measurement reports[6]
iv. Type Certificate
v. Any other relevant report specified in Evaluation report.

a. The above reports and certificates shall be submitted as per the IBR Unit Testing, Certification and Report Submission Guidelines specified at **S. No. 2 of Annexure – I (E)(a)**.

   Transferability of the results from another same or different make IBR model shall not be considered and each separate IBR model shall be tested & certified separately.

   Certificate of Accreditation of the certifying agency may also be asked for verification, if required.

b. Technical details of the plant shall be submitted as per the template provided in **Part-A of Annexure-I (E).**

c. Single IBR unit **Benchmarking Report** shall be submitted as per the guidelines specified at **S. No. 3 of Annexure – I (E)(a).**

d. Simulation report of the plant demonstrating compliance against CEA's *"Technical Standards for Connectivity to the Grid, 2007"* and subsequent amendments shall be submitted. The details of tests along with the methodology to be followed in this regard is specified in **Part-B of Annexure-I (E).**

e. Technical requirement of Power Plant Controllers (PPC) as specified in **S. No. 4 of Annexure-I(E)(a)** shall be ensured along with requisite document submission.

ii) After submission of the models and reports specified at **S. No. (i) above**, if there is any change in the plant equipment / layout /firmware / software etc. at a later stage due to some unforeseen/uncontrollable event, the revised models and reports shall

[4] **IBR-Inverter based resource;** IBR unit referred here can be the single solar inverter, single WTG (all types) or single BESS inverter.

[5] Report containing the results of conformity evaluations relating to certification, the basis for the decision to issue the Statement of Compliance/Conformity Statement Certificate

[6] Report indicating the electrical characteristic of IBR unit and referred for the purpose of Certification

be submitted to STU at least **three months** prior to the physical interconnection. The changes w.r.t. the models and reports submitted as per **S. No. (i)** above shall be clearly highlighted. STU shall share the revised data and models with SLDC. STU & SLDC shall jointly examine the submitted data and share their observations if any to the RE developer.

If there are no changes, a "letter of confirmation" confirming that there are no changes to the models and reports submitted at S. No. (i) and (ii) shall be submitted by the RE developer at least **three months** prior to the physical interconnection to STU.

At this stage, the details of the implemented controller and protection settings (both IBR and Power Plant Controller) shall be submitted as per the format specified in **Annexure - 1 E(b).** A letter of confirmation signed by an authorized company personnel certifying that the settings submitted are actual implemented settings and any change in the settings will be carried out in consultation with SLDC.

1.2. <u>Post-Commissioning Data Submission</u>

i) Within **03 months of the complete RE plant commissioning,** the validated detailed (only RMS) and equivalent models (RMS and EMT both) of the plant along with the validation report shall be submitted to both STU and SLDC. The guidelines required to be followed for model validation and validation report are provided at **S. No. 5 of Annexure – I (E)(a)**.

   Further, in case of any revision w.r.t. earlier submitted details, the updated implemented controller and protection settings (both IBR and Power Plant Controller) shall also be submitted as per the format specified in **Annexure - 1 E(b).** In case there are no changes, a letter of confirmation signed by an authorized company personnel certifying that there are no changes w.r.t. earlier submitted data shall be submitted.

ii) During the operational phase, if there is any change in the plant due to installation of any additional equipment, changes in controller settings etc., the updated models along with the validation report shall be submitted within **03 month** of any such activity. A letter certifying the same shall be submitted along with the final validated models.

iii) In compliance to CEA's "*Technical Standards for Connectivity to the Grid, 2007"* and subsequent amendments, power quality (harmonic content, DC injection, flicker etc.) measurements shall be carried out at least once in a year by NABL accredited labs. First measurement shall be carried out immediately after complete commissioning of plant and subsequently, it shall be repeated on annual basis. The assessment report shall be submitted to STU & SLDC on annual basis. Failure to carry out the annual power quality assessment shall make the plant liable for disconnection from the grid.

2. User Registration at SLDC and Document Submission

SPPD/WPPD/HPPD shall be responsible for registering the RE generating station with the SLDC as a User and shall submit Appendix-IV of KERC applicable Regulations or orders from time to time before getting connected at the Connection point with the In-STS for the first time

The SPPD/WPPD/HPPD shall be registered under category "Others" and therefore onetime registration fee shall be based as per KERC applicable Regulations or orders from time to time.

Further, RE Generators or lead generator shall also register as a User of SLDC before getting connected at the In-STS pooling station for the first time and shall pay monthly SLDC fees and charges as per Hon'ble KERC Regulations and orders from time to time.

Provided that Co-located Hybrid Power Plants (consisting Wind, Solar & with or without BESS) shall be registered based on their combined actual AC Installed Capacity (in MW) irrespective of the connectivity quantum. The scheduling from Hybrid Plant shall be restricted up to connectivity quantum (in MW). The technical & modelling data as per this procedure shall be submitted for the complete capacity.

Provided that Stand alone BESS shall be registered under the category of "Generating Station" and the registration fee and monthly Fees & Charges shall be based on Installed capacity (MW).

a) Submission of information in Appendix-IV of KERC "Fees and charges of, Regulations and orders as ***Annexure-VI***
b) Bank account details to be submitted along with Cancelled Cheque, PAN, TAN and GSTN details as ***Annexure-VI (A)***
c) Details of Payment of Registration fee to SLDC as ***Annexure-VI (B)***

i) Document submission during registration

a) **Connectivity Details:** Connectivity Agreement(FORMAT-CONN-CA-5)by STU, FORMAT-CONN-INT-1A,FORMAT-CONN-INT-1B,FORMAT-CONN-INT-1C, FORMAT-CONN-INT- 2,FORMAT-CONN-TD-1 FORMAT-CONN-TD-4 and any other applicable formats to be submitted to SLDCs specifying the point of connection, bay numbers etc.

b) **Access Details:** Access details granted by STU as per the extant Regulations/orders/Procedure on Connectivity / Access shall be submitted.

c) **PPA/PSA details**- Copy of signed power purchase agreement (PPA), power sale agreement (PSA) etc. as applicable may be submitted to the SLDC as mandated in the KEGC.

d) Copy of Coordination Agreement with the Qualified Coordinating Agency (QCA)/Lead/Principal Generator, Park Developer if any

e) Copy of agreement(s) between SPPD/WPPD/HPPD and SPD/WPD/HPD

f) Copy of Affidavit regarding PPA rates

g) Copy of registration with CEA in line with CEA "Framework for registration of generating Unit" dated 13.04.2018

h) Details of approval of Planning Committee Meeting/ RPC / CEA / STU Consultative meeting and approval for changes in the approved scheme, if any.

~~i)~~ **Technical Details-** Below mentioned technical details to be submitted

i) **Static Details:** Details of Wind / Solar/Hybrid power plant, Static parameters for wind generating station and Static parameters for solar generating station has been provided as per format **Annexure-I, Annexure-I(A) and Annexure- I(B)** respectively

ii) **Additional Details:** Following additional information are also required

a. The latitude and longitude of the solar farm shall be one coordinate for every 50 MW. (The solar farms are spread in a wide area and for proper forecasting, we shall have more positional details of the plant)

b. Number of PV panels, type, make & total area covered by PV panels

j) Indemnity Bond and Undertakings

i) **Indemnity Bond-under** clause 5.1.2 (j) of CERC approved procedure of 03.03.17 stated-

‘Keep the SLDCs indemnified at all times and shall undertake to indemnify, defend and save the SLDCs harmless from any and all damages, losses including commercial losses due to forecasting error, claims and actions including those relating to injury to or death of any person or damage to property, demands, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties, arising out of or resulting from the transactions undertaken by the Generators.’

Notarized Indemnify Bond to be submitted by generator as per ***Annexure-II.***

ii) **Undertaking on General Compliance Requirements as per KERC approved procedure:** RE Generator or Lead Generator or Principal Generator shall submit undertaking. Format for undertaking is as ***Annexure-III.***

iii) **Notarized undertaking towards exemption of transmission charge/loss (as applicable)**: Notarized undertaking to be submitted, if applicable. Format for undertaking is as per **Annexure-IV.**

iv) **Notarized Undertaking on Compliance of CEA Connectivity Standards**- As per Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2019, undertaking for LVRT, HVRT, power quality, Active power control set point and other compliances as well as for periodic (annual) measurement of power quality parameters shall be submitted by RE generators. Undertaking to be submitted by developers as per format specified in ***Annexure-V.***
Ref: Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2019

v) **Compliance to aviation safety norms**: Undertaking to be given by WPD for all the WTGs for the compliance of aviation safety norms viz. installation of LED on turbine blades etc.

vi) **Compliance to Cyber Security Measures**: Undertaking to be submitted by developers in compliance to Cyber Security Measures as per format specified in **Section-I** of this procedure.

k) **Geotagging Information for each wind turbine:** NIWE, Chennai developed geo-tagged database /online registry of wind turbines installed across the country. As per office memorandum of MNRE, all wind turbines in a project should be geo-tagged before Commercial Operation Date (COD). Copy of same to be submitted to SLDCs.

3. Pre-charging Activities

The following prerequisite must be ensured by the requester (Solar/Wind/BESS/Hybrid Plant/Park Developer) prior to first time energization of the plant/park or any associated power system element:

a) Installation of Interface Meters (through STU):

The metering scheme of QCA/lead generator /Solar/Wind/BESS/Hybrid power plant/park/energy storage shall be approved from concerning SLDC well in advance. As per CEA (Installation & Operation of Meters) Regulation-2006 & subsequent amendments, the concerning QCA/lead generator/ plant/park developer/energy storage shall coordinate with STU for installation of Interface Energy Meters with unique serial numbers along with data collecting devices (DCD) as per Metering Scheme approval issued by SLDC. The meter data from power plant/park and In-STS pooling station should be integrated with AMR system and data communication shall be on optical fibre link and until implementation of AMR system, the encrypted meter data shall be downloaded through DCD/MRI. The responsibility for providing the weekly encrypted data of meters, time drift correction report and changes in CT/PT ratios (if any) to SLDC shall be of the entity in whose premises the meters are installed.

b) Telemetry & Communication:

As per Clause 3.11 part 1 & 2 of KEGC, the developer shall provide:

- Reliable speech and data communication systems to facilitate necessary communication, data exchange, supervision and control of the grid by the NLDC, RLDC and SLDC in accordance with the CERC (Communication System for Inter State Transmission of Electricity) Regulations, 2017 and the CEA Technical Standards for Communication.

- The associated communication system to facilitate data flow up to appropriate data collection point on STU system. Inter-operability requirements shall also be established by the concerned user as specified by STU in the Connectivity Agreement.

Further, as per clause 7.8 of CERC (Communication System for Inter-state Transmission of Electricity) Regulations 2017, the users including renewable energy generators shall be responsible for provision of compatible equipment along with appropriate interface for uninterrupted communication with the concerned control centers (RLDCs/SLDCs/REMCs) and shall be responsible for successful integration with the communication system provided by CTU or STU for data communication as per guidelines issued by NLDC.

Real Time Telemetry & PMU data to SLDC:

i) Entity shall provide real time data for wind and solar plants for all parameters mentioned in ***Annexure- VII(A) and VII(B)*** to the SLDC @ resolution of 4-6 sec. *[Ref: - Central Electricity Authority (Technical Standards for Communication System in Power System Operation) Regulations, 2020]*

ii) Telemetered weather parameters like Ambient Temperature (^{0}C), Relative Humidity (%), Wind Speed, and Wind Direction etc. to be provided to SLDC. Segregation of telemetered points is as per ***Annexure-VII(C) and VII(D).***

iii) Gateways/RTUs installed shall report on Redundant communication channel to Main Control centre and backup control centre i.e. 2 channels to Main Control centre 1 and 2 channels to Main Control centre 2 (or to Backup as and when backup is available). The minimum number of ethernet ports on gateway must be 4 (two on each gateway for MCC and two on each gateway for BCC). Redundancy should work for all of the following failures:

- Single Communication link failure
- Single Port failure
- Single Gateway failure
- Single Master station polling server failure

vii) Communication equipment for all the nodes shall be provided with at least ten hours battery backup and extended backup shall be provided depending upon the requirement as per Clause 8.11 of *Central Electricity Authority (Technical Standards for Communication System in Power System Operation) Regulations, 2020]*

iv) Sample IEC-104 profile as provided in **Annexure-VII (F)** to be followed.

v) Phasor Measurement Units (PMUs) shall be installed at the RE Generating substation(s) of developer. The signal list for PMU data is provided at Annexure-VII(E) (signal list as per ***Annexure-VII(E)***) *Ref: Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022*

vi) Following details shall also be shared-

- Details of PMU (make and model)
- Details of gateway/RTU – Make and model
- Details of the Multiplexor owned by RE station

c) Power Plant Controllers shall be installed with following minimum features:

i) Active Power Control (with ramp rate control functionality)
ii) Reactive power Control (Voltage Control, Constant-Q control and PF Control)
iii) Frequency Controller
iv) Data logging facility (≤ 1 sec resolution)
v) Sequence of Event Logging Facility (in order to capture switching of IBRs)
vi) Facility to accept remote signals from load dispatch centres for varying active and reactive power set-point
vii) Facility to control shunt compensation devices like FACTs etc.

d) Necessary protection coordination shall be carried out with all adjacent substation.

e) Dedicated Voice communication from Solar/Wind/BESS Generating Plant to control centre (SLDC) using VOIP communication/landline mobile, and dedicated email Id of plant shall be ensured.

f) <u>Statutory Approval</u>

i. In line with the Central Electricity Authority (Measures relating to safety & electric supply) Regulation-2023 (as amended), a copy of charging approval obtained from CEA shall be submitted to SLDC before energisation of any electrical installation. PTCC Approval for dedicated transmission lines shall also be submitted.
[Ref.: CEA - Measures relating to Safety & Electric supply Regulations-2023)]

ii. The wind and solar, the ESS or the hybrid generating station developer, as the case may be, shall submit a certificate signed by the authorized signatory not below the rank of CMD or CEO or MD to the **SLDC** before declaration of COD, that the said generating station or the ESS as the case may be, including main plant equipment such as wind turbines or solar inverters or auxiliary systems, as the case may be, has complied with all relevant provisions of CEA Technical Standards for Connectivity, CEA Technical Standards for Communication, Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations,2023 and these regulations.

g) In line with the CEA (Technical Standards for Connectivity to the Grid) Regulations 2007, as amended, **Disturbance Recorder/Event Logging facility of the generating**

station shall be ensured. The DR / EL data at the time of first charging shall be submitted to SLDC.

Preferable DR trigger criteria and recording period for monitoring purpose is given below:

Setting Value	**Recording Period**
Voltage - >= 1.1 p.u. & <= 0.9 p.u.	Pre-fault – 0.5 s Post fault – 10 s Sampling – 1 kHz or higher
Frequency - >= 51 Hz & <= 49 Hz	

The developer shall be able to provide event logger data from IBR as and when requested by SLDC.

h) As per regulation 5.7 (6) of KEGC, 2025, following documents/ tests shall be submitted for wind and solar resources:

i. Type test report for Fault Ride through Test (LVRT and HVRT) for units commissioned after the specified date as per CEA Technical Standards for Connectivity mandating LVRT and HVRT capability.

ii. The following tests shall be performed at the point of interconnection:

- Frequency response of machines as per the extant CEA Technical Standards for Connectivity.
- Reactive power capability as per OEM rating at the available irradiance or the wind energy, as the case may be.

Provided that the generating company may submit offline simulation studies for the specified tests, in case testing is not feasible before COD, subject to the condition that tests shall be performed within a period of one year from the date of achieving COD.

The detailed report covering the results of the above tests shall be submitted to the SLDC.

i) As per regulation 5.7 (6) of KEGC, 2025, following documents/ tests shall be submitted for Energy Storage Systems:

The following tests shall be performed at the point of interconnection:

- Power output capability in MW and energy output capacity in MWh
- Frequency response of ESS
- Ramping capability as per design

The detailed report covering the results of the above tests shall be submitted to the SLDC.

4. Notice of Trial Run

a) The generating company proposing its generating station or a unit thereof for trial run or repeat of trial run shall give a **notice of not less than seven (7) days** to the SLDC, and the beneficiaries of the generating stations, including intermediary procurers, wherever identified:

Provided that in case the repeat trial run is to take place within forty-eight (48) hours of the failed trial run, fresh notice shall not be required.

b) The SLDC shall allow commencement of the trial run from the requested date or in the case of any system constraints, not later than seven (7) days from the proposed date of the trial run. The trial run shall commence from the time and date as decided and informed by the SLDC.

5. Trial Run Operation of Wind / Solar / BESS / Hybrid Generating Station

The trial run of Wind / Solar / BESS / Hybrid Generating Stations shall be carried out as per the provisions of extant grid code.

a) Trial run of the solar inverter unit(s) shall be performed for a minimum capacity aggregating to 5MW:

Provided that in the case of a project having a capacity of more than 50 MW, the trial run for the balance capacity shall be performed in a maximum of four instalments with a minimum capacity of 1 MW:

Provided further that the trial run for solar inverter unit(s) aggregating to less than 50 MW for entities approved by STU

b) Successful trial run of a solar inverter unit(s) covered under sub-clause (a) of this procedure shall mean the flow of power and communication signal for not less than four (4) hours on a cumulative basis between sunrise and sunset in a single day with the requisite metering system, power plant controller, telemetry and protection system in service. The generating company shall record the output of the unit(s) during the trial run and shall corroborate its performance with the temperature and solar irradiation recorded at site during the day and plant design parameters. Supporting documents for corroborating the output shall also be furnished :

Provided that:

i. the output below the corroborated performance level with the solar irradiation of the day shall call for a repeat of the trial run;

ii. if it is not possible to demonstrate the rated capacity of the plant due to insufficient solar irradiation, COD may be declared subject to the condition that the same shall be demonstrated immediately when sufficient solar irradiation is available after COD, within one year from the date of COD:

Provided that if such a generating station is not able to demonstrate the rated capacity when sufficient solar irradiation is available after COD, the generating company shall de-rate the capacity in terms of sub-clause 5(g) of this procedure.

c) Trial run of a wind turbine(s) shall be performed for a minimum capacity aggregating to 5 MW:

Provided that in the case of a project having a capacity of more than 5 MW, the trial run for wind turbine(s) above the capacity of 5 MW shall be performed in batch sizes of not less than 1 MW:

Provided further that the trial run for wind turbine(s) aggregating to less than 5 MW for entities approved by STU.

d) Successful trial run of a wind turbine(s) covered under sub-clause (c) of this clause shall mean the flow of power and communication signal for a period of not less than continuous four (4) hours during periods of wind availability with the requisite metering system, power plant controller, telemetry and protection system in service. The generating company shall record the output of the unit(s) during the trial run and corroborate its performance with the wind speed recorded at the site(s) during the day and plant design parameters. Supporting documents for corroborating the output shall also be furnished:

Provided that-

i. the output below the corroborated performance level with the wind speed of the day shall call for a repeat of the trial run;
ii. if it is not possible to demonstrate the rated capacity of the plant due to insufficient wind velocity, COD may be declared subject to the condition that the same shall be demonstrated immediately when sufficient wind velocity is available after COD, within one year from the date of COD:

Provided that if such a generating station is not able to demonstrate the rated capacity when sufficient wind velocity is available after COD, the generating company shall de- rate the capacity in terms of sub-clause 5(g) of this procedure.

e) Successful trial run of a standalone Battery Energy Storage System (BESS) shall mean one (1) cycle of charging and discharging of energy as per the design capabilities with the requisite metering, telemetry and protection system being in service

f) Successful trial run of a hybrid system shall mean successful trial run of each individual source of the hybrid system in accordance with the applicable provisions of these regulations.

g) Where, on the basis of the trial run, solar / wind / storage / hybrid generating station fails to demonstrate its rated capacity, the generating company shall have the option to either go for a repeat trial run or de-rate the capacity subject to a minimum aggregated de-rated capacity of 5 MW or 1 MW, as the case may be.

h) Notwithstanding the provisions contained in this procedure, where Power purchase Agreement provides for a specific capacity that can be declared COD, trial run shall be allowed for such capacity in terms of such Power purchase agreement.

i) Any switching operation viz. charging of EHV line or first charging of WTGs/solar inverters/BESS/Energy Storage shall be done by the developer after availing permission (in the form of an instruction code) from the SLDC control room. Similarly, the charging date and time must be intimated to SLDC control room within 10 (ten) minutes of the first charging of the said element.

j) The developer shall from time to time, ensure compliance to the technical standards & regulations promulgated by CEA, CERC, KERC, STU & SLDC in relation with trial operation & COD of Wind generating stations.

k) The developer shall be allowed to undertake testing by injecting infirm power into the grid before being put into commercial operation, after obtaining permission of the SLDC, which shall keep the grid security in view while granting such permission.

l) During the period of injection of infirm power, the SLDC control room shall be intimated in advance, the forecasted pattern of infirm injection.

m) The developer shall provide Plant/PPC log of 4 hours after first time charging of the plant. The log shall clearly demonstrate operation of plant in each mode viz. Voltage Control, Fixed Reactive Power Control and Constant Power Factor Control for at least 30 minutes.

n) The developer shall provide high resolution data (preferably ≤ 10ms accuracy) of the commissioned IBR units for at least 10 seconds period. The data shall be provided as per the format specified in Annexure-I(E)(c).

o) The developer shall submit any other data as sought by the SLDC for the purpose of verification of successful trial run operation.

p) After completion of the successful trial run and receipt of documents and test reports as mentioned in above sections, the SLDC shall issue a certificate to that effect to the concerned generating station or ESS, as the case may be, with a copy to their respective beneficiary(ies), within three days.

q) **Forecasting Scheduling & Deviation Settlement:** Power plants shall comply with the provision of extant KERC Regulations for facilitation of Forecasting, Scheduling & Deviation Settlement in respect of its power plants. **Annexure-VIII** provides the formats for submission of Available Capacity, day- ahead forecast & schedule data.

Further, in line with Clause 5.7 (2) of KEGC 2025, Scheduling of the generating station or unit thereof shall start from 0000 hours of D+2 (where D is the Commercial Operation Date of the said generating station or unit thereof).

6. **Periodic Testing-** Periodic Testing shall be carried out as per regulation 6.18 of the KEGC, 2025 and amendments thereof. It is desirable to submit report of such tests carried out (at the time of first Time Energization and Integration) while applying for trial run certificates.

    a. The tests shall be performed once every five (5) years or whenever major retrofitting is done. If any adverse performance is observed during any grid event, then the tests shall be carried out even earlier, if so advised by SLDC or SRLDC or NLDC or RPC, as the case may be.
    b. The owner of the plant/park shall implement the recommendations, if any, as suggested in the test reports in consultation with SLDC, NLDC, SRLDC, CEA, RPC and STU.
    c. Within 03 months of completion of the periodic tests, the owner of the plant/park shall submit the final validated model comparing the results of the periodic tests against the model response as per model validation guidelines specified in Annexure-I(E)(a). Further, the models shall be submitted as per the model compatibility guidelines specified at Annexure-I(E)(a).

7. Confidentiality Obligation

SLDC shall preserve the confidentiality of the information and data related with mathematical models (user defined models, source code etc.) and certification reports submitted to them in fulfilment of the obligations under this procedure and shall use them exclusively for the purpose they have been submitted, notably to verify the compliance of requirements set forth in extant regulations in Indian power system. The data may also be used for the purpose of system studies required for reliable and secure operation of the grid as per the Electricity Act and CEA/CERC regulations.

Note: Further amendment in the procedure can be done in line with KEGC/other CERC & CEA regulations/directive from time to time.

Enclosures

Annexure-I: Details of Wind/Solar Generating Station
Annexure-I(A): Static data of Wind Generating Station
Annexure-I(B): Static data of Solar Generating Station
Annexure-I(C): Guidelines for Exchange of data for RMS modelling (generic) of Wind Generating Station
Annexure-I(D): Guidelines for Exchange of data for RMS modelling (generic) of Solar Generating Station
Annexure-I(E): Template for Technical Details and Simulation Report Guidelines
Annexure-I(E)(a): Guidelines for Model Compatibility and Support, IBR Testing and Certification, PPC Technical Requirement, Model Benchmarking and Validation Report
Annexure-I(E)(b): IBR and PPC – Controller and Protection Settings
Annexure-I(E)(c): IBR Units - High Resolution Data Submission
Format Annexure-I(F): Single Generator Equivalent Model
Annexure-I(G): Battery Energy Storage System
Annexure-II: Indemnity Bond
Annexure-III: Undertaking by SPD / SPDD / WPD /
WPPD Annexure-IV: Undertaking by SPD /WPD
Annexure-V: Affidavit – Undertaking for Compliance of CEA Standards
Annexure-VI: Submission of information as per SLDC (Fees & Charges) Regulation
2019 Annexure-VI(A): Bank and Tax related details
Annexure-VI(B): Registration Fee Payment details
Annexure-VII(A): Real-time Telemetry Wind generating
plants Annexure-VII(B): Real-time Telemetry Solar generating
plants
Annexure-VII(C): Real-time Data Telemetry Requirement of Wind Turbine Generating plants
Annexure-VII(D): Real-time Data Telemetry Requirement of Solar Turbine Generating plants
Annexure-VII(E): PMU signal list
Annexure-VII(F): Sample IEC-104
Profile
Annexure-VIII: Forecast and Schedule Data to be submitted by Wind/Solar plants/ Lead generator, Principal generator

Annexure-I: Details of Wind and Solar Plants

Details to be submitted by the Wind/Solar generating station which are intra State **entities/lead generator**	
Types: Wind/Solar Generator	
Individual/on behalf of a group of Generators	
If on behalf of the group of generators group of then details of the agreement are to be attached	
Total Installed Capacity of generating station	
Total number of units with details	
The physical address of the RE-generating station	
Whether any PPA has been signed :(Y/N)	If yes, then attach details
Connectivity Details	Location/Voltage level
Metering details	Meter No. 1. Main 2. Check
Connectivity diagram	(Please enclosed)
Static Data	As per the attached sheet
Contact details of the Nodal Person	Name: Designation Number: Landline no Mob no. Fax No. Email-address

ANNEXURE- I (A): STATIC DATA OF WIND GENERATING STATION

S. No.	Particulars
1.	Type
2.	Manufacturer
3.	Make
4.	Model
5.	Capacity
6.	Commissioned date
7.	Hub height
8.	Total height
9.	Rpm range
10.	Rated wind speed
11.	Performance parameter
12.	Rated electrical power at rated wind speed
13.	Cut in speed
14.	Cut out speed
15.	Survival speed (max wind speed)
16.	Ambient temperature for out of operation
17.	Ambient temperature for in operation
18.	Survival temperature
19.	Low voltage ride through (LVRT) setting
20.	Hight voltage ride through (HVRT) setting
21.	Lighting strength (KA &in coulombs)
22.	Noise power in level (DB)
23.	Rotor
24.	Hub type
25.	Rotor type
26.	Rotor diameter
27.	Number of blades
28.	Area swept by blades
29.	Rated rotational speed
30.	Rotational direction
31.	Coning angle
32.	Tilting angle
33.	Design tip aped ratio
34.	Blade
35.	Length
36.	Diameter
37.	Material
38.	Twist angle
39.	Generator
40.	Generator type
41.	Generator no of pole

42.	Generator speed
43.	Winding type
44.	Rated gen. Voltage
45.	Rated gen. Frequency
46.	Generator current
47.	Rated temperature of generator
48.	Generator cooling
49.	Generator power factor
50.	Kw/mw @ rated wind speed
51.	Kw/mw @ peak continuous
52.	Frequency converter
53.	Filter generator side
54.	Filter grid side
55.	Transformer
56.	Transformer capacity
57.	Transformer cooling type voltage
58.	Winding configuration
59.	Weight
60.	Rotor weight
61.	Nacelle weight
62.	Tower weight
63.	Over speed protection
64.	Design life
65.	Design standard
66.	Latitude
67.	Longitude
68.	Cod details
69.	Past generation history from the cos to the date on which das facility provided at SLDC, if Applicable
70.	Distance above mean sea level

--xxx---xxx---xxx---xxx—

Annexure-I (B): Static data of Solar Generating Station

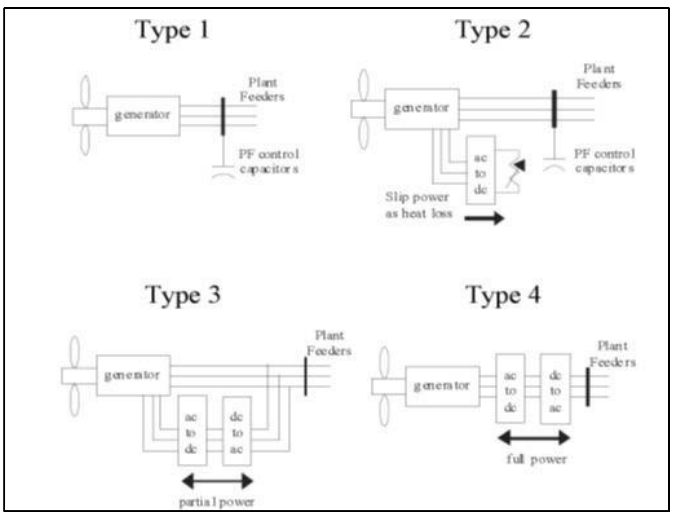
1. Latitude
2. Longitude
3. Turbine Power Curve
4. Elevation and orientation angles of arrays or concentrators
5. The generation capacity of the generating Facility
6. Distance above mean sea level etc.
7. COD details
8. Rated voltage
9. Details of Type of Mounting: (Tracking Technology if used, single axis or dual axis, auto or manual)
10. Manufacturer and modal (Of important components, such as Turbine, Concentrator Inverter, cable, PV module, transformer, cables)
11. DC installed Capacity
12. Module cell technology
13. I-V Characteristic of the Module
14. Inverter Rating at different temperature
15. Inverter Efficiency curve
16. Transformer Capacity & rating, evacuation, voltage, distance from injection point

Annexure-I(C): Guidelines for Exchange of data for RMS modelling (Generic) of Wind Generating Stations

1. Wind generation technologies:

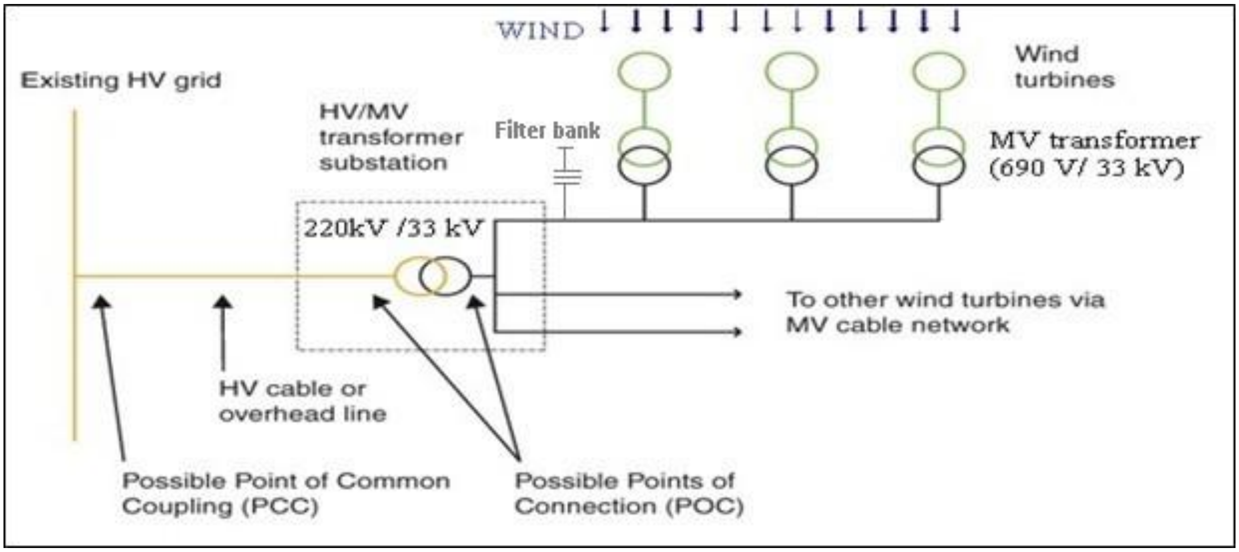
The majority of commercially available wind power plants use one of the wind turbine-generator (WTG) technologies listed below:

- Type-1 : Direct connected (Squirrel cage) induction generator (SCIG)
  - Fixed Speed stall control
  - Fixed Speed Active control
- Type-2 : Wound rotor induction generator (WRIG) with a variable resistor in the rotor circuit
- Type-3 : Doubly fed induction generator (DFIG) wind turbines ; Variable speed with rotor side converter
- Type-4 : Full converter wind turbine
  - Synchronous generator
  - Permanent Magnet Generator (PMG)



Wind energy plants are being increasingly coupled with complimentary Battery Energy Storage Systems (BESS) to reduce the variability of net power output from the renewable energy plant, provide higher output, or provide complimentary grid services such as frequency regulation. Modelling batteries / storage devices assume importance in such cases to capture the net impact of the plant on grid.

2. Models for Wind generators:

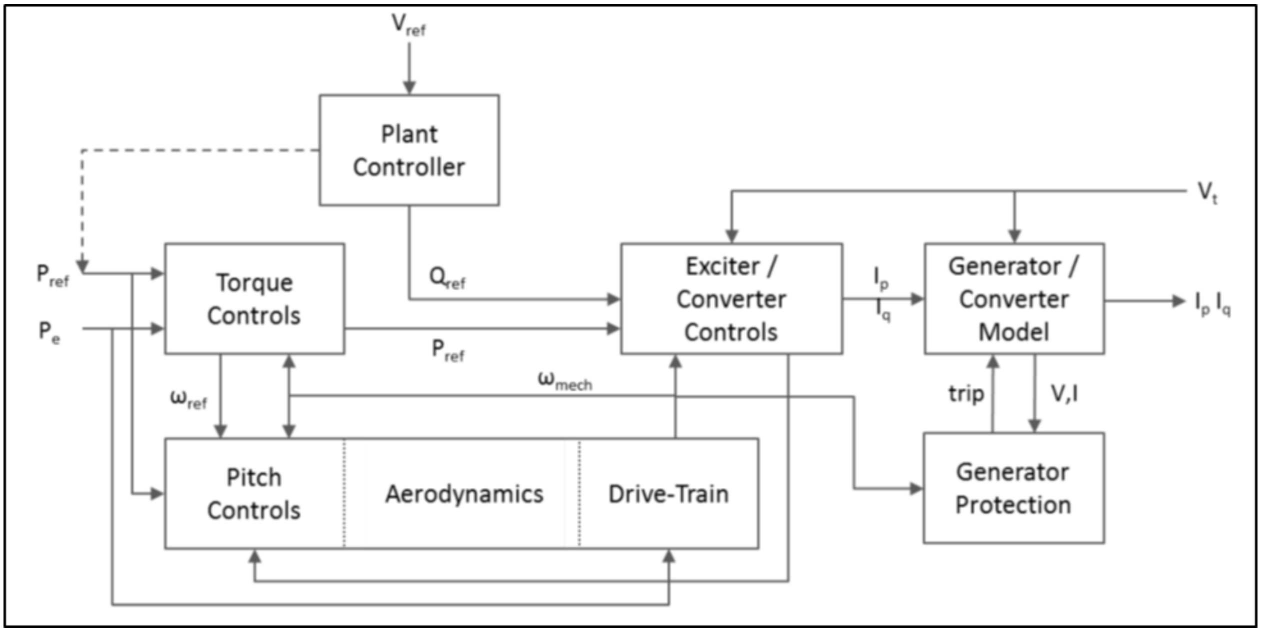


In a typical wind farm / park, individual WTGs (typically rated 3 MW or less) are connected in a system of twigs and feeders. Wind generation at around 660 V / 690 V is stepped up to a MV level of typically 33 kV in Indian system and finally pooled to grid at 220 kV / 400 kV through step-up transformers. A typical wind farm of 300 MW will be spread over an area of 600 acres, and power transmission within the farm is typically at 33 kV through overhead lines or underground cables. A Power Plant controllers (PPC) is usually installed at the point of interconnection to grid or at the reticulation system. The PPC(s) control behavior of wind farms in accordance with mandates as per grid codes.

The dynamic components of a wind farm consists of the following elements (illustrated in picture below):

1. Generator or Converter
2. Electrical control
3. Drive-Train model
4. Aerodynamics
5. Pitch controller
6. Torque controller
7. Power Plant Controller (PPC)
8. Energy storage (As applicable)

The components may or may not be present depending on the nature of technology used for wind power generation (i.e. type of turbine). Depending on the nature of technology, usage/configuration of components at site ('As built'), the requirements for steady state and dynamic modelling evolves.



