

Grid Code Compliance Assessment

Periodic Testing and Studies as per IEGC 2023 & CEA-TSCG

Agenda

- 1. IEGC 2023 relevant extracts**
- 2. Mandatory periodic tests as per IEGC 2023**
- 3. Periodic test procedures as per NLDC Guidelines**
- 4. Grid code compliance study as per CEA TSCG**

IEGC 2023-Periodic Testing Requirements

Regulatory Background

- The **Central Electricity Regulatory Commission (Indian Electricity Grid Code) Regulations, 2023** came into force on **1 October 2023**.
- The regulations apply to all power system stakeholders, including generating stations, transmission utilities, SLDCs, RLDCs, NLDC, REMCs, and other grid-connected entities.

Periodic Testing Requirements (Clause 40)

- Periodic tests shall be conducted to:
 - Validate mathematical models used in power system studies.
 - Verify equipment and control system performance during grid disturbances.
 - Ensure continued compliance with IEGC requirements.

Responsibilities of Power System Element Owners

- Conduct mandatory tests and submit reports to the concerned authorities (NLDC/RLDC/CEA/CTU/STU/SLDC, as applicable).
- Submit the annual testing plan to the concerned RPC by **31 October** for the following year.
- Inform the RPC of any changes in the approved testing schedule.

Testing Frequency

- **Once every five (5) years**, or
- After major retrofitting/modifications, or
- Earlier, if directed by SLDC/RLDC/NLDC/RPC due to observed adverse grid performance.

Relevant Extract for Periodic Testing

As per Grid Code 2023 Clause 40 (3)

Non synchronous Generator (Solar/Wind)	(1) Real and Reactive Power Capability for Generator (2) Power Plant Controller Function Test (3) Frequency Response Test (4) Active Power Set Point change test. (5) Reactive Power (Voltage / Power Factor / Q) Set Point change test	Applicable as per CEA Technical Standards for Connectivity.
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As per Grid Code 2023 Clause 40 (2) (b)

- At least Once in 5 years
- Thermal – 100 MW and above
- Hydro – 25 MW and above
- Gas – 50 MW and above
- WS seller – 10 MW and above connected at voltage level 33 kV and above.

With our proven expertise in conducting a range of tests, Solvina can contribute effectively in addressing requirements related to Clause 40 (3) specified in the Grid Code 2023.

Relevant Extract for Periodic Testing

(NLDC Guidelines)

Power Plant Controller Function Testing of Renewable Energy Based Generating Station

Section path of Final Procedure of Periodic Testing for Power System Elements submitted to CERC	Test / content block
5.3	Test Procedures
5.3.1	Inverter/WTG communication test
5.3.2	PQ Meter communication test
5.3.3	Active Power Set Point change test
5.3.4	Frequency response test
5.3.5	Reactive Power set point change test
5.3.5.a	Fixed Q-control mode with generation
5.3.5.a	Fixed Q-control mode during no generation
5.3.5.b	Voltage control mode
5.3.5.c	Power Factor Control mode
5.3.6	Operating frequency range test
5.3.7	Ability to receive signals from control center
5.3.8	PPC redundancy test
5.4	Data submission and closeout requirements

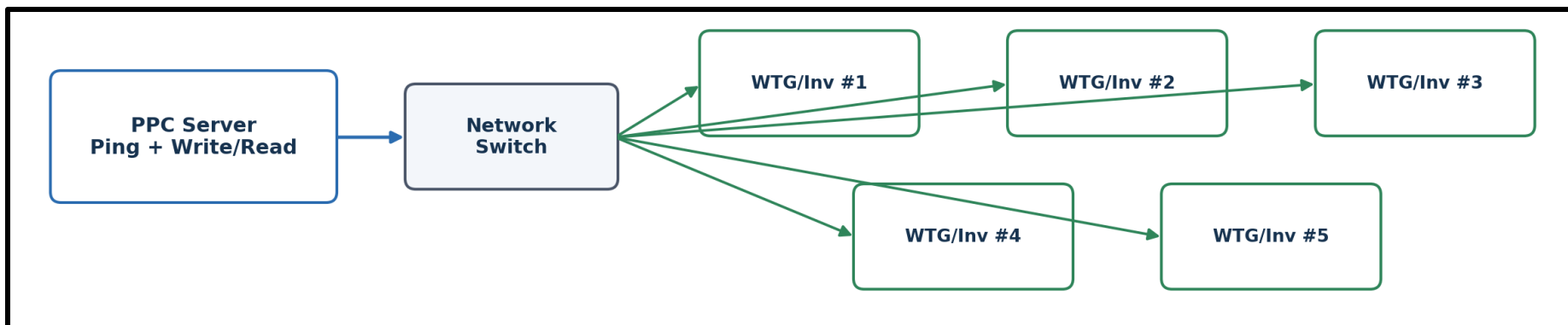
5.3.1 Inverter/ WTG Communication Test

- **Objective:** Verify communication between the PPC server and all inverters/WTGs through IP ping and command write/read checks.
- **Prerequisites:** PPC server access; list of inverter/WTG IP addresses; expected ping-response benchmark; ability to test command writing and reading status.
- **Test procedure:** Ping all inverters/WTGs IP addresses from the PPC server; record ping response time; verify that the response is less than the expected time; check and record commands writing and commands reading status.

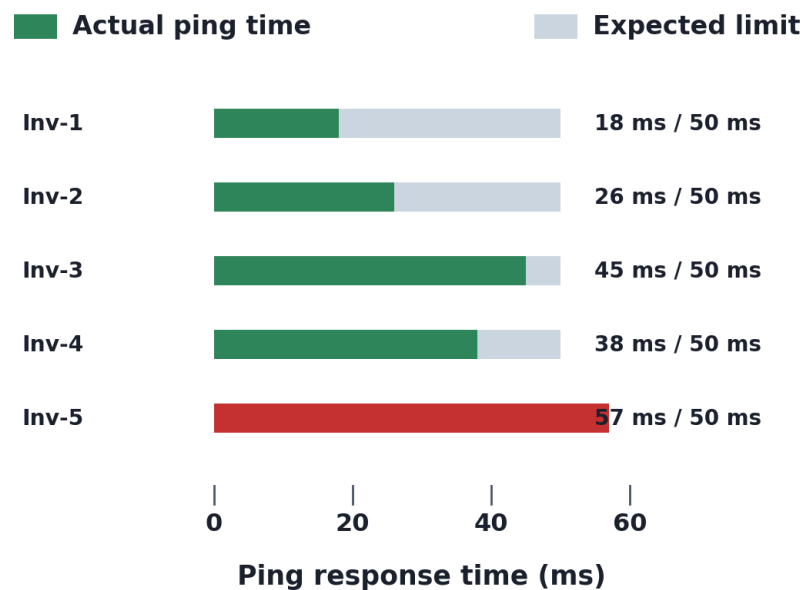
Inverter/WTG communication test format

Inverter/WTG Number	Inverter/WTG Name	Ping response Expected (ms)	Ping response Actual (ms)	Commands Writing (Ok)	Commands Reading (Ok)

