Workshop cum Stakeholders Meeting

Procedure for Assessment of Dynamic Reactive Reserve Prepared in Compliance to Clause 39 (6) of CERC IEGC Regulations, 2023

01st September 2023

Grid Controller of India Limited (Grid-India)

Erstwhile Power System Operation Corporation Limited (POSOCO)

SRLDC, Bengaluru

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39(6) of the CERC(IEGC) Regulations, 2023

Quote

…..(6) NLDC, RLDCs and SLDCs shall assess the dynamic reactive power reserve available at various substations or generating stations under any credible contingency on a regular basis based on technical details and data provided by the users, as per the procedure specified by NLDC

Unquote

*Reference to Nominal Voltage Limits, CEA Contingency Criteria for ready reference

Scope

- State Load Despatch Centres (SLDCs)
- Regional Load Despatch Centres (RLDCs)
- National Load Despatch Centre (NLDC) and
- all users to the extent applicable.

Reactive power resource

- Types defined by reactive power output controllability once connected to the grid
  - Static
  - Dynamic
- Static reactive resources
  - Fixed reactive power output at their nominal voltage, and their capability varies according to voltage squared.
  - Switched in or out of service based on system conditions.
  - Examples - shunt reactors, shunt capacitors (excluding HVDC automatic control), transformer tap change: generator transformer and inter-connecting transformer, HVDC filter bank.
  - Does not provide dynamic reactive support and shall not be considered while assessing the dynamic reactive reserve margins.

Reactive power resource

- Dynamic reactive resources
  - Adjust reactive power output automatically in real-time over a continuous range within a specified voltage band in response to changes in grid voltage.
  - Operate to maintain a set point voltage or operate in a voltage droop mode.
  - Examples - Synchronous generators, Synchronous condensers, static VAR compensators (SVC), STATCOM, VSC-based HVDC, non-synchronous inverter-based resources enabled to provide reactive power support.
- IEGC Mandate
  - All generating stations shall be capable of supplying reactive power support so as to maintain power factor at the point of interconnection within the limits of 0.95 lagging to 0.95 leading as per the CEA Connectivity Standard Regulations.
  - All generating stations connected to the grid shall generate or absorb reactive power within the capability limits of the respective generating units, where capability limits shall be as specified by the OEM.

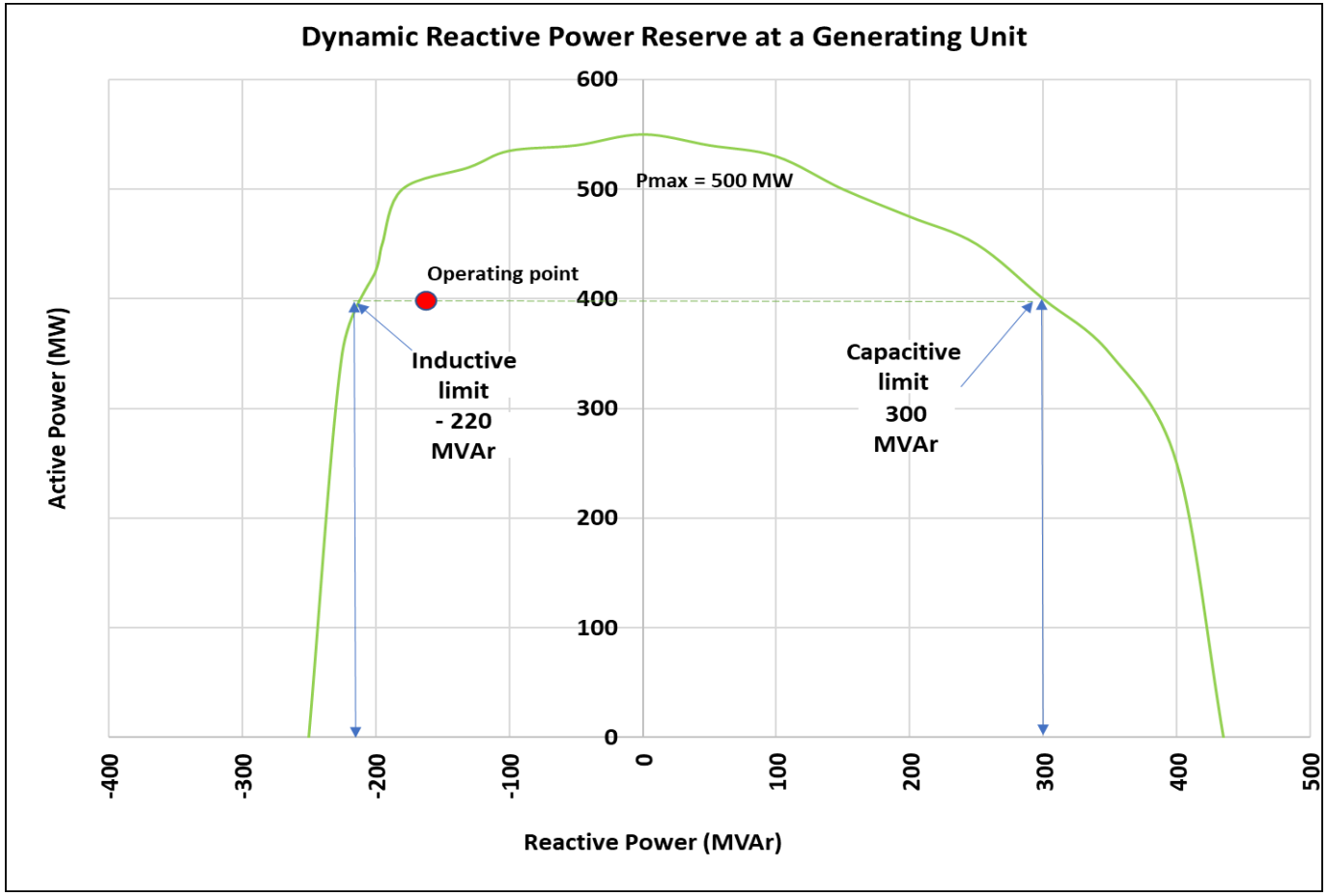
Submission of reactive capability and controller settings of reactive resources