3. Generic models in PSS/E for different technologies of Wind Turbines

Wind Turbine Type	Technology	Generic model	Model Description
Type-1	Direct connected (squirrel cage) induction generator (SCIG) a) Fixed Speed Stall Control b) Fixed Speed Active Control	WT1G1	Generator model (conventional induction generator)
		WT2T1	Drive train model (two-mass drive train model)
		wt1p_b	Pitch controller *(Use only for Type 1 with active stall)*
Type-2	Wound rotor induction generator (WRIG) with a variable resistor in the rotor circuit, and typically employs pitch control	WT2G1	Generator model (induction generator with external rotor resistance
		WT2E1	External resistance controller
		WT12T1	Drive train model
		wt1p_b (no equivalent in PSS/E)	Pitch controller
Type-3	Doubly fed induction generator (DFIG) wind turbines ; Variable speed with rotor side converter	REGCA1	Renewable energy generator converter model
		REECA1	Renewable energy controls model
		WTDTA1	Drive train model

Wind Turbine Type	Technology	Generic model	Model Description
		WTARA	Wind turbine aerodynamic model
		WTPTA1	Simplified pitch controller model
		WTTQA1	Wind generator torque control
		REPCTA1	Renewable energy plant controller
Type-4	Full converter wind turbine Generator types: a) Synchronous b) Permanent Magnet type	REGC	Renewable energy generator converter model
		REEC	Renewable energy controls model
		WTDTA1	Drive train model
		REPCA	Renewable energy plant controller
Storage	Utility Scale Battery Energy Storage System (BESS)	REECCU	Electrical Control Model (To be used along with REGCA1 and REPCA1)

4. Details of models in PSS/E for modelling Wind plants / farms / parks:

Category	Parameter Description	Data
Generator Nameplate	Connection point voltage (kV)	
	Terminal voltage (kV)	
	Wind Farm - Rated active power (sent out) in MW	
	Turbine – Rated MVA	
	Turbine – Rated active power (PMAX) in MW	
	Number of wind turbines (Type wise)	
Reactive power capability	Capability chart at connection point [If not available, then for each individual wind turbine, and mode of operation of Power Plant Controller]	-
	QMAX	
	QMIN	
Single Line Diagram	Single line diagram of the wind farm/park showing number and location of turbines, cable run, transformers, feeders (including type of cables and electrical R,X,B parameters), and connection to transmission system Preferable : Electrical Single Line Diagram including details between individual WTGs and b/w WTGs and aggregation points	
Wind Turbine Details	Manufacturer and product details (include Year of Manufacture)	
	Year of commissioning	
	Fixed speed or variable speed	
	Type of turbine: stall control, pitch control, active stall control, limited variable speed, variable speed with partial or full-scale frequency Converter	
	Hub height (in metre)	
	Rotor diameter (in metre)	
	Number of blades	
	Rotor speed (in rpm)	
	Gearbox ratio	
Generator	Type of generator: Type 1/ Type 2 / Type 3 / Type 4	
	Number of pole pairs	
	Stator resistance (in Ohms)	
	Rotor resistance (in Ohms)	
Speed control	Details of speed controller in wind turbine	
	Efficiency (Cp) curves	
	Cut-in wind speed	
	Wind speed at which full power is attained Cut-out wind speed	
	Pitch angle at low wind speed	

Category	Parameter Description	Data
Reticulation System	Voltage of the reticulation system	
	Number of feeders	
	Cable schedules (lengths, cable size, conductor material, rating info)	
Turbine Transformer	Details of the turbine transformer, including vector group, impedance, and number of taps, tap position, tap ratio	
	Nameplate details	
Wind-farm Step-up transformer	Details of the main wind farm step up transformer, including vector group, impedance, and tap position	
	Nameplate ; OLTC?	
	Controlled bus	
	Voltage setpoint	
	Dead band	
	Number of taps	
	Tap ratio range	
Connection Details	Voltage influence (maximum change etc)	
	Short circuit ratio (SCR)	
	· Min	
	· Max	
	Harmonic filters	
	STATCOM	
	Synchronous condensers	
	Battery Energy Storage System (if applicable)	
Power Plant Controller (PPC) Details	Does the wind farm have a PPC? If yes, whether PPC controls all or part of the WTGs in wind farm	
	What is the method of control – voltage regulation, power factor control, reactive power control?	
	Voltage control strategy (operating mode) - Controls MV Bus - Controls HV Bus - PF control - Q control - Voltage control	
	Is there a droop setting? - Voltage control - Frequency Control - Is there line drop compensation?	
	Is reactive power limited?	
	Temperature dependency	
	Active power ramp rate limiters	
	FRT protocols and setpoints - LVRT - HVRT	
	Provide settings from controller.	

5. Generic Models for Type-1 and Type-2 Wind turbine generators:

Description of some generic models available in PSS/E Library is provided below:

Category	Parameter Description	Data
GENERATOR model		
Generator : Type-1 (WT1G1)	Synchronous reactance (ohms or pu) Xs	
	Transient reactance (ohms or pu) X’	
	Wound rotor induction generator (WRIG) with a variable resistor in the rotor circuit, and typically employs pitch control	
	Leakage reactance, X_L	
	Saturation curve (E1, S(E1), E2, S(E2)	
Generator : Type-2 (WT2G1)	XA, stator reactance (pu)	
	Doubly fed induction generator (DFIG) wind turbines ; Variable speed with rotor side Converter	
	X1 rotor reactance (put)	
	R_Rot_Mach, rotor resistance (pu)	
	R_Rot_Max (sum of R_Rot_Mach + total external resistance) in pu	
	Saturation curve (E1, S(E1), E2, S(E2)	
	Power – slip curve (Top 5 points in the T-s curve)	
Electrical Control model		
Rotor Resistance Control : Type-2 (WT2E1)	TsP, rotor speed filter time constant, sec.	
	Tpe, power filter time constant, sec.	
	Ti, PI-controller integrator time constant, sec.	
	Kp, PI-controller proportional gain, pu	
	ROTRV_MAX, Output MAX limit	
	ROTRV_MIN, Output MIN limit	
Drive Train model		
Two-Mass Turbine Model for Type 1 and Type 2 Wind Generators : (WT12T1)	H, Total inertia constant, sec	
	DAMP, Machine damping factor, pu P/pu speed	
	Htfrac, Turbine inertia fraction (Hturb/H)1	
	Freq1, First shaft torsional resonant frequency, Hz	
	Dshaft, Shaft damping factor (pu)	

6. **Generic Models for Type-3 and Type-4 Wind turbine generators:**
Description of some generic models available in PSS/E Library is provided below:

Category	Parameter Description	Data
GENERATOR model		
Type-3 or Type-4 (REGCA1)	Tg, Converter time constant (s)	
	Rrpwr, Low Voltage Power Logic (LVPL) ramp rate limit (pu/s)	
	Wound rotor induction generator (WRIG) with a variable resistor in the rotor circuit, and typically employs pitch control	
	Zerox, LVPL characteristic voltage 1 (pu)	
	Lvpl1, LVPL gain (pu)	
	Volim, Voltage limit (pu) for high voltage reactive current manage-	
	Doubly fed induction generator (DFIG) wind turbines ; Variable speed with rotor side converter	
	Lvpnt1, High voltage point for low voltage active current manage-	
	ment (pu)	
	Lvpnt0, Low voltage point for low voltage active current manage-	
	ment (pu)	
	Iolim, Current limit (pu) for high voltage reactive current manage-	
	ment (specified as a negative value)	
	Tfltr, Voltage filter time constant for low voltage active current man-	
	agement (s)	
	Khv, Overvoltage compensation gain used in the high voltage reac-	
	tive current management	
	Iqrmax, Upper limit on rate of change for reactive current (pu)	
	Iqrmin, Lower limit on rate of change for reactive current (pu)	
	Accel, acceleration factor (0 < Accel <= 1)	
Electrical Control model		
Type-3 and Type-4 Wind turbines : (REECA1) [Refer Block Diagrams]	Vdip (pu), low voltage threshold to activate reactive current injection logic	
	Vup (pu), Voltage above which reactive current injection logic is activated	
	Trv (s), Voltage filter time constant	
	dbd1 (pu), Voltage error dead band lower threshold (≤0)	
	dbd2 (pu), Voltage error dead band upper threshold (≥0)	
	Kqv (pu), Reactive current injection gain during over and undervoltage conditions	
	Iqh1 (pu), Upper limit on reactive current injection Iqinj	
	Iql1 (pu), Lower limit on reactive current injection Iqinj	
	Vref0 (pu), User defined reference (if 0, model initializes it to initial terminal voltage)	
	Iqfrz (pu), Value at which Iqinj is held for Thld seconds following a voltage dip if Thld > 0	

Category	Parameter Description	Data
	Electrical Control model	
Type-3 and Type-4 Wind turbines : (REECA1) [Refer Block Diagrams]	Thld (s), Time for which Iqinj is held at Iqfrz after voltage dip returns to zero (see Note 1)	
	Thld2 (s) (≥0), Time for which the active current limit (IPMAX) is held at the faulted value after voltage dip returns to zero	
	Tp (s), Filter time constant for electrical power	
	QMax (pu), limit for reactive power regulator	
	QMin (pu) limit for reactive power regulator	
	VMAX (pu), Max. limit for voltage control	
	VMIN (pu), Min. limit for voltage control	
	Kqp (pu), Reactive power regulator proportional gain	
	Kqi (pu), Reactive power regulator integral gain	
	Kvp (pu), Voltage regulator proportional gain	
	Kvi (pu), Voltage regulator integral gain	
	Vbias (pu), User-defined bias (normally 0)	
	Tiq (s), Time constant on delay s4	
	dPmax (pu/s) (>0) Power reference max. ramp rate	
	dPmin (pu/s) (<0) Power reference min. ramp rate	
	PMAX (pu), Max. power limit	
	PMIN (pu), Min. power limit	
	Imax (pu), Maximum limit on total converter current	
	Tpord (s), Power filter time constant	
	VQ-IQ characteristic (at least two pairs, up to 4 pairs of voltage and current in pu)	
	VP-IP characteristic (at least two pairs, up to 4 pairs, of voltage and current in pu)	[Refer Block Diagrams]
	Is turbine in PF control or Q control (including controlled by external signal)?	
	Is the turbine controlling voltage (directly, not than through PPC)?	
	If controlling voltage directly what bus does it control?	
	Is the turbine in P or Q priority mode?	
	Drive Train model	
	H, Total inertia constant, sec	
	DAMP, Machine damping factor, pu P/pu speed	
	Htfrac, Turbine inertia fraction (Hturb/H)1	
	Freq1, First shaft torsional resonant frequency, Hz	
	Dshaft, Shaft damping factor (pu)	

Category	Parameter Description	Data
Pitch Control model [for Type-3 only]		
Generic Pitch Control model for Type-3 : (WTPA1)	Kiw, Pitch-control Integral Gain (pu)	
	Kpw, Pitch-control proportional gain (pu)	
	Kic, Pitch-compensation integral gain (pu)	
	Kpc, Pitch-compensation proportional gain (pu)	
	Kcc, Gain (pu)	
	Tp, Blade response time constant (s)	
	TetaMax, Maximum pitch angle (degrees)	
	TetaMin, Minimum pitch angle (degrees)	
	RTetaMax, Maximum pitch angle rate (degrees/s)	
	RTetaMin, Minimum pitch angle rate (degrees/s) (< 0)	
Aerodynamic model [For Type-3 only]		
(WTARA1)	Ka, Aerodynamic gain factor (pu/degrees)	
	Theta 0 Initial pitch angle (degrees)	
Torque Controller model [For Type-3 only]		
Generic Torque Controller for Type-3 wind machines : (WTTQA1)	Kpp, Proportional gain in torque regulator (pu)	
	KIP, Integrator gain in torque regulator (pu)	
	Tp, Electrical power filter time constant (s)	
	Twref, Speed-reference time constant (s)	
	Temax, Max limit in torque regulator (pu)	
	Temin, Min limit in torque regulator (pu)	
	p1, power (pu)	
	spd1, shaft speed for power p1 (pu)	
	p2, power (pu)	
	spd2, shaft speed for power p2 (pu)	
	p3, power (pu)	
	spd3, shaft speed for power p3 (pu)	
	p4, power (pu)	
	spd4, shaft speed for power p3 (pu)	
	TRATE, Total turbine rating (MW)	

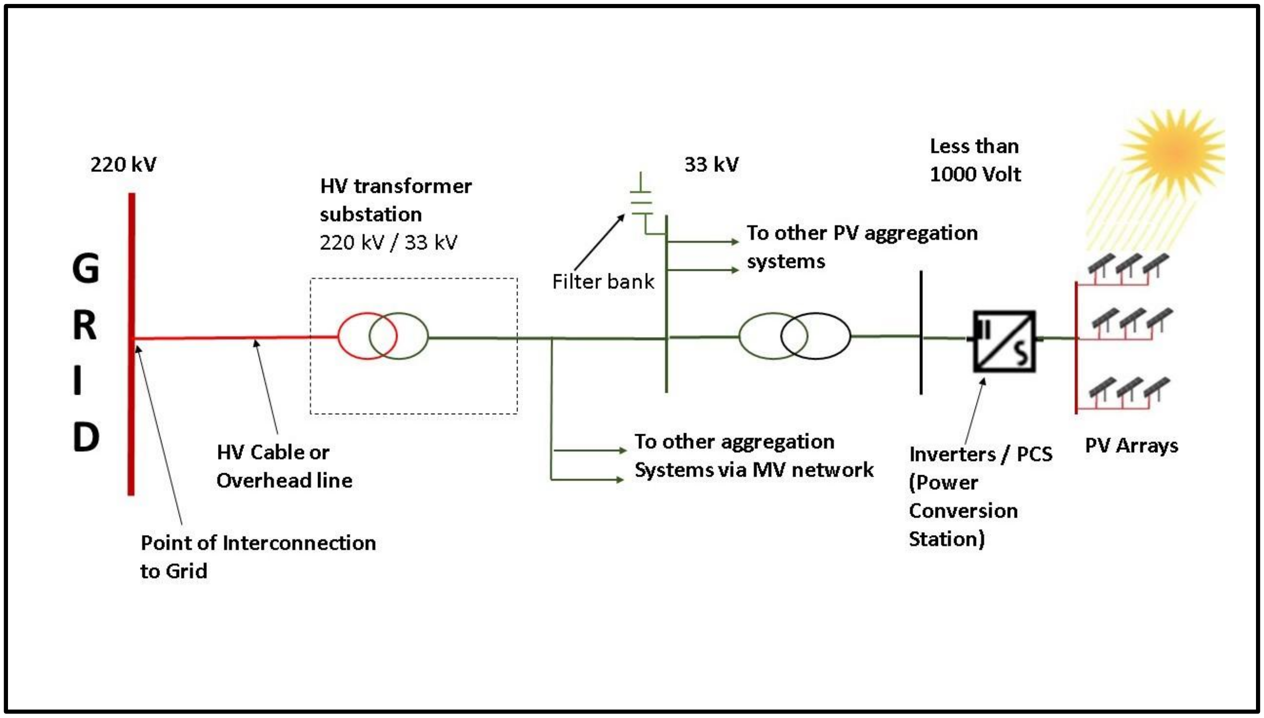
Category	Parameter Description	Data
Power Plant Controller (PPC) model		
Generic Power Plant Controller (PPC) model for Type-3 and Type-4 wind turbines : REPCTA1 for type 3, and REPCA1 for type 4 turbines	Tfltr, Voltage or reactive power measurement filter time constant (s)	
	Kp, Reactive power PI control proportional gain (pu)	
	Ki, Reactive power PI control integral gain (pu)	
	Tft, Lead time constant (s)	
	Tfv, Lag time constant (s)	
	Vfrz, Voltage below which State s2 is frozen (pu)	
	Rc, Line drop compensation resistance (pu)	
	Xc, Line drop compensation reactance (pu)	
	Kc, Reactive current compensation gain (pu)	
	emax, upper limit on deadband output (pu)	
	emin, lower limit on deadband output (pu)	
	dbd1, lower threshold for reactive power control deadband (<=0)	
	dbd2, upper threshold for reactive power control deadband (>=0)	
	Qmax, Upper limit on output of V/Q control (pu)	
	Qmin, Lower limit on output of V/Q control (pu)	
	Kpg, Proportional gain for power control (pu)	
	Kig, Proportional gain for power control (pu)	
	Tp, Real power measurement filter time constant (s)	
	fdbd1, Deadband for frequency control, lower threshold (<=0)	
	Fdbd2, Deadband for frequency control, upper threshold (>=0)	
	femax, frequency error upper limit (pu)	
	femin, frequency error lower limit (pu)	
	Pmax, upper limit on power reference (pu)	
	Pmin, lower limit on power reference (pu)	
	Tg, Power Controller lag time constant (s)	
	Ddn, droop for over-frequency conditions (pu)	
	Dup, droop for under-frequency conditions (pu)	

Category	Parameter Description	Data
Electrical Control model : BESS		
Generic Electrical Control model for Utility Scale BESS: (REECCU1)	Vdip (pu), low voltage threshold to activate reactive current injection logic	
	Vup (pu), Voltage above which reactive current injection logic is activated	
	Trv (s), Voltage filter time constant	
	dbd1 (pu), Voltage error dead band lower threshold (≤0)	
	dbd2 (pu), Voltage error dead band upper threshold (≥0)	
	Kqv (pu), Reactive current injection gain during over and undervoltage conditions	
	Iqh1 (pu), Upper limit on reactive current injection Iqinj	
	Iql1 (pu), Lower limit on reactive current injection Iqinj	
	Vref0 (pu), User defined reference (if 0, model initializes it to initial terminal voltage)	
	Tp (s), Filter time constant for electrical power	
	QMax (pu), limit for reactive power regulator	
	QMin (pu) limit for reactive power regulator	
	VMAX (pu), Max. limit for voltage control	
	VMIN (pu), Min. limit for voltage control	
	Kqp (pu), Reactive power regulator proportional gain	
	Kqi (pu), Reactive power regulator integral gain	
	Kvp (pu), Voltage regulator proportional gain	
	Kvi (pu), Voltage regulator integral gain	
	Tiq (s), Time constant on delay s4	
	dPmax (pu/s) (>0) Power reference max. ramp rate	
	dPmin (pu/s) (<0) Power reference min. ramp rate	
	PMAX (pu), Max. power limit	
	PMIN (pu), Min. power limit	
	Imax (pu), Maximum limit on total converter current	
	Tpord (s), Power filter time constant	
	Vq and Iq curve (Reactive Power V-I pair in p.u.) : 4 points	
	Vp and Ip curve (Active Power V-I pair in p.u.) : 4 points	
	T, battery discharge time (s) (<0)	
	SOCini (pu), Initial state of charge	
	SOCmax (pu), Maximum allowable state of charge	
	SOCmin (pu), Minimum allowable state of charge	

Note: SOCini represents the initial state of charge on the battery and is a user entered value. This is entered in pu; with 1 pu meaning that the batter is fully charged and 0 means the battery is completely discharged

Annexure-I(D): Guidelines for Exchange of data for RMS modelling (Generic) of Solar Generating Stations

1. Models for Utility scale Solar generation farms:



In a typical utility scale solar farm / park, arrays of Solar PV panels connected to an inverter (Power Conditioning System / Power Conversion Station – PCS), which is stepped up to form part of the MV reticulation system (typically at 33 kV or less). A number of inverters are pooled and then stepped up to the voltage of 220 kV / 400 kV prior to connection to EHV grid. A Power Plant controllers (PPC) is usually installed at the point of interconnection to grid or the reticulation system. The PPC(s) control behavior of solar farms in accordance with mandates as per grid codes.

The dynamic components of a solar farm or park consists of the following elements (illustrated in picture below):

1. Generator or Converter
2. Electrical control including fault ride through
3. Power Plant Controller (PPC)
4. Energy storage (i.e. battery), if applicable

Depending on the nature of technology and usage of components at site ('As built'), the requirements for steady state and dynamic modelling evolves.

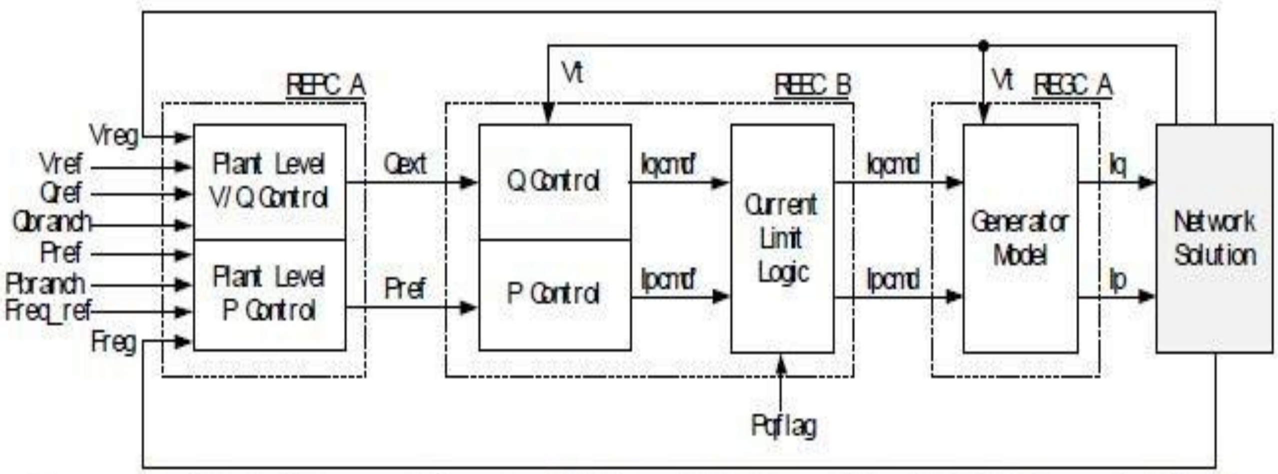


Figure 4 – Block Diagram Showing Different Modules of the WECC Generic Models

2. Generic models in PSS/E for modelling utility scale Solar PV and BESS installations:

Solar Technology	Generic model	Model Description
Utility Scale Solar PV	REGC	Renewable energy generator converter model
	REEC	Renewable energy controls model
	REPC	Renewable energy plant controller
Utility Scale Battery Energy Storage System (BESS)	REECCU	Electrical Control Model (To be used alongwith REGCA1 and REPCA1)

3. Details of models in PSS/E for modelling Solar plants / farms / parks:

Category	Parameter Description	Data
Inverter Details	Manufacturer, model number and product details	
	Year of commissioning	
	As found settings (obtained either from HMI or downloaded from controller in digital systems)	
Technology	• Grid following • Grid forming (viz. Assist in regulation of Voltage and Frequency) • Reactive power priority (Controls Pf or Voltage? Point of control?)	-
Single Line Diagram	Single line diagram of the solar farm showing number and location of inverters and PV arrays behind each inverter, cable run, transformers, feeders (including type of cables and electrical R,X,B parameters), and connection to transmission system Preferable : Electrical Single Line Diagram including details between PV-array to Inverters, Inverters to MV reticulation system, MV reticulation system till Point of Interconnection (POI) at EHV level (220 kV/400 kV)	
Capability	DC/AC ratio	
	Number of inverters	
	Panel type	
	Number of modules per string	
	Tracking in 0/1/2 axes	
	Capability diagram at nominal (STC) and typical temperature	
Controls	Does the solar farm have a PPC? If yes, whether PPC controls all or part of the inverters in Solar farm	
	What is the method of control – voltage regulation, power factor control, reactive power control?	
	Voltage control strategy (operating mode) • Controls MV bus • Controls HV bus • PF control • Q control	
	Is there a droop setting? • Voltage control • Frequency control	
	Is reactive power limited? Details thereof	
	Is active power limited below MPPT at high output? Details thereof	
	Temperature dependency details	
	Active power ramp rate limiters	
	Fault Ride Through (FRT) protocols and setpoints • LVRT • HVRT	
	Provide settings from controller	

Category	Parameter Description	Data
Reticulation System	Voltage of the reticulation system	
	Number of feeders	
	Cable schedules (lengths, cable size, conductor material, rating info)	
Inverter station transformer	Details of the turbine transformer, including vector group, impedance, and number of taps, tap position, tap ratio	
	Nameplate details	
Solar Farm step-up transformer	Details of the main solar farm step up transformer, including vector group, impedance, and tap position	
	Nameplate ; OLTC?	
	Controlled bus	
	Voltage setpoint	
	Dead band	
	Number of taps	
	Tap ratio range	
Connection Details	Voltage influence (maximum change etc)	
	Short circuit ratio (SCR)	
	· Min	
	· Max	
	Harmonic filters	
	STATCOM	
	Synchronous condensers	
	Battery Energy Storage System (if applicable)	
Power Plant Controller (PPC) Details	Does the solar farm have a PPC? If yes, whether PPC controls all or part of the inverters in solar farm	
	What is the method of control – voltage regulation, power factor control, reactive power control?	
	Voltage control strategy (operating mode) - Controls MV Bus - Controls HV Bus - PF control - Q control - Voltage control	
	Is there a droop setting? - Voltage control - Frequency Control - Is there line drop compensation?	
	Is reactive power limited?	
	Temperature dependency	
	Active power ramp rate limiters	
	FRT protocols and setpoints - LVRT - HVRT	
	Provide settings from controller.	

4. Generic Models for Utility Scale Solar-PV generation

Description of some generic models available in PSS/E Library are provided below:

Category	Parameter Description	Data
GENERATOR model		
Solar PV (REGCA 1)	Tg, Converter time constant (s)	
	Rrpwr, Low Voltage Power Logic (LVPL) ramp rate limit (pu/s)	
	Brkpt, LVPL characteristic voltage 2 (pu)	
	Zerox, LVPL characteristic voltage 1 (pu)	
	Lvpl1, LVPL gain (pu)	
	Volim, Voltage limit (pu) for high voltage reactive current manage-	
	Lvpnt1, High voltage point for low voltage active current management (pu)	
	Lvpnt0, Low voltage point for low voltage active current management (pu)	
	Iolim, Current limit (pu) for high voltage reactive current management (specified as a negative value)	
	Tfltr, Voltage filter time constant for low voltage active current management (s)-	
	Khv, Overvoltage compensation gain used in the high voltage reactive current management	
	Iqrmax, Upper limit on rate of change for reactive current (pu)	
	Iqrmin, Lower limit on rate of change for reactive current (pu)	
	Accel, acceleration factor (0 < Accel <= 1)	
Electrical Control model		
Large Solar PV : (REECB1) [Refer Block Diagrams]	Vdip (pu), low voltage threshold to activate reactive current injection logic	
	Vup (pu), Voltage above which reactive current injection logic is activated	
	Trv (s), Voltage filter time constant	
	dbd1 (pu), Voltage error dead band lower threshold (≤0)	
	dbd2 (pu), Voltage error dead band upper threshold (≥0)	
	Kqv (pu), Reactive current injection gain during over and undervoltage conditions	
	Iqh1 (pu), Upper limit on reactive current injection Iqinj	
	Iql1 (pu), Lower limit on reactive current injection Iqinj	
	Vref0 (pu), User defined reference (if 0, model initializes it to initial terminal voltage)	
	Tp (s), Filter time constant for electrical power	

Category	Parameter Description	Data
Electrical Control model		
Large Solar PV : (REECB1) [Refer Block Diagrams]	QMax (pu), limit for reactive power regulator	
	QMin (pu) limit for reactive power regulator	
	VMAX (pu), Max. limit for voltage control	
	VMIN (pu), Min. limit for voltage control	
	Kqp (pu), Reactive power regulator proportional gain	
	Kqi (pu), Reactive power regulator integral gain	
	Kvp (pu), Voltage regulator proportional gain	
	Kvi (pu), Voltage regulator integral gain	
	Tiq (s), Time constant on delay s4	
	dPmax (pu/s) (>0) Power reference max. ramp rate	
	dPmin (pu/s) (<0) Power reference min. ramp rate	
	PMAX (pu), Max. power limit	
	PMIN (pu), Min. power limit	
	Imax (pu), Maximum limit on total converter current	
	Tpord (s), Power filter time constant	

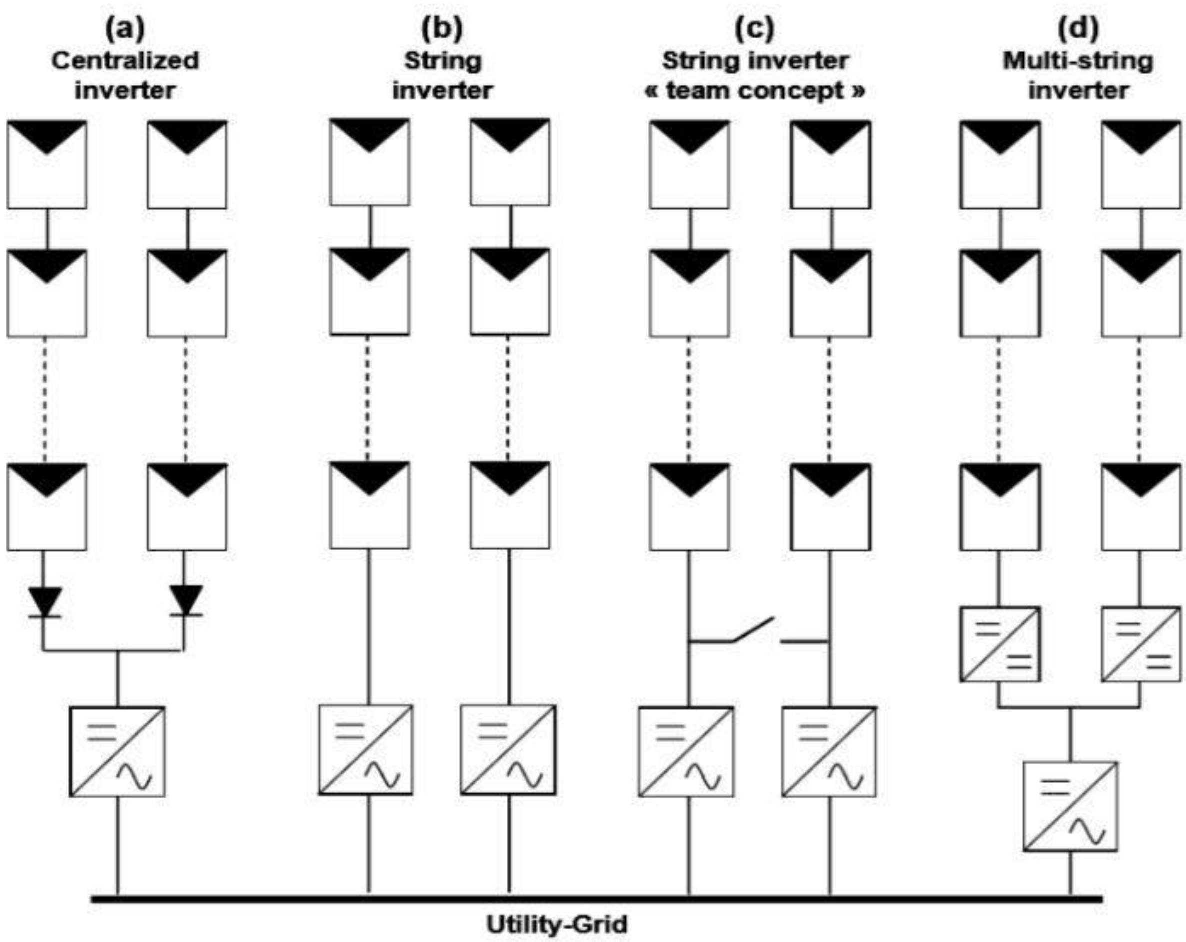
Category	Parameter Description	Data
Power Plant Controller (PPC) model		
Generic Power Plant Controller (PPC) model: (REPCA1)	Tfltr, Voltage or reactive power measurement filter time constant (s)	
	Kp, Reactive power PI control proportional gain (pu)	
	Ki, Reactive power PI control integral gain (pu)	
	Tft, Lead time constant (s)	
	Tfv, Lag time constant (s)	
	Vfrz, Voltage below which State s2 is frozen (pu)	
	Rc, Line drop compensation resistance (pu)	
	Xc, Line drop compensation reactance (pu)	
	Kc, Reactive current compensation gain (pu)	
	emax, upper limit on deadband output (pu)	
	emin, lower limit on deadband output (pu)	
	dbd1, lower threshold for reactive power control deadband (<=0)	
	dbd2, upper threshold for reactive power control deadband (>=0)	
	Qmax, Upper limit on output of V/Q control (pu)	
	Qmin, Lower limit on output of V/Q control (pu)	
	Kpg, Proportional gain for power control (pu)	
	Kig, Proportional gain for power control (pu)	
	Tp, Real power measurement filter time constant (s)	
	fdbd1, Deadband for frequency control, lower threshold (<=0)	
	Fdbd2, Deadband for frequency control, upper threshold (>=0)	
	femax, frequency error upper limit (pu)	
	femin, frequency error lower limit (pu)	
	Pmax, upper limit on power reference (pu)	
	Pmin, lower limit on power reference (pu)	
	Tg, Power Controller lag time constant (s)	
	Ddn, droop for over-frequency conditions (pu)	
	Dup, droop for under-frequency conditions (pu)	

Category	Parameter Description	Data
Electrical Control model : BESS		
Generic Electrical Control model for Utility Scale BESS: (REECCU1)	Vdip (pu), low voltage threshold to activate reactive current injection logic	
	Vup (pu), Voltage above which reactive current injection logic is activated	
	Trv (s), Voltage filter time constant	
	dbd1 (pu), Voltage error dead band lower threshold (≤0)	
	dbd2 (pu), Voltage error dead band upper threshold (≥0)	
	Kqv (pu), Reactive current injection gain during over and undervoltage conditions	
	Iqh1 (pu), Upper limit on reactive current injection Iqinj	
	Iql1 (pu), Lower limit on reactive current injection Iqinj	
	Vref0 (pu), User defined reference (if 0, model initializes it to initial terminal voltage)	
	Tp (s), Filter time constant for electrical power	
	QMax (pu), limit for reactive power regulator	
	QMin (pu) limit for reactive power regulator	
	VMAX (pu), Max. limit for voltage control	
	VMIN (pu), Min. limit for voltage control	
	Kqp (pu), Reactive power regulator proportional gain	
	Kqi (pu), Reactive power regulator integral gain	
	Kvp (pu), Voltage regulator proportional gain	
	Kvi (pu), Voltage regulator integral gain	
	Tiq (s), Time constant on delay s4	
	dPmax (pu/s) (>0) Power reference max. ramp rate	
	dPmin (pu/s) (<0) Power reference min. ramp rate	
	PMAX (pu), Max. power limit	
	PMIN (pu), Min. power limit	
	Imax (pu), Maximum limit on total converter current	
	Tpord (s), Power filter time constant	
	Vq and Iq curve (Reactive Power V-I pair in p.u.) : 4 points	
	Vp and Ip curve (Active Power V-I pair in p.u.) : 4 points	
	T, battery discharge time (s) (<0)	
	SOCini (pu), Initial state of charge	
	SOCmax (pu), Maximum allowable state of charge	
	SOCmin (pu), Minimum allowable state of charge	

Note: SOCini represents the initial state of charge on the battery and is a user entered value. This is entered in pu; with 1 pu meaning that the batter is fully charged and 0 means the battery is completely discharged

Inverter Configurations:

Inverters within a Solar farm can be present in different configurations, as indicated below:



The data furnished must take into account the individual inverter configurations accordingly.

Annexure-I (E): Template for Technical Details and Simulation Report Guidelines

Document Revision History

Revision No.	Release Date	Prepared By*	Checked/Issued by*	Changes

**Mention organisation name, designation & contact details*

1) General Information

Name of the RE/BESS[1] plant : …………………………………………………………………..

RE/BESS Plant Capacity : …………………………………………………………………..

In-STS Connectivity Point (POI[2] Bus) Name : …………………………………………………………………..

Type of RE Plant (Wind, Solar, Hybrid, BESS) : …………………………………………………………………..

Name of RE plant Developer : …………………………………………………………………..

Name of the Consultant for Simulation Study : …………………………………………………………………..

Ambient Temperature Considered in Study : …………………………………………………………………..

Short circuit ratio (SCR) considered in Study : …………………………………………………………………..

Whether Study is Complete or Partial : …………………………………………………………………..

Part A: Plant Technical Details

2) Technical Details

i) **IBR[3] unit details for each make-**

Table 1: Details of IBR units in the plant

IBR Unit Details	
IBR unit type (WTG or Inverter)	
Model & Make	
No of IBR units	
Terminal Voltage	
Rated MVA	
Rated power (MW)	
Source Impedance (R, X[4])*	
Ambient temperature	
Qmax & Qmin limits (MVAR)	

**pu values on machine MVA base or %. Add columns in same table for different make IBR units in the plant.*

Include IBR unit (s) technical datasheets. Power curve, Derating curve, PQ capability curve at 0.95 pu, 1 pu & 1.05 pu voltage level & ambient temperature considered in the study.

[1] BESS- Battery Energy Storage System
[2] POI- Point of Interconnection – means a point on the grid, including a sub-station or a switchyard, where the interconnection is established between the facility of the requester and the grid
[3] IBR-Inverter based resource. An IBR unit can be the single solar inverter, single WTG or single BESS inverter.
[4] NERC's (North American Electric Reliability Corporation) following guidelines (page-36) may be referred for short circuit modelling guidelines
https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Reliability_Guideline_IBR_Interconnection_Requirements_Improvements.pdf#search=Reliability%5FGuideline%5FIBR%5FInterconnection%5FRequirements%5FImprovements%2Epdf

ii) **IBR unit transformer details-**

Table 2 Details of IBR transformers in the plant

IBR Unit Transformer Details	
Rating (MVA)	
Type (...........) of cooling	
Voltage Ratio (HV to LV)	
Vector Group	
Tap changer (OLTC* or other)	
Tap changer in LV side or HV side	
Total Number of taps	
Nominal Tap position	
Current Tap Position	
Impedances (r, x) in %	
Short circuit Impedance (r_0 , x_0)	
Whether IBR transformer is the part of IBR unit or separate?	

**OLTC-Online tap changing*

Include transformer data sheet and nameplate.

iii) **Power Transformer Details-**

Table 3 Details of Power transformers in the IBR plant

Power Transformer Details	
Rating (in MVA)	
Type	
Ratio (HV to LV)	
Vector Group	
Tap changer	
Tap changer (OLTC or other)	
Tap changer in LV side or HV side	
Total Number of taps	
Nominal Tap position	
Considered Tap Position	
Impedances (r,x) in %	
Short circuit Impedance (r_0 , x_0) in %	
Over load capacity (Loading at 110%, 120%, 130%, 140% & 150% with time) to be provided else include Overload capability in MVA vs time Curve	

Include transformer data sheet and nameplate.

iv) **Conductor/Cable details-**

Table 4 Details of Collector system/reticulation system & EHV line details

Voltage (kV)	From Bus	To Bus	Ckt ID	Length (kM)	Conductor Type	Positive*			Zero*			Ampacity (In Ampere, with specified AT & CT) **	MVA Rating
						r_1	x_1	b_1	r_0	x_0	b_0		

**Positive & Zero Sequence impedance values in pu/ckt/km, **AT- Ambient temperature, CT-Conductor temperature.*

v) **Single line diagram (SLD) of the plant**

Single line diagram of the IBR plant showing number and location of IBR units, cable run, transformers, feeders (including type of cables and lengths), and connection to transmission system. Preferable: Electrical Single Line Diagram including details between individual IBR units and b/w IBR units and aggregation points. Include as Annexure.

vi) **Power Plant Controller (PPC) Details-**

Whether Only Master or Master with Slave PPC Configuration: Specify whether the plant having single or multiple PPC, If multiple PPCs then specify the details of master & slave PPC as below-

Master PPC OEM :
Master PPC Manual[5] :
Slave PPC-1 OEM (if applicable) :
Slave PPC-1 Manual :
Slave PPC-2 OEM (if applicable) :
Slave PPC-2 Manual :
Similarly specify for all the slave PPCs.
Specify Master PPC Control modes – Active, Reactive, frequency etc.
Specify the bus name/feeders where input to master PPC is taken for Voltage, Current, P, Q & frequency.
Specify the sampling rate of PPC input parameters measurement :
Specify whether line drop compensation is available in master PPC (Yes/No) : (whether it compensates collector system loss only or also includes EHV line loss)
Communication diagram for master/slave PPC control.