Expected Response



Example ping response summary



5.3.2 PQ Meter Communication Test

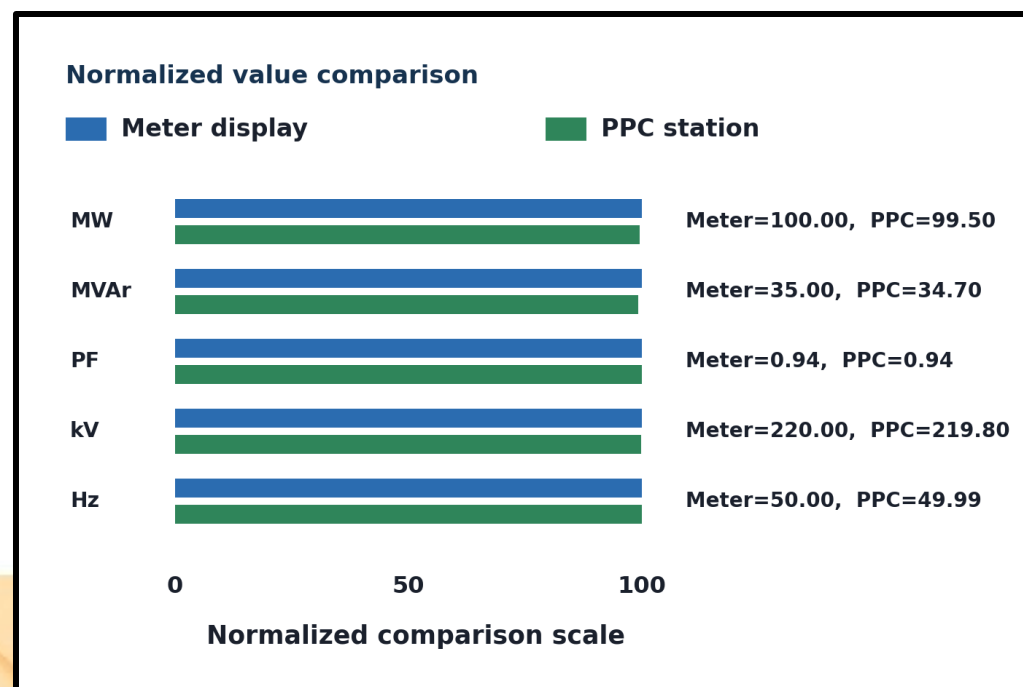
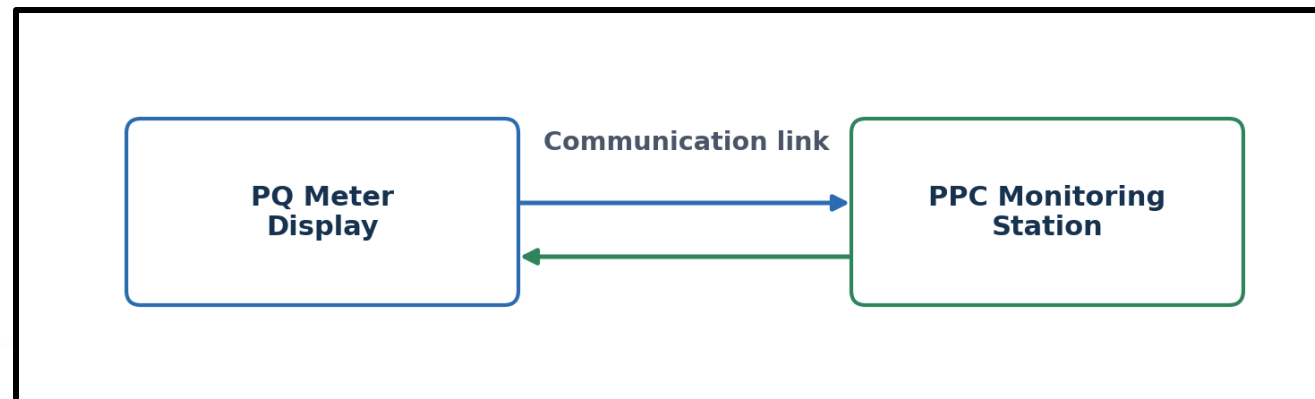
- **Objective:** Verify whether communication and reading from PQ meter is proper, and whether PPC reads the same values displayed on the PQ meter.
- **Prerequisites:** Live PQ meter display; PPC monitoring station; ability to record ping values and compare displayed/received parameters.
- **Test procedure:** Compare various parameter values shown on the PQ meter display with the parameters received at PPC from the PQ meter; check for correctness; capture test result, date, ping expected, and ping actual.

PQ Meter communication test format

Type of Test	Test Result	Date
Ping Expected (ms)		
Ping Actual (ms)		

Parameters	Value shown at PPC monitoring station	PQ meter display
Active power (MW)		
Reactive Power (MW)		
Power factor		
Voltage (Kv)		
Frequency (Hz)		