- Synchronous generators connected to the grid
  - Submit PQ capability curve of all the commissioned generating units to the respective RLDC/SLDC.
  - Limitations in providing dynamic reactive support such as armature thermal limits, rotor current limits, under excitation limits & other limits if any shall also be marked on the PQ capability curve.
  - AVR settings for synchronous machines, Controller settings for IBR shall be submitted.
- Existing IBR-based resources
  - Submit PQ capability curve at Point of Interconnection to RLDC/SLDC with due consideration of over voltage settings, over current settings, and other limitations of the IBR system.
- Other users owning or operating the dynamic reactive resources such as FACTS devices, HVDC
  - Shall submit the implemented PQ or VQ capability curves as applicable to NLDC/RLDC/SLDC.
- IEGC regulation 2 of 40(3) mandates reactive Capability tests or earlier based on SLDC or RLDC or NLDC or RPC advise
  - Revised capability curves and technical data shall be submitted to the respective LDC.

Computation of Dynamic reactive power reserves

- Reliable reactive reserve is the amount of reactive reserve in pre-contingency to ensure that a transient or post-transient voltage collapse does not occur following a disturbance.
- Computation of dynamic reactive reserve is computed for the buses where dynamic reactive capability is available.
- Dynamic reactive power reserves are computed by comparing the actual interchange of reactive power at HV side of reactive power resources with the dynamic reactive capability furnished by the respective users.
- During computation availability of resources on bar shall be factored suitably.
- Voltage being local phenomenon, dynamic reserves shall be computed at HV side of reactive power resources.
- Group of tightly coupled buses may be grouped as voltage zones. Zoning may be done based on analysis of the historical data or any other scientific approach may be considered.
- Dynamic reactive reserve of a device is measured as the difference between its present VAR output and its maximum var output in both directions. Its maximum VAR output is usually defined as that which can be sustained for an extended period (i.e., 30 minutes or longer).
- Reactive power limits are to be assessed at the point of interconnection after factoring drops in GT/UAT or collector system in the case of IBR.