[5] Manual shall at least consist of PPC architecture, control strategies (voltage control, power factor, Q control & associated curves), configurable control & parameters, technical specification among other details

Part B: Simulation Model and Study Report Details

3) **Wind/Solar/BESS/Hybrid Plant Simulation Models and Supporting Files:** The simulation study report shall include the RMS & EMT model file names, supporting files, model setup procedure, model user guide, RMS & EMT software version, compiler version etc.

Type of Model	Description	File Names
RMS (Root Mean Square)	**IBR Unit Model**	
	Detailed Plant Model (including PPC model)	
	Equivalent[6] Plant Model (including PPC model)	
EMT (Electro Magnetic Transient)	**IBR Unit Model**	
	Equivalent Plant Model (including PPC model)	
	Power Quality Assessment Model	

Case preparation: Ensure line lengths, line & transformer rating (Rate-1 SIL, Rate-2 Thermal, Rate-3 110% of Thermal), short circuit parameters, Qmax & Qmin limits are updated in the model. Further, actual IBR unit bus name shall be same as OEM of the machine. Include **100 sec** flat run plot for P, Q, V at POI.

4) **Simulation results showing the comparison of detailed plant model and equivalent model of the Wind/Solar farm/BESS/Hybrid - (Requirement is only for RMS model)**

a) Steady state comparison of P, Q, V, I to be included at **POI**
b) Detailed v/s Equivalent model response comparison of P, Q, V & I at POI to be demonstrated for different tests like P control, Q control, Voltage control, LVRT, HVRT, frequency response control operation etc.

The error between the detailed v/s equivalent model response shall be within a tolerance band as specified by SLDC. Suitable measures shall be taken to minimized the error.

[6] **Recommended procedure for calculating the equivalent collector impedance -** E. Muljadi, S. Pasupulati, A. Ellis, D. Kosterev, "Method of Equivalencing for a Large Wind Power Plant with Multiple Turbine Representation", presented at the IEEE Power Engineering Society, General Meeting, Pittsburgh, PA, July 20-24, 2008.

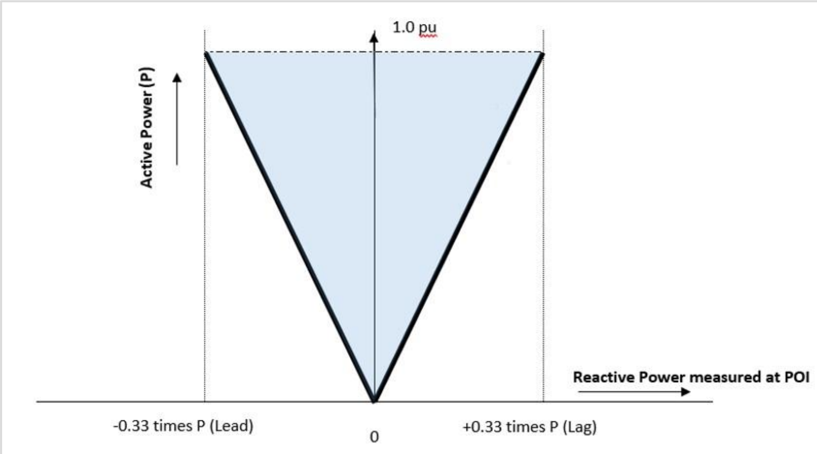
Annexure-I (F) may also be referred for single generator equivalent model configuration.

5) PQ Reactive Capability Curve plot of Wind/Solar Farm/BESS/Hybrid at POI -

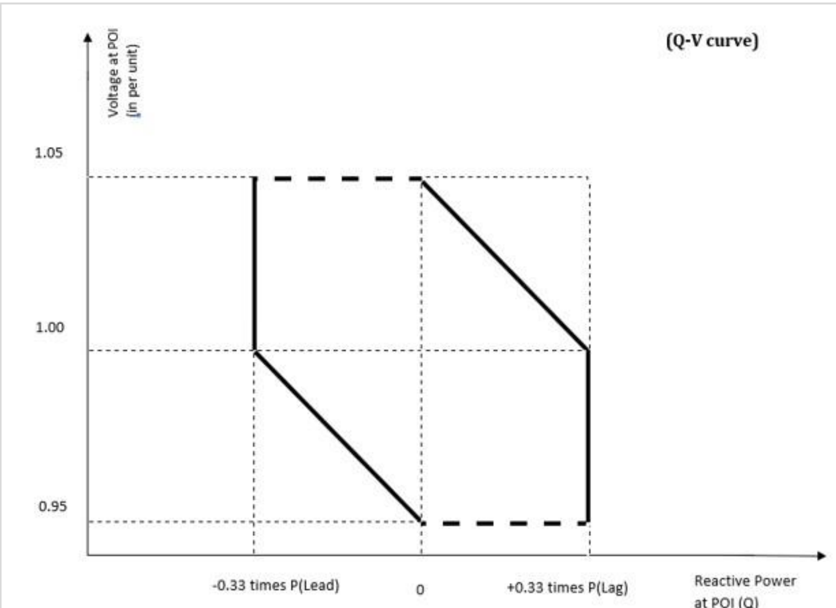
a) Simulation study results/plots demonstrating PQ capability of the plant at **POI** for **0.95 pu, 1 pu & 1.05 pu voltage at POI** (factoring in specified ambient temperature) shall be included for following cases:

- Without any additional reactive power compensation[7]
- With additional reactive power compensation (if required for compliance of reactive power capability at POI)
  The study shall be carried out on both **detailed RMS and equivalent EMT model.**

- Generating station shall be able to deliver rated output at **POI** (at specified ambient temperature) for the above-mentioned conditions at least up to the capability shown in the PQ curve below:



- The voltage dependence of reactive power capability of RE Generator shall be governed as per the QV curve shown below:



7 **Additional dynamic Reactive Power Compensation devices** may include FACTS devices like STATCOMs additional inverter,SVG or any combination of such devices

- For all cases, the report shall include details of both active and reactive power exchange by generation pooling station with the grid at **point of interconnection (POI).**

6) Short circuit study results for 3-phase/ single phase fault at POI -
The short circuit contribution from the plant for different fault conditions **at POI** shall be tabulated.

7) Below mentioned tests shall be performed:

a) Power Quality[8] - The power quality study results **(at POI)** for the following shall be included:

i) Harmonics
ii) DC Current injection
iii) Flicker

b) LVRT Test - Plot of P, Q, Vac, Iac at POI and Plot of P, Q, Vac, Iac, Id, Iq, Vd,Vq at IBR terminal (for any one IBR of each make) shall be included for:

i) Case-1: 3-ph impedance fault at POI for 3 sec for voltage of 0.85 pu during fault
ii) Case-2: 3-ph impedance fault at POI for 1.65 sec for voltage of 0.5 pu during fault
iii) Case-3: 3-ph impedance fault at POI for 300 msec for voltage of 0.15 pu during fault
iv) Case-4: 1-ph fault at POI for 3 sec for voltage of 0.85 pu during fault
v) Case-5: 1-ph fault at POI for 1.65 sec for voltage of 0.5 pu during fault
vi) Case-6: 1-ph fault at POI for 300 msec for voltage of 0.15 pu during fault

- Above cases shall be simulated for **both full (100%) and partial (25% and 50%) active power dispatch.**
- Id, Iq, Vd and Vq are IBR output current and voltage along with reference in d-q frame. To be provided only in case of EMT model response.

- **LVRT settings** (including "K" factor), Response Time (ms) shall be mentioned in the study results.
- **Suitable margin** shall be incorporated in inverter level settings (through line drop compensation studies) to enable LVRT operation at specified voltage at POI.

c) HVRT Test - Plot of P, Q, Vac, Iac at POI and Plot of P, Q, Vac, Iac, Id, Iq, Vd,Vq at IBR terminal (for any one IBR of each make) shall be included for:

i) Case-1: 3-Phase voltage rise at POI is up to 1.2 pu for 2 sec
ii) Case-2: 3-Phase voltage rise at POI is up to 1.3 pu for 200 msec
iii) Case-3: 1-ph voltage rise at POI is up to 1.2 pu for 2 sec
iv) Case-4: 1-ph voltage rise at POI is up to 1.3 pu for 200 msec

- Above cases shall be simulated for **both full (100%) and partial (25% and 50%) active power dispatch.**
- Id, Iq, Vd and Vq are IBR output current and voltage along with reference in d-q frame. To be provided only in case of EMT model response.

- **HVRT settings** (including "K" factor), Response Time (ms) shall be mentioned in the study results.

[8] Power quality study is required to be carried out either in Detailed EMT model or in Power Quality Assessment model

- **Suitable margin** shall be incorporated in inverter level settings (through line drop compensation studies) to enable HVRT operation at specified voltage at **POI**.
- The Protection settings of 33 kV feeders, Generator PS & Dedicated Trans. Line shall be coordinated to enable HVRT compliance at **POI**. Same shall also be specified in the study results.

d) Operating Frequency Range [Frequency control flag (F_{flag}) set 0 in PPC model]

i) Case -1: Rated Active Power Generation in the frequency range of 49.5 – 50.5 Hz.

Plots of P, Q, V, f at **POI** demonstrating the ability of the plant to deliver rated active power in the frequency range of 49.5 – 50.5 Hz shall be included.

ii) Case -2: Capability to operate (stable operation) in the frequency range of 47.5 – 52 Hz.
Plot of P, Q, V, f at **POI** demonstrating the ability of the plant to operate in the frequency range of 47.5 to 52 Hz shall be included.

PPC control parameter setting shall also be specified for the above cases.

e) Frequency Response Test – Perform frequency response test with dead band of **±0.03 Hz** and droop of **both 3% and 6%** for the following cases:

i) Case-1: Step change/increase in grid frequency from 50 Hz to 50.5 Hz
ii) Case-2: Step change/decrease in grid frequency from 50 Hz to 49.5 Hz

Above cases shall be conducted for active power output of **10%, 50% and 100%** of rated active

power. PPC settings & plots of P, Q, V, f at POI shall be included for above mentioned cases.

f) Dynamic Reactive Power Support (DPRS) at POI - Perform dynamic reactive power test for the following control modes and cases:

i) Voltage Control Mode - Perform test for dead band & droop of 2%
   a) Case-1: Step increase in Voltage at **POI** from 1 pu to 1.05 pu
   b) Case-2: Step decrease in Voltage at **POI** from 1 pu to 0.95 pu

ii) Q Control Mode
   a) Case-1: Step change in Reactive Power (Q) injection at **POI** from 0 to 16.5% and subsequently to 33% of Active Power Output (P)
   b) Case-2: Step change in Reactive Power (Q) absorption at **POI** from 0 to 16.5% and subsequently to 33% of Active Power Output (P)

iii) Power factor control mode-
   a) Case-1: Step change in Power factor at **POI** from unity to +0.98 pf and subsequently to +0.95pf
   b) Case-2: Step change in Power factor at **POI** from unity to -0.98 pf and subsequently to -0.95pf

Above cases shall be conducted for active power output of **50% and 100%** of rated active power. Plots of P, $Q_{desired}$, Q & V at **POI** along with IBR unit terminal voltage, P & Q shall be included.

g) **Ramping Capability -** Simulation test response demonstrating the rate of change of power output of the RE plant at a rate not more than +10% per minute shall be provided. The report shall include capability demonstration for both active power ramping up and ramping down scenario.

8) Conclusion: This section shall clearly indicate the compliance status as below-

S. No.	Simulation Test Description	Pass/Fail	Remarks
1.	Reactive Power Capability		
2.	Power Quality		
3.	Low Voltage Ride Through		
4.	High Voltage Ride Through		
5.	Operating Frequency Range		
6.	Frequency Response		
7.	Dynamic Reactive Power Support		
8.	Ramping Capability		

9) Recommendation:

Any parameter change, suggested setting to be kept in plant while commissioning shall be clearly indicated here like voltage, frequency, gain-parameters, Qmax, Qmin limits, active & reactive power ramp rates in IBR & PPC, droop, dead-band, polling rate coordination etc. or any other setting which require modification during commissioning.

10) Guidelines for Simulation Studies – The specified simulation tests shall be carried out on the simulation models mentioned below:

S. No.	Simulation Test Description	Simulation to be carried out on:
1.	Reactive Power Capability	Both - Detailed RMS and Equivalent EMT Model
2.	Power Quality	Detailed EMT / Power Quality Assessment Model
3.	Low Voltage Ride Through	Detailed and Equivalent RMS and Equivalent EMT Model
4.	High Voltage Ride Through	Detailed and Equivalent RMS and Equivalent EMT Model
5.	Operating Frequency Range	Both - Equivalent RMS and EMT Model
6.	Frequency Response	Both - Equivalent RMS and EMT Model
7.	Dynamic Reactive Power Support	Both - Equivalent RMS and EMT Model
8.	Ramping Capability	Both - Equivalent RMS and EMT Model

--xxx---xxx---xxx---xxx—

Annexure-I (E) (a): Guidelines for Model Compatibility and Support, IBR Testing and Certification, PPC Technical Requirement, Model Benchmarking and Validation Report

1. Model Compatibility and Support Guidelines:

i) Following RMS and EMT models along with detailed model user guide shall be submitted for the Wind/Solar/BESS/Hybrid Plant:

Type of Model	Description
RMS (Root Mean Square)	**IBR Unit Model**
	Detailed Plant Model (including PPC model)
	Equivalent[1] Plant Model (including PPC model)
EMT (Electro Magnetic Transient)	**IBR Unit Model**
	Equivalent Plant Model (including PPC model)
	Power Quality Assessment Model

ii) The models shall be compatible with the power system software simulation products as specified by SLDC below: -

a) RMS models shall be compatible with **PSS/E version 35** and above.

Provided that the SLDC may accept the model compatible with version 34 also under special circumstances. The decision in this regard will be at the discretion of the SLDC only.

The RMS models are required to be **generic**[2] models and shall not contain any encrypted or compiled parts, as the system operator must be able to maintain the same without the restrictions of software updates etc.

If there is significant difference in the actual performance of the plant vis-à-vis the response of the generic model, then **user defined model (UDM)** shall also be submitted in addition to the generic RMS model.

[1] **Recommended procedure for calculating the equivalent collector impedance -** E. Muljadi, S. Pasupulati, A. Ellis, D. Kosterev, "Method of Equivalencing for a Large Wind Power Plant with Multiple Turbine Representation", presented at the IEEE Power Engineering Society, General Meeting, Pittsburgh, PA, July 20-24, 2008.

Annexure-I (F) may also be referred for single generator equivalent model configuration.

[2] **Annexure – I(C), I(D) and I(G)** may be referred for submitting generic RMS modelling data of Wind, Solar and BESS respectively.

In case of submission of User Defined Models (UDMs), the submission of the **source code and compiling procedure** along with the model is mandatory.
Further, a comparison report highlighting the difference between the simulation response obtained from Generic and UDM for the tests specified in **Part-B (point 3 onwards) of Annexure-I (E)** shall be required in case of UDM submission.

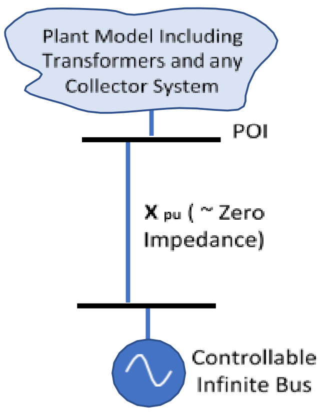
b) EMT models shall be compatible with PSCAD version 4.6.3 and above with the following –

i. Intel 15 Update 5 and newer (32-bit) and Visual Studio 2015 and newer and
ii. Intel 15 Update 5 and newer (64-bit) and Visual Studio 2015 and newer
iii. Model works across a range of time steps and does not require a specific time step

These models must not be dependent on a specific Intel Visual FORTRAN version and should not have dependencies on additional external commercial software.

iii) The plant simulation models (applicable for generic and UDMs) shall:

a) Be able to accurately represent the characteristics of the generating station at the point of inter-connection (POI). The POI bus can be connected to controllable infinite bus whose voltage and frequency can be adjusted to regulate the POI bus fault level, SCR etc. for verification/testing of compliances. A typical representation is as below:



For Short circuit ratio (SCR), following formula can be used-

$$XX_{pu} = \frac{11111}{MW_{Capacity} * SCR}$$

Where,

$MW_{Capacity}$ = Total MW capacity of generator(s) under study
SCR = Desired short circuit ratio to test
X_{pu} = Per unit line reactance, on a 100 MVA system base

b) Be supported by model descriptions that, as a minimum, shall include Laplace domain transfer functions (for RMS models), and function descriptions of the arithmetical, logical and sequence-controlled modules used in the simulation model.

c) Include descriptions of the individual model components and related parameters including saturation, non-linearity, dead band, time delays, polling rates, and constraint functions (non-wind-up/anti wind-up) etc.

d) Include descriptions of the set-up of the simulation model as well as any limitations to the application thereof. There shall be no initialization errors for the dynamic models. The warning messages shall be reviewed and resolution or explanation shall be provided.

e) Work for a range of dynamic simulation solution parameters rather than for specific settings only.

f) Be numerically stable for the full operating range including a wide range of grid SCR.

g) Include all relevant control and protection settings i.e. the models shall have all pertinent protection systems modelled in detail for power system transient and voltage stability analysis, including balanced and unbalanced fault conditions, frequency and voltage disturbances. Provision for disabling/modifying the protection systems shall be provided. Further, protection settings like K-factors, LVRT, HVRT, frequency settings, over/under voltage, momentary cessation, ramp rates, local control modes, enable/disable local remote-control mode etc. shall be available to user. MW, MVAR, Voltage Ratings of IBRs & other components shall be clearly included.

h) Evacuating transmission line shall be modelled as frequency dependent (phase) model with tower geometry.

i) Plant controllers input, output parameters/reference parameters etc. shall be available to user for view & modification using GUI. Important control functions enable/disable feature shall be available in plant controllers.

j) Accurately represent any time delay due to PPC or IBR processing time, polling rates, communication delay etc.

iv) Any model validity limitations due to system impedance or strength or any other reason shall be clearly defined.

v) Models shall not show any characteristics that are not present in the actual plant response.

vi) **Model user guide** including model setup procedure, RMS & EMT software version, compiler, visual studio version etc. shall be submitted along with the model.

vii) Description of IBR and plant level settings with units and range of adjustability for any applicable settings shall be included.

viii) Model limitations, maximum solution time step etc. to be included in user guide

ix) EMT model shall not contain any dependant libraries. The submitted workspace file (.pswx) must not load any PSCAD library (.pslx) files apart from the PSCAD master library. The model shall be capable of running with no extra steps aside from clicking “Run” option in PSCAD. EMT model shall have snapshot capability.

x) **Model Aggregation –** The aggregated/equivalent[3] model shall be developed using the benchmarked IBR unit model (benchmarking guidelines provided in subsequent section).
The aggregated/equivalent model must:

a) Supported by documentation which shall include descriptions of the principles used for aggregation and any limitations on the use of this.

b) Any switching controls like OLTCs, FACTs or filter banks etc. used in the plant shall be included in model along with switching logic.

c) Ensure that aggregation is not used to combine power system elements of different types or makes and shall have accurate representation. There might be some generation plants that consist of individual installations of multiple types (e.g. hybrid plants comprising of a combination of wind, solar, storage etc.) or make (e.g. solar plants with inverters of different make or wind plants with WTGs of different make) but come over as an aggregate generation facility at the POI. The model aggregation for such plants shall be carried out separately for each type of individual installation (e.g. separate aggregation model for solar, wind, storage installation etc.) and for each make of individual installation (e.g. one separate aggregated model for each make of inverter/WTG) so that the modelling of these individual installations of different types/make can be verified separately. Further, any representation due to permanent bus split arrangements in the collector system shall be suitably incorporated.

d) The generation plant shall be dispatched at full real power output and the Point of Interconnection (POI) bus voltage is initialized to nominal 1.0 per-unit unless the test requires otherwise. The initial reactive power exchange at the POI should be near zero unless the test requires otherwise.

[3] **Recommended procedure for calculating the equivalent collector impedance -** E. Muljadi, S. Pasupulati, A. Ellis, D. Kosterev, “Method of Equivalencing for a Large Wind Power Plant with Multiple Turbine Representation”, presented at the IEEE Power Engineering Society, General Meeting, Pittsburgh, PA, July 20-24, 2008.

e) Station transformer taps and static switched shunts should be initialized to a nominal position appropriate for the initial POI voltage and real power dispatch.

f) Aggregate Generation Resources, such as wind and solar, should be represented by a single equivalent aggregate model and include a representation for the collector impedance and pad-mount transformer. Multi-unit aggregated representation due to different make/model of IBRs & permanent bus split arrangements in the collector system shall be suitably incorporated along with accurate representation with dynamic models.

g) Explicit frequency protection relay models shall be provided for all IBRs where relays are set to trip.

h) Explicit voltage protection relay models shall be provided for all IBRs where relays are set to trip the resource.

2. IBR Unit Testing, Certification and Report Submission Guidelines:

i) Statement of Compliance (SoC) or Evaluation report shall include the final firmware/controller software version etc. for which the IBR is tested & certified.

ii) If there is any upgrade in the firmware/controller software version w.r.t. the tested IBR unit, the same shall be certified/approved by the Accreditation agency and the relevant changes shall be clearly highlighted in the evaluation report.

iii) Testing of IBR shall be carried out for extreme voltage, frequency, power factor, other parameters (terminal level settings shall be coordinated w.r.t. compliance of extant CEA Technical Standards at POI) etc.

For e.g. Compliance of continuous operation of the plant at 1.1 p.u. voltage at POI may result in continuous operation of individual IBRs at voltage >1.1 p.u. Therefore, design and testing of IBRs shall be carried out so as to factor in the maximum voltage difference between POI and IBR terminal.

iv) Assessment of behaviour of IBR unit during and after the fault shall be stable and shall not cause any abnormal behaviour.

v) Final list of protection settings kept in IBR unit during testing shall be included in the evaluation/measurement report. Further, configurable range of settable parameters shall also be specified.

vi) Actual LVRT & HVRT capability curve along with Reactive Power Capability Curve of IBR unit shall also be included in measurement/evaluation report.

vii) Control Response time[4] of the IBR unit during transient condition shall preferably be in the range of 20 – 40 ms.

viii) IBR unit shall be able to operate in coordinated Q/V control with PPC and provision for the same shall also be tested.

[4] **Control Response Time** is the time between the step change in a system quantity measured at a defined location and when the output of the system reaches 90% of required output change, before any overshoot.

Reference: IEEE Standard (2800-2022) for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems

3. IBR Unit - Model Benchmarking

The response of IBR unit simulation model (RMS and EMT both) shall be benchmarked against lab/factory/field test results for all the technical requirements specified in CEA's *"Technical Standards for Connectivity to the Grid, 2007"* and subsequent amendments. Before testing, the IBR unit models (both RMS & EMT) shall be tuned such that error w.r.t. lab/factory/field test results is minimum.

These results shall be submitted as benchmarking report which shall include the following:

i) For RMS models, a table of all simulation model parameters - STATEs, VARs, CONS, ICONs, their values as implemented in the dynamic data files and a description of each function.

ii) For EMT models, provide a table of all user-definable settings and status code outputs for all plant within the generating system, a range of acceptable values for each user-changeable variable and a description of each entry's function.

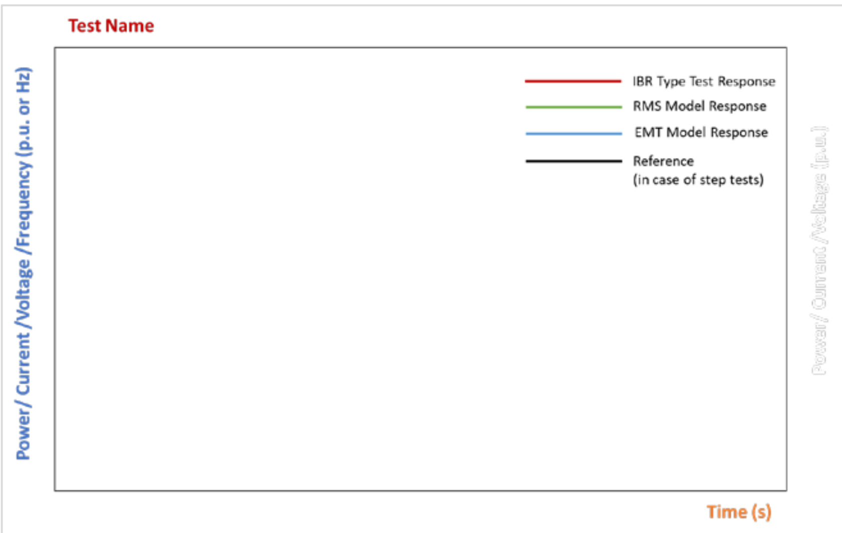
iii) Software version of controller & Firmware version of converter unit shall be mentioned.

iv) Lab/factory/field test reports shall be referenced in the benchmarking report.

v) The settings kept in IBR unit during testing & actual unit installed at site must be kept same. A table demonstrating the similarity between simulation model parameters/settings and tested IBR unit shall be provided.

If there is any mismatch in settings, justification for the same shall be included.

vi) Comparison of type/lab/factory test measurement with simulation results as per the format shown below.



- The tests to be conducted are mentioned in **Point – 5 to 7 of Annexure – I (E).**
- **The testing methodology specified in Annexure- I (E)** shall be applicable for the purpose of benchmarking also.

vii) Along with graphical comparison of lab/factory/field test measurement with simulation results, time series measurements/data of lab/factory/field test and simulation response (of same time resolution) shall also be provided in suitable soft format (preferably .csv file).

viii) Inverter/WTG unit model files which shall include .sav, .dyr, .py, .idv, .sld, .out files and PSCAD
.pscx and other supporting files shall be provided along with the benchmarking report.

Note: The benchmarked single inverter / WTG models shall be used for preparing the detailed and equivalent models of the plant.

4. Power Plant Controller (PPC) – Technical Requirement

a) PPC shall be certified by an Accredited agency.

b) Simulation models (both EMT & RMS) of PPC shall also be benchmarked.

5. Plant Model Validation Report

Post-commissioning of the complete RE plant, the response of models (RMS and EMT both) shall be validated against field measurements/on-site test results and validated models along with the validation report shall be submitted within 03 months of the complete commissioning RE plant. The guidelines to be followed for model validation are given below:

i) For LVRT and HVRT, the response of the models (RMS and EMT both) shall be validated preferably against field test results. In case the same is not possible within prescribed time-frame, the plant model shall be validated against grid event, if any, after complete plant commissioning and same shall be included in the validation report.

ii) For all other tests mentioned in **Annexure – I (E) Point – 5 to 7**, the response of the models (RMS and EMT both) shall be validated against field measurements/on-site test results. **The testing methodology specified in Annexure- I (E)** shall be applicable for the purpose of model validation also.

iii) The validation report shall include the following:

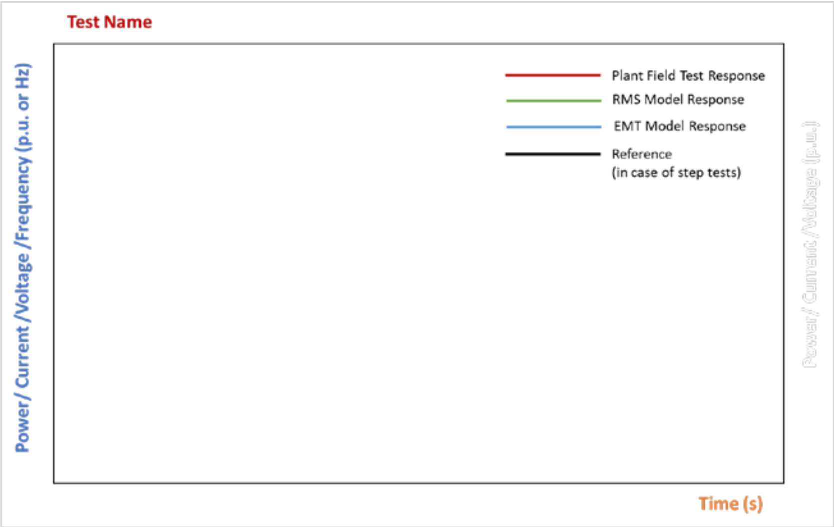
a. Model file names of RMS & EMT model.

b. Final simulation model parameters of Generator model, Electrical control model, drive train model, PPC etc. (for both RMS & EMT model).

c. The settings kept in inverter/WTG units as well as PPC during testing shall be same as the settings implemented at site. The table demonstrating the similarity between simulation model parameters/settings and settings implemented at site shall be provided.

d. Table for inverter/WTG unit controller setting and RMS & EMT model parameter for different control parameters (for both RMS & EMT) shall be provided.

e. Comparison of field measurement/on-site test measurement with simulation results as per the format shown below.



f. For model validation, all the field test signals shall be measured at point of inter- connection.

g. Along with graphical comparison of field test measurement with simulation results, time series measurements/data of field test and simulation response (of same time resolution) shall also be provided in suitable format (preferably .csv file).

h. Model Validation report shall provide details of the causes of deviation from simulated behaviour and suggest corrective actions.

iv) Actual/implemented controller and protection settings of IBR units, PPC and other elements as downloaded from control software shall be provided as per the format specified in **Annexe-I(E)(b).** These settings shall be signed by company's (RE Developer) authorized official.

Annexure - I(E)(b)

Renewable Plant Details	
RE plant substation	
RE developer	
In-STS Pooling station	

Document classification		
Document Number	NLDC/FTE&I/Renewables/Annex-I E(b)	
Document description	IBR unit controller & PPC protection & control settings	
Document classification	Public	
Document revision history		
Date	**Rev. No.**	**Description**
11.05.2023	1.0	Initial release for protection & controller settings.

Note- Check for updated format in Grid-India website

IBR Controller and Protection Settings (Downloaded)					
	Date of setting extraction from IBR unit :				
S. No.	**Feature**	**Enabled/Disabled**	**Setting/Detail**	**Time Delay (seconds)**	**Controller Snapshot**
1	**General**				
	IBR unit OEM				
	IBR unit model				
	IBR unit capacity				
2	**Software/Firmware details**				
	Converter Firmware Version				
	Controller Software Version				
3	**IBR Voltage Range**				
	Operating Voltage- Max				
	Operating Voltage- Nominal				
	Operating Voltage- Min				
	Withstand Voltage – Max				
4	**HVRT related-**				
	HVRT enabled or disabled ?	Not Available			
	Alarm				
	Level-1				
	Level-2				
	Level-3				
	Level-4				
	Level-5				
	HVRT Activation level (voltage)				
	HVRT activation type (select from drop down)				
	HVRT Reset level (voltage)				
	HVRT grid support mode (symetric fault)	No support (reactive current is set to zero)			
	HVRT grid support mode (asymetric fault)	No support (reactive current is set to zero)			
	Maximum reactive current support during HVRT (in pu)				
	HVRT Response Time (ms)				
	HVRT dead time (minimum time required b/w two consecutive fault for successful ride through)				
	How many number of consecutive faults IBR unit can sustain ?				
5	**LVRT related**				
	LVRT enabled or disabled ?	Not Available			
	Alarm				
	Level-1				
	Level-2				
	Level-3				
	Level-4				
	Level-5				
	LVRT Activation level (voltage)				
	LVRT activation type (select from drop down)				
	LVRT Reset level (voltage)				
	LVRT grid support mode (symetric fault)	Disabled			
	LVRT grid support mode (asymetric fault)	Disabled			
	Maximum reactive current support during LVRT (in pu)				
	LVRT Response Time (ms)				
	LVRT dead time (minimum time required b/w two consecutive fault for successful ride through)				
	How many number of consecutive faults IBR unit can sustain ?				
	Voltage Threshold to block IBR current injection (for momentary cessation if any)		To be filled.		
6	**Frequency Settings**				
	Under Frequency				
	Alarm				
	Level-1				
	Level-2				
	Level-3				
	Level-4				
	Over Frequency				
	Alarm				
	Level-1				
	Level-2				
	Level-3				
	Level-4				
	Reactive power control (RPC)-				
	Reactive Power Control Method	Not Available			
	Reactive power control mode	Local constant power factor (pf) control			

7	Reactive Power at Rated Power-Max (injection)				
	Reactive Power at Rated Power-Min (Absorption)				
	Reactive power ramp rate (In steady state condition for all available RPC modes)				
	Extra Q mode	Not Available			
	If communication between IBR unit & PPC failed, then what would be the reactive control mode of operation of IBR unit.				
	IBR unit input command polling rate (minimum time required between two consecutive input commands)				
8	**Active power control-**				
	Active Power Control Method	Not Available			
	If communication between IBR unit & PPC failed, then what would be the active power set point in IBR unit.				
	IBR unit input command polling rate (minimum time required between two consecutive input commands)				
	IBR unit active power ramp rate (In steady state condition)				
	Enhanced or extra active power mode	Not Available			
9	LVRT to HVRT (and vice-versa) Transition Time				
10	**IBR unit night mode/ Standstill reactive mode**				
	Qmax (injection KVAr)				
	Qmin (absorption KVAr)				
11	**Post Fault characteristics of IBR unit**				
	Active Power recovery rate				
	Reactive Power recovery rate				
	Recovery time delay/ Hold time, if any ?				
	Active & reactive currrent freeze state during hold time. If any ?				
12	**Any other Protection Setting**				

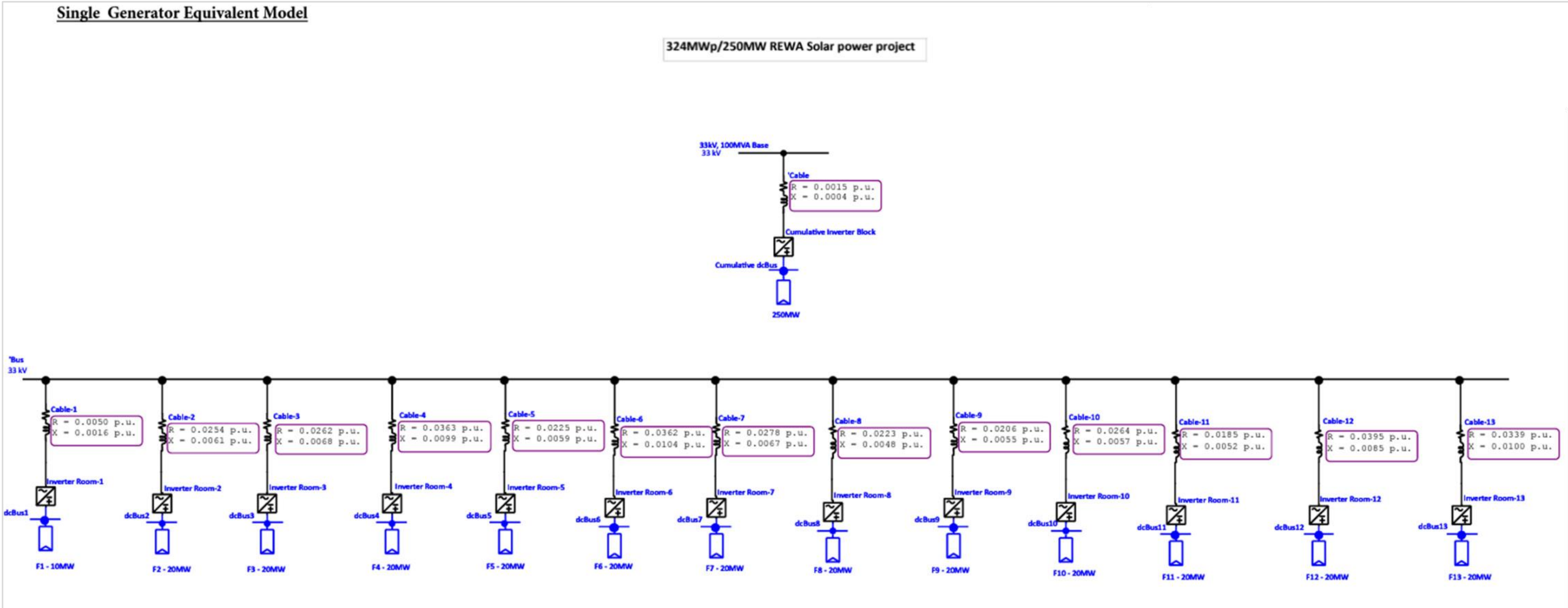
Power Plant Controller & PQM Setting details				
	Date of setting extraction from PPC			
S. No.	**Particulars**	**Enabled/Disabled**	**Setting**	**Snapshot**
1	**General**			
	OEM			
	Model			
	Hardware version			
	Software version			
	Configured as Master or Slave	Select		
	Actual input to PPC provided from	33kV feeder level		
	Number of IBRs handling capability			
2	**PQ meter related**			
	OEM			
	Model			
	Output update rate (time between two successive outputs)			
3	**Communcation & processing related**			
	PPC input refresh rate (time between two successive inputs)			
	Processing time taken by PPC controller			
	PPC output P & Q command update rate (time between two successive outputs)			
4	**Active Power Control Mode**			
	Active Power Control Mode Status	Not Available		
	Active Power Ramp rate (MW/second)			
	Active Power gain parameters (Kp, Ki, Kd parameters)			
	Active power set maximum limit (Pmax)			
	Active power set minimum limit (Pmin)			
5	**Reactive power control (RPC)-**			
	Reactive Power Control Mode Status	Not Available		
	Type of Reactive Power Control Enabled	Voltage		
	Reactive power gain parameters (Kp, Ki, Kd, Hysterisis parameters)			
	Reactive power ramp rate (In steady state condition for all available RPC modes)			
	Reactive power injection limit (Qmax)			
	Reactive power absorption limit (Qmin)			
	FACTs/Capacitor/Reactor control	Not Available		
6	**Frequency Control**			
	Frequency control mode	Not Available		
	Ripple factor			
	Droop			
	Deadband			

Annexure-I(E)(c): IBR Units – High Resolution Data Submission Format

S.No	Description	Data Single IBR1	
1	Date (DD-MM-YYYY)	…	…
2	Time(HH:MM:SS)	…	…
3	Milisecond	…	…
4	Active Power (KW)	…	…
5	Reactive Power (KVAR)	…	…
6	Wind Speed (MPS)	…	…
7	Voltage_R (VOLTS)	…	…
8	Voltage_Y (VOLTS)	…	…
9	Voltage_B (VOLTS)	…	…
10	Current_R (AMP)	…	…
11	Current_Y (AMP)	…	…
12	Current_B (AMP)	…	…
13	Frequency (HZ)	…	…
14	Ambient Temperature (Degree Centigrade)	…	…
15	PowerFactor (PF)	…	…
16	Positive Sequence Voltage Angle (Degree)	…	…