Expected Response

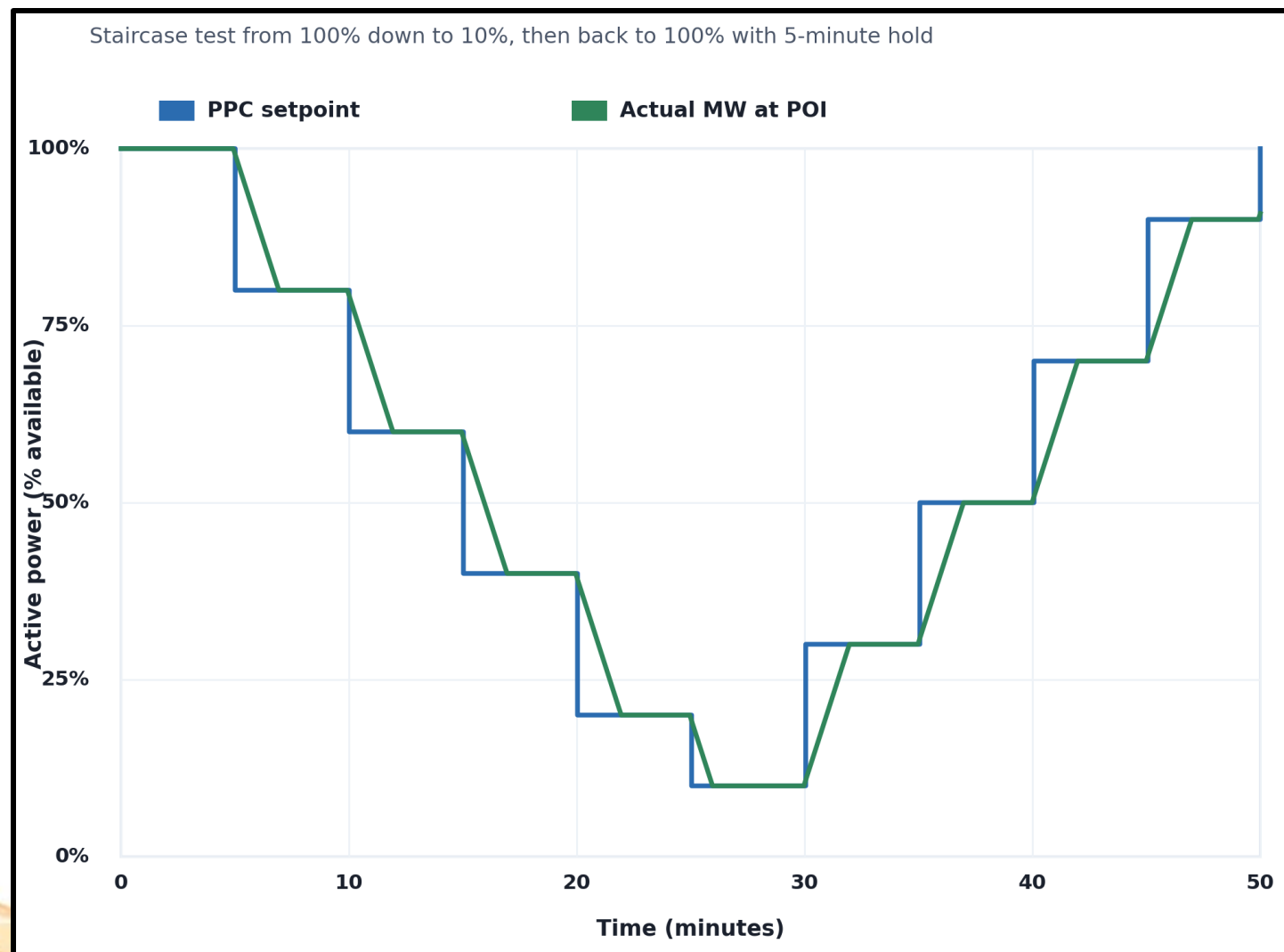


Solvina

- ## Test format for WTG/ PV Inverter plant

[illegible]

Expected Response



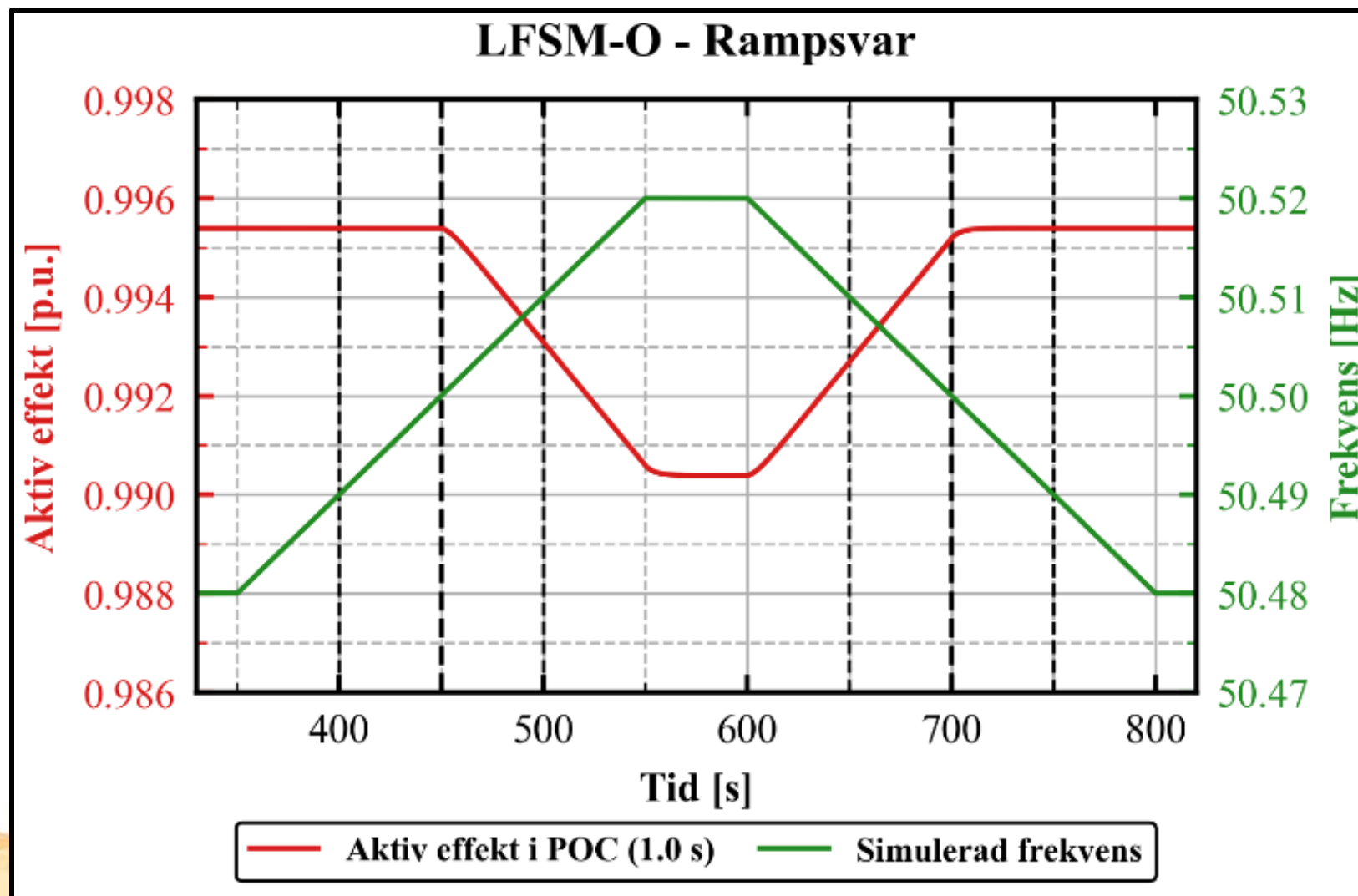
5.3.4 Frequency Response Test

- **Objective:** Check whether the RE plant is providing frequency response as specified in the cited CEA connectivity requirements.
- **Prerequisites:** Implemented droop setting in the range of 3%–6%; testing at different generation levels; at the time of testing, maximum available active power generation as per prevailing weather conditions shall not be less than 70% of rated capacity; preferably peak solar or maximum wind period depending on plant type.
- **Test procedure:** Perform the test at the implemented droop setting; apply the specified frequency changes at approximately 90% (or maximum) active power, 50% active power, and 25% active power; record the variables in the specified format for each testing step.



[illegible]

Expected Response



5.3.5 Reactive Power Control Test

- **Objective:** Introduce the three reactive-power control modes to be demonstrated under the PPC test program.
- **Prerequisites:** Plant capable of generating active power for the normal mode tests; optional no-generation capability where available for Fixed Q and Voltage control.
- **Test procedure:** State that three types of reactive power control—**Fixed reactive power control (Q control), Power factor (PF) control, and voltage control**—shall be performed when the plant is generating active power; **Fixed Q and Voltage control tests** shall also be performed during no generation period where the feature is available.



5.3.5.a Fixed Q-Control Mode with Active Generation

- **Objective:** Check whether the plant generates reactive power as per the given set point while the plant is generating active power.
- **Prerequisites:** Testing in coordination with RLDC/SLDC in real time based on POI voltage; testing at full generation (or maximum available generation above 70%) and at 50% of full generation.
- **Test procedure:** Apply reactive-power set points of 20%, 50%, and 100% of maximum reactive power at the point of interconnection, and then -25%, -50%, and -100% of maximum reactive power, at the prescribed generation levels; record the response; plot reactive-power set point versus actual reactive power.