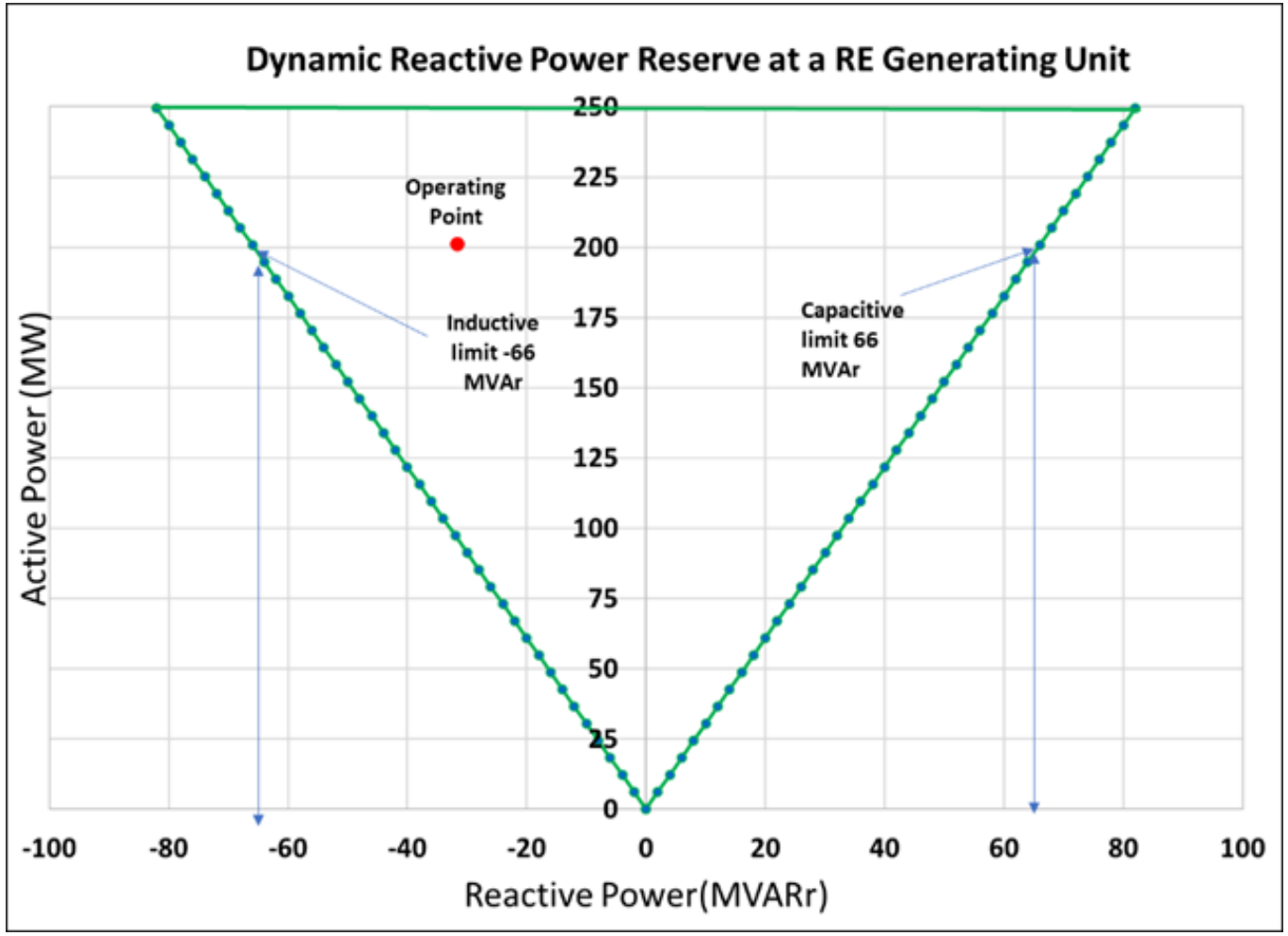
Reactive limits-Synchronous Generators & Condensers:



- D-shaped PQ capability curves limited by field current, load angle, etc.
- Q limits corresponding to 55%, 75%, and 100% generation levels can be modeled as limits.

Sl No	Generating Station	On Bar Active Capability	Operating Point	On bar reactive Capability at that bus in MVAr	
		MW	MW	Qmax(+)	Qmin(-)
1	Unit 1 at Station A	500	400	300	-220

Reactive limits-IBR-based Resources:



- 0.95 lagging to 0.95 leading
- PQ capability at POI is known for each RE station by the capability test and modeling studies which are carried out as part of the commissioning / FTC procedure

Installed Capacity	Operating Point	On bar reactive Capability at that bus in MVAr	
MW	MW	Qmax(+)	Qmin(-)
A	B	C	D
250	200	66	-66

Reactive limits-SVC, STATCOM:

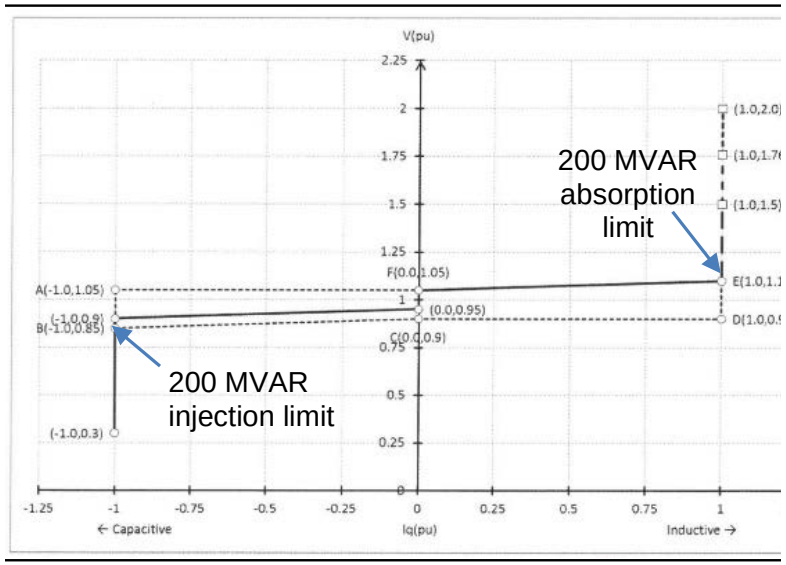


Figure 1: voltage and current output characteristics of 2 x 100Mvar STATCOM

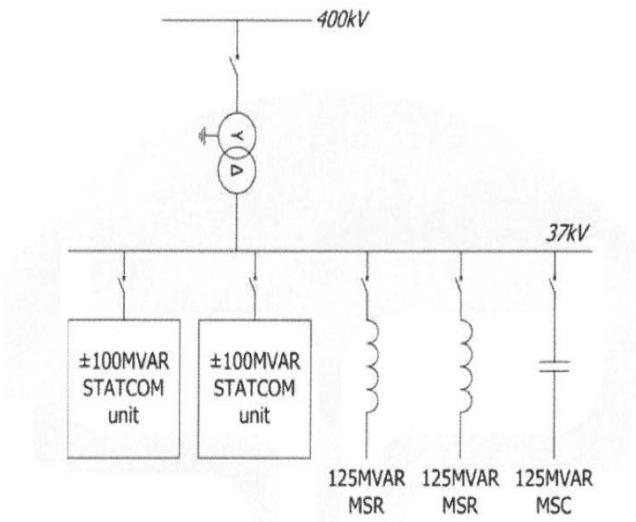


Figure 2: Schematic diagram of STATCOM Station

- Operates w.r.t Voltage on a slope with a dead band.
- VQ capability of these devices is to be considered.
- Illustration: V-Q curve given shows a limit of dynamic reactive reserve for the STATCOM having the reactive capability of 2 x 100 MVAR

Reactive limits : HVDC(VSC):