S.No	Description	Data Single TBRN	
1	Date (DD-MM-YYYY)	…	…
2	Time(HH:MM:SS)	…	…
3	Milisecond	…	…
4	Active Power (KW)	…	…
5	Reactive Power (KVAR)	…	…
6	Wind Speed (MPS)	…	…
7	Voltage_R (VOLTS)	…	…
8	Voltage_Y (VOLTS)	…	…
9	Voltage_B (VOLTS)	…	…
10	Current_R (AMP)	…	…
11	Current_Y (AMP)	…	…
12	Current_B (AMP)	…	…
13	Frequency (HZ)	…	…
14	Ambient Temperature (Degree Centigrade)	…	…
15	PowerFactor (PF)	…	…
16	Positive Sequence Voltage Angle (Degree)	…	…

Annexure-I (F): Single Generator Equivalent Model



Annexure-I (G): Procedure for First Time Charging of Battery Energy Storage System (BESS)

BESS shall consist of:

i) A power conversion system (PCS)

ii) An energy storage

iii) Battery Management System (BMS)

iv) Monitoring, information and control system(MIC)

Basic components of BESS are as follows:

i) Batteries as its underlying storage technology to be connected to an electrical network
ii) Bidirectional inverter is the main device that converts power between the AC line voltage and the DC battery terminals, and allows for power to flow both ways to charge and discharge the battery
iii) Other components of a BESS may include an isolation transformer, protection devices (e.g. circuit breakers), cooling systems, and a high-level control system to coordinate the operation of all components in the system

Documents and data to be submitted for integration of BESS:

1. The applicant shall furnish the undertaking to comply with CEA Technical Standards for connectivity to the Grid Regulations. The following information also need to be provided along with the application:

S. No.	Description	Details to be furnished
A	**Battery**	
1	Make/Manufacturer	
2	Type / Chemistry	
3	Design capacity of battery in terms of KWh	
4	Self-Discharge rate	
5	DoD	
6	Life cycle of battery	
7	Round trip efficiency	
8	Dimensions and weight of battery	
9	Test certificate available for battery cell/module (IEC Standards	
10	Number of series & parallel connected cells and modules	
11	Power/energy rating cells and modules	

12	BESS favorable operating temperature	
B	**PowerConditioningUnit**	
1	Make/manufacturer	
2	Type of charge controller (DC-DC converter)	
3	Inverter- power rating & efficiency	
4	Inverter minimum response time	
5	Test certificate available (IEC Standards)	
C	**Measurement and control Devices**	
1	Sensors	
2	Sensitivity Type/Make	
3	Accuracy/Precision	

Battery Static Parameters:

Details	**Technical requirement**
AC ratings	
Total rated output power to load @ nominal voltage(charge) MW to (discharge) MW	
Apparent power @ nominal voltage	
No of units	
Rate output power of each unit	
Real and reactive power control accuracy (%)	
Voltage range	
Type of output	
Frequency (Nominal Frequency and the tolerance band)	
VAR production (full MVAR production at rated Voltage)	
Harmonics (as per CEA standards)	
DC input ratings	
Voltage range	
Ripple voltage	
Ripple current (% of full current peak to Peak)	
Environmental ratings	
Operating temperature	
Humidity	
Functions/Features	

Power flow operation (, Support four - quadrant control)	Yes / NO

Real power control (Positive and negative)	Yes / NO
Reactive power control (capacitive and inductive)	Yes / NO
Combination of real and reactive power control (priority real power)	Yes / NO
Load following (renewable smoothing)	Yes / NO
Low-voltage & High Voltage ride through compliance	Yes / NO
Synchro-check and Remote synchronisation function	Yes / NO
Operation modes	
Black start enabled (external command)	Yes / NO
Commanded power (external command)	Yes / NO
Commanded VAR (external command)	Yes / NO
Frequency regulation	Yes / NO
Frequency response (Automatic)	Yes / NO
Islanding	Yes / NO
Renewable smoothing (if applicable , automatic)	Yes / NO
Scheduled power (preconfigured time/date of work power profiles	Yes / NO
Voltage regulation	Yes / NO
Response time of PCS to the command received (Milli seconds)	
Communications	
Communications with LDC (main /standby)	Yes / NO
Battery technologies	
Battery technologies supported(Ex Li-Ion etc ..)	
Battery Cycle life	> 4,000 at 20-80% SOC
Voltage Regulation (%)	
Reactive Power Regulation (Var flow level Range +/- example +/- 5%))	
Frequency Regulation (+/_ cycle /second)	
Capacity (Ah)	
Power factor	
Battery temperature (average/extreme)	
Overload capability (%) and Switching frequency(in kHz) State of Charge (SOC)	
Protection system	
Under/over voltage (DC and AC)	
Under/over frequency	

Over current protection	
Ground fault protection	
Over heat protection	

2. Following parameters need to be telemetered at SLDC:

i. Operating Mode:
   a. Grid connected/ Standalone mode
   b. Automatic/ Manual mode
   c. Charge/discharge
ii. Measurements (Voltage, Current, P, Q, Status of Charging, charge/discharge rate freq., energy export/import)
iii. Events and alarms Breaker position/operation
iv. BESS Start Inhibit Status
v. Ambient Temperature
vi. Parameters of PCS such as active power, reactive power, power factor, operating DC voltage etc.
vii. Number of battery inverters in operation and Number of battery inverters available in BESS
viii. Full pack energy: Estimated maximum energy capacity of the batteries
ix. Energy remaining: Estimated energy remaining of the batteries
x. Available maximum capacity: State of energy available in batteries
xi. Possible charge and discharge power
xii. Local MW set point
xiii. Reference set points for voltage, power factor and reactive power control
xiv. Local limit for charge and discharge
xv. Charge and discharge ramp up and ramp down rates
xvi. MW reference (AGC)
xvii. AGC availability status
xviii. Control mode: AGC/Local
xix. Indication of frequency control status
xx. Indication of control modes; voltage, power factor, reactive power
xxi. State of Charge (SOC) (Mwh)
xxii. Maximum/Minimum State of Charge (Mwh)

3. Test Certificates:

The applicant shall furnish the following test certificates prior to trial run:

i. Verification of sensors, metering and alarms
ii. Verification of all control functions including automatic, local and remote control
iii. Verification of the performance criteria as per CEA Technical Standards
iv. Demonstration of all the intended applications including Black start
v. Demonstration of grid interface protection & control system
vi. Verification of power quality parameters

4. PCS Design requirements

Grid-tied energy storage units are predominately DC in nature. To utilize the energy storage capability on the AC electric grid, the energy from batteries must be converted to a standard AC level and regulated through a converter, generally known as the Power Conversion System (PCS). The PCS serves as the interface between the DC battery system and the AC system, providing bi-directional conversion from DC to AC (for discharging batteries) and AC to DC (for charging batteries). The PCS may consist of one or more parallel units. The PCS shall be bi-directional converter that can be operated in inverting mode for battery discharging and rectifying mode for battery charging. Power Conversion System Operation conditions:

i. The AC power transformed efficiently from the DC power of the battery arrays shall be bi-directionally transferred to or from the distribution line without causing harmonics higher than as mandated in extant CEA regulations.

ii. The PCS shall contain a remote synchronization feature, as well as the standard synchronization used when starting the PCS online. The remote synchronization feature allows the PCS to synchronize its voltage and frequency to any other remote AC bus or generator.

iii. Black start capability

iv. The PCS shall have the ability to perform four-quadrant control.

v. The PCS shall be able to perform load following (for PV smoothing) Voltage shall be maintained at +/- 5% nominal under normal operating conditions and +/- 10% under emergency conditions.

vi. The PCS shall have the synchro-check function to allow parallel operation with the grid, diesel and PV generators/wind.

vii. PCS shall be able to operate in the following four modes of operation:

   a. Active and reactive power control: In this mode of operation, PCS controls the output active and reactive powers supplied to the grid following their reference values which may be set locally or remotely.

b. Voltage and frequency control: In this mode of operation, PCS controls its own voltage and frequency, enabling it to create an islanded grid. Voltage and frequency control is possible when the PCS is in the voltage source operating mode.
c. Virtual synchronous generator: This mode of operation makes the PCS work as a voltage source converter. Under this mode, the BESS shall be able to provide its own voltage and frequency to an islanded grid, or to work in parallel with the utility grid in the grid-connected mode.
d. Voltage and frequency droop for parallel operation: The voltage droop allows reactive power sharing when the BESS is in an islanded mode or paralleled with other voltage sources. The frequency droop allows active power sharing when the BESS is in an islanded mode or paralleled with other voltage sources.

5. Functional requirements of MIC system

Data acquisition: The MIC system should be able to collect the analog and status quantities of PCCs and interconnection points as well as other data of the BESS.

Data processing: The MIC system should be able to conduct calculation and analysis, data backup, out-of limit alarm, rationality check, and processing for collected data (including voltage, current, active power, reactive power, frequency, etc.).

Data storage: The MIC system should store operating data, alarm information, and events based on configurations.

Event handling: The MIC system should have functions of event sequence recording and accident recalling.

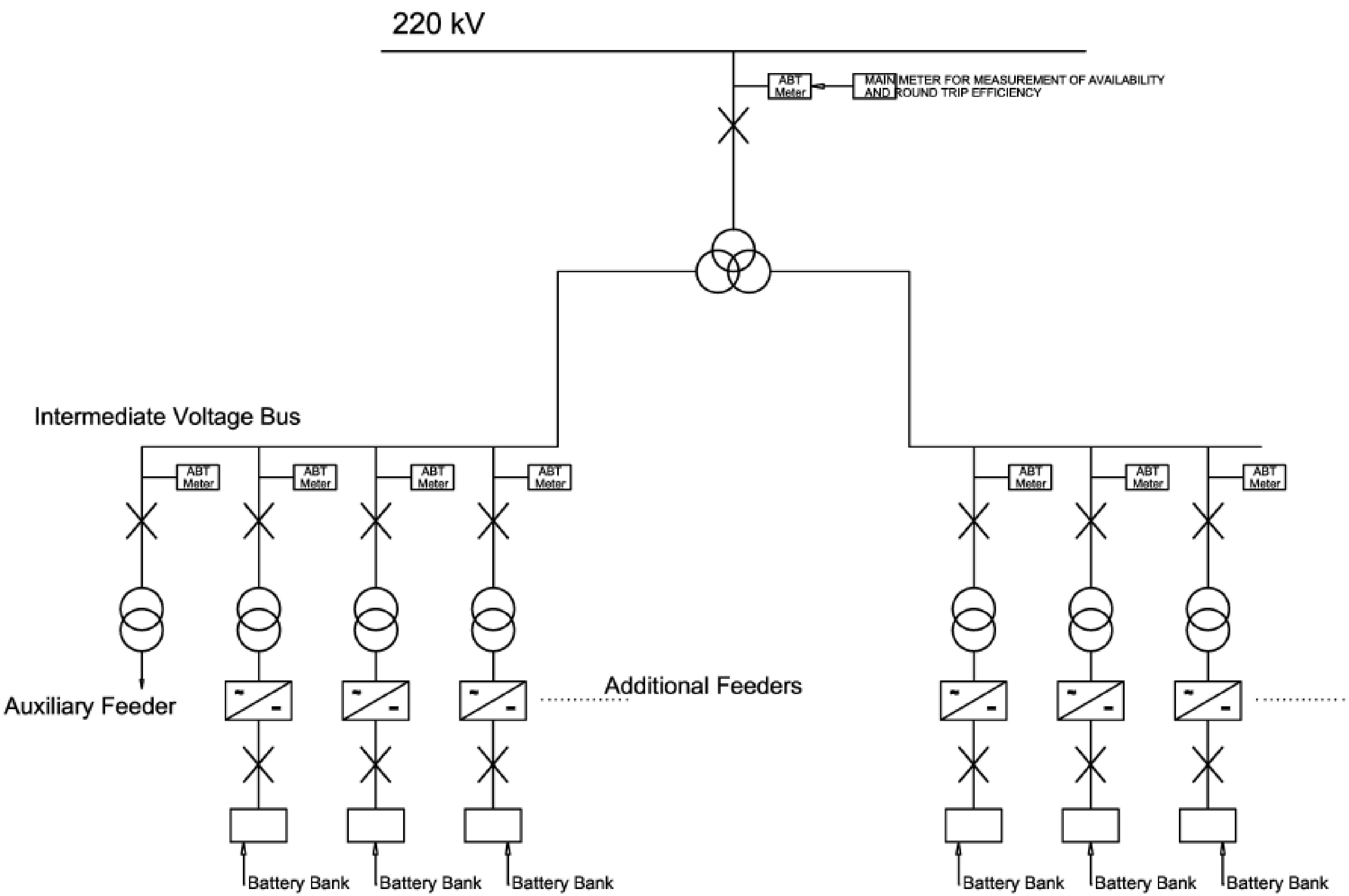
Interconnection with external systems: The MIC system shall carry out interconnection with external systems according to application demands. It shall be capable to be interconnected with the distribution management system, automatic generation control system, etc. and so on to achieve exchange of BESS data and information such as charge and discharge power, energy quantities, operating status, etc. and control of setpoint from appropriate load dispatch centres.

6. Layout drawing submission:

A sample connectivity of the BESS connected with the system is given below. BESS system is shown to be inter-connected with grid at secondary terminal of power transformer.

7. PMU Placement

PMU shall be placed at the Point of Interconnection of BESS which shall be reporting the parameters like three phase voltage, three phase current, angles, frequency, active power and reactive power etc.



220 kV
ABT Meter
MAIN METER FOR MEASUREMENT OF AVAILABILITY AND ROUND TRIP EFFICIENCY
Intermediate Voltage Bus
ABT Meter
Auxiliary Feeder
Additional Feeders
Battery Bank

Guidelines for exchange of data for modelling BESS

Category	Parameter Description	Date
	Electrical control Model: BESS	
	Vdip(pu), low voltage threshold to activate reactive current injection logic	
	Vup(pu), Voltage above which reactive current injection logic is activated	
	Trv(s), Voltage Filter time constant	
	Dbd1 (pu), Voltage error dead band lower threshold (<0)	
	Dbd2 (pu), Voltage error dead band upper threshold (>0)	
	Kqv (pu), Reactive current injection gain during over and under voltage condition	
	Iqh1 (pu), Upper limit on reactive current injection iqinj	
	Iqh1 (pu), lower limit on reactive current injection iqinj	
	Vref0 (pu), User Defined reference (if 0, model initializes it to initial terminal voltage)	
	Tp(s), Filter time constant for electrical power	
	QMAX (pu), limit for reactive power regulator	
	QMin (pu), limit for reactive power regulator	
	VMAX (pu), Max. limit for voltage control	
	VMIN (pu), Max. limit for voltage control	
	Kqp(pu), Reactive power Regulator proportional gain	
	Kqi(pu), Reactive power Regulator integtal gain	
	Kvp (pu), Voltage Regulator proportional gain	
	Kvi (pu), Voltage Regulator integral gain	
	Tiq(s), Time constant on delay s4	
	Dpmax (pu/s) (>0) Power reference max. ramp rate	
	Dpmin (pu/s) (<0) Power reference min. ramp rate	
	PMAX(pu),Max Power limit	
	PMin(pu),Min Power limit	
	Imax(pu), Max. limit on total converter current	
	Tpord (pu), Power filter time constant	
	Vq and Iq curve (reactive power V-I pair in p.u.) :4 points	
	Vp and Iq curve (active power V-I pair in p.u.) :4 points	
	T, battery discharge time (s) (<0)	
	SOCinimax (pu), Max. allowed state of charge	
	SOCinimin (pu), Min. allowed state of charge	

Annexure-II: Indemnity Bond

(Stamp paper of Rs. 100)

Indemnity Bond

This bond of indemnity is executed at ……. (time) on this … day of …. (month) in the year 2018 by Sh./Smt. …. **[Name of authorized personal]** on behalf of M/s … **[Name of company]** (herein after referred to as the 'declarant') registered under ……….act, having its registered address at …**[registered address of company]** in favour of **State** Load Dispatch Centre (SLDC), **Place**, having its registered address at B-9, first floor Qutab Institutional Area, New Delhi 110016.

I, …... **[Name of authorized personal]** working as … **[designation of authorized personal] at** M/s …. **[Name of company]**, which has an ultimate installed capacity of … **[Installed Capacity]** MW and which has connectivity to In-STS at … **[Name of Station Name, voltage level and Transmission licensee]**, do here by solemnly state and confirm as under:

1. I am authorized representative of M/s …. [name of Company] and is legally entitled to sign this indemnity bond.
2. That this indemnity bond is being signed on behalf of M/S …. **[Name of company]** in compliance to the clause 5.1.2.j. of the CERC Approved Procedure dated 03.03.2017 for Implementation of Framework on Forecasting, Scheduling and Imbalance handling for Renewable energy generation stations including power parks based on **Wind/Solar** at Interstate level
3. Pursuant to the above, **…..[Name of company]** including its successor shall keep each of SLDC indemnified at all times and undertake to indemnify, defend and save the SLDC harmless from any and all damages, losses including commercial losses due to forecasting error, claims and actions including those relating to injury to or death of any person or damage to property, demands, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties, arising out of or resulting from the transactions undertaken by our generators.

(Signature of the Declarant with seal)

Witness1:	**Witness2:**
Signature:	Signature:
Name:	Name:
Address:	Address:
Email ID:	Email ID:
Telephone no.:	Telephone no.:

Annexure-III: Undertaking by SPD / SPDD / WPD / WPPD on General Compliance Requirements

This Undertaking is executed by MR. ……….**[Name of authorized personal]** on behalf of M/s

…………….**[Name of company]** having its registered address at……….**[registered address of company]**, in favour of **State Load Dispatch Centre (SLDC), Place**, having its registered address at **SLDC Address**.

I, ………..**[Name of authorized personal]** working as ……………..**[designation of authorized personal]** at M/s .... **[Name of company]** with an ultimate installed capacity of ..**[Installed Capacity]** MW and having connectivity to In-STS at ..**[Name of Station Name, voltage level and Transmission licensee],** do here by solemnly state and confirm as under:

1. Shall be responsible for ensuring metering (ABT compliant meter), data collection and weekly transmission of data (in **SLDC** data format) to **SLDC** as per KEGC and extant KERC Regulations.
2. Shall under take commercial settlement of all deviation settlement charges to the State Pool Account on Weekly basis, as per applicable KERC Regulations.
3. Shall be responsible for commercial settlement on scheduled generation with it beneficiaries as per the monthly Energy Account (EA) issued by **SLDC**.
4. Shall abide by the KEGC/IEGC and Central Electricity Authority/KERC/CERC Regulations.
5. Shall follow the new element / generator procedure of **SLDC** while connecting to the grid.
6. Shall undertake to indemnify , defend and save **SLDC** harmless from any and all damages, losses including commercial losses due to forecasting error, claims and actions including commercial losses due to forecasting error, claims and actions including those relating to injury to or death of any person or damage to property, demands, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties, arising out of or resulting from the transactions undertaken by the generators.
7. Shall be responsible for sending the SCADA data to the SLDC and to the Renewable Energy management Center, as and when required.
8. Shall inform **SLDC** regarding the new additions / deletion of Power system elements within the solar park, as and when there is a change.
9. Shall provide the information sought by **SLDC** regarding the solar park activities from time by coordinating with the SPDs.
10. Shall submit to **SLDC** the grant of connectivity agreement with CTU / STU and the agreements entered with SPDs.

Place:

Date:

Signature:

Name of the authorized personal:

Designation of the authorized person:

Annexure-IV

(Stamp paper of Rs. 100)

Undertaking by SPD/WPD

This undertaking is executed by **………** on behalf of M/s **………………**, having its registered address at................. , in favour of …. State Load Despatch Centre having its registered address at ……………….

I **……….** authorized signatory of M/s **……….** with an ultimate installed capacity of … MW and having connectivity to In-STS at .... **,** do here by solemnly state and confirm as under:

<Name of solar / wind / hybrid/ESS project > is eligible for waiver of transmission charges for use of Inter State Transmission System, as it falls under KERC Regulations and its subsequent amendments issued by KERC from time to time.

1. Such generation capacity has been awarded through competitive bidding process in accordance with the guidelines issued by the Central Government. [Supporting document attached as annex-1] (please strike through in case project is planned to supply power to exchange or bilateral sale etc.)
2. This exemption is being sought for above mentioned generation capacity in line with clause reference no ……………..of regulation KERC and its subsequent amendments.

Place :
Date :

Signature:

Name:
Designation:

Annexure-V: Undertaking on Compliance of CEA Connectivity Standards

To be notarized on a Rs 100 non-judicial stamp paper)

Affidavit

I__________, Son/Daughter/Wife of__________________, aged about___________years, residing at ____________do hereby solemnly affirm and sincerely state as follows:

1. That I am the____________(Designation) of the___________(Company Name). I have been authorized by the________________(*company name)* vide Board Resolution / Power of Attorney / Authorization Letter dated …………….to sign this affidavit on behalf of the company.

2. The____MW Wind/Solar /Hybrid/ESS plant__(*Plant Name*) situated at Village: _______, Taluka:_________, District________has been awarded via competitive bidding conducted by____________vide Letter of Intent______________dated__________ or plan to sell power at exchange / bilateral. (strike through which ever is not applicable)

3. The above Wind/Solar /Hybrid/ESS Plant is scheduled to be commissioned by ……………………(dd.mm.yyyy) *(ref. PPA dated..........................).*

4. The date of Commercial operation (COD) will be intimated by _______________________(*Name of WPD/SPD/HPD/ESS*) to SLDC prior to commencement of scheduling of power.

5. I state that______________*(*Wind/Solar /Hybrid/ESS *Name)* undertakes to ensure compliance to following regulations and guidelines as amended from time to time:

   a. Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 and any subsequent amendments thereof including but not limited to the norms for Low Voltage Ride Through (LVRT) and High Voltage Ride Through Capabilities (HVRT) as specified under standard B2 of the CEA (Technical Standards for Connectivity (Amendment) Regulations 2019.

b. KERC terms and conditions of open access regulations 2025 and subsequent amendments thereof.

6. I undertake to submit the test report and Statement of Compliance (SoC)/ Conformity Statement (CS) as stipulated in MNRE guidelines demonstrating the compliance of applicable CEA Technical standards for Connectivity to the Grid (as amended from time to time) including LVRT/HVRT.

DEPONENT

Verification: -

Verified at__________________, this the_________day of_____________20 , that the contents in the above affidavit is true and correct to the best of knowledge and belief. No part of this affidavit is wrong and nothing material has been concealed therefrom.

DEPONENT

Solemnly Affirmed at ………………

On this…………day of ....20….

And signed his/her name in my presence Deponent signed beforeme.

Annexure-VI: Submission of information as per SLDC

1. **Name of the entity (in bold letters):**

2. **Registered office address**:

3. **ESCOM in which registration is sought:**
   i. BESCOM
   ii. HESCOM
   iii. MESCOM
   iv. GESCOM
   v. CESC

4. **User category:**
   i. Generating Station
   ii. Seller
   iii. Buyer
   iv. Transmission Licensee
   v. Distribution Licensee
   vi. Trading Licensee
   vii. Power Exchange
   viii. Battery Energy Storage system
   ix. QCA / Aggregators
   x. Others

5. User details (as on 31st March of last financial year):

   i. Category – generating Station
   i. Total Installed Capacity
   ii. Maximum Contracted Capacity (MW) using In-STS
   iii. Points of connection to the In-STS:

Sl. No.	Point of connection	Voltage level (kV)	Number of Special Energy Meters (Main) installed at this location

   ii. Category - Seller/Buyer/Distribution Licensee
   i. Maximum Contracted Capacity (MW) using In-STS
   ii. Points of connection to the In-STS:

Sl. No.	Point of connection	Voltage level (kV)	Number of Special Energy Meters (Main) installed at this location

iii. **Category - Transmission Licensee (intra state /inter-State)**

i. Sub-stations:

Sl. No.	**Sub-station Name**	**Number of transformer**	**Total Transformation Capacity or Design MVA handling capacity if switching Station**

ii. Transmission lines(:line wise details to be given)

Sl. No.	Voltage level (kV)	Number of transmission lines	Total Circuit-Kilometers

iv. **Category (Others):** Please specify details.

6. Contact person(s) details for billing related [to SLDC **:**

i. Name:

ii. Designation:

iii. Telephone No.:

iv. E-mail address:

v. Postal address:

7. Other Details:

i. PAN No.:

ii. GST No.:

iii. Bank Account No.:

iv. Bank Name and Address:

v. MICR No:

The above information is true to the best of my knowledge and belief.

Signature of Authorized Representative

Place: Name:

Date: Designation:

Contact number:

Annexure-VI(A): Bank and Tax related details

Bank and Tax related details

Please furnish the details of the Entity User, Bank details for DSM, TRAS, Congestion, Reactive, SLDC Fees & Charges payments with cancelled cheque:

Name of the Entity:

1. Account Name:

2. Account Number:

3. Name of the Bank:

4. Branch:

5. IFSC Code:

6. PAN:

7. GSTIN :

8. TAN:

9. RTGS Details (No./Date/Amount):

10. DD/Cheque Details (No./Date/Amount):

Place: Signature :

Date: Name of the authorized personnel

Seal of the authorized person

ANNEXURE-VI(B)

(On Letter Head of Company)

Registration Fee Payment details

1	Name of the Entity:
2	Registration Fee Paid as per SLDC Fee and Charges Regulation 2019:
3	Registration Fee Paid in account No:
3	Mode of Payment (RTGS /NEFT/ DD/Cheque):
4	Transaction (RTGS/NEFT/DD/Cheque) No.:
5	DD/Cheque issuing Bank details(Name and Branch):
6	Date of Payment:

Place:

Date:

Signature

Name of Authorised Representative

Seal of the authorized person

Annexure-VII (A): Real time Telemetry of Wind generating plants

1. Turbine Generation (MW and MVAR)
2. Wind Speed(meter/second)
3. Generator Status (on/off line)- this is required for calculation of availability of the WTG
4. Wind Direction (degrees from true north)
5. Voltage (Volt)
6. Ambient air temperature (^{o} C)
7. Barometric Pressure (Pascal)
8. Relative humidity (%)
9. Air Density (kg/m^3)
10. Power plant controller signals

Annexure-VII (B): Real time Telemetry of Solar generating plants

1. Solar Generation unit/Inverter-wise (MW and MVAR)
2. Voltage at interconnection point (Volt)
3. Generator/Inverter status (on/off line)
4. Global horizontal irradiance (GHI) –Watt per meter square
5. Ambient temperature (^{o} C)
6. Diffuse Irradiance –Watt per meter square
7. Direct Irradiance –Watt per meter square
8. Sun rise and sunset timings
9. Cloud cover (Okta)
10. Rainfall (mm)
11. Relative humidity (%)
12. Performance ratio
13. Power plant controller signals

Annexure-VII (C)

Wind Turbine Generating Plants

Name	Unit	Data type	Remarks
Telemetry from WTG			
Active Power	MW	Analog	
Reactive Power	MVAR	Analog	
Wind Speed	m/s	Analog	
WTG CB status	Boolean	Status	
LVRT trigger	Boolean	SOE	
HVRT trigger	Boolean	SOE	
Plant level Telemetry			
No. of WTG online	Numbers	Analog	
Available Active Power	MW	Analog	
Voltage Control Mode	Boolean	Status	
Voltage Control Set Point (Vref)	kV	Analog	
Actual Voltage	kV	Analog	
Slope/Droop - Voltage Control Mode	-	Analog	
Deadband - Voltage Control Mode	% of nominal voltage	Analog	
Constant Reactive Power Control Mode	Boolean	Status	
Constant Reactive Power Control – Set Point	MVAR	Analog	
Constant Reactive Power Control – Actual MVAR	MVAR	Analog	
Constant Power Factor Mode	Boolean	Status	
Constant Power Factor Control - Setpoint	-	Analog	
Constant Power Factor Control - Actual	-	Analog	
Maximum reactive power absorption limit (Qmin)	MVAR	Analog	
Maximum reactive power injection limit (Qmax)	MVAR	Analog	
Active Power Control mode	Boolean	Status	
Active Power Set Point	MW	Analog	
Active Power UP Ramp Rate	MW/minute	Analog	
Active Power DN Ramp Rate	MW/minute	Analog	
Frequency Control Mode	Boolean	Status	
Frequency Control Droop	%	Analog	
Frequency Control UP Dead band value	Hz	Analog	

Frequency Control DN Dead band value	Hz	Analog	
Any overriding command received to stall the complete wind farm must be shared with SLDC in SCADA	Boolean	Status	
PPC Inputs from POI	Boolean	Status	

Telemetry from Developer Pooling Station

Active Power	MW	Analog	
Reactive Power	MVAR	Analog	
CB Status	Boolean	Status	
Isolator Status	Boolean	Status	Below 220 kV level, Isolator status not to be taken
Bus Voltage	KV	Analog	
Bus Frequency	Hz	Analog	Below 220 kV level, Bus Frequency not to be taken
Wind Speed	Meter/Second	Analog	From Weather Station
Ambient Air Temperature	^{O}C	Analog	
Barometric Pressure	Pascal	Analog	
Relative Humidity	%	Analog	
Air Density	Kg/m^3	Analog	
Wind Direction	Degrees from North	Analog	

Note:

Developer pooling station shall preferably provide telemetry to the SLDCs from the Gateway of the Developer Pooling station. In case direct integration of the Gateway is not feasible, telemetry could be provided from Central Control Centre of the developer. However, in case the telemetry is provided from a Central Control Centre of the Developer, efforts should be made to integrate communication to the nearest wideband node of In-STS for transmitting the data to the SLDCs over IEC-104.

Annexure-VII (D)

Solar Generating plants

Name	Unit	Data type	Remarks
Telemetry from Inverter/IDT*			
Inverter/IDT(33kV)* Power	MW	Analog	
Inverter/IDT(33kV)* Reactive Power	MVAR	Analog	
Inverter/IDT(33kV)*	Boolean	Status	
LVRT trigger**	Boolean	SOE	
HVRT trigger**	Boolean	SOE	
Plant level Telemetry			
Total numbers of Inverters	-	Analog	
No. of Inverters in Service	-	Analog	
Performance Ratio	-	Analog	
Voltage Control Mode	Boolean	Status	
Voltage Control Set Point (Vref)	or kV	Analog	
Actual Voltage	kV	Analog	
Slope/Droop - Voltage Control Mode	-	Analog	
Deadband - Voltage Control Mode	% of nominal voltage	Analog	
Constant Reactive Power Control Mode	Boolean	Status	
Constant Reactive Power Control – Set Point	MVAR	Analog	
Constant Reactive Power Control – Actual MVAR	MVAR	Analog	
Constant Power Factor Mode	Boolean	Status	
Constant Power Factor Control - Setpoint	-	Analog	
Constant Power Factor Control - Actual	-	Analog	
Maximum reactive power absorption limit (Qmin)	MVAR	Analog	
Maximum reactive power injection limit (Qmax)	MVAR	Analog	
Active Power Control mode	Boolean	Status	
Active Power Set Point	MW	Analog	
Active Power UP Ramp Rate	MW/minute	Analog	

Active Power DN Ramp Rate	MW/ minute	Analog	
Frequency Control Mode	Boolean	Status	
Frequency Control Droop	%	Analog	
Frequency Control UP Dead band value	Hz	Analog	
Frequency Control DN Dead band value	Hz	Analog	
PPC Inputs from POI	Boolean	Status	

Telemetry from Developer Pooling Station			
Active Power	MW	Analog	
Reactive Power	MVAR	Analog	
CB Status	Boolean	Status	
Isolator Status	Boolean	Status	Below 220kV level, Isolator status not to be taken except sectionaliser
Bus Voltage	KV	Analog	
Bus Frequency	Hz	Analog	
Sun-rise time	HHMM	Analog	
Sunset time	HHMM	Analog	
Ambient Air Temperature	^{o}C	Analog	From Weather Station
Relative Humidity	%	Analog	
Air Density	Kg/m^3	Analog	
Rainfall	Mm	Analog	
GHI	W/m2	Analog	
GI	W/m2	Analog	
Cloud Cover***	Okta	Analog	

*In case of string inverter, Inverter Duty Transformer Status and Analog to be taken as the number of inverters is large
** For LVRT & HVRT trigger status in case of string inverters, LVRT/HVRT trigger status of one string inverter in LV side of each IDT is to be provided.
***If Cloud Cover measuring instrument is available otherwise cloud cover data can be taken from Weather Service Provider

Note: Developer pooling station shall preferably provide telemetry to the SLDCs from the Gateway of the Developer Pooling Station. In case direct integration of Gateway is not feasible, telemetry could be provided from Central Control Centre of the Developer. However, in case the telemetry is provided from a Central Control Centre of the Developer, efforts should be made to integrate communication to the nearest wideband node of In-STS for transmitting the data to the SLDCs over IEC-104.

Annexure-VII(E): PMU signal list

S. No.	Description	Analog Points	Digital Points	Protection Signal
1	Line	VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MW, MVAR, F , DF/DT	-Main Breaker status -Tie Breaker status -Isolators	Main1/Main2 protection
2	Bays		- Breaker -Isolators	
3	Main Buses	- VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} F , DF/DT	Bus sectionalizer Breaker	
4	Transformer/Coupling Transformer/Converter Transformer	- VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MW/MVAR	-Breaker -Isolators	Main1/Main2 protection
5	Reactor/Capacitor (if applicable)	VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MVAR	-Breaker -Isolators	

Annexure-VII (F)

Sample IEC 104 Profile

STATION Id:

5.1 Interrogation and Periodic Groups		
I/O Point Type	**Class**	**Cause of transmission**
All DI (Single, Double)	1	By exception (Spontaneous)
All Analog Input	2	Periodic, Rate of reporting as per CEA (Technical Standards for Communication in Power System Operation) Regulations , 2020, clause 31, Schedule I

5.2 Event Variation for I/O Points		
	Event Variation	**Remarks**
All AI	Without Time tag Type 13:M_ME_NC_1	Analog without time stamp No deadband in analog values
Di Points (Isolator Status)	Without Time tag Type 1/3 M_SP_NA/M_DP_N A	Events enabled but without time stamp
All other DI points (CB and Protection)	With Time tag Type 30: M_SP_TB_1, Type 31: M_DP_TB_1	CB and Events enabled with time stamp long format
Set point command (for RE generators above 500MW as per CEA Technical standards for Connectivity to Grid 2007)	Without time tag Type 50: C_SE_NC	

5.3 IOA Address	
I/O Point Type	**Start Address**
Single DI	To be taken from SLDC
Double DI	
Analog Inputs	

5.3 Host IP Address	
Host /MASTER	**IP**
CFE 1 (Main SLDC)	
CFE 2 (Main SLDC)	
CFE 1 (Backup SLDC)	
CFE 2 (Backup SLDC)	

5.4 RTU IP Address			
Host	**IP**	**Subnet**	**Gateway**

RTU (Port 1) to Main CC 1			
RTU (Port 2) to Main CC 2			
RTU (Port 3) to Backup CC 1			
RTU (Port 4) to Backup CC 2			
ASDU address = 1			
5.5 Scans in Master			
Initialization	**Period**		
Test Link	-		
General Interrogation	-		
Periodic			
Test Link	10 Seconds		
General Interrogation	10 minutes		

PROTOCOL SUMMARY	
Common Address Size of ASDU	2 Byte
Information object Address Structure	3 Byte
T0: Connection Time Out	30 Sec
T1: APDU Time Out	15 Sec
T2: Acknowledge Time Out	10 Sec
T3: Test Frame Time Out	20 Sec
Max Rcv (w)	8 Sec
Max Xmt (k)	12 Sec
Cause of Transmission	2 Byte

ANNEXURE-VIII

Forecast and schedule data to be submitted by wind/solar plants/ Lead generator, principal generator, ESS, Hybrid

Format: A (to be submitted a day in advance)

15 min time block (96 block in a day)	Time	Available capacity (MW)- day ahead	Day ahead forecast (MW)	Day ahead schedule (MW)
1	00:00-00:15			
2	00:15-00:30			
3	00:30-00:45			
4	00:45-01:00			
94				
95				
96				

Note: The forecast should ideally factor forecasting errors.as such schedule should ordinarily be same as forecast.

Format: B (to be submitted on the day of actual generation, revision of availability and schedule, if any, shall be done as per KEGC regulation

15 min time block (96 block in a day)	Time	Day ahead schedule (MW)	Current available capacity (MW)	Revised schedule
1	00:00-00:15			
2	00:15-00:30			
3	00:30-00:45			
4	00:45-01:00			
94				
95				
96				

Section 4

Procedure for First Time Energization of new/refurbished HVDC and Issuance of Certificate of Successful Trial Run

Procedure for First Time Energization of new/refurbished HVDC and Issuance of Certificate of Successful Trial Operation

First time charging and issuance of trial operation certificate of new/refurbished HVDC shall be in accordance with **Section-1** of this procedure. The formats and annexures (A1-A6, B1- B5(a) and C1-C4) mentioned in section-1 need to be submitted to the SLDC in accordance with the mentioned timelines.

Further, apart from the requirements mentioned in section-1, following guidelines shall be followed for the first-time energization of HVDC.

1. Pre-Charging Activities

a) Technical Data Submission

Following technical data/models/reports shall be provided by the owners of HVDC before first time charging:

i. Name plate details
ii. Main Circuit Parameter Design report (Forward and Reverse Direction)
iii. Minimum power in different configuration
iv. Active and reactive power control
v. Frequency controller study report
vi. Emergency Power control study report
vii. Power order compensation details and study report
viii. HVDC Operation & Control Strategy Document
ix. Protection philosophy document with implemented settings
x. Different modes of operation of HVDC
xi. HVDC Operation Manual
xii. Filter bank arrangement with rating. filter bank requirements at various operating loads and monopolar and/or bipolar configuration
xiii. Run Back features
xiv. Reduced voltage mode of operation
xv. AC filter Protection
xvi. Power Oscillation Damping (POD) Status along with the document on tuning.

xvii. Steady state and Dynamic (both RMS and EMT) Simulation Models along with detailed model user guide for HVDC.

The model shall include auxiliary models such as Frequency Controller Model, POD controller Model, Voltage controller model etc.