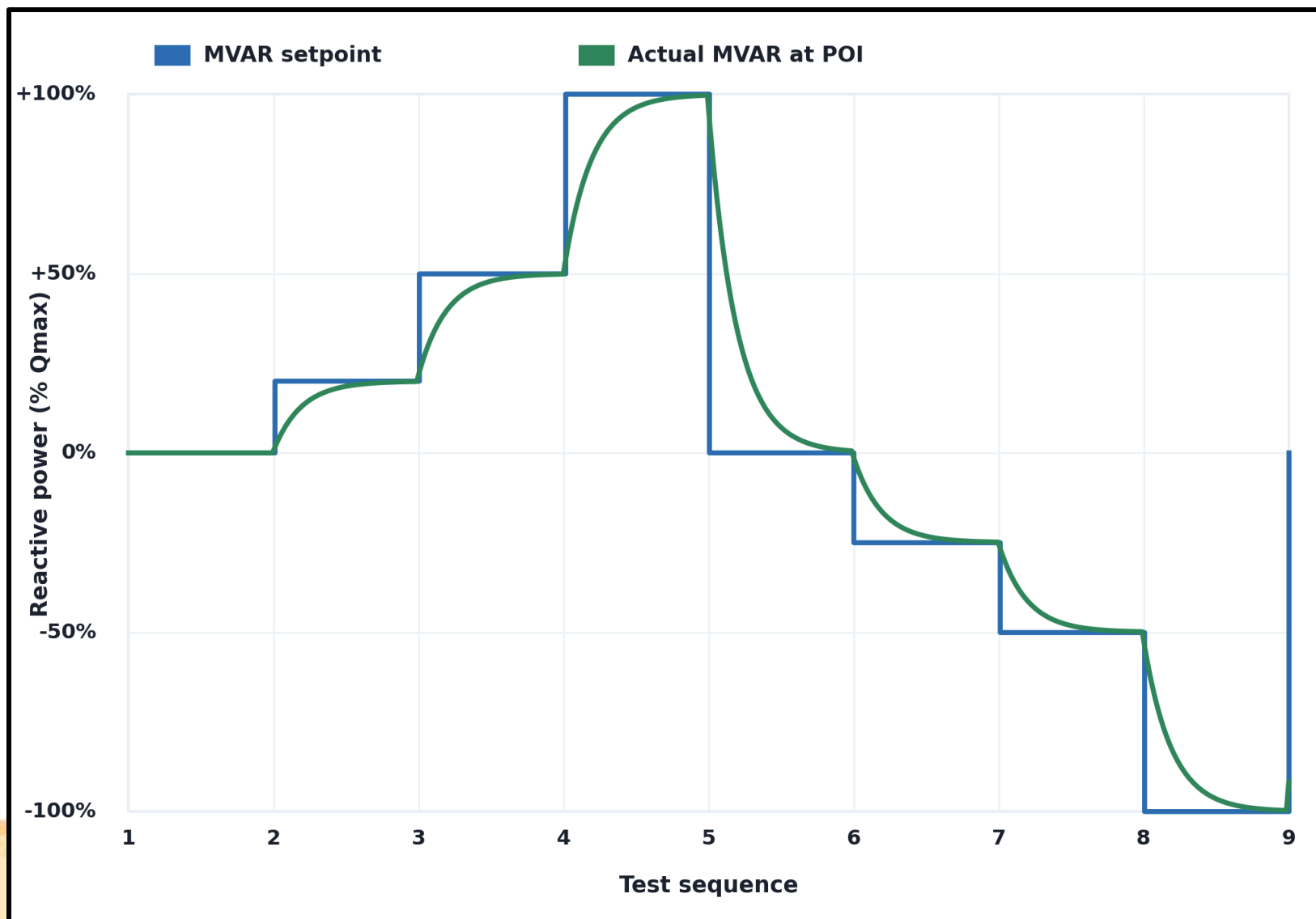
Fixed Q-Control Mode test format

Start Time	End Time	MVAR Set point given	MVAR at start time	MVAR at End time	POI Voltage at start time	POI Voltage at end time	PF at end time	Response Time (Sec)

Reactive power set point vs actual reactive power shall be plotted

Note: Maximum reactive power is 33% of the rated active power capacity at POI

Expected Response



5.3.5.a Fixed Q-Control Mode during No-Generation Period

- **Objective:** Check whether the plant generates reactive power as per the given reactive-power set point during no generation period.
- **Prerequisites:** Feature must be available; for PV, this corresponds to night time; for WTG, no wind period; testing in coordination with RLDC/SLDC in real time based on POI voltage; testing steps selected based on real-time grid conditions.
- **Test procedure:** Apply set-point changes of 0%, 50%, 100%, -50%, and -100% of maximum reactive power at the point of connection; record each step using the prescribed table.

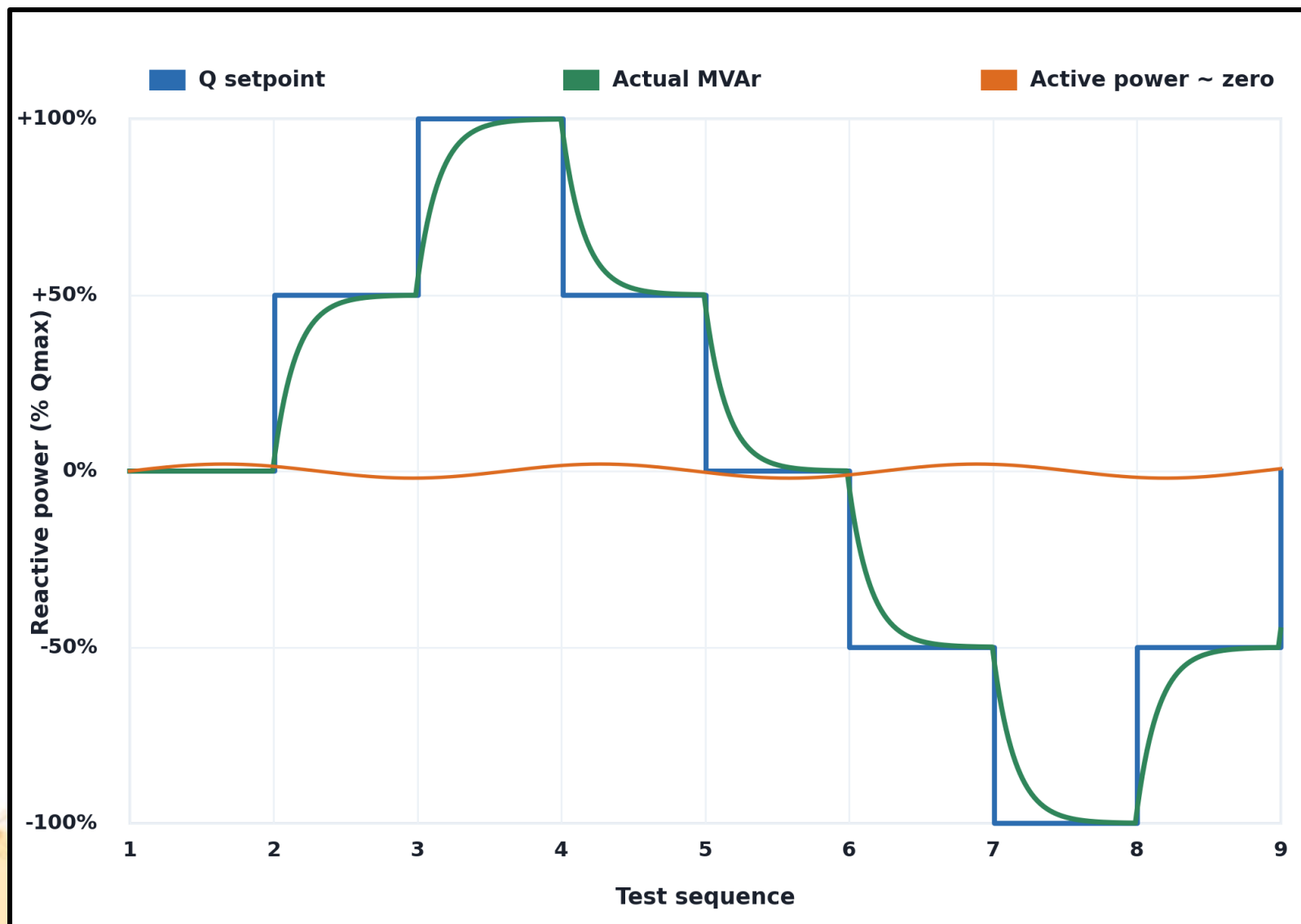
Fixed Q-Control Mode test format

Start Time	End Time	MVAR Set point given	MVAR at start time	MVAR at End time	POI Voltage at start time	POI Voltage at end time	PF at end time	Response Time (Sec)