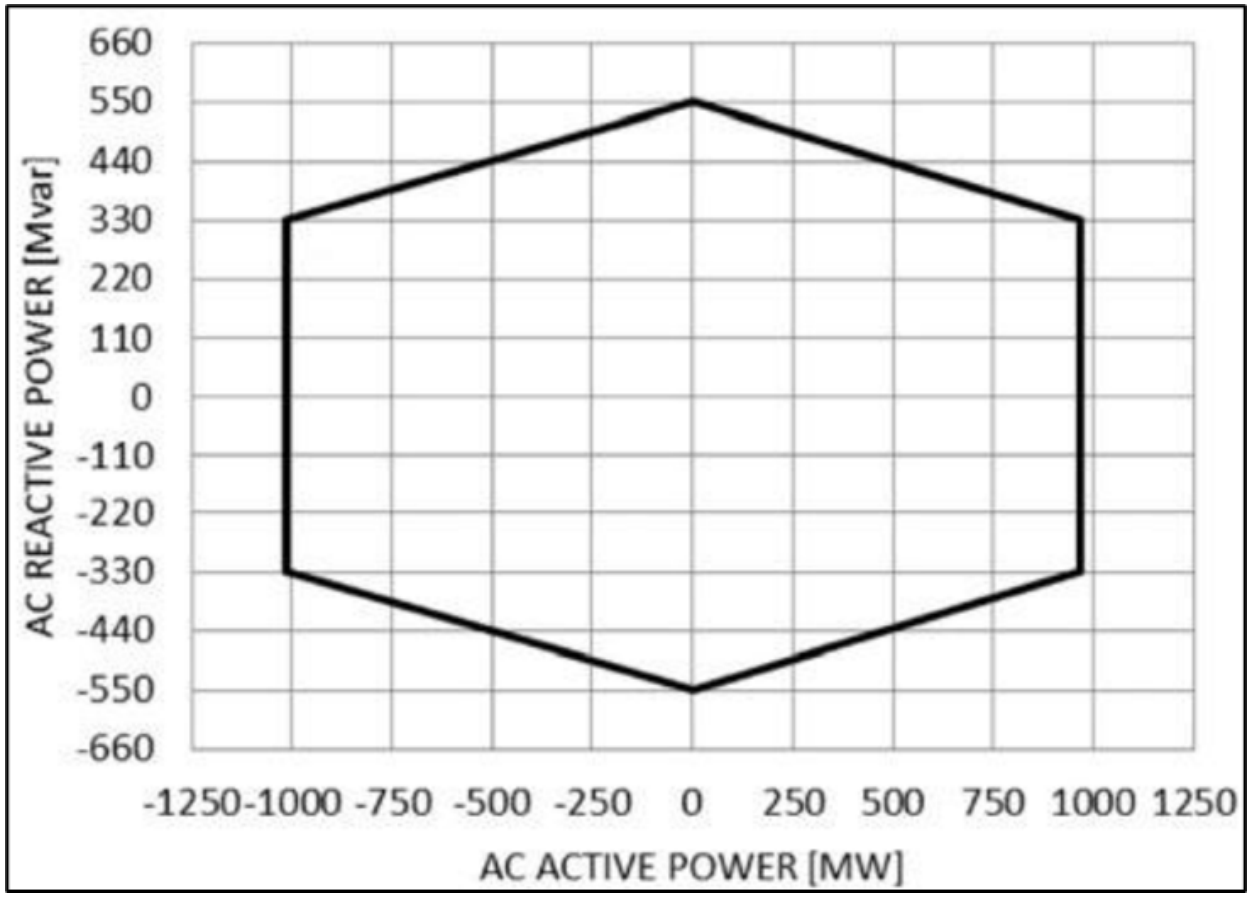


Figure 5: P-Q Capability curve of VSC Pugalur-Thrissur

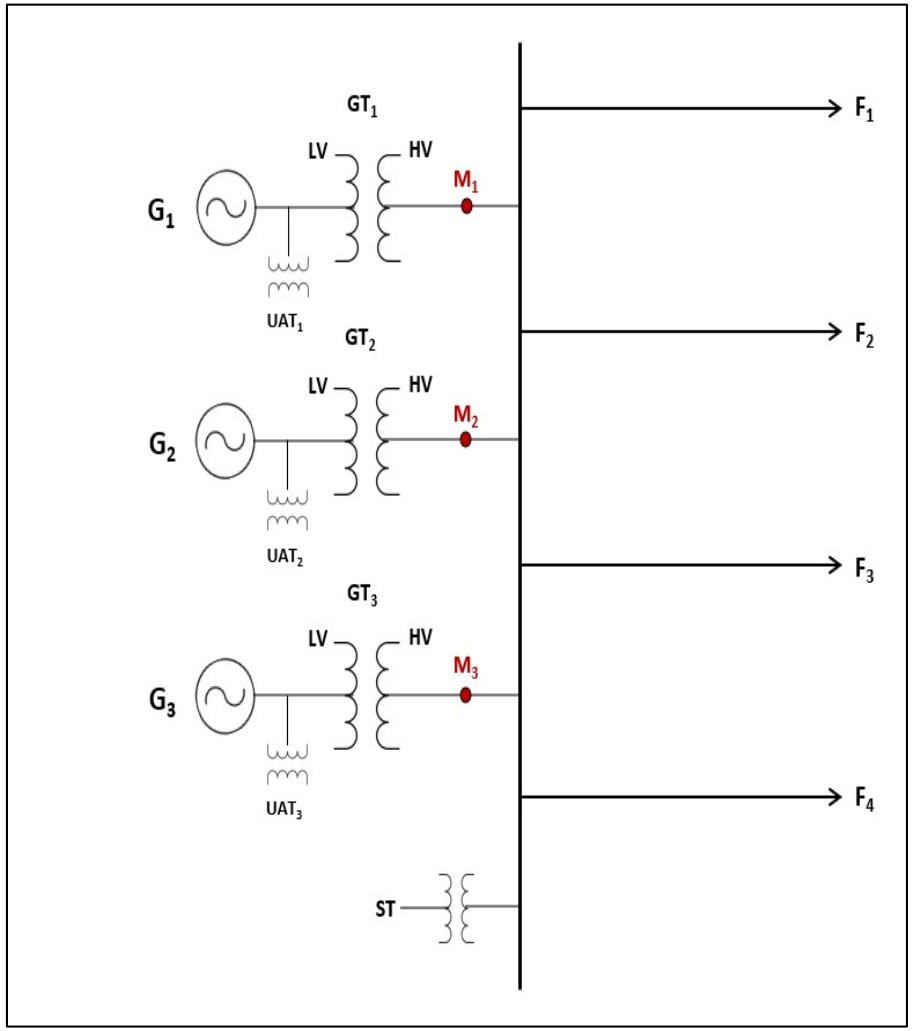
- Each monopole of VSC Pugalur-Thrissur at each station is able to deliver/consume minimum reactive power of value equal to 330MVar at any active power level up to rated power (1000MW).
- Above capability requirements are valid for AC system voltage between 380-420 kV.
- For voltages outside the continuous limits the reactive power capability may be reduced. When operating at zero active power level the reactive