The models shall be submitted as per the model compatibility guidelines specified at **Annexure-I.**

xviii. Load flow and stability report
xix. Dynamic Performance Study report
xx. Sub synchronous resonance study report
xxi. Fundamental Frequency Temporary over voltages (FFTOV) study report
xxii. Dynamic Multi Infeed interaction report
xxiii. Any other information as required by SLDC

b) <u>Data Telemetry Requirements</u>

Following SCADA points shall be made available to the SLDC control room:

Analog Signal

i. AC Active and Reactive power flow for converter transformer
ii. Tap position of converter transformer
iii. DC Voltage
iv. DC Power Flow
v. DC Current
vi. Individual and cumulative Filter MVAR
vii. Firing Angle-Alpha
viii. Extinction angle- Gamma, etc.
ix. Power order, set point
x. Compensation settings if applicable

Digital Signal

i. Individual Filter Status
ii. HVDC Mode (Metallic return / Ground return)
iii. Isolator/CB Status of DC Switchyard
iv. RPC Status
v. Run back Status
vi. POD Status
vii. SSDC Status
viii. SOE with Time Stamping
ix. DMRs
x. MRTB status
xi. GRTB status
xii. SoE for HVDC auto restart
xiii. Any other relevant signal sought by SLDC

Protection Signal

i. DC line Fault Protection
ii. ESOF (emergency Switch Off) and HVDC Pole Block protection
iii. POD Status (operated or not)

PMUs shall be installed at the HV side of converter/interface transformer of HVDC stations (all terminals in case of multi-terminal HVDC). The signal list for PMU data is provided at **Annexure-II**.

c) Other Pre-charging Activities

Following miscellaneous details shall be submitted by the HVDC owner before first time charging of the HVDC:

a. Details of the approval of the transmission scheme from the Planning Committee Meeting/ RPC / CEA / CTU/STU Consultative meeting and approval for changes in the approved scheme, if any.

b. CEA approval for energization as per Central Electricity Authority (Measures Relating to Safety & Electric Supply) Regulations, 2023.

c. PTCC clearance certificate

d. Owners of the HVDCs shall submit a detailed proposal for testing before or along with the intimation of first-time charging (Format -A). Proposed testing schedule of HVDC transmission elements shall be duly approved by SRPC.

e. As per regulation 24 of KEGC, 2023: *"The following tests shall be performed:*
(i) Minimum load operation.
(ii) Ramp rate.
(iii) Overload capability, subject to grid condition.
(iv) Black start capability in the case of Voltage source convertor (VSC) HVDC wherever feasible
(v) Dynamic Reactive Power Support (in the case of VSC based HVDC)"

The detailed report covering the results of the above tests shall be submitted to the SLDC.

e. The auxiliary consumption of HVDC station is generally drawn from the tertiary of the 400/220/33 kV or 765/400/33 kV transformer at the substation. The meter reading of this transformer would include the auxiliary consumption of HVDC station as well. Therefore, a No Objection Certificate (NOC) from the local DISCOM and SLDC would also be provided by the owner of the HVDC station.

2. Notice of Trial Run

a) The "transmission licensee/HVDC Owner" proposing the trial run for HVDC shall give a notice of not less than **seven days** to the c SLDC, STU, distribution licensees of the region and the owner of the inter-connecting system.

b) The SLDC shall allow commencement of the trial run from the requested date or in the case of any system constraints, not later than seven (7) days from the proposed date of the trial run. The trial run shall commence from the time and date as decided and informed by the SLDC.

3. Trial Run Operation of HVDC

a) The settings of HVDC to be kept during the trial run shall be decided by the TSP in consultation with the SLDC before the commencement of the trial run.

b) The trial operation for the purpose of HVDC link/Pole shall be continuous operation for 24 hrs at its nominal system voltage in bi-direction (wherever applicable) through interconnection with the grid for a continuous twenty-four (24) hours flow of power and communication signal from the sending end to the receiving end and with the requisite metering system, telemetry and protection system.

c) During the trial operation minimum load operation, ramp rate, overload capability (subject to grid condition) and black start capability in case of Voltage source convertor (VSC) HVDC station, Dynamic Reactive Power Support (in the case of VSC based HVDC), reversal of power (maximum/minimum power order) shall be demonstrated as desired by NLDC/SLDCs.

4. Post Charging Activities

a) Successful Trial Operation completion certificate for HVDC shall be issued by SLDC in accordance with relevant provisions in **section-1** of this procedure.

b) Following data shall be provided by the owner of HVDC station after successful trial operation for issuance of trial operation completion certificate:

   i. Converter/Interface transformer meter reading for the period of trial operation from both end
   ii. SCADA readings/plot of active and reactive power flow from both the end during the trial operation
   iii. Event log indicating opening/closing of breakers
   iv. Output of Disturbance Recorder for the period of trial operation
   v. Any other data as required by SLDC.

c) If any fault has taken place in the nearby system, then HVDC disturbance recorder data for the event shall be provided for verification performance.

d) After completion of the successful trial run and receipt of documents and test reports as mentioned in above sections, the SLDC shall issue a certificate to that effect to the concerned transmission licensee/HVDC owner, as the case may be, with a copy to their respective beneficiary (ies) and the SRPC, within three days.

e) **Submission of final as-built validated model:** Within 03 months of the issuance of successful trial run certificate, asset owner shall submit a final as built validated simulation model (both EMT and RMS) along-with model validation report of the HVDC for both steady state (both voltage and Q-control) and transient conditions. For steady- state validation, real-time PMU data shall be used. For transient condition validation, disturbance recorder data shall be used.

   Steady state condition validation shall be carried out for step change in active power of HVDC.

   Further, in case of VSC based HVDC, steady state validation shall be carried out for the following tests also at both the converter stations:

   i) **Voltage Control Mode -** Perform test for dead-band (in the range of 0 to 0.05 p.u.) & droop (in the range of 1-5%)

      a) **Case-1:** Step increase in reference voltage from 0.95 p.u. to 1 pu and subsequently to 1.05 pu
      b) **Case-2:** Step decrease in reference voltage from 1.05 pu to 1 pu and subsequently to 0.95 pu

Test shall be repeated for multiple dead-band and droop settings in the range specified above.

ii) **Fixed 'Q' Control Mode**

a) Case-1: Step change in Reactive Power (Q) injection from 0 to 50% and subsequently to 100% of rated reactive power
b) Case-2: Step change in Reactive Power (Q) absorption from 0 to 50% and subsequently to 100% of rated reactive power

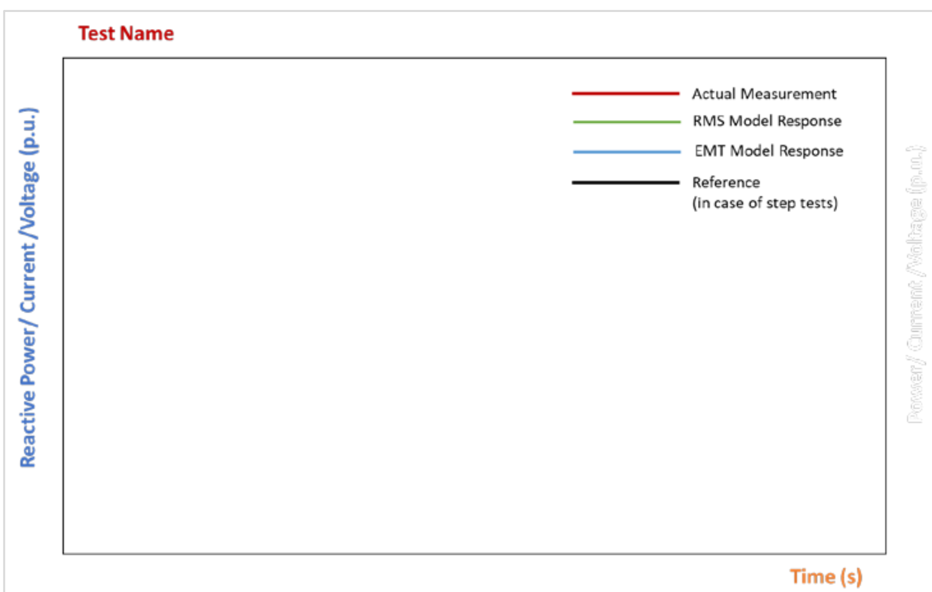
The validation report shall include the following:

a. Model file names of RMS & EMT model.

b. Final simulation model parameters of STATCOM/SVC.

c. The table demonstrating the similarity between simulation model parameters/settings and settings implemented at site (in real-time operation) shall be provided.

d. Comparison of on-site test measurement with simulation results shall be provided as per the format shown below:



e. Along with graphical comparison of field test measurement with simulation results, time series measurements/data of field test and simulation response (of same time resolution) shall also be provided in suitable format (preferably .csv file).

f. Model Validation report shall provide details of the causes of deviation from simulated behaviour and suggest corrective actions.

5. Periodic Testing

a) Periodic Testing shall be carried out as per regulation (6.18) of the KEGC, 2025 and amendments thereof. It is desirable to submit report of such tests carried out (at the time of first Time Energization and Integration) while applying for trial run certificates.

b) The tests shall be performed once every five (5) years or whenever major retrofitting is done. If any adverse performance is observed during any grid event, then the tests shall be carried out even earlier, if so advised by SLDC or SRLDC or NLDC or RPC, as the case may be.

c) Within 03 months of completion of the periodic tests, the owner of the HVDC shall submit the final validated model comparing the results of the periodic tests against the model response as specified in section-4 (d) above. The models shall be submitted as per the model compatibility guidelines specified at Annexure-I.

6. Confidentiality Obligation

SLDC shall preserve the confidentiality of the information and data related with mathematical models (user defined model, source code etc.) and certification reports submitted to them in fulfillment of the obligations under this procedure and shall use them exclusively for the purpose they have been submitted, notably to verify the compliance of requirements set forth in extant regulations in Indian power system. The data may also be used for the purpose of system studies required for reliable and secure operation of the grid as per the Electricity Act and CEA/CERC regulations.

Note: Further amendment in the procedure can be done in line with KEGC/other CERC & CEA regulations/directive from time to time.

Enclosures:

Annexure-I: Model Compatibility and Support Guidelines for HVDC
Annexure-I (a): Guidelines for Collection of Modelling data (Generic) from HVDC stations
Annexure-II: PMU Signal List

Annexure-I: Guidelines for Model Compatibility and Support for HVDC

1. Model Compatibility and Support Guidelines for HVDC

i. RMS and EMT models of the HVDC shall be submitted. The model shall include auxiliary models also (Frequency Controller Model, POD controller Model, Sub synchronous damping controller model, Voltage controller model etc., as applicable).

ii. The models shall be compatible with the power system software simulation products as specified by SLDC below: -

a) RMS models shall be compatible with **PSS/E version 35** and above.

Provided that the SLDC may accept the model compatible with version 34 also under special circumstances. The decision in this regard will be at the discretion of the SLDC only.

Both **generic**[1] and **user defined (UDM) RMS models** are required to be submitted.

The response of the generic model shall be benchmarked against the UDM response for both steady state and transient conditions.

Further, the generic model shall not contain any encrypted or compiled parts, as the system operator must be able to maintain the same without the restrictions of software updates etc.

In case of submission of User Defined Models (UDMs), the submission of the **source code and compiling procedure** along with the model is mandatory.

b) EMT models shall be compatible with PSCAD version 4.6.3 and above with the following –

i. Intel 15 Update 5 and newer (32-bit) and Visual Studio 2015 and newer
ii. Intel 15 Update 5 and newer (64-bit) and Visual Studio 2015 and newer
iii. Model works across a range of time steps and does not require a specific time step

These models must not be dependent on a specific Intel Visual FORTRAN version and should not have dependencies on additional external commercial software.

[1] **Annexure-I(a)** may be referred for submitting generic RMS modelling data for HVDC

iii. The HVDC simulation models (applicable for generic and UDMs) shall:

a) Be submitted in the form of HVDC and Converter transformer connected to the representation of the Grid (Thevenin-equivalent) SMIB (Single Machine Infinite Bus) model.

b) Be supported by model descriptions that, as a minimum, shall include Laplace domain transfer functions (for RMS models), and function descriptions of the arithmetical, logical and sequence-controlled modules used in the simulation model.

c) Include descriptions of the individual model components and related parameters including saturation, non-linearity, dead band, time delays and constraint functions (non-wind-up/anti wind-up) etc.

d) Include descriptions of the set-up of the simulation model as well as any limitations to the application hereof. There shall be no initialization errors for the dynamic models. The warning messages shall be reviewed and resolution or explanation shall be provided.

e) Work for a range of dynamic simulation solution parameters rather than for specific settings only.

iv) Any model validity limitations due to system impedance or strength or any other reason shall be clearly defined.

v) Models shall not show any characteristics that are not present in the actual HVDC response.

vi) Model user guide including model setup procedure, RMS & EMT software version, compiler, visual studio version etc. shall be submitted along with the model.

vii) Model limitations, maximum solution time step etc. to be included in user guide

viii) EMT model shall not contain any dependent libraries. The submitted workspace file (.pswx) must not load any PSCAD library (.pslx) files apart from the PSCAD master library. The model shall be capable of running with no extra steps aside from clicking “Run” option in PSCAD.

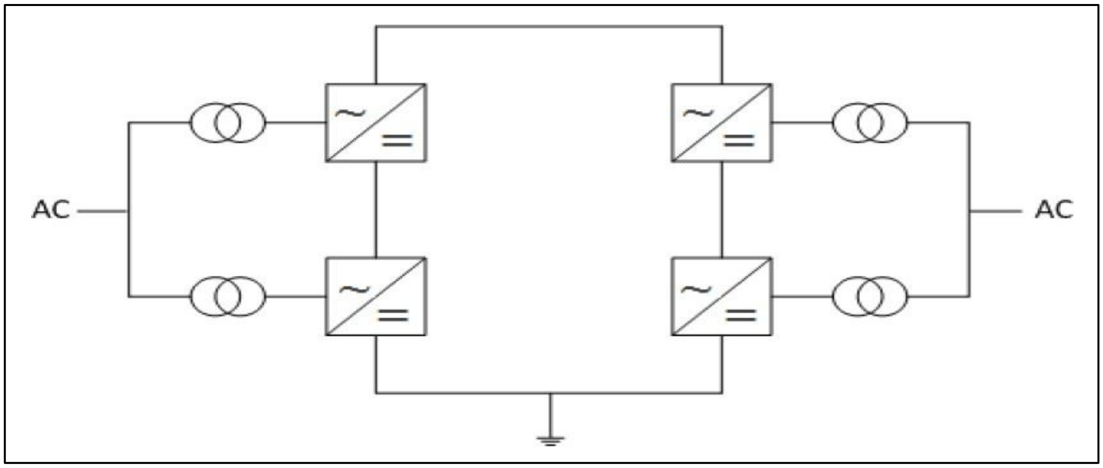
Annexure-I (a): Guidelines for furnishing RMS Modelling Data (Generic) of HVDC

1. HVDC technologies

HVDC systems are widely recognized as having the ability to transfer more power over longer distances than comparable HVAC (high voltage alternating current) systems, along with several other benefits such as lower transmission losses, higher stability, and more controllability. HVDCs can also be utilized to connect parts of the grid at different frequencies (such as connections between India and Bangladesh in Eastern Region) as well as facilitate long distance undersea cable transmission (such as proposed transmission between India and Sri Lanka). HVDC schemes can be classified in two types:

- Back-to-Back schemes
- Long distance transmission schemes

Back-to-back schemes are usually used to interconnect two AC networks with different frequencies. Both the converters in this scheme are located in the same location and no transmission line is used between them. Because no DC conductor is used back-to-back schemes are operated with high currents (3-4 KA) in order to minimize the cost and losses of the converter equipment.



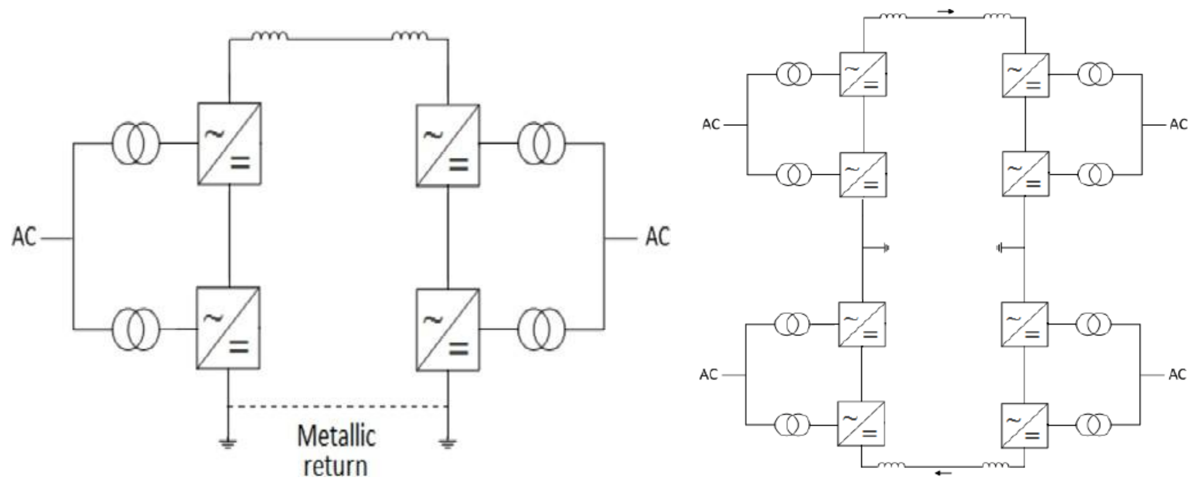
Back to Back Scheme

On the other hand, transmission schemes are used for bulk energy transmission over long distances. The two converter stations are connected through a DC conductor, either a transmission line or an underground/submarine cable. Two configurations are usually used for this scheme:

- Monopolar configuration
- Bipolar configuration

In monopolar configuration, the return is accomplished either by ground or sea (depending on the application) or by a metallic conductor.

The bipolar configuration has two independent poles, each consisting of an independent converter. This configuration uses two conductors; one has positive polarity while the other negative. Power flow can be in one or both directions. The bipolar configuration is arranged in such a way that the return currents cancel each other out. Each pole can operate separately or in a master slave configuration.



<u>Monopolar and Bipolar HVDC links</u>

The power electronic based converters (rectifiers at sending end, and inverters at receiving end) are the core component of HVDC systems. Depending on the type of technologies used in converters, 2 broad categories of HVDC systems are in place:

1. Line Commutated Converter (LCC) based HVDCs
2. Voltage Source Converter (VSC) based HVDCs

With integration of inherently variable renewable energy generation in Indian grid, the operation of HVDCs assumes greater importance.

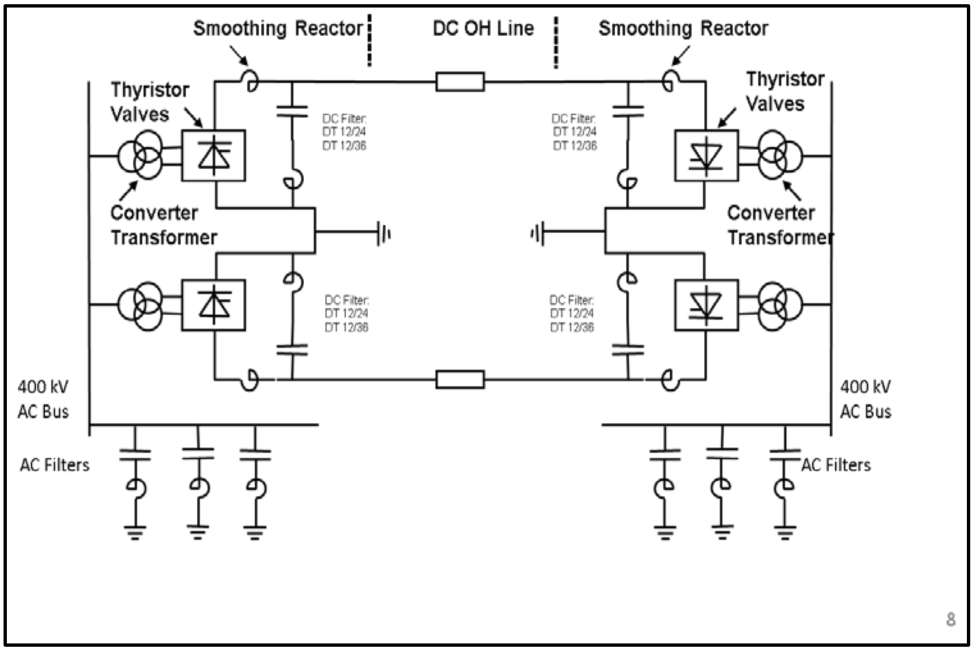
2. **<u>Models for HVDC links:</u>**

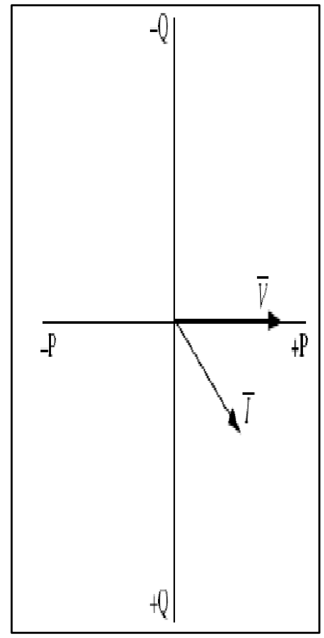
- **Line Commutated Converter (LCC) based HVDCs**

LCCs are also known as line commutated converters. As the name indicates, conversion depends on the line voltage of the AC system. This happens because the switching device used in this type of converters is a thyristor. In order to achieve high voltage levels needed for HVDC transmission applications, each thyristor valve of the converter bridge consists of a series connection of a number of thyristors. For typical applications 24 to 30 thyristors are connected in series to create a valve. Regarding the mode of operation LCCs operate in the two lower quadrants of the PQ plane. This means that they can provide or absorb active power but only absorb reactive power.

The reactive power consumption of CSC converters is usually about 50% to 60% of the active power transferred. Due to this reactive power consumption reactive power sources such as shunt capacitors, must be connected at the terminals of the converters.

Components of a typical LCC HVDC system are depicted in figure below:



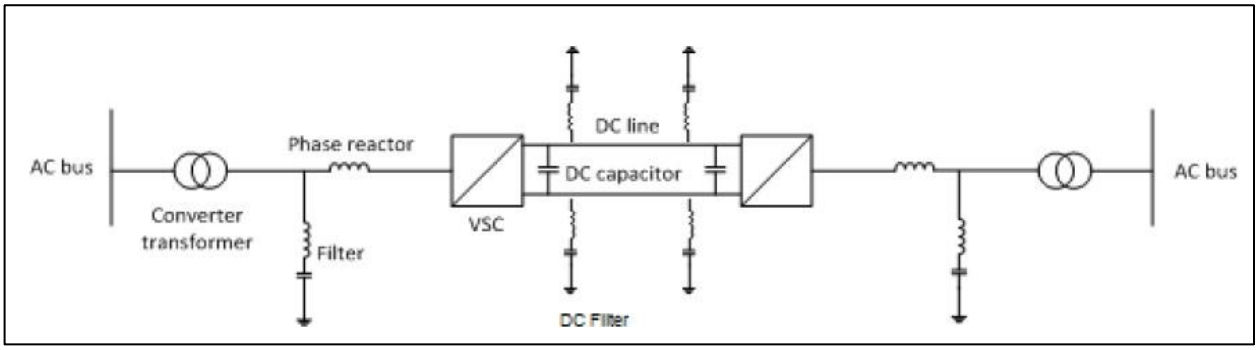


Typical components of LCC HVDC installation

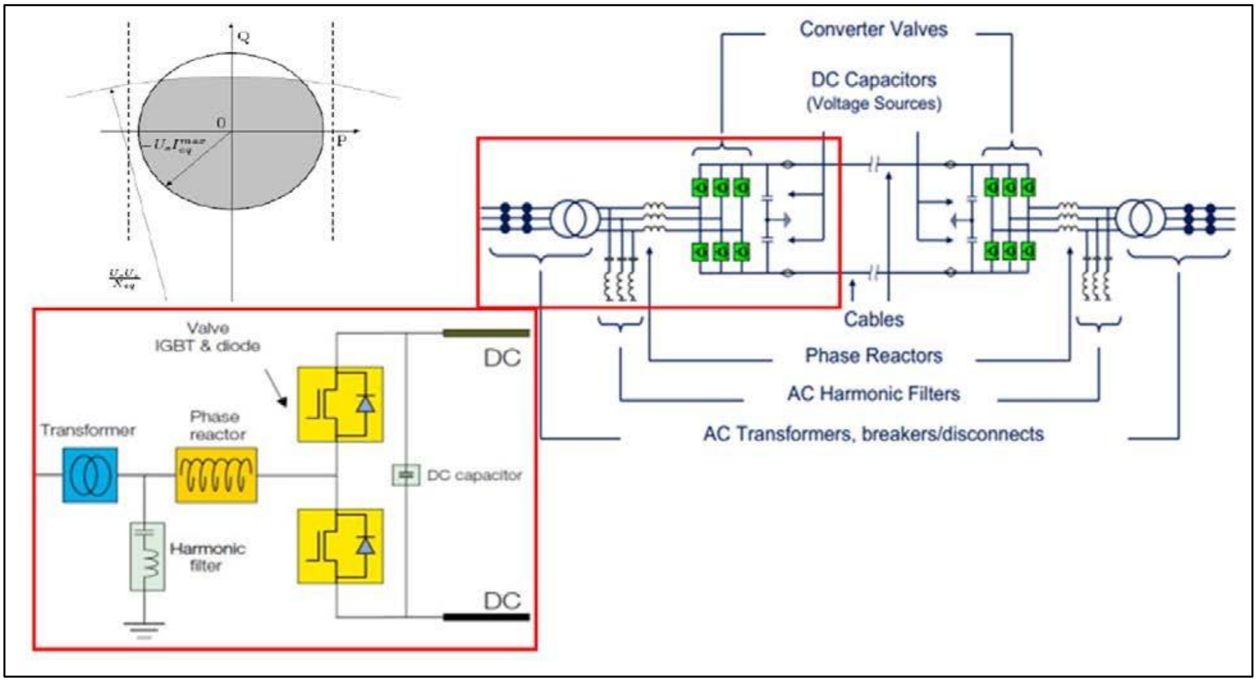
- **Voltage Source Converter Based VSC:**

VSC-HVDC links consist of the converter station and the DC conductor. VSCs use solid state devices such as IGBTs (for high switching frequency) or thyristor-type devices such as GTOs or IGCTs (for low switching frequencies) so that their switching-on and switching-off are fully controlled. This allows VSCs to operate on the four quadrants of the P-Q plane and therefore can generate or absorb reactive power in contrast to LCCs which only absorb.

In VSC-HVDC transmission the voltage polarity is constant and power flow reversal is accomplished through current reversal. Just as in the LCC case, filters are needed in order to block harmonics in the converter's output reach the AC grid. Filters in VSC-HVDC schemes are much smaller than in LCC-HVDC schemes due to the smaller harmonic content of the VSC converter output. Components of typical VSC HVDC are depicted in figure below:



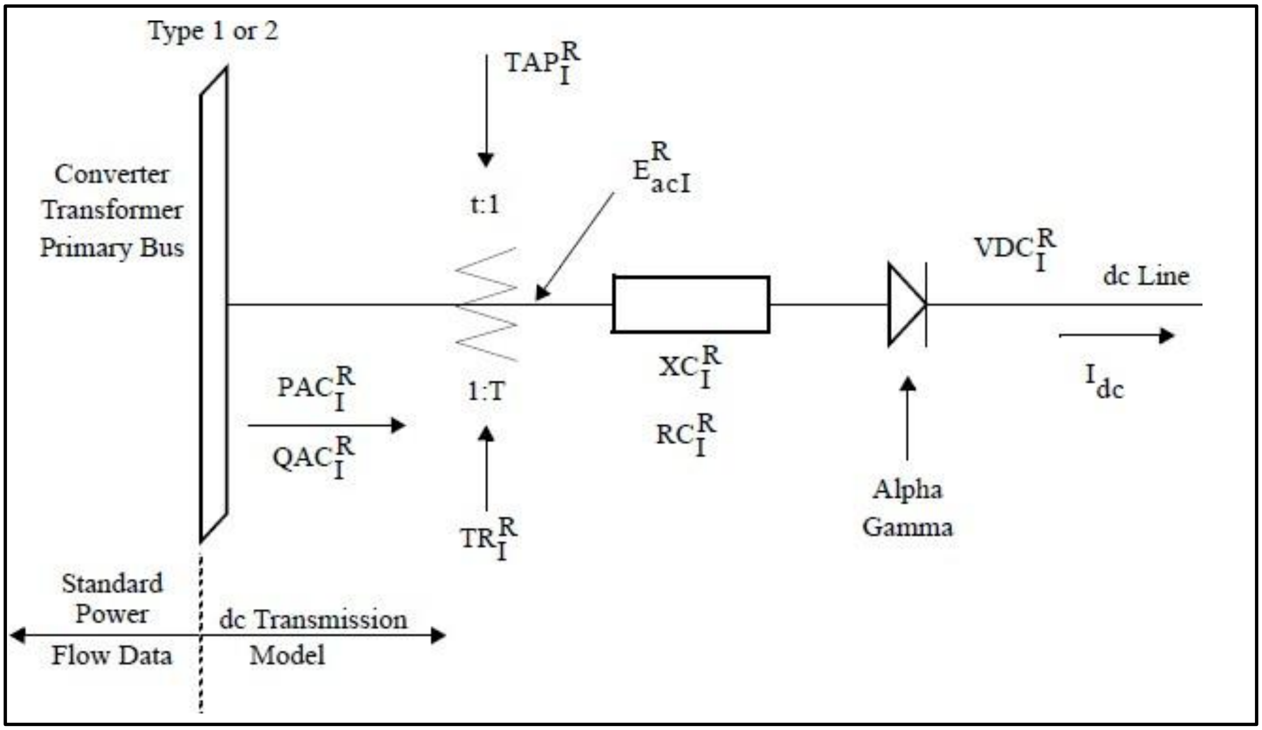
Typical VSC link



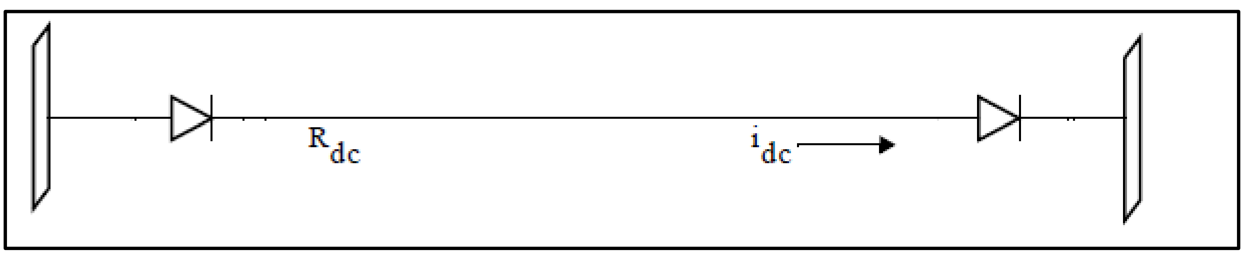
VSC Components and capability chart

Within PSSE the transformer impedance data is only required to be separated if a three winding converter transformer is used and there is reactive power equipment connected to its tertiary winding. In this case, the star-point to secondary data must be entered into the HVDC model however the primary to star-point and star-point to tertiary impedances must be represented explicitly as AC branches within the load-flow case (with appropriate equivalencing if there are multiple transformers in parallel). Otherwise, the primary to secondary converter transformer impedances should be calculated and directly entered into the DC line data with no additional AC components. Please refer to the PSSE manual (PAG Volume 1).

3. PSS/E representation for HVDC links:



PSS/E rectifier/inverter representation of HVDC link



PSS/E power flow representation of HVDC model

The power flow representation of HVDC links in PSS/E is depicted in figures above.

Details of models in PSS/E for modelling HVDC Links:

A. **Steady State model (Power Flow)**

Information for Steady State model of HVDC links

Category	Parameter Description	Data
Link OEM and rating	Manufacturer and product details (for example Siemens, GE, ABB, etc.)	
	Year of commissioning	
	Rated DC voltage	
	Length of the link	
	Conductor Type (of DC lines)	
	Number of Poles	
	Rating of Each Pole (Power-MW, and Current-Amperes)	
	Minimum Power flow on DC link (per pole) in MW	
	Overload capability of DC link (per pole) in MW and no. of hours	
	LCC, Rectifier controls maintain - constant DC power or DC current?	
	LCC, Inverter controls maintain - constant DC voltage or extinction angle?	
	LCC, For DC voltage control, whether any compensation is utilized?	
	LCC, Inverter current margin	
	VSC, converter controls DC voltage or DC power?	
	VSC, converter controls AC voltage or power factor?	
Technology	Converters: - LCC (conventional) - Voltage Source Converter (VSC) - Multi-terminal	
DC Components	Smoothing Reactors	
	DC Line resistance (Rdc) in Ohms	
	Minimum inverter dc voltage for power control mode (in kV)	
Converter transformer	Make	
	MVA rating	
	Two winding transformer or three winding transformers	
	If three winding, any auxiliary equipment connected to tertiary winding?	
	AC side base voltage	
	DC side base voltage	
	Impedance (in Ohms, in % on 100 MVA base and mention Voltage reference side)	
	Converter transformer secondary commutating reactance in ohms per bridge [Star point to Secondary]	
	Converter transformer secondary commutating resistance in ohms per bridge [Star point to Secondary]	
	Primary to Star-point impedance of Converter transformer (R+jX)	
	Tertiary to Star-point impedance of Converter transformer (R+jX)	

Category	Parameter Description	Data
	Maximum value of converter transformer tap ratio (in p.u. of Voltage)	
	Minimum value of converter transformer tap ratio (in p.u. of Voltage)	
	Converter transformer tap-step (in pu of voltage)	
Converter Details	Minimum firing (delay) angle of rectifier in degrees (Alpha-min)	
	Maximum firing (delay) angle objective for rectifier in degrees (Alpha-max)	
	Minimum margin angle of inverter in degrees (Gamma-min)	
	Maximum margin angle objective for inverter in degrees (Gamma-max)	
	Number of Pulses (Ex. 12 pulse bridge, with 2 nos. 6 pulse bridge in series)	
	Alpha-min, actual absolute minimum firing angle during transients	
	Gamma-min, actual absolute minimum extinction angle during Transients	
Additional information for VSC HVDC	AC side MVA rating	
	Q limits	
	Converter Losses	
	Voltage Control Settings	
AC Filters	Details of AC filters (Switching sequence w.r.t. Power order, MVAR values at nominal voltage and fundamental frequency	

B. <u>Transient simulation model (Dynamics):</u>

For representation of the electromechanical transient behavior of HVDC links, standard models are available in PSS/E library. A list of standard models is listed below:

Generic Models for HVDC links

Category	Type	Model Description
CDC1T	LCC	Two-terminal dc line model
CDC4T	LCC	Two-terminal dc line model
CDC6T	LCC	Two-terminal dc line model
CDC6TA	LCC	Two-terminal dc line model
CDC7T	LCC	DC line model
CDCABT	LCC	ABB dc line model for Kontek line
CEELRIT	LCC	New Eel River dc line and auxiliaries' model
CEELT	LCC	New Eel River dc line and auxiliaries' model
CHIGATT	LCC	Highgate dc line model.
CHVDC2U1	LCC	WECC Generic 2-Terminal HVDC Model

CMDWAST	LCC	Madawaska dc line model
CMDWS2T	LCC	New Madawaska dc line model
CMFORDT	LCC	Comerford dc line model
HVDCPL1	VSC	Siemens HVDC plus model
VSCDCT	VSC	Two-terminal VSC dc line model
MTDC1T	MTDC	Multiterminal (five converter) dc line model
MTDC2T	MTDC	Multiterminal (five converter) dc line model
MTDC3T	MTDC	Multiterminal (eight converter) dc line model

Source: PSSE Model Library, for models other than the above list refer to

https://w3.usa.siemens.com/smartgrid/us/en/transmission-grid/products/grid-analysis-tools/transmission-system-planning/transmission-system-planning-tab/pages/user-support.aspx

At present, it is preferred to use one of the three models viz., CDC4T, CDC7T, and CHVDC2U1 for LCC type HVDCs.

In addition to the above, any modulation control of relevance to system performance for RMS simulations should be modelled utilizing generic HVDC auxiliary models as listed below:

Generic HVDC auxiliary signal models

Model	Model Description
CHAAUT	Chateauguay auxiliary signal model
CPAAUT	Frequency sensitive auxiliary signal model
DCCAUT	Comerford auxiliary signal model
DCVRFT	HVDC ac voltage controller model
FCTAXBU1	FACTS device Auxiliary Control Model
HVDCAT	General purpose auxiliary signal model
PAUX1T	Frequency sensitive auxiliary signal model
PAUX2T	Bus voltage angle sensitive auxiliary signal model
RBKELT	Runback model
RUNBKT	Runback model
SQBAUT	dc line auxiliary signal model

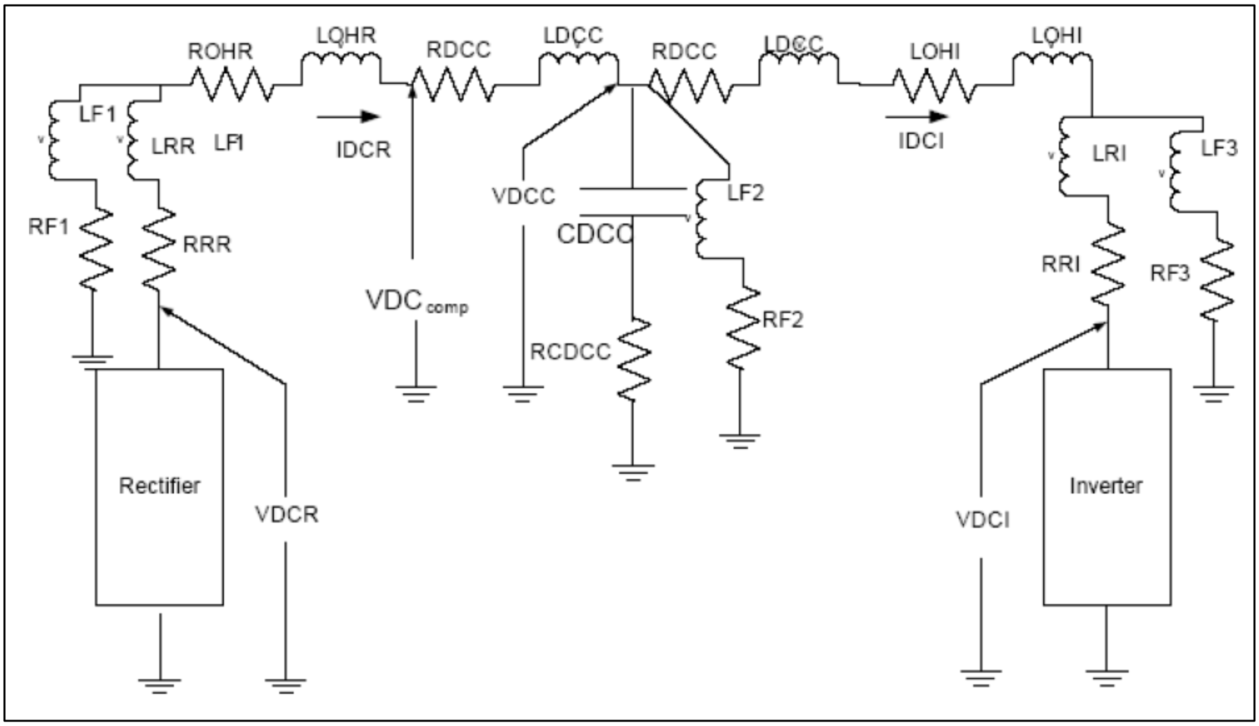
Commonly Used LCC based HVDCs:

- **CDC4T: Two-terminal dc line model**

CDC4T is a pseudo steady-state model and omit some of the dynamics of HVDC converters such as L/R dynamics of DC line, smoothing reactors, and high frequency controller dynamics. A more detailed representation (CDC7T / CHVDC2U1) would be preferred if information pertaining to the same are verifiable against actual measurements.