Reactive power set point vs actual reactive power shall be plotted

Note: Maximum reactive power is 33% of the rated active power capacity at POI

Expected Response



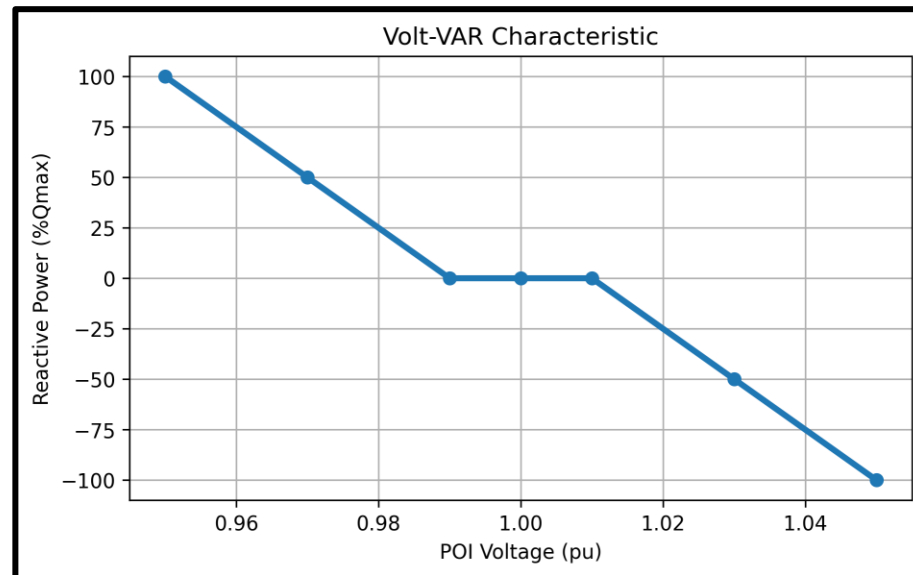
5.3.5.b Voltage Control Mode

- **Objective:** Check whether the plant generates reactive power proportionally to the error between the voltage set-point and the actual voltage value.
- **Prerequisites:** Details of implemented droop and dead band settings of voltage-control mode to be submitted; testing in coordination with RLDC/SLDC in real time based on POI voltage; test at maximum available active power generation not less than 70% of rated capacity and during no-generation period.
- **Test procedure:** Conduct the test under operator-coordinated POI voltage conditions and record the result as per the source format capturing simulated voltage and resulting MVar behaviour.

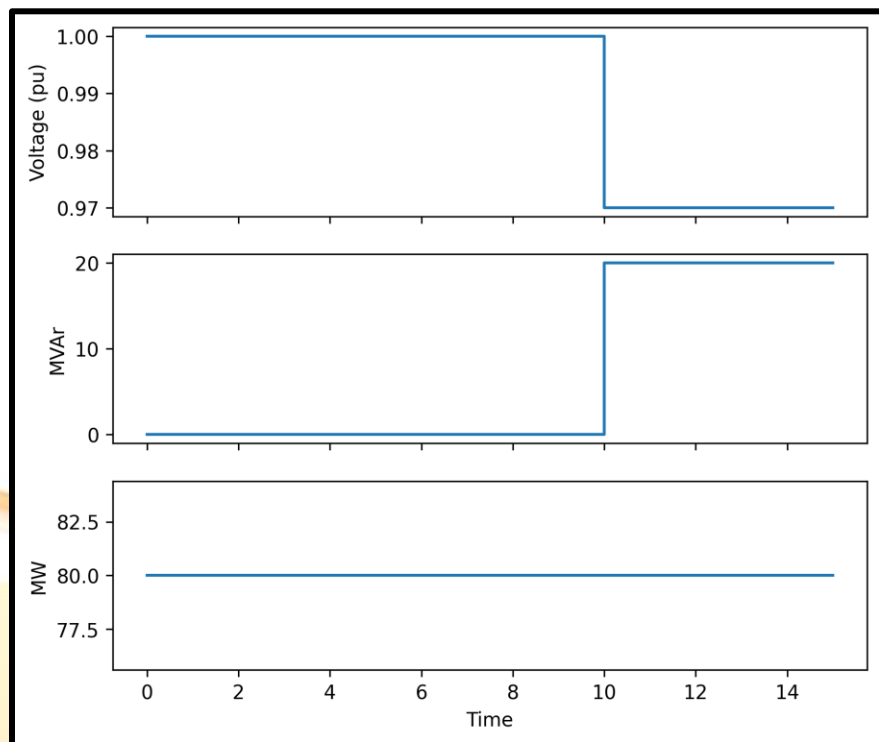
Voltage Control Mode test format

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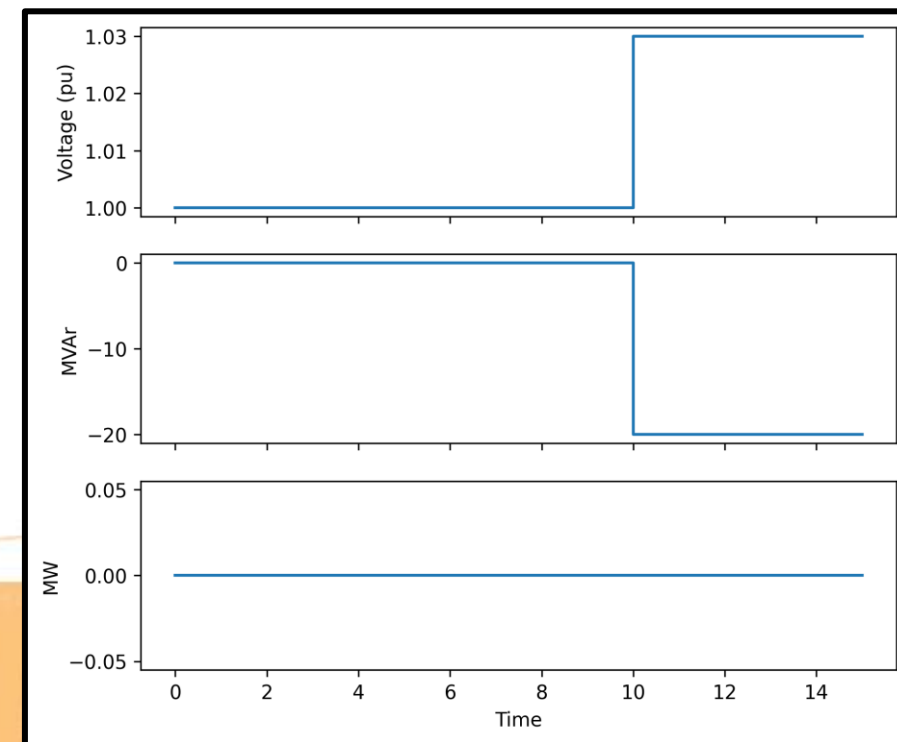
Expected Response