power capability of each converter (both inductive and capacitive) shall be at least 50% of its MVA rating(550MVAR).

Telemetry

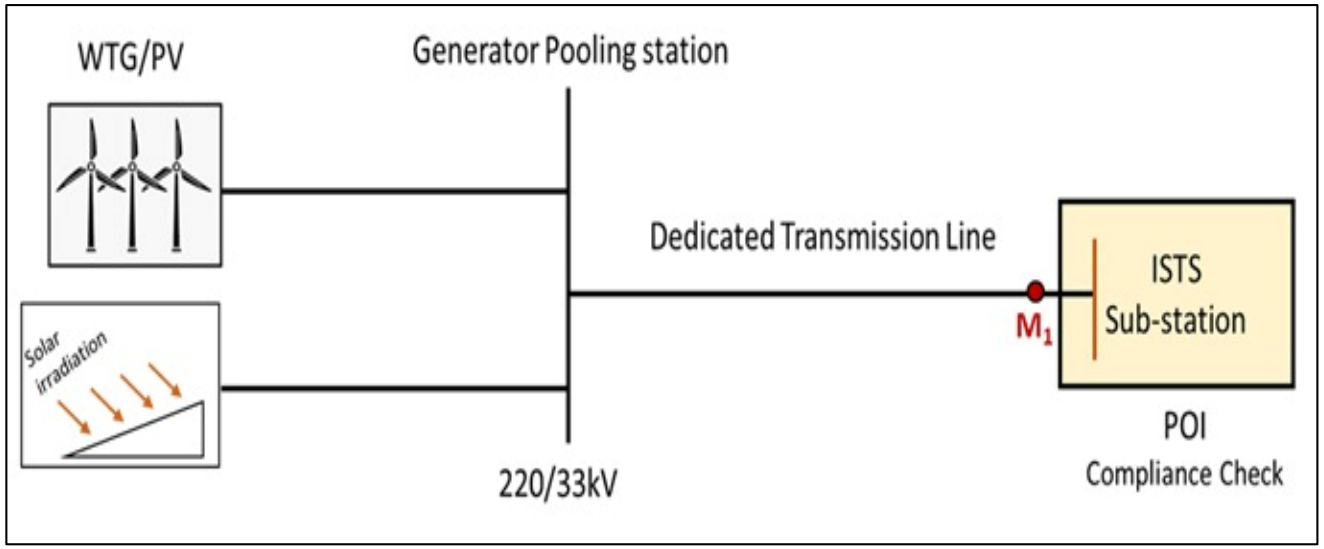
- Telemetry of reactive power resources shall be ensured at SLDC/RLDC comprising of analog and digital signals/data as per First Time charging procedure. .
- In case of interruptions, action shall be taken to restore the same. During the intervening period, data shall be provided over email.
- All users shall endeavor to ensure healthy & reliable real-time data at all times.