- **CDC7T: DC line model**

There are significant differences between this model and generic HVDC models, such as CDC4T or CDC6T, available in the PSS®E library. The CDC4T and CDC6T models assume an instantaneous response of the dc system to disturbances coming from adjacent grids. The dc circuit arrangement that can be simulated by the CDC7T model is shown in figure below. A dc line may comprise overhead lines from both rectifier and inverter sides and a cable.



A DC Circuit Arrangement Simulated by the CDC7T Model

Although the dc line can be represented by a T-circuit with lumped Rdc and Ldc parameters, for the sake of flexibility the model uses resistances and inductances of overhead lines on rectifier (ROHR, LOHR) and inverter (ROHI, LOHI) sides, resistance, inductance, and capacitance of the dc cable (RDCC, LDCC, CDCC), and resistance and inductance of smoothing reactors on both sides (RRR, LRR and RRI, LRI). CDC7T model has a provision for choosing the control configuration. The CDC7T model uses 79 parameters of the dc circuit and controls.

Category	Parameters	Data
LCC based HVDC		
CDC4T	ALFDY, minimum alpha for dynamics (degrees)	
	GAMDYa, minimum gamma for dynamics (degrees)	
	TVDC, dc voltage transducer time constant (sec)	
	TIDC, dc current transducer time constant (sec)	
	VBLOCK, rectifier ac blocking voltage (pu)	
	VUNBL, rectifier ac unblocking voltage (pu)	
	TBLOCK, minimum blocking time (sec)	
	VBYPAS, inverter dc bypassing voltage (kV)	
	VUNBY, inverter ac unbypassing voltage (pu)	
	TBYPAS, minimum bypassing time (sec)	
	RSVOLT, minimum dc voltage following block (kV)	
	RSCUR, minimum dc current following block (amps	
	VRAMP, voltage recovery rate (pu/sec)	
	CRAMP, current recovery rate (pu/sec)	
	C0, minimum current demand (amps)	
	V1, voltage limit point 1 (kV)	
	C1, Current limit point 1 (amps); >C0	
	V2, voltage limit point 2 (kV)	
	C2, current limit point 2 (amps)	
	V3, voltage limit point 3 (kV)	
	C3, current limit point 3 (amps)	
	TCMODE, minimum time stays in switched mode (sec)	
CDC7T	dc voltage sensor time constant, sec.	
	dc current sensor time constant, sec.	
	Rectifier smoothing reactor inductance, mH	
	Rectifier smoothing reactor resistance, ohm	
	Inverter smoothing reactor inductance, mH	
	Inverter smoothing reactor resistance, ohm	
	Inductance of O/H dc line from rectifier side, mH	
	Resistance of O/H dc line from rectifier side, ohm	
	Inductance of O/H dc line from inverter side, mH	
	Resistance of O/H dc line from inverter side, ohm	
	Inductance of dc cable line, Mh	
	Damping resistance of dc cable line, ohm	
	dc line capacitance, µF	
	dc fault shunt inductance, rectifier side, mH	
	dc fault shunt resistance, rectifier side, ohm	

Category	Parameters	Data
LCC based HVDC		
CDC7T	dc fault shunt inductance, mid-line, mH	
	dc fault shunt resistance, mid-line, ohm	
	dc fault shunt inductance, inverter side, mH	
	dc fault shunt resistance, inverter side, ohm	
	dc cable damping resistor	
	Rated dc current, A	
	Rated dc voltage, kV	
	VDComp down time constant for VDCL, rectifier, sec	
	VDComp up time constant for VDCL, rectifier, sec	
	VDComp down time constant for VDCL, inverter, sec	
	VDComp up time constant for VDCL, inverter, sec	
	Current margin, rectifier, pu	
	Current margin, inverter, pu	
	Voltage margin, rectifier, pu	
	Voltage margin, inverter, pu	
	Gamma margin, rectifier, pu	
	Gamma margin, inverter, pu	
	IDC error to V-control gain, rectifier	
	IDC error to V-control gain, inverter	
	IDC error to Gamma-control gain, inverter	
	VDComp filter gain, rectifier, pu	
	VDComp filter gain, inverter, pu	
	VDComp filter time constant, rectifier, sec.	
	VDComp filter time constant, inverter, sec.	
	Selected controller output gain, rectifier	
	Selected controller output gain, inverter	
	PI-controller proportional gain, rectifier	
	PI-controller integrator time constant, rectifier, sec.	
	PI-controller proportional gain, inverter	
	PI-controller integrator time constant, inverter, sec.	
	Max Alfa limit, rectifier	
	Min Alfa limit, rectifier	
	Max Alfa limit, inverter	
	Min Alfa limit, inverter	
	Control configuration 1	
	Control configuration 3	
	Min GAMA in dynamics	
	Rate of current order change when blocking, A/sec	
	Rate of current order change when unblocking, A/sec	
	VDC filter time constant for Pordr calculation, sec.	
	5 pairs of rectifier VDCL coordinates (Vd1, Id1) … (Vd5, Id5)1	
	5 pairs of inverter VDCL coordinates (Vd1, Id1) … (Vd5, Id5)1	

Category	Parameters	Data

VSC based HVDC		
HVDCPL 1	Rated AC voltage on DC side of converter Xfmr [kV]	
	Rectifier transformer impedance [pu of SBASE]	
	Inverter transformer impedance [pu of SBASE]	
	DC line total inductance [H]	
	DC line total capacitance [F]	
	Gain GQr of the rectifier reactive power controller	
	Lead time constant TLeadQr of the rectifier reactive power controller [s]	
	Lag time constant TLagQr of the rectifier reactive power controller [s]	
	Gain GQi of the inverter reactive power controller	
	Lead time constant TLeadQi of the inverter reactive power controller [s]	
	Lag time constant TLagQi of the inverter reactive power controller [s]	
	Gain G1Ud of the DC voltage controller	
	Lead time constant TLead1Ud of the DC voltage controller [s]	
	Lag time constant TLag1Ud of the DC voltage controller [s]	
	Gain G2Ud of the DC voltage controller	
	Lead time constant TLead2Ud of the DC voltage controller [s]	
	Lag time constant TLag2Ud of the DC voltage controller [s]	
	Ramp rate of the inverter active power setting value [p.u./s] (used for interconnected application)	
	Gain G1P of the inverter active power controller (interconnected application)	
	Lead time constant TLead1P of the inverter active power controller [s] (interconnected application)	
	Lag time constant TLag1P of the inverter active power controller [s] (interconnected application)	
	Gain G2P of the inverter active power controller (interconnected application)	
	Lead time constant TLead2P of the inverter active power controller [s] (interconnected application)	
	Lag time constant TLag2P of the inverter active power controller [s] (interconnected application)	
	TIntQr (s); Rectifier Q controller integrator time constant	
	LMXQr (pu); Rectifier Q controller integrator upper limit	
	LMNQr (pu); Rectifier Q controller integrator lower limit	
	TIntQi (s); Inverter Q controller integrator time constant	
	LMXQi (pu); Inverter Q controller integrator upper limit	
	LMNQi (pu); Inverter Q controller integrator lower limit	
	TIntUd (s); Inverter dc voltage controller integrator time constant	
	LMXIUd (pu); Inverter dc voltage controller integrator upper limit	
	LMNIUd(pu); Inverter dc voltage controller integrator lower limit	
	TIntP (s); Inverter P controller integrator time constant	
	LMXP (pu); Inverter P controller integrator upper limit	
	LMNP (pu); Inverter P controller integrator lower limit	
	Tsync (s); Inverter POI Angle measurement delay	
	LMX1Ud (deg.); Rectifier dc voltage controller first lead-lag upper limit	

Category	Parameters	Data
VSC based HVDC		
HVDCPL 1	LMN1Ud (deg.); Rectifier dc voltage controller first lead-lag lower limit	
	LMX2Ud (deg.); Rectifier dc voltage controller second lead-lag upper limit	
	LMN2Ud (deg.); Rectifier dc voltage controller second lead-lag lower limit	
	LMX1P (deg.); Inverter P controller first lead-lag upper limit	
	LMN1P (deg.); Inverter P controller first lead-lag lower limit	
	LMX2P (deg.); Inverter P controller second lead-lag upper limit	
	LMN2P (deg.); Inverter P controller second lead-lag lower limit	
	C_Module (F),Converter module capacitor	
	V_Module (kV), Converter module rated capacitor voltage	
	Protection threshold peak current of the IGBTs, kA	
	Model Acceleration factor(>0 and <=1)	
	Undervoltage characteristics, X1 (measured AC-voltage in pu)	
	Undervoltage characteristics, Y1 (AC-voltage reference in pu)	
	Undervoltage characteristics, X2	
	Undervoltage characteristics, Y2	
	Undervoltage characteristics, X3	
	Undervoltage characteristics, Y3	
	Undervoltage characteristics, X4	
	Undervoltage characteristics, Y4	
	Undervoltage characteristics, X5	
	Undervoltage characteristics, Y5	
	Undervoltage characteristics, X6	
	Undervoltage characteristics, Y6	
	Undervoltage characteristics, X7	
	Undervoltage characteristics, Y7	
	Undervoltage characteristics, X8	
	Undervoltage characteristics, Y8	
	Undervoltage characteristics, X9	
	Undervoltage characteristics, Y9	
	Undervoltage characteristics, X10	
	Undervoltage characteristics, Y10	
	Power-Voltage characteristics, X1 (measured AC-voltage in pu)	
	Power-Voltage characteristics, Y1 (maximum active power in pu of MVA rating of second converter)	
	Power-Voltage characteristics, X2	
	Power-Voltage characteristics, Y2	
	Power-Voltage characteristics, X3	
	Power-Voltage characteristics, Y3	
	Power-Voltage characteristics, X4	
	Power-Voltage characteristics, Y4	
	Power-Voltage characteristics, X5	
	Power-Voltage characteristics, Y5	
Category	**Parameters**	**Data**
VSC based HVDC		

HVDCPL 1	Power-Voltage characteristics, X6	
	Power-Voltage characteristics, Y6	
	DC Chopper characteristics, X1 (Direct voltage in pu)	
	DC Chopper V-I characteristics, Y1 (chopper current in kA)	
	DC Chopper characteristics, X2	
	DC Chopper characteristics, Y2	
	DC Chopper characteristics, X3	
	DC Chopper characteristics, Y3	
	DC Chopper characteristics, X4	
	DC Chopper characteristics, Y4	
	DC Chopper characteristics, X5	
	DC Chopper characteristics, Y5	
	DC Chopper characteristics, X6	
	DC Chopper characteristics, Y6	
	DC Chopper characteristics, X7	
	DC Chopper characteristics, X7	
	DC Chopper characteristics, X8	
	DC Chopper characteristics, X8	
	DC Chopper characteristics, X9	
	DC Chopper characteristics, X9	
	DC Chopper characteristics, X10	
	DC Chopper characteristics, X10	
VSCDCT	Tpo_1, Time constant of active power order controller, sec (For VSC # 1).	
	AC_VC_Limits_1, Reactive power limit for ac voltage control, pu on converter MVA rating. When 0, it is not used and Qmax/Qmin pair is used instead (For VSC # 1).	
	AC_Vctrl_kp_1, AC Voltage control proportional gain, converter MVA rating/BASEKV (For VSC # 1).	
	Tac_1 > 0.0, Time constant for AC voltage PI integral, sec (For VSC # 1). When 0, VSC#1 is ignored.	
	Tacm_1, Time constant of the ac voltage transducer, sec (For VSC # 1).	
	Iacmax_1, Current Limit, pu on converter MVA rating (For VSC # 1).	
	Droop_1, AC Voltage control droop, converter MVA rating/BASEKV (For VSC # 1).	
	VCMX_1, Maximum VSC Bridge Internal Voltage (For VSC # 1).	
	XREACT_1 > 0.0, Pu reactance of the ac series reactor on converter MVA rating (For VSC # 1). When 0.0, default value 0.17 is used.	
	QMAX_1, Maximum system reactive limits in Mvars (For VSC # 1). When AC-VC_Limits_1 >0, QMAX_1 is not used.	
	QMIN_1, Minimum system reactive limits in MVARs (For VSC # 1). When AC-VC_Limits_1 >0, QMIN_1 is not used.	
	AC_VC_KT_1, Adjustment Parameter for the feedback from reactive power limiter to ac voltage controller (For VSC #1).	
	AC_VC_KTP_1, Adjustment Parameter for the feedback from current order limiter to ac voltage controller (For VSC #1).	
	Tpo_2, Time constant of active power order controller, sec (For VSC # 2).	

Category	Parameters	Data
VSC based HVDC		
VSCDCT	AC_VC_Limits_2, Reactive power limit for ac voltage control, pu on converter MVA rating. When 0, it is not used and Qmax/Qmin pair is used instead (For VSC # 2).	
	AC_Vctrl_kp_2, AC Voltage control proportional gain, converter MVA rating/BASEKV (For VSC # 2).	
	Tac_2 > 0.0, Time constant for AC voltage PI integral, sec (For VSC # 2). When 0, VSC#2 is ignored.	
	Tacm_2, Time constant of the ac voltage transducer, sec (For VSC # 2).	
	Iacmax_2, Current Limit, pu on converter MVA rating (For VSC # 2).	
	Droop_2, AC Voltage control droop, converter MVA rating/BASEKV (For VSC # 2).	
	VCMX_2, Maximum VSC Bridge Internal Voltage (For VSC # 2).	
	XREACT_2 > 0.0, Pu reactance of the ac series reactor on converter MVA rating (For VSC # 2). When 0.0, default value 0.17 is used.	
	QMAX_2, Maximum system reactive limits in MVARs (For VSC # 2). When AC-VC_Limits_2 >0, QMAX_2 is not used.	
	QMIN_2, Minimum system reactive limits in MVARs (For VSC # 2). When AC-VC_Limits_2 >0, QMIN_2 is not used.	
	AC_VC_KT_2, Adjustment Parameter for the feedback from reactive power limiter to ac voltage controller (For VSC #2).	
	AC_VC_KTP_2, Adjustment Parameter for the feedback from current order limiter to ac voltage controller (For VSC #2).	
	Tpo_DCL, Time constant of the power order controller, sec (For DC Line).	
	Tpo_lim, Time constant of the power order limit controller, sec (For DC Line).	
MTDC		
MTDC1T	DY1, minimum angle converter 1 (degrees)	
	TVAC1, ac voltage transducer converter 1 (sec)	
	TVDC1, dc voltage transducer converter 1 (sec)	
	TIDC1, current transducer converter 1 (sec)	
	RSVLT1, minimum dc voltage following block, converter 1 (kV)1	
	RSCUR1, minimum dc current following block, converter 1 (amps)2	
	VRMP1, voltage recovery rate, converter 1 (pu/sec)1	
	CRMP1, current recovery rate, converter 1 (pu/sec)2	
	C0-1, minimum current demand converter 1 (amps)3	
	V1-1, voltage limit point 1, converter 1 (kV)2	
	C1-1, current limit point 1, converter 1 (amps)2	
	V2-1, voltage limit point 2, converter 1 (kV)2	
	C2-1, current limit point 2, converter 1 (amps)2	
	V3-1, voltage limit point 3, converter 1 (kV)2	
	C3-1, current limit point 3, converter 1 (amps)2	
	DY2, minimum angle converter 2 (degrees)	
	TVAC2, ac voltage transducer converter 2 (sec)	
	TVDC2, dc voltage transducer converter 2 (sec)	

	TIDC2, current transducer converter 2 (sec)	
	RSVLT2, minimum dc voltage following block, converter 2 (kV)1	
	RSCUR2, minimum dc current following block, converter 2 (amps)2	
Category	**Parameters**	**Data**
	MTDC	
MTDC1T	VRMP2, voltage recovery rate, converter 2 (pu/sec)1	
	CRMP2, current recovery rate, converter 2 (pu/sec)2	
	C0-2, minimum current demand converter 2 (amps)3	
	V1-2, voltage limit point 1, converter 2 (kV)2	
	C1-2, current limit point 1, converter 2 (amps)2	
	V2-2, voltage limit point 2, converter 2 (kV)2	
	C2-2, current limit point 2, converter 2 (amps)2	
	V3-2, voltage limit point 3, converter 2 (kV)2	
	C3-2, current limit point 3, converter 2 (amps)2	
	DY3, minimum angle converter 3 (degrees)	
	TVAC3, ac voltage transducer converter 3 (sec)	
	TVDC3, dc voltage transducer converter 3 (sec)	
	TIDC3, current transducer converter 3 (sec)	
	RSVLT3, minimum dc voltage following block, converter 3 (kV)1	
	RSCUR3, minimum dc current following block, converter 3 (amps)2	
	VRMP3, voltage recovery rate, converter 3 (pu/sec)1	
	CRMP3, current recovery rate, converter 3 (pu/sec)2	
	C0-3, minimum current demand converter 3 (amps)3	
	V1-3, current limit point 1, converter 3 (kV)2	
	C1-3, current limit point 1, converter 3 (amps)2	
	V2-3, voltage limit point 2, converter 3 (kV)2	
	C2-3, current limit point 2, converter 3 (amps)2	
	V3-3, voltage limit point 3, converter 3 (kV)2	
	C3-3, current limit point 3, converter 3 (amps)2	
	DY4, minimum angle converter 4 (degrees)	
	TVAC4, ac voltage transducer converter 4 (sec)	
	TVDC4, dc voltage transducer converter 4 (sec)	
	TIDC4, current transducer converter 4 (sec)	
	RSVLT4, minimum dc voltage following block, converter 4 (kV)1	
	RSCUR4, minimum dc current following block, converter 4 (amps)2	
	VRMP4, voltage recovery rate, converter 4 (pu/sec)1	
	CRMP4, current recovery rate, converter 4 (pu/sec)2	
	C0-4, minimum current demand converter 4 (amps)3	
	V1-4, voltage limit point 1, converter 4 (kV)2	
	C1-4, current limit point 1, converter 4 (amps)2	
	V2-4, voltage limit point 2, converter 4 (kV)2	
	C2-4, current limit point 2, converter 4 (amps)2	
	V3-4, voltage limit point 3, converter 4 (kV)2	
	C3-4, current limit point 3, converter 4 (amps)2	
	DY5, minimum angle converter 5 (degrees)	
	TVAC5, ac voltage transducer converter 5 (sec)	

	TVDC5, dc voltage transducer converter 5 (sec)	
Category	**Parameters**	**Data**
MTDC		
MTDC1T	TIDC5, current transducer converter 5 (sec)	
	RSVLT5, minimum dc voltage following block, converter 5 (kV)1	
	RSCUR5, minimum dc current following block, converter 5 (amps)2	
	VRMP5, Voltage recovery rate, converter 5 (pu/sec)1	
	CRMP5, current recovery rate, converter 5 (pu/sec)2	
	C0-5, minimum current demand converter 5 (amps)3	
	V1-5, voltage limit point 1, converter 5 (kV)2	
	C1-5, current limit point 1, converter 5 (amps)2	
	V2-5, voltage limit point 2, converter 5 (kV)2	
	C2-5, current limit point 2, converter 5 (amps)2	
	V3-5, voltage limit point 3, converter 5 (kV)2	
	C3-5, current limit point 3, converter 5 (amps)2	
	TCMODE (sec)	
MTDC2T	DY1, minimum angle converter 1 (degrees)	
	TVAC1, ac voltage transducer converter 1 (sec)	
	TVDC1, dc voltage transducer converter 1 (sec)	
	TIDC1, current transducer converter 1 (sec)	
	RSVLT1, minimum dc voltage following block, converter 1 (kV)1	
	RSCUR1, minimum dc current following block, converter 1 (amps)	
	VRMP1, voltage recovery rate, converter 1 (pu/sec)1	
	CRMP1, current recover rate, converter 1 (pu/sec)	
	C0-1, minimum current demand converter 1 (amps)	
	V1-1, minimum current demand converter 1	
	C1-1, minimum current demand converter 1 (amps)	
	V2-1, minimum current demand converter 1	
	C2-1, minimum current demand converter 1 (amps)	
	V3-1, minimum current demand converter 1	
	C3-1, minimum current demand converter 1 (amps)	
	DY2, minimum angle converter 2 (degrees)	
	TVAC2, ac voltage transducer converter 2 (sec)	
	TVDC2, dc voltage transducer converter 2 (sec)	
	TIDC2, current transducer converter 2 (sec)	
	RSVLT2, minimum dc voltage following block, converter 2 (kV)1	
	RSCUR2, minimum dc current following block, converter 2 (amps)	
	VRMP2, voltage recovery rate, converter 2 (pu/sec)1	
	CRMP2, current recover rate, converter 2 (pu/sec)	
	C0-2, minimum current demand converter 2 (amps)	
	V1-2, minimum current demand converter 2	
	C1-2, minimum current demand converter 2 (amps)	
	V2-2, minimum current demand converter 2	
	C2-2, minimum current demand converter 2 (amps)	
	V3-2, minimum current demand converter 2	
Category	**Parameters**	**Data**

MTDC		
MTDC2T	C3-2, minimum current demand converter 2 (amps)	
	DY3, minimum angle converter 3 (degrees)	
	TVAC3, ac voltage transducer converter 3 (sec)	
	TVDC3, dc voltage transducer converter 3 (sec)	
	TIDC3, current transducer converter 3 (sec)	
	RSVLT3, minimum dc voltage following block, converter 3 (kV)1	
	RSCUR3, minimum dc current following block, converter 3 (amps)	
	VRMP3, voltage recovery rate, converter 3 (pu/sec)1	
	CRMP3, current recover rate, converter 3 (pu/sec)	
	C0-3, minimum current demand converter 3 (amps)	
	V1-3, minimum current demand converter 3	
	C1-3, minimum current demand converter 3 (amps)	
	V2-3, minimum current demand converter 3	
	C2-3, minimum current demand converter 3 (amps)	
	V3-3, minimum current demand converter 3	
	C3-3, minimum current demand converter 3 (amps)	
	DY4, minimum angle converter 4 (degrees)	
	TVAC4, ac voltage transducer converter 4 (sec)	
	TVDC4, dc voltage transducer converter 4 (sec)	
	TIDC4, current transducer converter 4 (sec)	
	RSVLT4, minimum dc voltage following block, converter 4 (kV)1	
	RSCUR4, minimum dc current following block, converter 4 (amps)	
	VRMP4, voltage recovery rate, converter 4 (pu/sec)1	
	CRMP4, current recovery rate, converter 4 (pu/sec)	
	C0-4, minimum current demand converter 4 (amps)	
	V1-4, minimum current demand converter 4	
	C1-4, minimum current demand converter 4 (amps)	
	V2-4, minimum current demand converter 4	
	C2-4, minimum current demand converter 4 (amps)	
	V3-4, minimum current demand converter 4	
	C3-4, minimum current demand converter 4 (amps)	
	DY5, minimum angle converter 5 (degrees)	
	TVAC5, ac voltage transducer converter 5 (seconds)	
	TVDC5, dc voltage transducer converter 5 (seconds)	
	TIDC5, current transducer converter 5 (seconds)	
	RSVLT5, minimum dc voltage following block, converter 5 (kV)1	
	RSCUR5, minimum dc current following block, converter 5 (amps)	
	VRMP5, voltage recovery rate, converter 5 (pu/sec)1	
	CRMP5, current recovery rate, converter 5 (pu/sec)	
	C0-5, minimum current demand converter 5 (amps)	
	V1-5, minimum current demand converter 5	
	C1-5, minimum current demand converter 5 (amps)	

Category	Parameters	Data
MTDC		
MTDC2T	V2-5, minimum current demand converter 5	
	C2-5, minimum current demand converter 5 (amps)	
	V3-5, minimum current demand converter 5	
	C3-5, minimum current demand converter 5 (amps)	

	TVF, power control VDC transducer time constant (sec)	
	VDCOLUP, voltage transducer time constants (sec)	
	VDCOLON, voltage transducer time constants (sec)	
	Current margin (amps)	
	Converter 1 DV/DI multiplier (pu)2	
	Converter 2 DV/DI multiplier (pu)2	
	Converter 3 DV/DI multiplier (pu)2	
	Converter 4 DV/DI multiplier (pu)2	
	Converter 5 DV/DI multiplier (pu)2	

CDC4T: Two-terminal dc line model

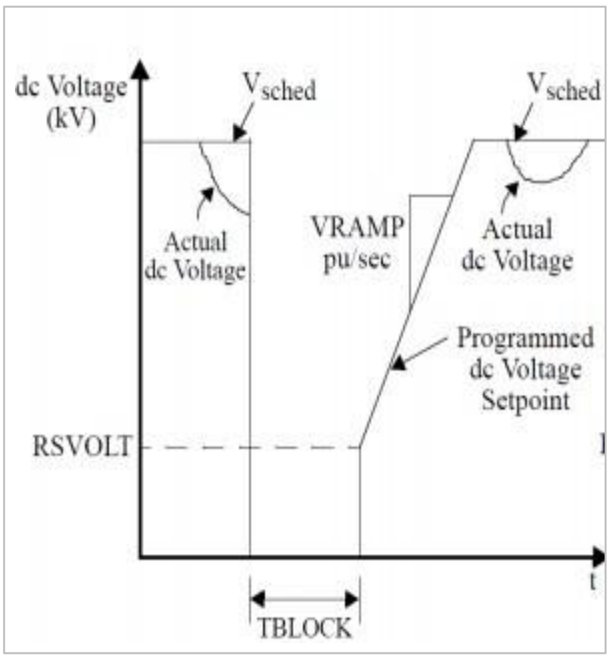


Illustration of RSVOLT, VRAMP

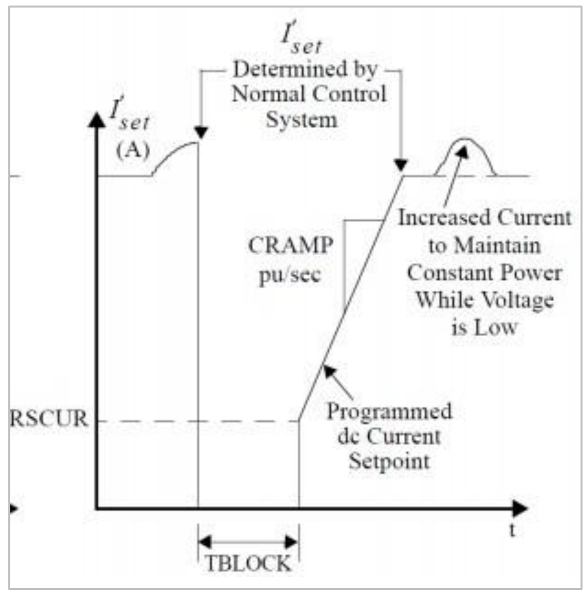


Illustration of RSCUR, CRAMP

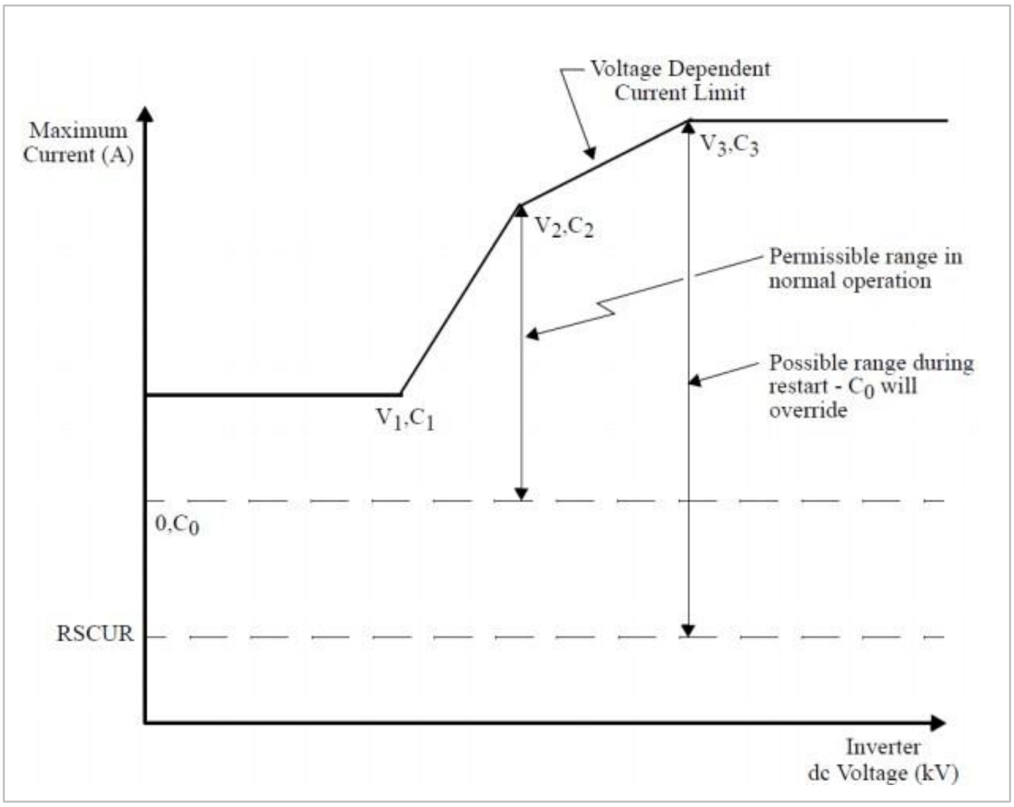
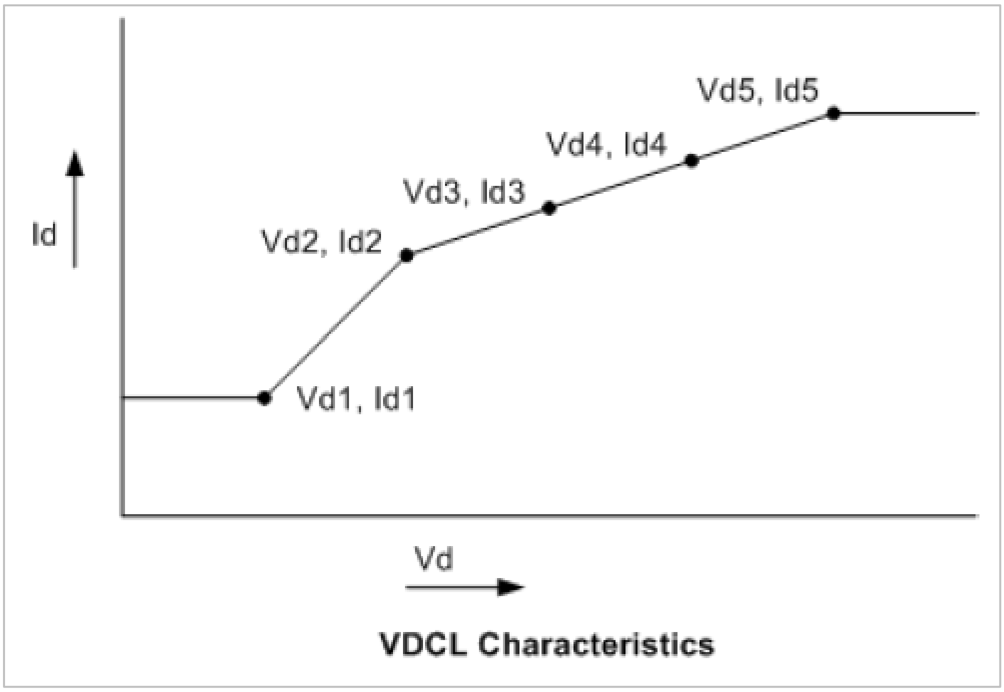
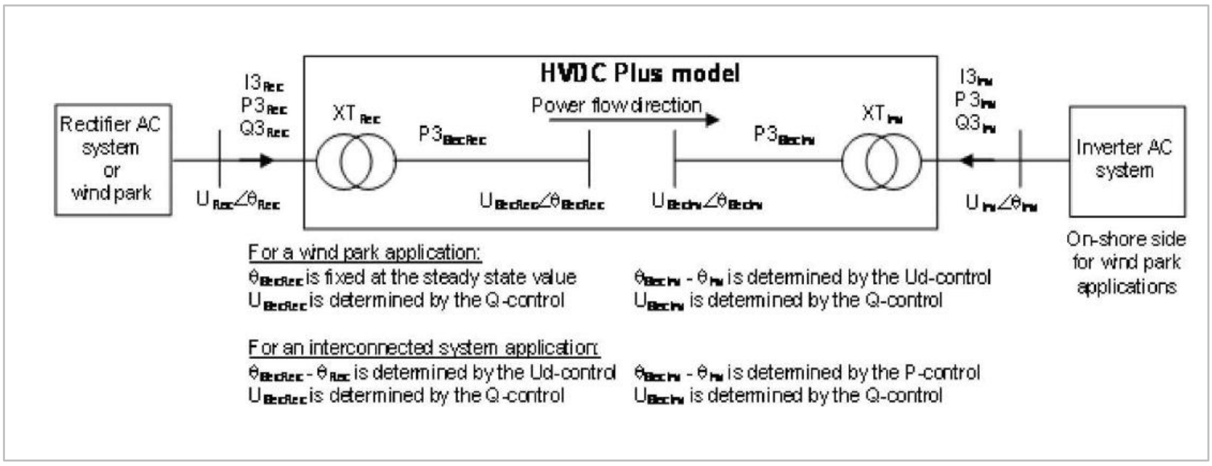


Illustration of VDCOL characteristic

- **CDC7T: dc Line VDCOL**



- **HVDCPL1: DC Line Model**



Annexure-III: PMU Signal List

S. No.	Description	Analog Points	Digital Points	Protection Signal
1	Line/HVDC Station	VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MW, MVAR, F, DF/DT	-Main Breaker status -Tie Breaker status -Isolators	Main1/Main2 protection
2	Bays		- Breaker -Isolators	
3	Main Buses	- VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} F , DF/DT	Bus sectionalizer Breaker	
4	Transformer/Coupling Transformer/Converter Transformer	- VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MW/MVAR	-Breaker -Isolators	Main1/Main2 protection
5	Reactor/Capacitor (if applicable)	VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MVAR	-Breaker -Isolators	

Section 5:

Procedure for First Time Energization of New/Refurbished STATCOM/SVC and Issuance of Certificate of Successful Trial Run

Procedure for First Time Energization of New/Refurbished STATCOM/SVC and Issuance of Certificate of Successful Trial Operation

First time charging and issuance of trial operation certificate of new/refurbished STATCOM/SVC shall be in accordance with **Section-1** of this procedure. The formats and annexures (A1-A6, B1-B5(a) and C1-C4) mentioned in section-1 need to be submitted to the SLDC in accordance with the mentioned timelines.

Further, apart from the requirements mentioned in section-1, following guidelines shall be followed for the first-time energization of STATCOM/SVC.

1. Pre-Charging Activities

a) Data Submission

Following technical data/models/reports shall be provided by the owners of STATCOM/SVC before first time charging:

i. Steady state and Dynamic (both RMS and EMT) Simulation Models along with detailed model user guide for STATCOM /SVC

   The models shall be submitted as per the model compatibility guidelines specified at **Annexure-I.**

ii. Detailed Single Line Diagram of STATCOM
iii. Number of Blocks and rating of each block
iv. V/I Characteristics
v. MSR and MSC design parameters and coordinated control philosophy
vi. Main Circuit Parameters Report
vii. Different Operating Modes of STATCOM
viii. Operation, Control and Protection Philosophy Document
ix. Dynamic Performance Study Report
x. Coupling Transformer Rating / Impedance and other technical details
xi. Power Oscillating Damper (POD) – Study Report along with status of POD (If not in service, then reasons for the same). The results of an offline simulation-based study to validate the performance of POD.
xii. Any other information as required by SLDC

b) Data Telemetry Requirements

a. Following SCADA points shall be made available to the NLDC/SLDC control room:

i. Q_{MSR} & Q_{MSC} : Reactive power exchange with MSR and MSC
ii. Q_{stat} : Reactive power exchange with STATCOM (VSC units – dynamic part)
iii. V_{HV} & V_{MV} : Voltage of LV and HV side of coupling transformer
iv. Q_{Tra} : Reactive power through the coupling transformer
v. P_{aux} & Q_{aux} : Active and reactive power through the auxiliary supply
vi. Circuit Breaker and Isolator Status
vii. Tap position of coupling transformer
viii. POD enabled/disabled status along-with setting parameters
ix. STATCOM Operating Modes with status
x. MSC and MSR Switch In/Out set-points -> voltage or current, as applicable

An indicative SLD specifying these parameters are enclosed as **Annexure-II**.

b. PMUs shall be installed at HV side of coupling transformer of the STATCOM station. The signal list for PMU data is provided at **Annexure-III.**

c) Other Pre-charging Activities

Following miscellaneous details shall be submitted by the STATCOM/SVC owner before first time charging of the HVDC:

a. Submission of STU charging instructions, as the case may be. The charging instructions shall clearly mention about the assumptions made in the studies.

b. Submission of details of the approval of the transmission scheme from the Planning Committee Meeting/ RPC / CEA / CTUIL/sSTU Consultative meeting and approval for changes in the approved scheme, if any.

c. State EI approval for energization as per Central Electricity Authority (Measures Relating to Safety & Electric Supply) Regulations, 2023.

d. Owners of the STATCOM shall submit a detailed proposal for testing before or along with the intimation of first-time charging (Format -A).

e. As per regulation 5.7 of KEGC, 2025: “The following tests shall be performed to validate the full reactive power capability of SVC and STATCOM in both directions i.e. absorption as well as injection mode:

(i) POD performance test
(ii) dynamic performance testing

Provided that the transmission licensee may submit offline simulation studies for the specified tests, in case the conduct of tests is not feasible before COD, subject to the condition that tests shall be performed within a period of one year from the date of achieving COD.”