Voltage Control Test (>70% Generation)



Voltage Control Test (No Generation)



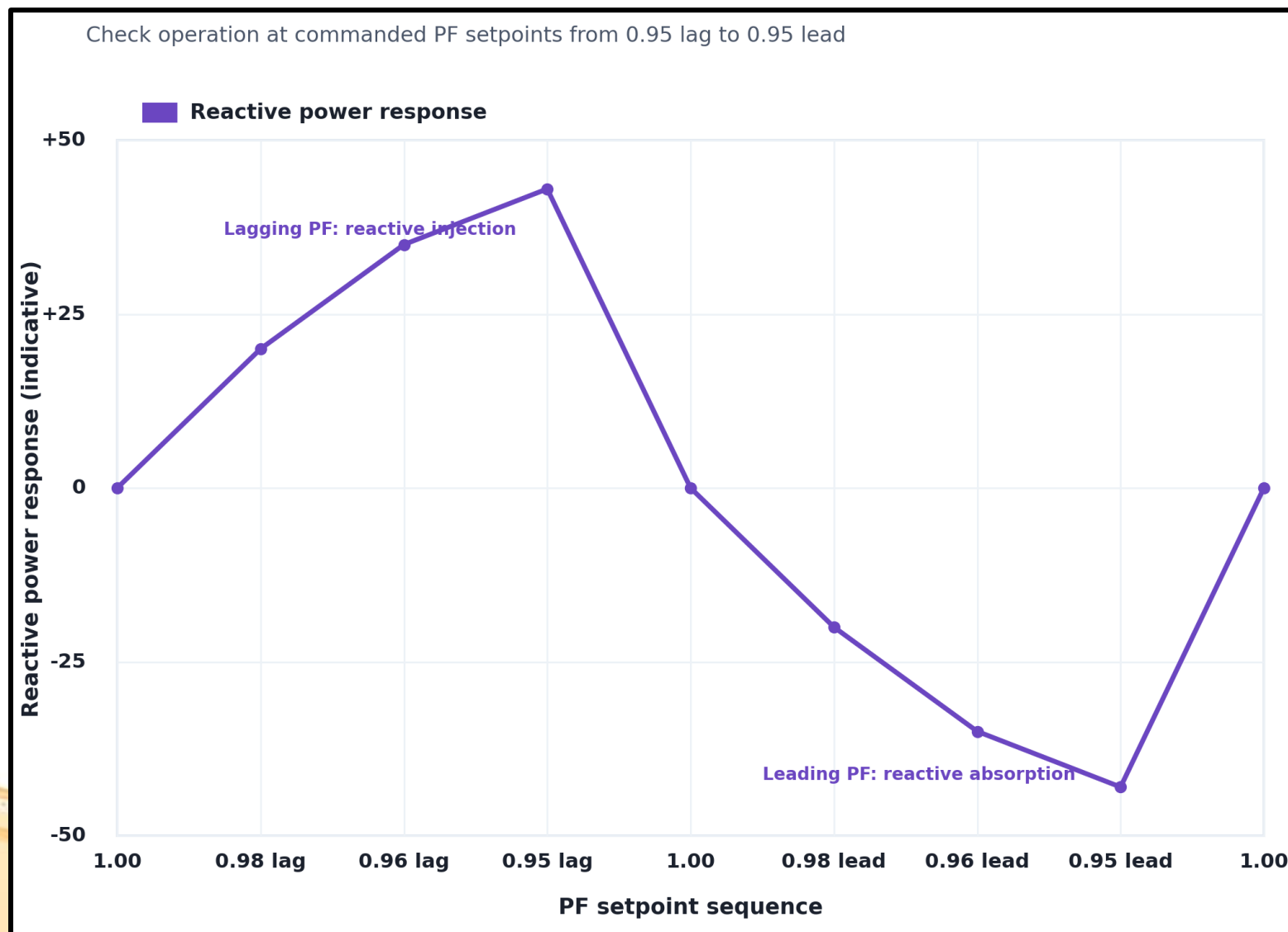
5.3.5.c Power Factor Control mode

- **Objective:** Check that the plant is operating with a power factor equal to the set-point value.
- **Prerequisites:** Testing in coordination with RLDC/SLDC in real time based on POI voltage; conduct at 100% power generation or maximum possible generation not less than 70% of rated capacity and also at 50% generation level.
- **Test procedure:** Change power-factor set points from 0.95 pf lead to 0.95 lag in steps of 0.02; tabulate lagging power-factor test and leading power-factor test results as shown in the source.

Power Factor Control test format

Power Factor Set-point Change	Active Power at POI (MW)	Reactive Power at POI (MVAR)	Power Factor at POI	POI Voltage (kV)	StartTime	End Time	Duration	Remarks
--								Initial conditions
Lagging power factor test								
1.00→0.98								
0.98→0.96								
0.96→0.95								
0.95→1.00								
Leading power factor test								
1.00→0.98								
0.98→0.96								
0.96→0.95								
0.95→1.00								