Telemetry

Conventional Power Plants

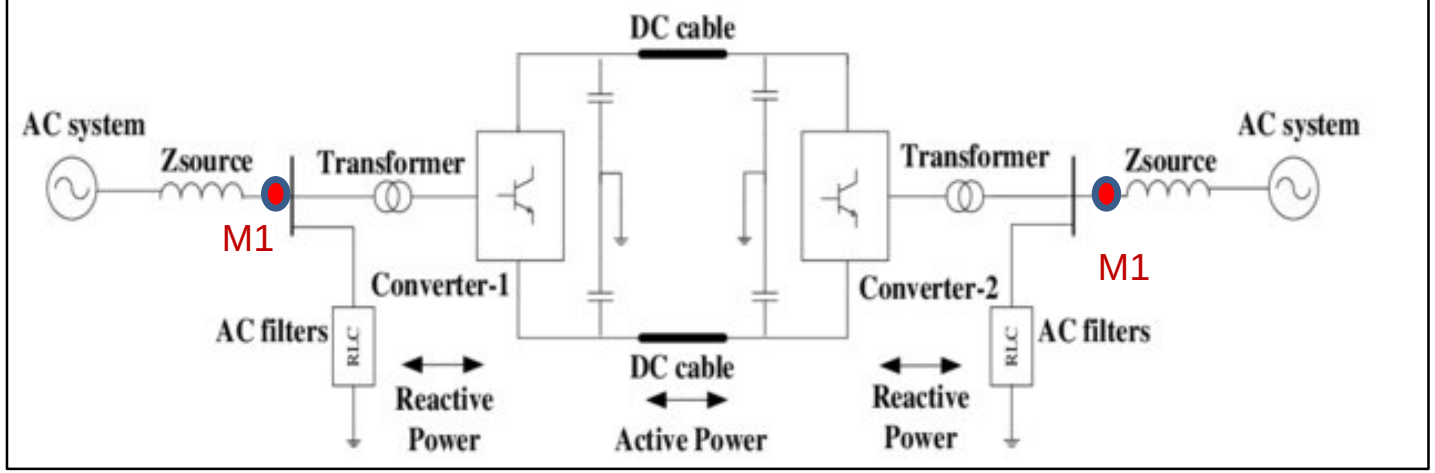


Invertor Based Resources

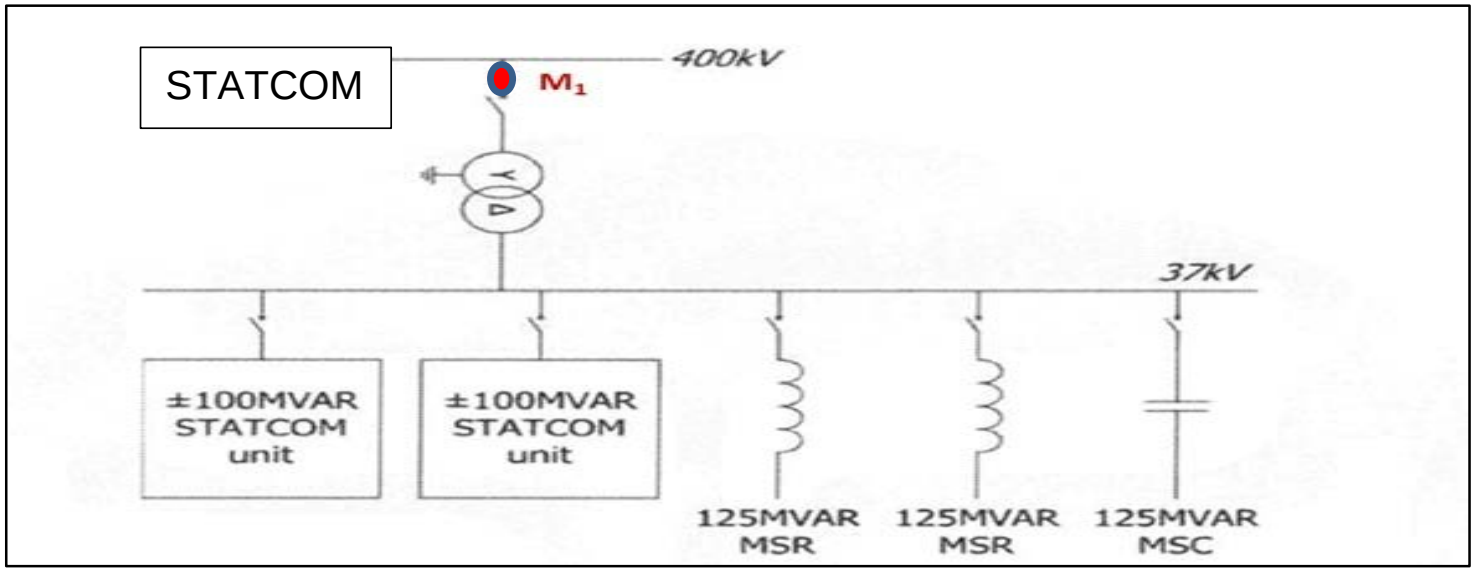


Telemetry

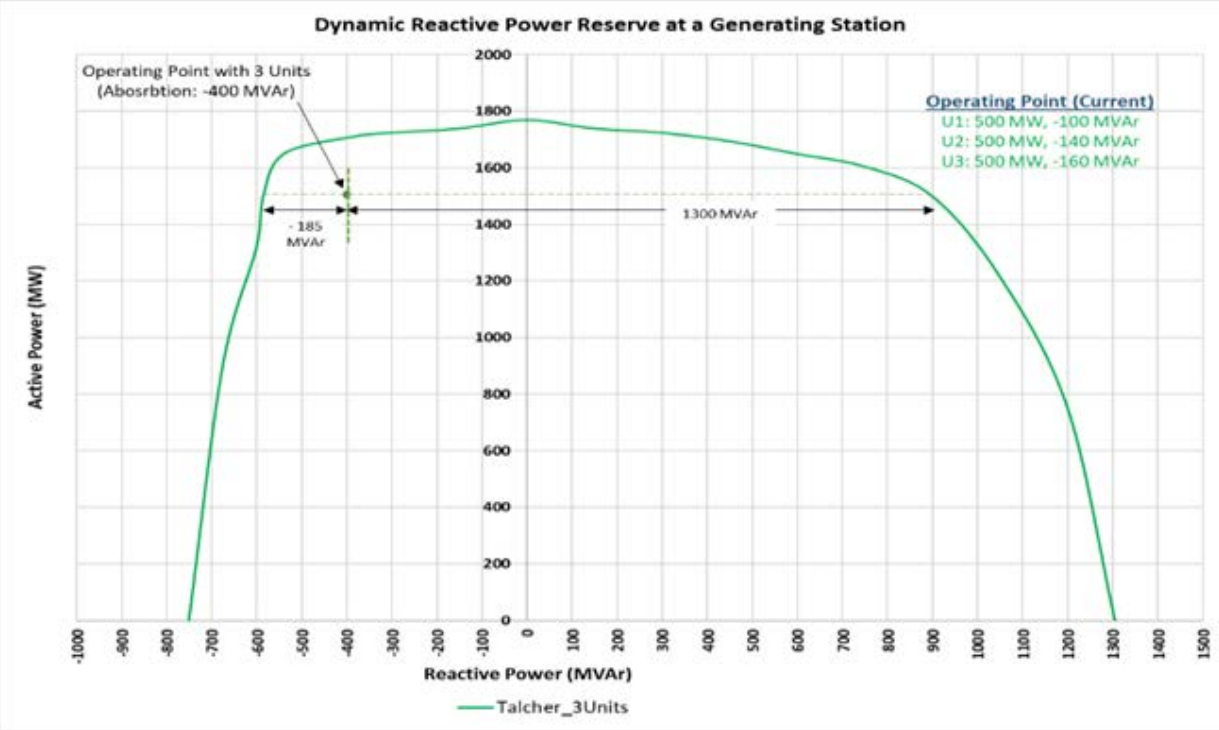
VSC Based HVDC



STATCOM



Generating stations / Condenser / IBR



- Generating station has four units of 500 MW each with an installed capacity of 2000MW.
- One of the units is considered to be under outage. Thereby On bar capability is 1500MW