The detailed report covering the results of the above tests shall be submitted to the SLDC.

f. The auxiliary consumption of STATCOM is generally drawn from the tertiary of the 400/220/33 kV transformer at the substation. The meter reading of this transformer would include the auxiliary consumption of STATCOM as well. Therefore, a No Objection Certificate (NOC) from the local DISCOM and SLDC shall be provided by the owner of the STATCOM.

g. Special Energy Meter shall be installed by STU at the coupling transformer as well in consultation with SLDC. The dummy meter readings shall be sent to SLDC along with B typeformats.

2. Notice of Trial Run

a) The “transmission licensee/STATCOM or SVC Owner” proposing the trial run for STATCOM/SVC shall give a notice of not less than **seven days** to the SLDC, STU, distribution licensees of the region and the owner of the inter- connecting system.

b) The SLDC shall allow commencement of the trial run from the requested date or in the case of any system constraints, not later than seven (7) days from the proposed date of the trial run. The trial run shall commence from the time and date as decided and informed by the SLDC.

3. Trial Run Operation of STATCOM/SVC

a) The settings (Vref, deadband, droop etc.) of STATCOM/SVC (including MSC and MSR) to be kept during the trial run shall be decided by the TSP in consultation with the SLDC before the commencement of the trial run.

b) The trial operation of STATCOM/SVC shall start only after all the units/blocks are in operation and telemetry of the points as defined above are available at SLDC.

c) The trial operation for the purpose of STATCOM/SVC shall be continuous operation for 72 hrs.

   During the trial operation, performance of MSR, MSC and STATCOM/SVC needs to be verified. Hence, MSR, MSC and VSC (with or without MSR/MSC) units shall be operated continuously for 24 hours one by one.

   Provided that no interruption apart from switching time shall be allowed during trial operation.

d) The continuous of operation of MSR, MSC and the operating range test of STATCOM/SVC (capacitive and inductive) shall be demonstrated during the trial operation.

e) The trial run of STATCOM/SVC shall cover operation in Voltage Control Mode (by changing Vref) and Constant Reactive Power Control Mode (by Qcmd inductive and capacitive). To facilitate these tests, if required, reactors at the substation may be switched for this purpose if system conditions are favorable.

4. Post Charging Activities

a) Successful Trial Operation completion certificate for STATCOM/SVC shall be issued by SLDC in accordance with relevant provisions in section-1 of this procedure.

b) Following data shall be provided by the owner of STATCOM/SVC post successful trial operation for issuance of successful trial operation completion certificate:

i. Coupling transformer meter reading for the period of trial operation
ii. SCADA readings/plot of reactive power injected or absorbed by each element (along with control mode) for the 72-hour trial run period
iii. SCADA readings/plot of current drawn by theSTATCOM
iv. SCADA readings/plot of STATCOM HV bus
v. Event log indicating closing of STATCOM breaker
vi. Output of Disturbance Recorder for the period of trialoperation
vii. If any fault has taken place in the nearby system, then STATCOM/SVC disturbance recorder data for the event shall be provided for verification performance.
viii. Any other data as required by SLDC to ascertain effective operation of STATCOM/SVC

c) After completion of the successful trial run and receipt of documents and test reports as mentioned in above sections, the SLDC shall issue a certificate to that effect to the concerned transmission licensee/STATCOM owner, as the case may be, with a copy to their respective beneficiary(ies) and the STU, within three days.

d) **Submission of final as-built validated model:** Within 03 months of the issuance of successful trial run certificate, the asset owner shall submit a final as built validated simulation model (both EMT and RMS) along-with model validation report of the STATCOM/SVC for steady state (both voltage and Q-control) and transient conditions. For steady-state validation, real-time PMU data may be used. For transient condition validation, disturbance recorder data may be used.

Steady state validation shall be carried out for the following tests:

i) **Voltage Control Mode -** Perform test for dead-band (in the range of 0 to 0.05 p.u.) & droop (in the range of 1-5%)

a) **Case-1:** Step increase in reference voltage from 0.95 p.u. to 1 pu and subsequently to 1.05 pu
b) **Case-2:** Step decrease in reference voltage from 1.05 pu to 1 pu and subsequently to 0.95 pu

Test shall be repeated for multiple dead-band and droop settings in the range specified above.

ii) **Fixed 'Q' Control Mode**

a) Case-1: Step change in Reactive Power (Q) injection from 0 to 50% and subsequently to 100% of rated reactive power
b) Case-2: Step change in Reactive Power (Q) absorption from 0 to 50% and subsequently to 100% of rated reactive power

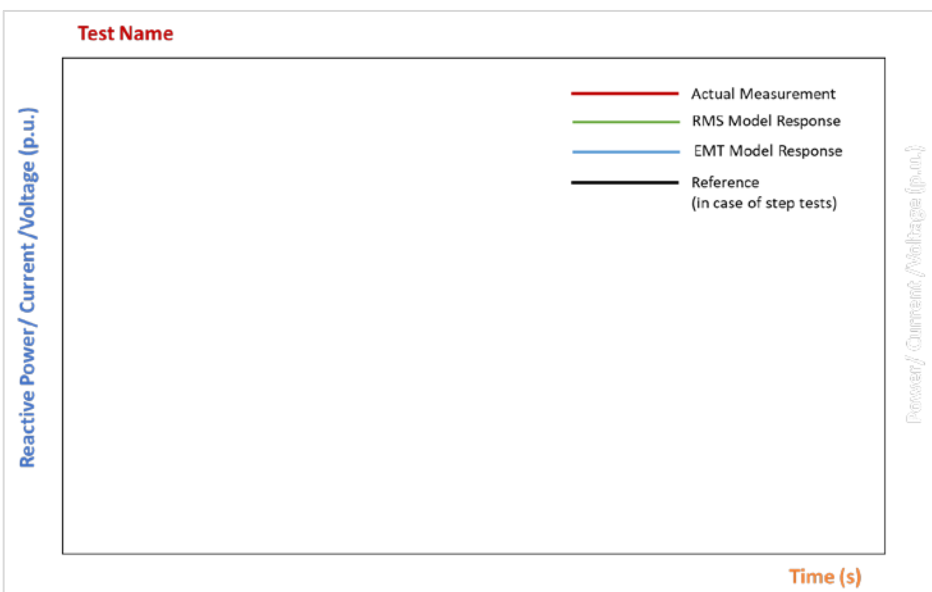
The validation report shall include the following:

a. Model file names of RMS & EMT model.

b. Final simulation model parameters of STATCOM/SVC.

c. The table demonstrating the similarity between simulation model parameters/settings and settings implemented at site (in real-time operation) shall be provided.

d. Comparison of on-site test measurement with simulation results shall be provided as per the format shown below:



e. Along with graphical comparison of field test measurement with simulation results, time series measurements/data of field test and simulation response (of same time resolution) shall also be provided in suitable format (preferably .csv file).

f. Model Validation report shall provide details of the causes of deviation from simulated behavior and suggest corrective actions.

5. Periodic Testing

Periodic Testing shall be carried out as per regulation (6.18) of the KEGC, 2025 and amendments thereof. It is desirable to submit report of such test carried out (at the time of First Time Energization & Integration) while applying for trial run certificates.

a) The tests shall be performed once every five (5) years or whenever major retrofitting is done. If any adverse performance is observed during any grid event, then the tests shall be carried out even earlier, if so advised by SLDC or RPC, as the case may be.

b) The owner of the STATCOM/SVC shall implement the recommendations, if any, as suggested in the test reports in consultation with NLDC, SLDC, CEA, RPC and STU.

c) Within 03 months of completion of the periodic tests, the owner of the STATCOM/SVC shall submit the final validated model comparing the results of the periodic tests against the model response as specified in section-4 (d) above. The models shall be submitted as per the model compatibility guidelines specified at Annexure-I.

6. Confidentiality Obligation

SLDC shall preserve the confidentiality of the information and data related with mathematical models (user defined model, source code etc.) and certification reports submitted to them in fulfillment of the obligations under this procedure and shall use them exclusively for the purpose they have been submitted, notably to verify the compliance of requirements set forth in extant regulations in Indian power system. The data may also be used for the purpose of system studies required for reliable and secure operation of the grid as per the Electricity Act and CEA/CERC Regulations.
Note: Further amendment in the procedure can be done in line with KEGC/other CERC & CEA regulations/directive from time to time.

Enclosures:

a) **Annexure-I:** Simulation Model Compatibility Guidelines for STATCOM/SVC
b) **Annexure-I(a):** Guidelines for furnishing RMS Modelling Data (Generic) of STATCOM
c) **Annexure-II:** Indicative SLD
d) **Annexure-III:** PMU Signal List

Annexure-I: Guidelines for Model Compatibility and Support for STATCOM/SVC

1. Model Compatibility and Support Guidelines for STATCOM/SVC

i) RMS and EMT models of the STATCOM/SVC shall be submitted. The model shall include auxiliary models such as POD controller model etc.

ii) The models shall be compatible with the power system software simulation products as specified by SLDC below: -

a) RMS models shall be compatible with **PSS/E version 35 and above.**

Provided that the SLDC may accept the model compatible with version 34 also under special circumstances. The decision in this regard will be at the discretion of the SLDC only.

Both **generic**[1] and **user defined (UDM) RMS models** are required to be submitted.

The response of the generic model shall be benchmarked against the UDM response for both steady state and transient conditions.

Further, the generic model shall not contain any encrypted or compiled parts, as the system operator must be able to maintain the same without the restrictions of software updates etc.

In case of submission of User Defined Models (UDMs), the submission of the **source code and compiling procedure** along with the model is mandatory.

b) EMT models shall be compatible with PSCAD version 4.6.3 and above with the following –

i. Intel 15 Update 5 and newer (32-bit) and Visual Studio 2015 and newer
ii. Intel 15 Update 5 and newer (64-bit) and Visual Studio 2015 and newer
iii. Model works across a range of time steps and does not require a specific time step

These models must not be dependent on a specific Intel Visual FORTRAN version and should not have dependencies on additional external commercial software.

[1] **Annexure-I(a)** may be referred for submitting generic RMS modelling data for STATCOM

iii) The STATCOM/SVC simulation models (applicable for generic and UDMs) shall:

a) Be submitted in the form of STATCOM/SVC and Coupling Transformer connected to the representation of the Grid (Thevenin-equivalent) SMIB (Single Machine Infinite Bus) model.

b) Be supported by model descriptions that, as a minimum, shall include Laplace domain transfer functions (for RMS models), and function descriptions of the arithmetical, logical and sequence-controlled modules used in the simulation model.

c) Include descriptions of the individual model components and related parameters including saturation, non-linearity, dead band, time delays and constraint functions (non-wind-up/anti wind-up) etc.

d) Include descriptions of the set-up of the simulation model as well as any limitations to the application hereof. There shall be no initialization errors for the dynamic models. The warning messages shall be reviewed and resolution or explanation shall be provided.

e) Work for a range of dynamic simulation solution parameters rather than for specific settings only.

f) Include all relevant control and protection settings of STATCOM (including MSC/MSR) or SVC

iv) Any model validity limitations due to system impedance or strength or any other reason shall be clearly defined.

v) Models shall not show any characteristics that are not present in the actual plant response.

vi) Model user guide including model setup procedure, RMS & EMT software version, compiler, visual studio version etc. shall be submitted along with the model.

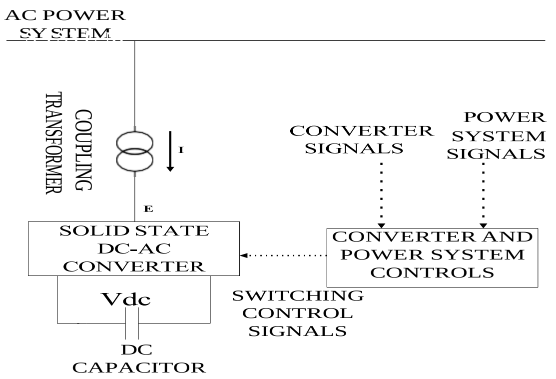
vii) Model limitations, maximum solution time step etc. to be included in user guide

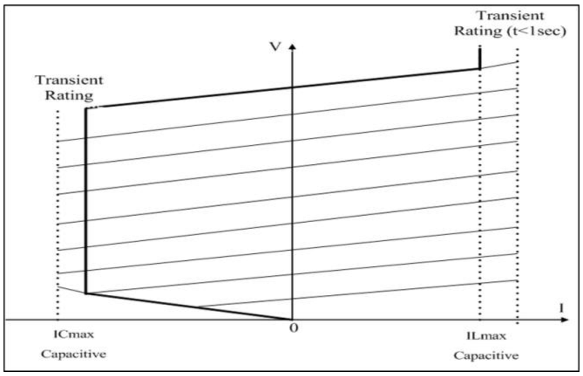
viii) EMT model shall not contain any dependent libraries. The submitted workspace file (.pswx) must not load any PSCAD library (.pslx) files apart from the PSCAD master library. The model shall be capable of running with no extra steps aside from clicking “Run” option in PSCAD.

Annexure-I (a): Guidelines for furnishing RMS Modelling Data (Generic) of STATCOM

1. STATCOM

Static Synchronous Compensator (STATCOM) is a reactive power regulating device based on the voltage source converter (VSC) used to maintain AC system voltage and enhance stability of the AC system. STATCOM provides operating characteristic similar to rotating synchronous compensator (condenser) but without mechanical inertia since it has no rotating component. By generating and absorbing reactive power within its working output range the STATCOM is able to maintain virtually constant voltage at its point of connection to the power system. STATCOM may be combined with mechanically switched Reactors & Capacitors controlled by STATCOM controller. The STATCOM would be primarily for dynamic compensation while the mechanically switched reactors/capacitors would be for reactive compensation under steady state.





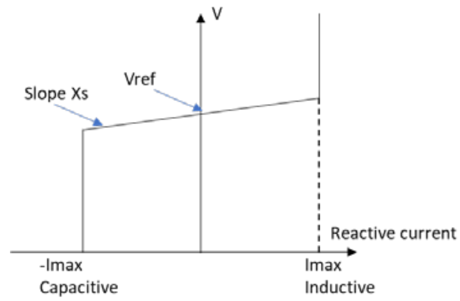
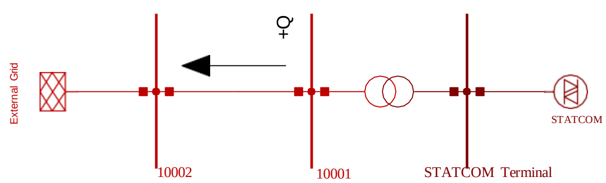
2. Data for STATCOM

A. Steady State model (Power Flow):

The steady state modelling parameters shall be provided as per the format specified in table below:

Steady State STATCOM model parameters with example value for voltage droop control

Parameter	Example value
STATCOM rating (MVA) This is the MVA base for all control parameters.	10 MVA
Continuous current limit (kA)	0.175 Ka
Nominal voltage at the controlled remote bus (kV)	33 kV
Nominal voltage at the converter terminal (kV)	0.5 kV
Temperature and voltage dependence of STATCOM rating (e.g. 90% of MVA base when voltage is at 90%)	9 MVAr when terminal voltage is at 90% of nominal voltage.
Overload capacity	+25% of nominal current for 1second
Modulation limit	1.0

Parameter	Example value
No-load loss (kW)	100 kW
Switching loss factor (kW/A)	5 kW/A
Resistive loss factor (ohm)	0 ohm
Negative sequence impedance r2, x2	998 + j1503 pu
Typical control mode (Voltage control, voltage droop, reactive power, or power factor)	Voltage droop
Typical setpoint (Voltage, reactive power, or power factor)	1.0 pu
Voltage droop (% of MVA base) or relevant V-I curve	4% Or V-I curve as shown below 
Voltage deviation deadband for reducing controller sensitivity (pu)	0.0 pu
Load flow single line diagram of the STATCOM  	As shown
Remote bus for voltage measurement	10001/Bus Name & Voltage Level
Remote bus for branch / line for reactive power measurement – sending end (where reactive current injection convention to this bus is positive)	10001/Bus Name & Voltage Level
Remote bus for branch / line for reactive power measurement – receiving end (where reactive current injection convention to this bus is negative)	10002/Bus Name & Voltage Level

B. Transient simulation model (Dynamics):

For representation of the RMS behavior of STATCOMs, two standard generic models are available in the PSS/E library, namely SVSMO3T2 and CSTCNT. Details for SVSMO3T2 and CSTCNT models are given below. The SVSMO3T2 has been described as STATCOM based SVC with logic to trip mechanically switched shunts (MSS). In comparison, the CSTCNT is a simpler representation of STATCOM with no dependence on shunt devices.

Parameters of SVSMO3T2 generic STATCOM model

Parameter (Controller parameters or PSS/E CON)	**Value**
Xc0, linear droop	
Tc1, voltage measurement lead time constant (sec)	
Tb1, voltage measurement lag time constant (sec)	
Kp, proportional gain	
Ki, integral gain	
Vemax, voltage error max. (pu)	
Vemin, voltage error min. (pu)	
T0, firing sequence control delay (sec)	
Imax1, max. continuous current rating (pu on STBASE)	
dbd, deadband range for voltage control (pu)	
Kdbd, ratio of outer to inner deadband	
Tdbd, deadband time (sec)	
Kpr, proportional gain for slow-reset control	
Kir, integral gain for slow-reset control	
Idbd, deadband range for slow-reset control (pu on STBASE)	
Vrmax, max. limit on slow-reset control output (pu)	
Vrmin, min. limit on slow-reset control output (pu)	
Ishrt, max. short-term current rating as a multiplier of max. cont. current rating (pu)	
UV1, voltage at which STATCOM limit starts to be reduced linearly (pu)	
UV2, voltage below which STATCOM is blocked (pu)	
OV1, voltage above which STATCOM limit linearly drops (pu)	
OV2, voltage above which STATCOM blocks (pu)	
Vtrip, voltage above which STATCOM trips after time delay Tdelay2 (pu)	
Tdelay1, short-term rating time(sec)	
Tdelay2, trip time for V .GT. Vtrip(sec)	
Vrefmax, max. limit on voltage reference (pu)	
Vrefmin, min. limit on voltage reference (pu)	
Tc2, lead time constant(sec)	
Tb2, lag time constant(sec)	
I2t, short-term limit	
Reset, reset rate for I2t limit	
hyst, width of hysteresis loop for I2t limit	
Xc1, non-linear droop slope 1	
Xc2, non-linear droop slope 2	
Xc3, non-linear droop slope 3	
V1, non-linear droop upper voltage (pu)	
V2, non-linear droop lower voltage (pu)	
Tmssbrk, time for MSS breaker to operate (sec)	

Parameter (Controller parameters or PSS/E CON)	Value
Tout, time MSC should be out before switching back in (sec)	
TdelLC, Time delay for switching in a MSS(sec)	
Iupr, Upper threshold for switching MSSs(pu on STBASE)	
Ilwr, Lower threshold for switching MSSs(pu on STBASE)	
Sdelay, time STATCOM should remain blocked before being unblocked	
STBASE (>0), STATCOM BASE MVA	

Parameters of SVSMO3T2 generic STATCOM model – additional information

Parameter (Other relevant information or PSS/E ICON)	Value
Remote bus number for voltage regulation	Bus Name & Voltage Level
Disable or enable coordinated MSS switching, 0 - no MSS switching, 1 - MSS switching based on STATCOM current	
flag1, slow-reset off/on, flag1 (0/1)	
flag2, non-linear droop off/on, flag2 (0/1)	
1st MSS bus #	
1st MSS Id (to be entered within single quotes)	
2nd MSS bus #	
2nd MSS Id (to be entered within single quotes)	
3rd MSS bus #	
3rd MSS Id (to be entered within single quotes)	
4th MSS bus #	
4th MSS Id (to be entered within single quotes)	
5th MSS bus #	
5th MSS Id (to be entered within single quotes)	
6th MSS bus #	
6th MSS Id (to be entered within single quotes)	
7th MSS bus #	
7th MSS Id (to be entered within single quotes)	
8th MSS bus #	
8th MSS Id (to be entered within single quotes)	

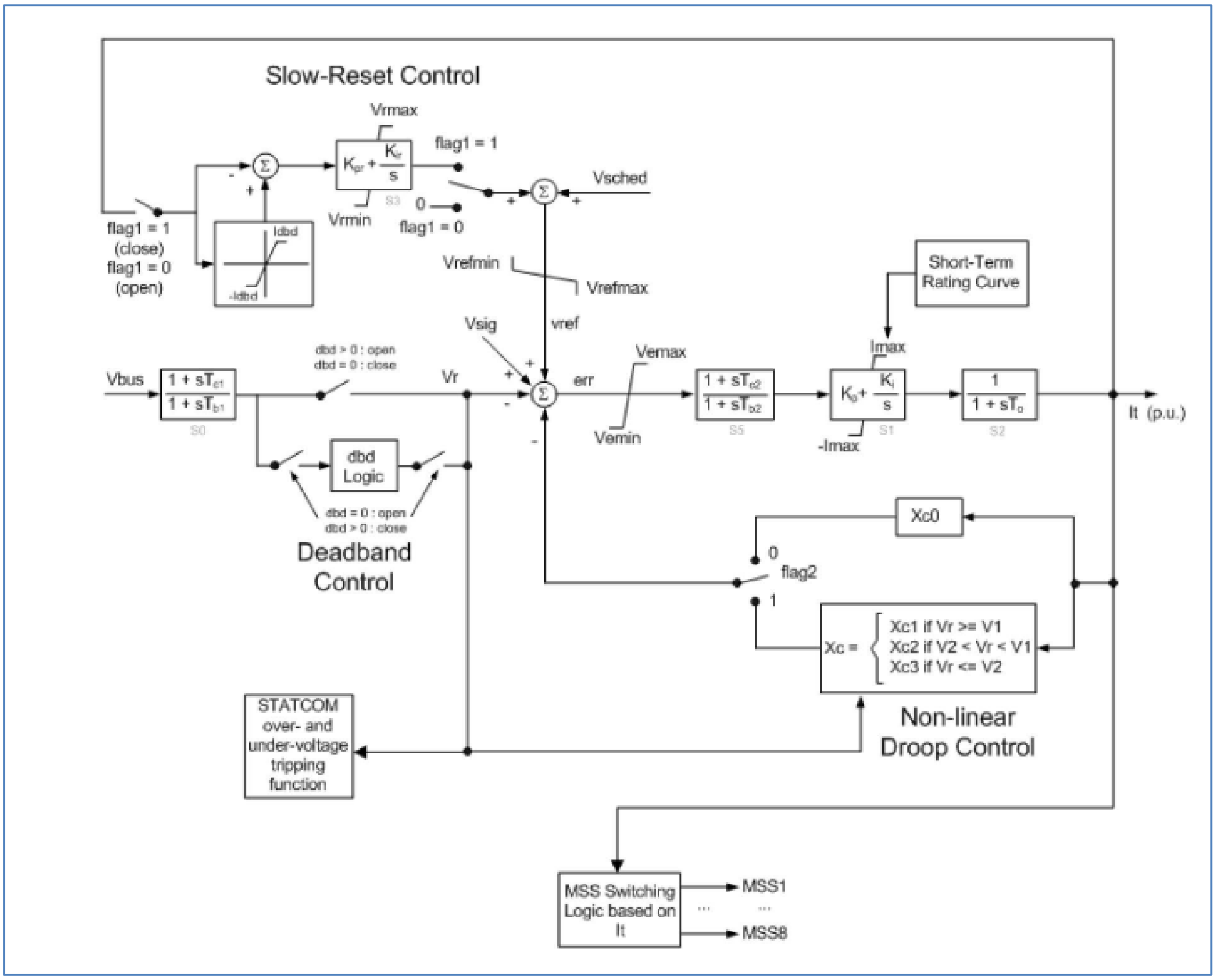


Illustration of STATCOM characteristic for model SVSMO3T2

Parameters of CSTCNT generic STATCON model

Parameter (Controller parameters or PSS/E CON)	Value
T1 (>0)	
T2 (>0)	
T3 (>0)	
T4 (>0)	
K(Typical = 25/(dv/dei))	
Droop (typical = 0.03)	
VMAX (typical = 999)	
VMIN (typical = -999)	
ICMAX (typical = 1.25) Max capacitive current	
ILMAX (typical = 1.25) Max inductive current	
Vcutout (typical = 0.2)	
Elimit (typical = 1.2)	
Xt (>0) (transformer reactance, typical = 0.1)	
Acc (acceleration factor, typical = 0.5)	
STBASE (>0) STATCON base MVA	

Parameters of CSTCNT generic STATCOM model – additional information

Parameter (Other relevant information or PSS/E ICON)	Value
IB, remotely regulated bus	Bus Name & Voltage Level

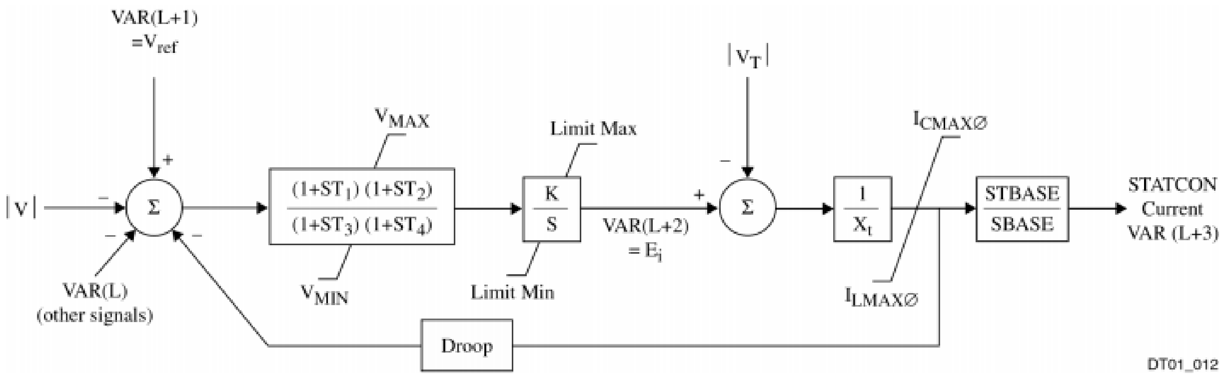
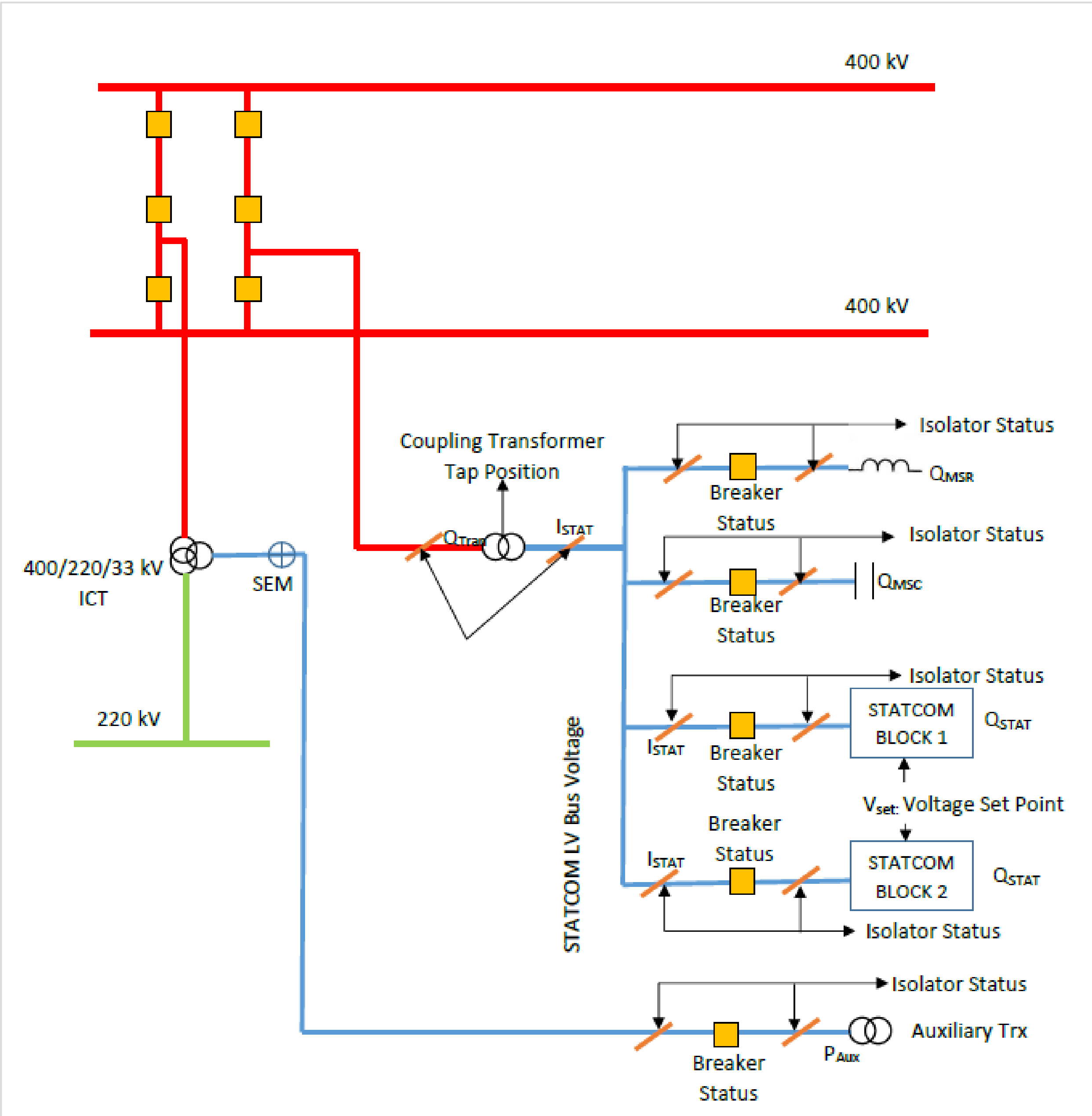


Illustration of STATCOM characteristic for model CSTCNT

Annexure-II: Indicative SLD



Annexure-II: PMU Signal List

S. No.	Description	Analog Points	Digital Points	Protection Signal
1	Line/STATCOM Blocks	VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MW, MVAR, F, DF/DT	-Main Breaker status -Tie Breaker status -Isolators	Main1/Main2 protection
2	Bays		- Breaker -Isolators	
3	Main Buses	- VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} F , DF/DT	Bus sectionalizer Breaker	
4	Transformer/Coupling Transformer/Converter Transformer	- VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MW/MVAR	-Breaker -Isolators	Main1/Main2 protection
5	Reactor/Capacitor (if applicable)	VOLTAGE {VRM, VYM, VBM, VPM, VRA, VYA, VBA, VPA} CURRENT {IRM, IYM, IBM, IPM, IRA, IYA, IBA, IPA} MVAR	-Breaker -Isolators	

Section 6:

Procedure

for certification of commissioning of Communication equipment and issuance of certificate by State Load Despatch Centre (SLDC)

Procedure for certification of commissioning of Communication equipment and issue of certificate by State Load Despatch Centres (SLDC)

This procedure is applicable for Installation and Commissioning of Inter-State or Intra-State and Inter-Regional communication System:

- OPGW
- Communication Equipment
- Auxiliary Power Supply of communication System
- Communication system developed by communication system provider
- Firewall

A. Hon'ble Central Electricity Regulatory Commission (Communication System for inter- State transmission of electricity) Regulation, 2017 have been notified vide: File No. L-1/210/2016/CERC; dated: 15th May 2017. Under clause 12, *"Communication System Availability"* stating that-

"All users of CTU, NLDC, SLDCs, SLDCs, STUs shall maintain the communication channel availability at 99.9% annually:

Provided that with back up communication system, the availability of communication system should be 100%.

~~B.~~ KEGC-2025 under Section 5.10 "DECLARATION OF COMMERCIAL OPERATION (DOCO) AND COMMERCIAL OPERATION DATE (COD)"
(1)(d) stated that-
"Date of commercial operation in relation to a communication system or an element thereof shall mean the date declared by the transmission licensee from 0000 hours of which a communication system or element thereof shall be put into service after completion of the site acceptance test including transfer of voice and data to the respective control centres as certified by the State Load Despatch Centre."

In accordance with the above provisions procedure for Certification of Communication System belonging to any transmission licensee by State Load Despatch Centre (SLDC) has been formulated. The details of the same are as follows:

1. **Compliance to the regulations:** All the transmission licensee shall comply to the above-mentioned regulations along with Technical Standards for Communication System in Power System Operations and Cyber Security Regulations notified by Central Electricity Authority & their subsequent amendments in future.

2. **Inter-State or Intra-State Communication Systems:**
Installation and commissioning of communication systems to exchange data between stations within the State jurisdiction are called intra-State communication systems. A list of documents that are required for the issuance of a certificate for inter-state or intra-State communication systems by the State Load Dispatch Center after a successful trial run is attached at ***Appendix-CA***.

3. **Inter-State Communication Systems:**

Installation and commissioning of communication systems to exchange data between stations coming under the jurisdiction of different regions are called inter-State communication systems. The Regional Load Despatch Center, in coordination with the SRLDC, shall issue certificates for inter-regional communication systems after a successful trial run. A list of documents that are required for the issuance of a certificate is attached as ***Appendix-CA.***

4. **Transnational Communication Systems:**

Installation and commissioning of communication systems to exchange data between stations coming under the jurisdiction of different national boundaries. National Load Despatch Centre in coordination with the SRLDC in which the communication link is getting terminated shall issue certificate for transnational communication systems by the after a successful trial run. A list of documents that are required for issuance of certificate is attached at ***Appendix-CA***.

5. **Intimation regarding anticipated commissioning to SLDC:**

All the Intra State Entity including deemed transmission licensees intending to commission a new or modified any communication system, which is part of Intra state entity, shall intimate the SLDC the details as per the formats given below not less than seven (7) days to the anticipated date of SAT/Integration. The Intra State Entity shall also submit the ***Annexure-CA1, CA2, CA3, CA4 & CA5*** of ***Appendix-CA***.

6. **Acknowledgement of Receipt of Certificate Requisition:**

Within 3 days of submission of above information by the Intra state Entity, SLDC shall acknowledge the receipt of the same, as per **Format II**, and seek clarifications, if any. The transmission licensee shall submit the desired information/documents to the SLDC within next three days.

7. **Request for Certification:**

The request for certification along with SAT report and undertaking from concerned Intra state for which communication system is established shall be submitted by concerned transmission licensee within 7 days after completion of SAT and data transfer to concerned control center. The Intra State Entity shall also submit the ***Annexure-CB1, CB2, CB3 & CB4*** of ***Appendix-CA***.

Within three (03) working days of submission of the documents as per Appendix-A,SLDC shall issue the certificate for successful commissioning of Communication Equipment as per **Format IV** subject to the correctness of information provided by the transmission licensee. If any clarification is required from Intra State Entity then certificate will be issued after resolving all the issues.

x- - - x- - - x

Appendix-CA

Documents to be submitted by communication provider to SLDCs for certification of commissioning of Communication equipment

Annexure	Subject	Remarks
Annexure CA1	Intimation regarding anticipated commissioning of New Communication equipment	As per Format I Intimation for commissioning link required to be done to concern SLDC on or before commencing of the installation work.
Annexure CA2	List of equipment to be powered on and equipment capacity details	As per Format I A
Annexure CA3	Proposed Link connectivity with the existing network	Document provided by communication system provider showing proposed connectivity of communication links for associated Region/s showing the proposed connectivity for intra- State links and Intra State entity.
Annexure CA4	Channel diagram for proposed data telemetry and voice communication and provision for redundant link	Document provided by communication system provider showing connectivity with Main and Protection path for communication link from Station/s to associated SLDCs.
Annexure CA5	Approval details of the communication links being commissioned.	Document provided by communication system provider for approval of the proposed communication links by STU
Annexure CB1	Request for Commercial Operation of the new Equipment	As per Format III
Annexure CB2	Undertaking in respect of Terminal Equipment	As per Format III A
Annexure CB3	Undertaking in respect of Telemetry and voice Communication	As per Format III B
Annexure CB4	Undertaking in respect of Completion of SAT	**As per Format III C** SAT report for Communication Equipment/OPGW/Auxiliary Supply System etc required to be furnished
	Firewall????	

Annexure CA1

Format I

Intimation regarding anticipated commissioning of New Communication equipment

(Fibre Optic Communication System, WAM, EMS/SCADA, Auxiliary Power Supply, RTU, EPABX, Radio)

<Name of the Organisation>

Name of the communication system :

Point of interface with existing system :

Owner of the Transmission Asset :

Owner of the Communication Asset :

Likely Date and time of powering on :

Likely Date and time of start of Communication Asset:

Place: New Delhi

Date:

Encl: Please provide full details.

(Name and Designation of the authorized person with official seal)

☐ Annexure CA1 : Format I: Intimation regarding anticipated commissioning of New Communication equipments

☐ Annexure CA2 : Format IA: List of equipments to be charged and equipment rating details

☐ Annexure CA3 : Proposed Link connectivity with the existing network

☐ Annexure CA4: Channel routing details for proposed data telemetry and voice communication and provision for redundant link

☐ Annexure CA5: Approval details of the communication equipment being commissioned

Annexure CA2

Format I A

List of equipment to be commissioned

(Fibre Optic Communication System, Auxiliary Power Supply, RTU, EPABX, Radio)

I. List of equipments to be Commissioned :

S.No	Name of Equipment	Rating/Details
1		

(Name and Designation of the authorized person with official seal)

Format II

<Name of the Organisation>

Acknowledgement of Receipt by

This is to acknowledge that the intimation of likely commissioning of ……………………………………………has been received from ………………………………………… on (........).

Kindly complete the technical formalities in connection with integration of the equipments, SAT of the equipment and establishment of real time data and voice communication facilities and inform us of the same three (3) days before Commissioning of the above communication equipment as per Formats III, IIIA, IIIB and IIIC.