Expected Response



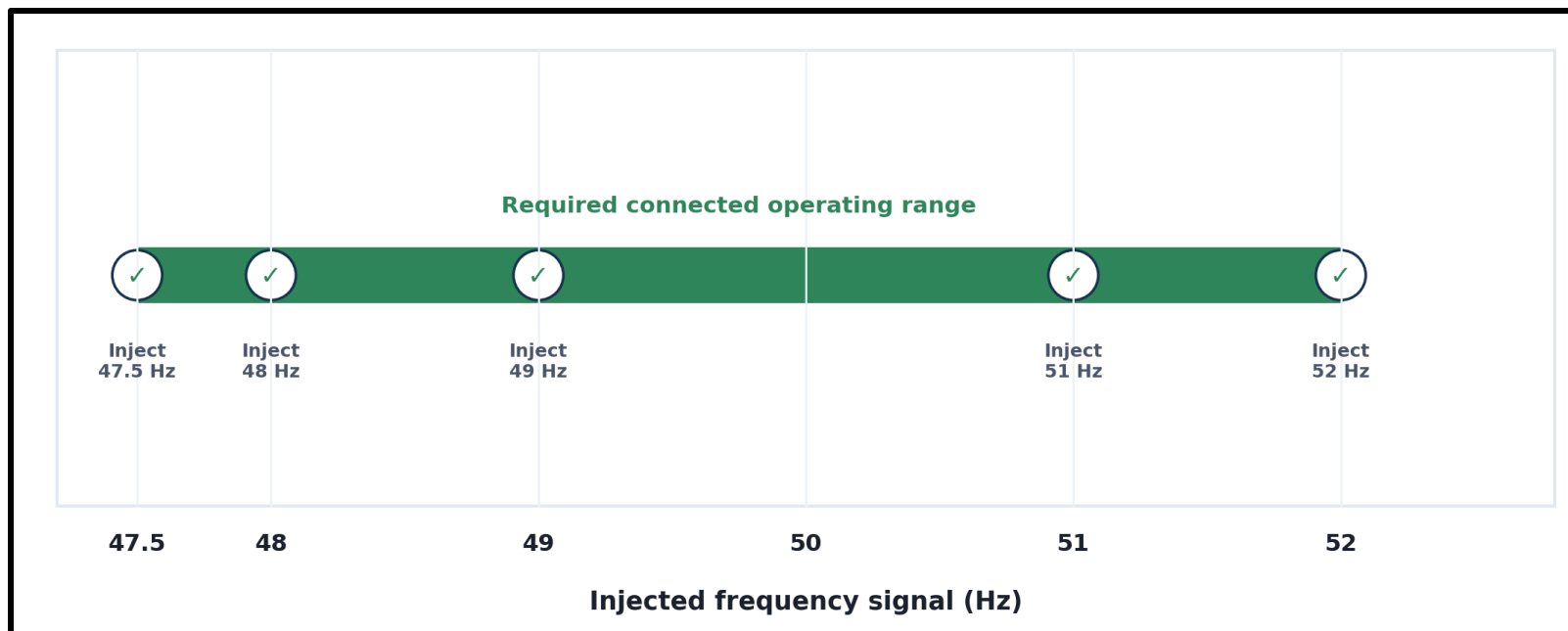
5.3.6 Operating frequency range test

- **Objective:** Check whether the generating unit has the capability to remain connected to grid when grid frequency is in the range of 47.5 to 52 Hz.
- **Prerequisites:** Test performed on sample WTGs/Inverters; the sample should include WTG/Inverter of different makes.
- **Test procedure:** Inject frequency signals of 49 Hz, 48 Hz, 47.5 Hz, 51 Hz, and 52 Hz in the WTG controller; record the WTG/Inverter status.

Operating frequency range test

Sl. No	WTG/Inverter number	Frequency signal injected in HZ	WTG/Inverter status (In service/Trip)

Expected Response



Key observations

- Perform this test on sample WTGs / inverters, including different makes.
- Record WTG / inverter number, injected frequency and status: in service or trip.
- Pass condition: units stay connected for the tested points within 47.5 Hz to 52 Hz.

5.3.7 Ability to Receive Signals from Control Center

- **Objective:** Validate that active and reactive power set points sent from SLDC/RLDC are received correctly and produce the corresponding plant response.
- **Prerequisites:** The section quotes the requirement for generating stations of aggregate capacity of 500 MW and above to have the provision to receive the signal from SLDC or RLDC for varying active and reactive power output.
- **Test procedure:** Send active-power set points from RLDC/SLDC and verify receipt at site; record initial and final generation and time taken. Then send reactive-power set points and verify receipt at site; record initial and final MVAR and time taken.

Active-power signal reception from control center

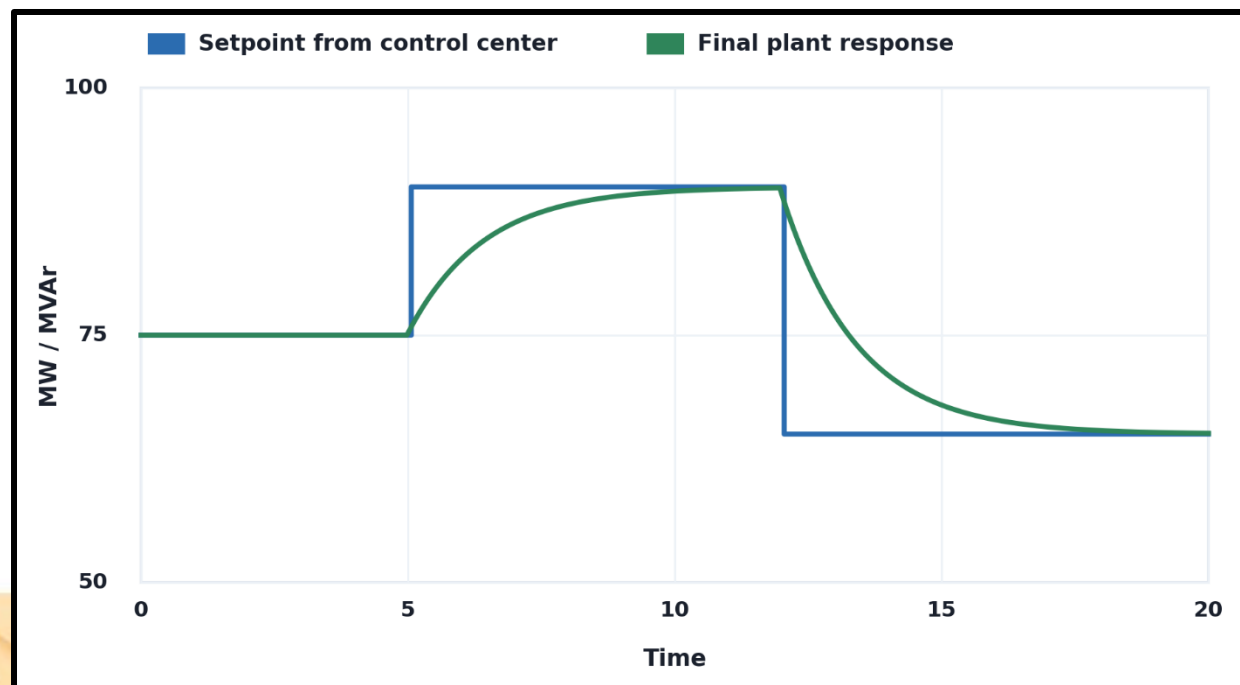
Sl.No	Active power Set Point sent from RLDC/SLDC	Set point received at Site (Yes/No)	Initial generation (MW)	Final Generation (MW)	Time taken (Sec)

Reactive-power signal reception from control center

Sl.No	Reactive power Set Point sent from RLDC/SLDC	Set point received at Site (Yes/No)	Initial MVAR	Final MVAR	Time taken (Sec)