Sl No	Generating Station	Installed Capacity	On Bar Active Capability	On Bar Current Generation	On bar reactive Capability at that bus in MVAr		Actual Reactive Injection (+)/ Absorption (-) in MVAr	Dynamic reactive power reserves in MVAr	
		MW	MW	MW	Qmax(+)	Qmin(-)		Qmax(+)	Qmin(-)
		A	B	C	D	E	F	G=D-F	H=E-F
1	Talcher Stage 2	2000	1500	1500	900	-585	-400	1300	-185
2									

STATCOM operates w.r.t Voltage on a slope with a dead band

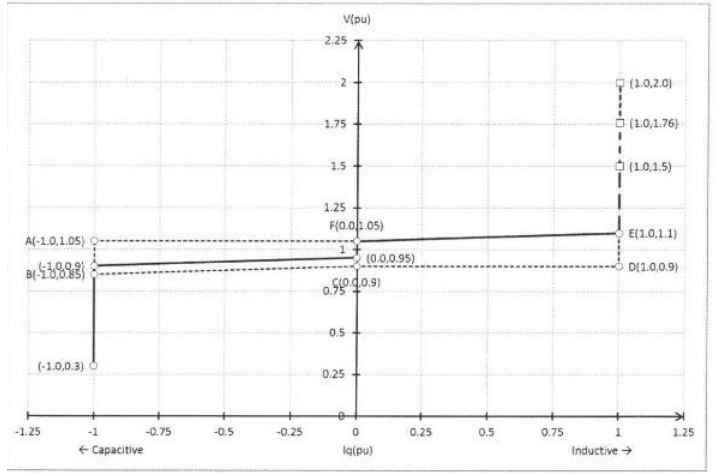


Figure-1 Power system voltage and current output characteristics of 2 x 100Mvar STATCOM

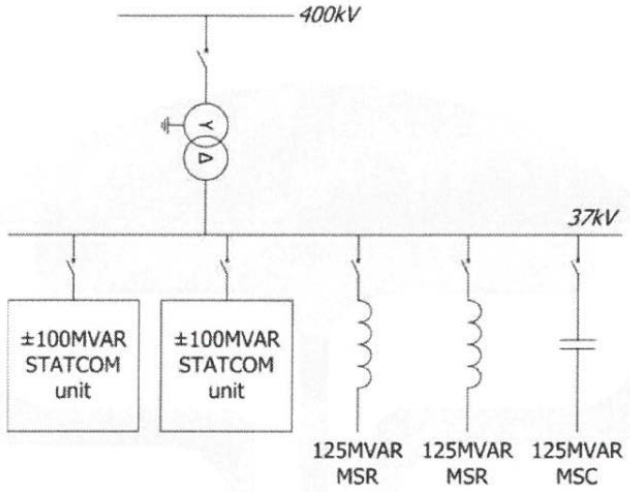


Figure2-Schematic diagram of STATCOM Station

Assessment of dynamic reactive reserve for the STATCOM having the reactive capability of 2 x 100 MVAR.

Location: Trichy/Ghanapur/Udamalapet

Sl No	Substation Name	Capacity	Voltage at the bus	Reactive Capability at that bus in MVAr		Actual Reactive Injection (+)/ Absorption (-) in MVAr	Dynamic reactive power reserves in MVAr (Under Contingency)		Static Reactive Power Reserves	
		MVAR	kV	Qmax (+)	Qmin (-)		Qmax(+)	Qmin(-)	Reactor Absorption (-) in MVAr	Capacitor injection (+) in MVAr
		A	B	C	D	E	F=C-E	G=D-E	H	I
1	X station	2000	418	200	-200	-30	230	-170		
2										

HVDC(VSC)

Each pole has a certain limit for a particular active power level.
Each pole of VSC-based HVDC in the SR region has the capability of 550 MVAR at 0MW and 330MVAR at 1000MW.

Sl No	Substation Name	Capacity	Voltage at the bus	Active Power	Reactive Capability at that bus in MVAr		Actual Reactive Injection (+)/ Absorption (-) in MVAr	Dynamic reactive power reserves in MVAr	
		MW	kV	MW	Qmax(+)	Qmin(-)		Qmax(+)	Qmin (-)
		A	B	C	D	E	F	G=D-F	H=E-F
1	Pugalur-Trissur @ Trissur	2000	418	600	968	-968	-400	1368	-568
2									

Monitoring

- Any short-term derating of reactive capability shall be immediately reported by utility to SLDC/RLDC.
- No unit equipment replacement or modification that reduces the reactive capability of the reactive reserve-providing unit shall be undertaken without approval from SLDC/RLDC.
- High reactive loading and reactive oscillations on generation units shall be immediately communicated to the SLDC/RLDC.
- Data from PMU shall be used to assess the performance of dynamic reactive resources during transient conditions.
- SLDC/RLDC shall monthly analyze the periods when the reactive reserve performance is below the declared capability.

Revision of Procedure

- Procedure shall be reviewed and revised by NLDC after stakeholder consultation and with intimation to the Commission.
- Under exigencies, the procedure shall be reviewed and revised by NLDC with intimation to the Commission. Stakeholder consultation shall follow subsequently.

Thank you !!

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