Or

The intimation is incomplete and the following information may be submitted within three (3) days of issue of this acknowledgment receipt.

1. ______________________________
2. ______________________________
3. ______________________________

………………………………..

Date

Signature
Name:
Designation:
~~N~~SLDC

Annexure CB1

Format III

Request for Commercial Operation of the new Equipments

(Fibre Optic Communication System)

Past references :

Name of the communication FO link / Equipment :

Name of the transmission line on which FO link / :

Premises where the new equipment is installed :

Interface point with the existing link / :
Interface details of the new equipment

Owner of the Transmission Asset / Owner of the premises
where the new equipment is installed :

Owner of the communication Asset :

Date and time of power-on :

Date and time of Commissioning :

Place: Date:

(Name and Designation of the authorized person with official seal)

Encl:

Annexure B2 : Undertaking in respect of Terminal equipment as per Format III A Annexure B3

: Undertaking in respect of Telemetry and voice communication as per Format IIIB

Annexure B4: Undertaking in respect of successful completion of SAT as per Format III C

Annexure CB2

Format IIIA

< Name of the Organisation >

Undertaking in respect of Terminal Equipment

The following Communication systems have been powered on and commissioned as per details given below:

List of equipments charged:

Sl No.	**Name of the equipment**	Rating/Details	**Date & Time**

Note: Any deviation from the previous intimation may be indicated

It is certified that all the systems as stipulated in the BOQ of the said asset have been commissioned & tested and found complied with the approved technical specification and have been put to service to cater requirement of data and voice communication.

Place: New Delhi
Date: 02.03.2021

(Name and Designation of the authorized person with official seal)

Annexure CB3

Format IIIB

< Name of the Organisation >

Undertaking in respect of data telemetry and voice communication

The following communication equipment has been commissioned to facilitate data and voice communication

Name of communication link :

Details of the telemetry equipment :

Contact nos. for voice communication :

The details of the channel connectivity through which data telemetry has been made available to < ………. > in real time had been indicated vide communication dated ……….. It is certified that real time data is available to < …….> through the newly commissioned equipment put to service and commissioned.

It is also certified that the data through main channel is made available to SLDC as well as alternate communication channel is available for data transfer to < SLDC> using the FO communication link to ensure reliable and redundant data as per KEGC (as amended from time to time). Also, Voice communication is established as per KEGC as mentioned above. The arrangements are of permanent nature. In case of any interruption in data in real time, the undersigned undertakes to get the same restored at the earliest.

It is hereby certified that relevant KERC/ CERC Regulations and CEA standards / regulations and compliance of other Statutory Authorities regulations have been followed and complied with for commissioning of the aforesaid communication asset.

Place:
Date:

(Name and Designation of the authorized person with official seal)

Annexure CB4

Format III C

< Name of the Organisation > Undertaking in respect of Completion SAT

It is hereby certified that Site Acceptance Test has been carried out successfully for the following equipment in compliance with the technical specification.

I. List of equipments charged:

Sl No.	Name of the equipment	Time
1		

II. The connectivity to NMS shall be done for centralized monitoring on completion of the total communication network.

Place:
Date:

(Name and Designation of the authorized person with official seal)

Format-IV

KPTCL

State Load Dispatch Centre

Certificate Number: ………………………………………………………   **Date: .**

Certificate of successful commissioning of **Communication equipment**

Reference:

i. Communication dated ……. from Transmission Licensee to SLDC/SRLDC/NLDC in Format-I and IA.
ii. Communication from communication system provider to SLDC/SRLDC/NLDC dated........... in Format III, IIIA, IIIB and IIIC.

Based on the above reference, it is hereby certified that the following Communication link has been successfully commissioned

I. List of equipments charged:

Sl No.	Name of the equipment	Time
1		
2		

This certificate is being issued in accordance with Regulation 5.10 (d) of KEGC-2025 to certify successful Commissioning of the communication link. Usage of this certificate for any other purpose is prohibited

(**Head of SLDC)**

Place:
Copy to:

I.

II

सत्यमेव जयते

भारत सरकार/Govt. of India
विद्युत मंत्रालय/Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority
मुख्य विद्युत निरीक्षणालय प्रभाग/Chief Electrical Inspectorate Division

****

No. CEI/1/4/2022/270 **Dated: 26.05.2022**

To,

As per list of Participants at Annex-I.

Sub: Minutes of the Meeting on "Submission of statutory clearances for charging of modified/replaced power system elements" held on 10-05-2022-reg.

Please find the enclosed minutes of the meeting on the above mentioned subject.

Mukul Kumar
26-05-22
(Mukul Kumar)
Assistant Director

Minutes of the Meeting on Submission of statutory clearances for charging of modified/replaced power system elements held on 10-05-2022.

***

List of Participants is at **Annex-I.**

At the outset, Chief Electrical Inspector (CEI), CEA welcomed all the participants and requested Deputy Director (CEI), CEA to brief the background and agenda of the meeting.

Then Deputy Director (CEI), CEA gave the background by stating that CEA vide letter dated 08.09.2015 requested POSOCO to ensure the statutory inspection as per CEA (Measures Relating to Safety and Electric Supply) regulation, 2010 before allowing charging of any modified Electrical installation. He also mentioned that this discussion is only for utilities which falls under jurisdiction of Central Government.

Thereafter, Deputy Director (CEI), CEA stated that this meeting has been called to discuss the difficulties faced by utilities in respect of processing of approval for Charging after routine/emergency replacement and upgradation of substation equipment like CT, PT, CVT, Isolator, CB, LA, Bushing and Wave trap. Deputy Director (CEI), CEA, further stated that after understanding the difficulties being faced by the utilities, way forward to mitigate the difficulties would be discussed and consensus would be made for modalities for processing of approval for Charging. After that he requested the utilities to deliberate on the issue.

Executive Director, PGCIL requested for devising any methodology for expediting the process of getting safety clearance from Electrical Inspector in emergency situations. He emphasized that they usually ensure healthiness and safety of the system whenever they replace the faulty elements for restoring the system without any change in modifications.

Representative of PGCIL, Corporate Centre emphasized that replacement of any substation element of same type and rating does not require approval of Electrical Inspector. However, CEI, CEA explained that as per Sub-regulation 43(7) , any installation shall not connect to the supply unless and until such alteration or addition has been approved in writing by the Electrical Inspector. He further added that as per Regulation 29, any alteration or addition includes replacement also expect for plug and play equipment of voltage not exceed 250 Volts.

Representative of BBMB Panipat appreciated that CEA was giving prompt response to their requests, however, he expressed his concern for obtaining safety clearances during night hours and requested to develop some framework to address such issues. In this regard, CEI, CEA stated that as per prevailing regulations, the consent of Electrical Inspector is statutory requirement and not possible to waive off. However, CEA is providing all possible assistance in giving the consent at the appropriate time.

Representative of NPCIL Narora said that they have experience that CEA is giving prompt response in obtaining safety clearances from Electrical Inspectors for their installations. However, he requested for a change in Work Completion format for emergency situations and CEI, CEA agreed for such modifications.

CEI, CEA stated that the diversion work, restoration of damaged/collapsed towers are planned activity and utilities have sufficient time to apply. Also, these applications/requests for diversion work were pro-actively attended by CEA.

Representative of PGCIL, Bhiwani raised the concern that RLDC are also insisting that the consent from CEA is required for switching over the single phase transformer which is already energized. In this regard, CEI, CEA clarified that any transformer bank which is already energized can be switched with spare transformer without the consent of Electrical Inspector, however, replacement with spare transformer would require the consent of Electrical Inspector.

After the detailed deliberation, CEI,CEA elaborated the procedure which may be used for obtaining consent for charging after emergency replacement and upgradation of substation equipment like CT, PT, CVT, Isolator, CB, LA, Bushing and Wave trap :

- Apply online for clearance on CEA web portal which is readily and universally accessible and details of nodal officers are also available therein.
- Upload the latest and relevant Test Reports of equipment or any test report asked by the electrical inspector.
- Submit the planned maintenance schedule beforehand.
- If the documents are found in order, Consent for Charging would be granted.
- Physical inspection would be done during the next Periodical Inspection.
- For any assistance, the nodal officers of the respective jurisdiction may be contacted for better coordination.

CEI, CEA stated the following procedure would be followed for restoration of line through Emergency Restoration system towers: -

- ERS plan, schedule to be shared to the concerned RIO over email and telephonic intimation to be conveyed beforehand.
- All Electrical Safety measures at the ERS site must be followed strictly.
- Time span for the ERS work should be reasonable & limited and have approval from the concerned RIO.
- Subsequent to completion of Diversion/restoration works, Electrical inspection would have to be done under regulation 43 for charging the line.

CEI, CEA also requested to utilities to submit safety guidelines to be followed by them for restoration of line through Emergency Restoration system towers.

Further CEI, CEA stated that replacement of one phase of a failed Transformers /Reactor takes time and thus can apply as regular application for approval for energization. The approval for energization of such equipment would be given after inspection.

CEI, CEA informed that the draft safety regulations would be available in public domain for comments and therefore, requested the utilities to give suggestions on the draft of CEA Electrical safety regulations to address such issues for ease of doing business.

The meeting ended with vote of thanks.

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Annex-I

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Minutes of meeting chaired by Member (Power Systems), CEA on 03.08.2023, on references related to CEA's Safety Regulations received from power sector CPSUs and other issues.

A meeting was held under the Chairmanship of Member (Power Systems), CEA on 3rd August, 2023 to discuss the references related to CEA Safety Regulations received from Power Sector Public Sector Undertakings (PSUs) and other issues.

The list of participants is enclosed at **Annexure-I.**

At the outset, the Chief Engineer, CEI Division welcomed the Member (PS) and all the participants and apprised about the agenda to be discussed in the meeting. Member (PS) also welcomed all the officers and informed all participants about the important agenda points to be discussed in the meeting. He then directed the Deputy Director, CEI to present the agenda. The agenda wise discussion of the meeting is as under: -

1. **Periodicity of inspection of the electrical installation by the electrical inspector as mandated in Regulation 32 of Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023.**

As per Regulation 32 (2)

a) "*The periodicity of electrical inspection by the Electrical Inspector or the self-certification by the supplier, owner or consumer shall be as directed by the Appropriate Government.*

Provided that the periodicity of electrical inspection and self-certification shall not exceed five years".

b) It was proposed that under Regulation 32 of CEA Safety Regulations (including first periodic Self- Certification), the First Periodic Inspection may be carried out at an interval of 2 years from the date of initial Inspection/Self-Certification (under Regulation 45 of CEA Safety Regulations). After that, the subsequent periodic inspections or Periodic Self-Certifications may be carried out at an interval of 4.5 years from the date of last periodic inspection/Self-Certification, however it shall not exceed 5 years from the date of the last Periodical Inspection or Periodic Self-Certification, as the case may be.

c) Director RIO (E), explained that the approval of charging under Regulation 45 for the new project/installation is being issued by RIOs of CEA based on the compliance report as submitted by the applicants against the observations raised by the inspector after the inspection of the installation. Many petty works/ civil finishing works/housekeeping works still remain on the verge of completion at that stage. Therefore, the first periodic inspection should be carried out in 2 years and should comply with the provisions of the Safety Regulations and the next periodic inspections to be scheduled every 4.5 years but not exceeding 5 years.

d) The utilities agreed to the proposal that the first periodic inspection shall be carried out ~~in 2 years~~ and thereafter the next periodic inspection will be carried out every 4.5 years but not exceeding 5 years.

e) The representative from GAIL enquired that the 1st periodic inspection which was carried out in the recent past had validity for 2 yrs. So, after issuing guidelines of revised periodicity of 4.5 years whether the validity of the previous approvals be extended to 4.5 years automatically or they will have to apply afresh again for periodic inspection as stated in their approval certificate. CE, CEI explained that in case of the already issued certificates those will comply with the provisions in force at that time.

f) Member (PS) stated that from the safety point of view, it is important that the transmission lines be always maintained in completely safe conditions through regular inspection, patrolling and rectifying the defects/abnormality noticed. A record of the main activities undertaken should be maintained by the concerned utility. In case of failure/accident a thorough examination is a must.

Following deliberations also took place:

i. Good upkeep of the transmission lines is quite important. CE, CEI enquired about the practice of periodic inspection for Transmission Lines currently undergoing in different organizations.
ii. The representative from POWERGRID informed that normally routine patrolling/inspection is done regularly by themselves (3 months in case of vulnerable towers, 4 months in hilly and difficult terrain, and 6 months in plain areas) and all the trippings are well attended on time by carrying out root cause analysis etc.
iii. The representative from Kohima-Mariani Transmission Ltd. (KMTL) informed that currently they are applying for periodic inspection of transmission lines but suggested if extension of approval in case of Transmission lines could be given on the basis of patrolling data and other routine inspection reports conducted by the utility on their level.
iv. CE, CEI informed that presently the applications for periodic inspection for Transmission Lines are being received from very few utilities. It was informed by the utilities that it is quite difficult to inspect sites of Transmission Lines (along the line length) because of non-accessible sites and difficult terrain and long lines. It was also informed by different utilities that they are doing routine mandatory inspections by themselves by taking the help of drones, Cameras, and with latest technologies and other means.

g) Member (PS) requested POWERGRID to share guidelines/ write-up for the procedure for Transmission Line's periodic checkup/inspection so that other utilities may also follow the same procedure for minimum disturbance.

Conclusion

On the basis of the above deliberations following was decided:

i. **The periodicity of periodic inspection shall be 2 years for 1st Periodic Inspection after new Installation.**
ii. **The periodicity of subsequent periodic inspections after the first periodic inspection (which is to be carried out within 2 years) may be 4.5 years but not exceeding 5 Years.**
iii. **The above changes will come into effect after notification by the Central Government.**
iv. **POWERGRID submitted the Guidelines for the operation and maintenance of the Transmission lines and is attached at Annexure-II.**
v. **POWERGRID to share guidelines/write up being followed for inspection/patrolling of the transmission lines.**

2. Review of the procedure adopted for giving consent of charging of power system elements after replacement of (CT/PT/CVT/WT/LA/Isolator/Bushing and CB), Emergency Restoration System (ERS), Interim bypass arrangement, Restoration and Modification of Transmission Tower.

a) Member (PS) informed about the existing/proposed line of action by CEA as:

For granting consent after the replacement and upgradation of substation equipment (CT, PT, CVT, Isolator, CB, LA, bushing, and wave trap), following procedure is adopted:

i. Apply online for clearance through NSWS which is readily and universally accessible.
ii. Upload the latest and relevant test reports of the concerned equipment.
iii. Submit the planned maintenance/replacement schedule in advance.
iv. Also submit an undertaking in the format being provided by CEA, on the portal as well as on email.
v. If the documents are found to be in order, consent for charging would be granted.
vi. Physical inspection will be done during the next periodic inspection of substation equipment.
vii. For any assistance, nodal officers of the respective RIOs may be contacted for better coordination.
viii. In this connection it is proposed that in an **undertaking** by concerned CGM/GM and in case of private utilities (like Vice President/GM) or equivalent level officer shall also be provided.

b) It was informed that at present the procedure mentioned above at a (i. to vii) is already being followed by the utilities in the case of replacement of CT/PT/CVT/WT/LA/Isolator/Bushing and CB. Now it is proposed that :

(i) The procedure at **a)** may also be extended for giving consent of charging in case of Emergency Restoration System (ERS), Interim bypass arrangement, Restoration and Modification of Transmission Tower(s) except wherever there is a case of diversion of transmission lines.

(ii) Utilities has also to submit an Undertaking (attached at Annexure-III) along with the application.

c) Utilities agreed to the above.

d) POWERGRID stated that replacement of substation equipment such as CT, PT, CVT, WT, LA, Isolator, Bushing and CB is done with equipment of similar technical specifications without modification in the existing structure. Such replacement is generally carried out due to their normal aging/failure, without any alteration in the existing technical parameters/layout/connection arrangement. Further, in order to ensure the reliability, availability, and security of the system, replacement of equipment is taken up on an urgent basis even during odd hours i.e. during night or holidays to minimize the outage hours. Complete replacement activities are carried out by competent manpower adhering to standard pre-commissioning checks, testing requirements and safety procedures. In view of the above, the replacement of apparatus, cable, or equipment with the same specification shall not be considered an alteration. Hence requirement of CEA inspection/approval for charging of elements in case of replacement of substation equipment like CT, PT, CVT, Isolator, CB, LA, Bushing and Wave trap may be exempted with a view to enhancing the grid reliability and security.

e) The Representative from NFL stated that in the event of any breakdown in the switchyard elements at 66/132 kV voltage level; these are normally replaced with the same rating and design and are required to be charged immediately after replacement to restore power in continuous process plants like fertilizer, refineries, and petrochemical complexes. So it is proposed that charging of the system may be allowed on an emergency basis and site inspection may be carried out at a later date. This is an emergency charging requirement because fertilizer is an essential commodity and loss of production is a national loss.

   Representative of GAIL, Adani Transmission, views were also on the same line.

f) It was clarified that ERS has to be installed in a quick manner to restore the supply. After the installation of ERS, when the line is ready, consent will be provided for charging the line after receiving the undertaking and relevant test results from the utility.

g) After discussions it was decided that in order to bring ease of doing business the procedure mentioned at 2 (a) (i to viii) may also be extended in the case of inspection ERS, Interim bypass arrangement, Restoration and Modification of Transmission Tower along with replacement of (CT/PT/CVT/WT/LA/Isolator/Bushing and CB). In case of the modification/shifting of lines involving Road/Railway line/River crossing, inspection will be carried out by the Inspector, before charging the same.

h) DD, CEI informed that in the last MoM dated 10.05.2022 utilities were requested to share safety guidelines followed by them for restoration of lines through the Emergency Restoration System (ERS).

i) Representatives from Adani and NTPC enquired whether approval is required for replacing the spare transformer/reactor. DD, RIO (N) clarified that in the case of “cold spare” physical inspection is mandatory and for “hot spare” consent is given by the inspector after receipt of relevant test reports.

j) Representative from POWERGRID informed that in 765 kV substations, single-phase transformers/ reactors are supplied along with a “hot spare”. Hot spare can be charged in place of any in-service unit in case of failure/ violation/routine maintenance works etc to ensure reliability and availability of the system. However, SLDC is insisting on CEA’s clearance for charging the hot spare transformer/ reactor in place of the in- service unit. Further, CEA vide meeting on 10.05.2022 clarified that “any transformer bank which is already energized can be switched with spare transformer without consent of electrical inspector.” In view of the above, the requirement of CEA inspection in case of charging a “hot spare transformer/ reactor” unit may be exempted. It was agreed.

k) Director RIO East mentioned the issue of charging clearance for **Hot Spare of Power System elements (like spare bank of ICT/Reactor)**, It was informed that as per the deliberation of the meeting held on 10th May, 2022 the single-phase transformer bank which is already energized can be switched on with a spare bank of transformer without the consent of inspector. However, the replacement of any transformer or transformer bank with a spare one (cold spare) would require the approval of an electrical inspector.

Conclusion

On the basis of above deliberations following were decided:

(i) **The existing procedure for replacement of CT/PT/CVT/WT/LA/Isolator/Bushing and CB indicated at 2 (a) may also be extended for giving consent of charging in case of ERS, Interim bypass arrangement, Restoration and modification of Transmission Tower in the interest of enhancing grid reliability and security for ease of doing business**

(ii) **However, wherever there is a case of railway line/road/river crossing (with or without the use of ERS) and diversions or Interim bypass arrangement or Restoration and Modification of Transmission line/tower involving crossing of another line physical inspection of lines is mandatory.**

(iii) **The safety Guidelines for ERS installation by Adani Pvt Ltd is attached at Annexure IIA. Utilities may follow the same at the time of installation of ERS System as best practices.**

(iv) **Utilities have also to submit an undertaking (attached at Annexure-III) along with the application for all the cases. The undertaking must be signed not below the rank of CGM/GM and in case of private utilities (like Vice President/GM) or equivalent level officer.**

(v) **Utilities to share safety guidelines followed by them for restoration of lines through Emergency Restoration System, Interim bypass arrangement, Restoration and Modification of Transmission lines.**

(vi) **It was clarified that in the case of a work contract by CPSU, no separate license is required from the particular state in which work is to be executed for CPSUs.**

(vii) **Any transformer bank/Reactor that is already energized can be switched on with a spare transformer without the consent of the electrical inspector and the requirement of CEA inspection in case of charging a hot spare transformer/ reactor unit may not be required. However, the replacement of any transformer or transformer bank, or reactor with a spare)"cold spare") one would require the approval of an electrical inspector.**

3. Proposal by DVC for increasing notified voltage up to 33 kV for self-certification of electrical installation under Regulation 32 and 45."

a) As per Regulation 32 (1) "The *periodic inspection and testing of installation of voltage above the* ***notified voltage*** *belonging to the owner or supplier or consumer, as the case may be, shall be carried out by the Electrical Inspector:*

Provided that the electrical installation below or equal to the notified voltage shall be self-certified by the owner or supplier or consumer, as the case may be."

As per Regulation 45 (2) "The voltage above which inspection and testing of electrical installations including installations of supplier or consumer to be carried out by the Electrical Inspector, ***shall be notified by the Appropriate Government".***

"As per clause (zu) "notified voltage" means a voltage notified by the Appropriate Government under intimation to the Authority for the purpose of specifying the voltage level up to which self-certification is to be carried out under regulation 32 and regulation 45".

b) DD, CEI informed that at present notified voltage is 11 kV. The gazette notification in this regard is attached at Annexure- IV.

c) DNH was informed that for the inspection of the installation of the distribution system up to 11 kV and below self-certification is allowed and they may prepare a procedure at the utility level to do so. RIO (W) and RIO(S) were requested to assist them in preparing the procedure. However, in the case of the installation covered under Section 54 of the Electricity Act, 2003, inspection is to be carried out as per the provisions of CEA's Safety Regulations.

d) It was also informed that the respective States can notify the voltage level for the purpose of self-certification.

e) Representatives from Airport Authority of India (AAI) informed that they have substations at 33 kV voltage level and enquired whether they need self-certification for solar plants in their premises. Director, RIO (E), informed AAI comes under Section-54 of the Electricity Act, 2003 and therefore physical inspection by Electrical installation is mandatory. As per Regulation 45(b) under Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations 2023 "Notwithstanding anything contained in clause (a), every electrical installation covered under section 54 of the Act including every electrical installation of railways shall be inspected and tested by the Electrical Inspector of the Appropriate Government as specified in sub- regulation (3)". As per present regulations, the inspection of AAI's installations irrespective of voltage level is mandatory.

f) With the advancement of technology and an increase in number of installations upto 11 kV, the self-certifications may be proposed for 33 kV and below voltage level. CE, CEI informed that some States have already notified 33 kV as notified Voltage for self-certification, so the central government may also notify 33 kV as notified voltage.

<u>Conclusion</u>

On the basis of the above deliberations following were decided:

(i) In order to increase the notified voltage up to 33 kV for self-certification in

respect of DVC may be considered. Accordingly MoP may be approached for the same.

(ii) **DNH may prepare a procedure for inspection of installation of their distribution system upto and including 11 kV for self-certification. RIO (W)/RIO(s) were requested to assist them in preparing the procedure. The same may be completed within one (1) months' time of the issue of MoM.**

4. **Proposal for increasing the notified voltage for central sector installation up to 33 kV or above may be taken up separately.**

5. **Issue related to submission of application on NSWS portal by liaisoning officer**

DD, CEI stated that the application for inspection shall be filled only by the Permanent Employee of the owner organization with complete details. CE, CEI informed that for those not abiding by it, the application is liable to be rejected on NSWS portal. A message in this regard may be displayed on NSWS portal.

Conclusion

All stakeholders agreed to the above deliberations. CEI division may take up with NSWS team for displaying the message for rejecting the application in case it is not filled by the Permanent Employee of the owner organization with complete details

The meeting ended with a vote of thanks to the Chair.

Annexure-I

List of some participants: -CEA

1. Sh. A. K. Rajput, Member (Power Systems), CEA................. In chair
2. Smt. Rishika Sharan, Chief Engineer, CEI Division, CEA.
3. Sh. U.M.Rao.Bhogi, Director, RIO (South).
4. Sh. D.K.Bauri, Director, RIO (East).
5. Sh. Raghvendra Pratap Singh, Director, RIO (West).
6. Sh. R. K. Tiwari, Deputy Director, CEI Division.
7. Sh. Farooque Iqbal, Deputy Director, RIO (NE).
8. Sh. Ratnesh Kumar Yadav, Deputy Director, RIO (North).
9. Sh. M Srikanth Reddy, Deputy Director, RIO (South).
10. Sh. Mohit Bansal, Deputy Director, RIO (East).
11. Sh. Lenin B., Deputy Director, RIO (South).
12. Sh. P. P. Reddy, Deputy Director, RIO (West).
13. Sh. Rahul Singh, Deputy Director, CEI Division.
14. Sh. Ajit Kumar Ray, Deputy Director, RIO (NE).
15. Sh. Mukul Kumar, Assistant Director-I, RIO (North).
16. Sh. Gaurav Srivastava, Assistant Director-I, CEI Division.
17. Sh. Vikram Thorat, Assistant Director-I, RIO (West).
18. Sh. B. Chandrashekhar, Assistant Director-II, RIO (South).
19. Sh. Argha Kamal Das, Assistant Director -II, RIO (NE).

Power Sector CPSUs

S. No.	Name of officer(Shri/Smt)	Organisation	Designation	Email-Id
1.	S Adhikari	NHPC	ED(O&M)	
2.	Pradeep Kumar	POWERGRID	CGM (Asset Management)	pradeepkumar@powergrid.i n
3.	Tajender Kaur	Transmission System BBMB	SE/HQ	sehqts@bbmb.nic.in
4.	Narendra Sharma	Dehar Power HouseBBMB	SE DPH	naren68514@gmail.com
5.	Tarun Dewan	BBMB HISAR	Addl.SE O&M	xenomhsr@bbmb.nic.in
6.	Er. Sanjay KumarSaushik	O&M BBMB Dhulkote, Haryana	Sr. executive Engineer	xenomdkt@bbmb.nic.in
7.	Ravinder Pal Singh	BBMB	Engineer	
8.	Davinder Sethi	DPH Slapper BBMB	Sr.XEN	
9.	K. Ravi Kumar	NTPC	AGM(PE-Elec)	kuraravikumar@ntpc.co.in
10.	Virendra Singhal	NTPC		
11.	Anirudh Bishnoi	THDCIL, Koteshwar	GM (Project)	
12.	Ravi Shanker Gupta	THDCIL, koteshwar	Ch. Mgr.	
13.	C.V. Raghunathan	NLCIL	DGM	
14.	Sandip Pal	DVC Kolkata	CGM(SPM)	sandip.pal@dvc.gov.in
15.	Mukesh Yadav	Airports Authority of India	Jt.GM Engg (Elect.)	
16.	P S Murthy	HPCL	ED-HSE Corporate	

17.	Saladi Shrinivasu	HPCL	Dy. GM-HSE	saladisrinivasu@hpcl.in
18.	Abhishek Lodhi	BPCL	Chief Manager (Elect)	abhishekl@bharatpetoleum .i n
19.	Dibyendu Sarkar	BPCL	Project Head (RE)	
20.	Dinesh Rana	IOCL Northern Region	Sr. Mgr(HSE)	ranad@indianoil.in
21.	Satya Prakash Dwivedi	Gail	Ch. Manager (Electrical)	
22.	Ajay Bhardwaj	Gail	Senior Manager	
23.	Ravi Shanker Gupta	Gail Pata	Ch. Mgr.	rs.gupta@gail.co.in
24.	Anil Kumar Rajput			anil.rajpoot@gail.co.in
25.	Arsh Khanna	ReNew Power	Manager	
26.	Shashi ranjan	ReNew Power	Manager EHS	shashi.ranjan@acme.in
27.	Sangeet Attri	Regulator y Operation	Sr. Manager	sangeet.attri@indigrid.com
28.	Satish komer	ACME Group	AGM_D&E	satish.komer@acme.in
29.	Sanjay Kaushik	ACME	Engineer	
30.	Ravi Shekhawat	ReNew Power	Dy. Manager(eBOP)	
31.	Dharmesh Dave	DNHDDPDC	General Manager	
32.	Kailash Chandra Pandey	ReNew Power	AVP	
33.	Ravi Shekhawat	ReNew Power	Dy Manager	ravi.shekhawat@renew.co m
34.	Vivek Karthikeyan	IndiGrid	AGM(Asset management)	vivek.karthikeyan1@
35.	Narendra Kumar Ojha	Adani Group	Manager(Busine ssDevelopment)	narendran.ojha@adani.co m
36.	Abhishek Kukreja	Adani Energy Solutuios Ltd.	Lead Substation Maintenance	abhishek.kukreja@adani.co m
37.	Himanshu Sharma	K W Powerhouse	Manager(Operation)	
38.	Rajat Sangwan	ACME Group	DM-BD	rajat.sangwan@acme.in
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40.	Parmod Kumar	JSW hydro EnergyLtd.	AGM(Electrica lMaintemance)	parmod.kumar@jsw.in

41.	Hunny Kalia	JSW hydro EnergyLtd.	Manager at KarchamWangtoo	hunny.kalia@jsw.in
42.	Brajesh Kumar	ReNew Link		brajesh.kumar@re
43.	Roshan Zipta	JSW hydro EnergyLtd.	AGM(Operation andC&I)	roshan.zipta@jsw.in

File No.CEA-PS-17-11(19)/1/2022-PCD Division

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
विद्युत संचार विकास प्रभाग
Power Communication Development Division

No. PTCC/Misc/2022/391********393

Subject: Clarifications regarding submission of PTCC clearance for FTC of existing transmission lines after modification/route diversion and safety clearance for FTC of existing power system elements after any modification/replacement – regd.

Reference: Your letter no. POSOCO/NLDC/FTC/2022/01/232 dated 08.04.2022

The matter stated in your letter under reference has been examined and submissions from PCD Division on requirement of PTCC clearance of existing transmission lines after modification/route diversion are as under:

1. The referred CEA letter dated 18.01.2019 does not mention "new transmission line" but advises, in general, to seek documentary evidence of PTCC clearance from the concerned transmission licensee before issuing charging code/permission.
2. PTCC clearance for existing transmission line is not required for increase in tower height, provided that other factors like course of transmission line and nature of power flow remain unaltered, as the interference with communication system will be further reduced.
3. In cases involving change in course of transmission line or change in nature of power flow, induction on nearby telecom assets may change and Induced Voltage may exceed the safe limit. Such cases may be forwarded to CEA for examination and issuing suitable advisory on requirement of fresh PTCC clearance.

This issues with the approval of Chief Engineer, PCD.

राघवेन्द्र प्रताप सिंह
06.05.22
Director

To:-
1. Executive Director, NLDC, B-9, First Floor, Qutab Institutional Area, Katwaria Sarai, New Delhi – 110016

Copy to:-
1. Principal Chief Engineer-I, Central Electricity Authority
2. Member (Power System), Central Electricity Authority

File No.CEA-PS-17-11(19)/1/2022-PCD Division

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
विद्युत संचार विकास प्रभाग
Power Communication Development Division

सं. पीटीसी/मि./2022/391 ******* 393

विषय: संशोधन/रूट डायवर्जन के बाद मौजूदा ट्रांसमिशन लाइनों के एफटीसी के लिए पीटीसीसी अनुमोदन जमा करने के संबंध में स्पष्टीकरण और किसी भी संशोधन/प्रतिस्थापन के बाद मौजूदा पावर सिस्टम तत्वों के एफटीसी के लिए सुरक्षा मंजूरी - के संबंध में

सन्दर्भ: आपका पत्र सं. POSOCO/NLDC/FTC/2022/01/232 दिनांकित 08.04.2022

उपरोक्त संदर्भ पत्र में उल्लिखित मामले की जांच की गई है और संशोधन/रूट डायवर्जन के बाद मौजूदा ट्रांसमिशन लाइनों की पीटीसीसी अनुमोदन की आवश्यकता पर पीसीडी डिवीजन से प्रस्तुतीकरण निम्नानुसार हैं:

1. संदर्भित के.वि.प्रा. पत्र दिनांक 18.01.2019 में "नई ट्रांसमिशन लाइन" का उल्लेख नहीं है, यद्यपि सामान्य तौर पर सलाह दी गयी है कि चार्जिंग कोड/अनुमति जारी करने से पहले संबंधित ट्रांसमिशन लाइसेंसधारी से पीटीसीसी अनुमोदन के दस्तावेजी साक्ष्य प्राप्त करें।

2. टावर की ऊंचाई में वृद्धि के लिए मौजूदा ट्रांसमिशन लाइन के लिए पीटीसीसी अनुमोदन की आवश्यकता नहीं है, बशर्ते कि ट्रांसमिशन लाइन के मार्ग और बिजली प्रवाह की प्रकृति जैसे अन्य कारक अपरिवर्तित रहें, क्योंकि संचार प्रणाली में प्रेरण और कम हो जाएगा।

3. ट्रांसमिशन लाइन के मार्ग परिवर्तन या बिजली प्रवाह की प्रकृति में परिवर्तन से जुड़े मामलों में, पास की दूरसंचार संपत्तियों पर प्रेरण बदल सकता है और प्रेरित वोल्टेज सुरक्षित सीमा से अधिक हो सकता है। ऐसे मामलों को पीटीसीसी अनुमोदन की आवश्यकता पर जांच और उपयुक्त सलाह जारी करने के लिए कि.वि.प्रा. को भेजा जा सकता है।

इसे मुख्य अभियंता, पी.सी.डी. के अनुमोदन से जारी किया जाता है |

राघवेन्द्र प्रताप सिंह
06.05.22
निदेशक

सेवा में:-

कार्यकारी निदेशक, एनएलडीसी, बी-9, प्रथम तल, कुतुब इंस्टिट्यूशनल एरिया, कटवारिया सराय, नई दिल्ली – 110016

प्रति:-

1. प्रधान मुख्य अभियंता – I, के.वि.प्रा.
2. सदस्य (विद्युत् प्रणाली), के.वि.प्रा.

Government of India
Central Electricity Authority
Electrical Inspectorate Division
Wnig No-5, 1st Floor, West Block-2,
R.K.Puram, New Delhi – 110 066.

Telefax: 011-2610 9336

Subject: Central Electricity Authority (Measures Relating to Safety & Electric Supply), Amendment Regulations 2015 – Anti-theft charging of transmission lines-Regarding.

It is intimated that the Regulation 43 of the Central Electricity Authority (Measures Relating to Safety & Electric Supply), Regulations 2010 had been inter-alia amended w.e.f 13th April 2015 entitled as "Central Electricity Authority (Measures Relating to Safety & Electric Supply), Amendment Regulations 2015". The proviso of sub-regulation 5 of regulation 43 of the regulations is as under:

> "Provided that the supplier may energise the aforesaid electric supply lines or apparatus for the purpose of tests specified in regulation 46 and after successful testing, the owner may energise the section of a line to prevent theft of conductors or towers, subject to compliance of all the provisions of these regulations."

In view of the above, it may be mentioned that the supplier/owner of the lines may energise their own with compliance of all the provisions of these regulations for anti-theft purposes and therefore the application for Anti-theft charging may not be accepted henceforth.

Once the line is completed in all respects and terminated at both ends and ready for charging at rated voltage, the application for approval of the Electrical Inspector may be submitted by supplier/owner of the lines as per the existing procedure.

(डी.के.जैन)
(D.K.Jain)
Chief Electrical Inspector
to the Govt. of India

S.E.(RIO-North, East, Northeast), Dy. Director(RIO-West & South)

सं. सी.ई.आई/1/2/2015/ 761 — दिनाँक: 23.06.2015

Government of India
Central Electricity Authority
Electrical Inspectorate Division
3rd Floor, NRPC Building
18-A, Shahid Jeet Singh Marg
Katwaria Sarai, New Delhi-100 016

(आई.एस.ओ. : 9001:2000)

सी.ई.आई./1/2/2015/ 1204 Dated: 08.09.2015

To,

Shri S R Narasimhan
Additional General Manager,
System Operation, NLDC,
Power System Operation Corporation Limited,
B-9, 1st Floor, Qutub Institutional Area,
Katwaria Sarai,
New Delhi- 110 016

O/c

Subject: Statutory approval of Electrical Inspectorate, CEA for charging/energization of electrical installations.

Ref.:

1. Your Letter No.: POSOCO/NLDC/System Operation/CEA_Safety723 Dated: 24.08.2015
2. Our Letter No.: CEI/1/2/2015/844 Dated: 14.07.2015
3. Our Letter No.: CEI/1/2/2015/761 Dated: 23.06.2015

Sir,

Kind attention is invited to your letter cited at 1 above seeking clarification on the issues regarding statutory approval of Electrical Inspectorate, CEA for energization of electrical installations. In this connection, it is clarified that as per regulation 43 of the Central Electricity Authority (Measures Relating to Safety & Electric Supply), Regulations 2010, the electrical installations/lines, before commencement of supply or recommencement after shutdown for six months and above shall not be charged/energized without the approval of the Electrical Inspector in writing to ensure safety measures specified under the said regulations in the electrical installations. In order to ensure the approval of installation by EI, this office vide letter dated 14.07.2015 requested POSOCO to secure a copy of the approval of the Electrical Inspector before issuing the charging code.

However, in this connection, it may be mentioned that after an amendment of regulation 43 of said regulations notified on 13.04.2015, the supplier/owner may charge the line which is not terminated at both ends/a section of a line to prevent theft of conductors or towers without the inspection and approval of the Electrical Inspector, and therefore, POSOCO may issue charging code after taking an undertaking from the supplier/owner to the effect that the compliance of all the provisions of the said regulations are complied with by the supplier/owner. After completion and termination of the line at Bay/sub-station at both ends, the approval of the Electrical Inspector shall be obtained by Supplier/owner before charging/energization of the complete line.

Further, regarding tapping of the lines above 66 kV and above, it may be clarified that the provision of sub-regulation (6) of regulation 44 of the said regulations shall be strictly complied with in all conditions. However, any matter in this regard may be taken up with the Chief Electrical Inspector for his consideration who is responsible for enforcement of the said regulations in the electrical installations belonging to the Central Government/ISTS/ISGS.

08/09/2015

(Ram Chandra)
Director

Copy to: Shri Anil Jain, Executive Director (Corporate Monitoring), PGCIL, 'SUDAMINI', Plot No-2, Sec-29, Gurgaon- 122 001 (Haryana)