Expected Response

Validate active and reactive setpoints sent from SLDC / RLDC



5.3.8 PPC Redundancy Test

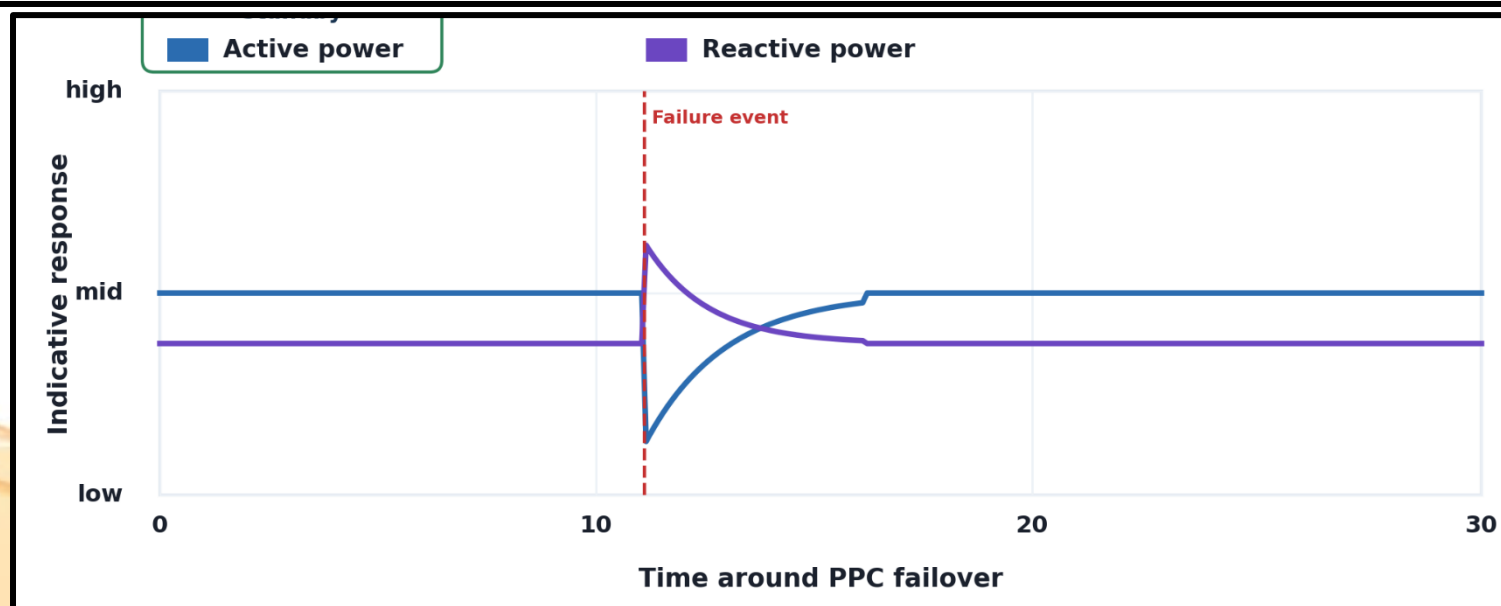
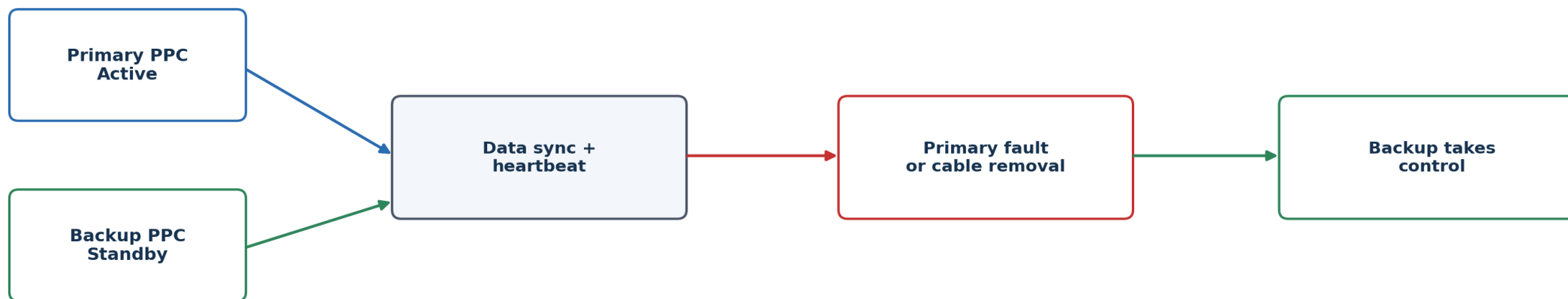
- **Objective:** Confirm that the PPC system automatically switches over from primary to back-up processor when a fault occurs in the primary and that normal plant operation is preserved in the event of communication failure or PPC failure.
- **Prerequisites:** Redundant PPC architecture; visibility of PPC synchronization status; user-interface ability to change set points; if master and slave PPCs are available, both failure cases must be tested.
- **Test procedure:** Stop the primary processor; check PPC status for synchronization and whether secondary PPC takes control through user-interface set-point changes; remove the communication cable to PPC and check plant active and reactive power at POI; repeat for master/slave failure if applicable.

PPC Redundancy test format

Sl. No	Active power (MW) before PPC failure	Active power (MW) after PPC failure	Reactive power (MW) before PPC failure	Reactive power (MW) after PPC failure	Remarks

Expected Response

Automatic switchover from primary to backup controller without abnormal plant operation



5.4 Data Submission

State that all recording parameters for each test shall be submitted in csv/excel format with 100 milli sec resolution wherever available; if 100 ms is not available, next higher available resolution data not more than 1 second shall be considered; data should cover the testing period and 5 minutes before and after; the test report shall cover all tests performed, recording tables, relevant plots, and conclusion on compliance to applicable CEA technical standards.

PV Inverter/WTG details

Sl. No	Data	Unit / description	Value
1	Power plant name	Name	
2	WTG/ PV Inverter	Make & Model	
3	Plant Installed Capacity	MW	
5	Plant Peak Capacity	MW	
6	WTG/Inverter rating in MVA	MVA	
7	WTG/Inverter active power rating in MW	MW	
8	Number WTGs/Inverters	Numbers	
9	Master PPC	Make	
10	Auxiliary PPCs	Number and Make	

GRID CODE COMPLIANCE STUDY

RE Generators/Parks



Relevant Standard/Regulation

- CEA Technical Standard for Grid Connectivity 2007 and Amendment 2013, 2019
- Working group committee report 2022
- IEGC 2023
- CTU List of studies/tests to be conducted by generators/parks in process of submission of final technical connection data for demonstrating compliance with cea technical standards for connectivity to the grid (2025)



List of models & reports to be submitted at plant level

Sr N o.	Relevant Regulation Clauses	Description	Reports (R) / Simulation Models(SM)
1	CEA TSCG 6(6)	Compliance Report in RMS(PSS/E) Reactive power analysis	R
2		Compliance Report in RMS(PSS/E) Dynamic Studies	
3		Compliance Report in EMT(PSCAD) Dynamic & other applicable tests	
4		Compliance Report in EMT(PSCAD) for power quality assessment	
5		Report on comparison of RMS & EMT equivalent model response under steady state & dynamic conditions	
6	CEA TSCG 6(6)	Generic RMS (PSS/E) model of RE plant (detailed) along with all supporting files (.dyr, .sav, .raw, .sld, .py, model user guide etc.)	SM
7		Generic RMS (PSS/E) model of RE plant (equivalent) along with all supporting files (.dyr, .sav, .raw, .sld, .py, model user guide etc.)	
8		RE Plant EMT (PSCAD) model of RE plant (equivalent model) along with all supporting files including model user guide	
9		RE Plant EMT (PSCAD) Power Quality Assessment model along with all supporting files including model user guide	
10	CEA TSCG: Part-III.5	Short Circuit (Non-Conventional Source - Fault Contribution) Table & Model (.seq)	

Details of Models for carrying out different studies

Sr No.	Simulation test Description	Simulation to be carried out on
1	Reactive Power capability	Detailed RMS and Equivalent EMT Model
2	Power Quality	Power Quality Assessment Model
3	Low Voltage Ride Through (LVRT)	Equivalent RMS and Equivalent EMT Model
4	High Voltage Ride Through (HVRT)	
5	Operating Frequency Range	
6	Frequency Response	
7	Dynamic Reactive Power Support	
8	Ramping Capability	

- *CTU (2025)List of studies/tests to be conducted by generators/parks in process of submission of final technical connection data for demonstrating compliance with cea technical standards for connectivity to the grid*

GCC Study

- Steady State Study
- Dynamic Study using RMS model (PSS/E)
- Dynamic Study using EMT model (PSCAD/EMTDC)
- Power Quality Study



Steady State Study

CEA TSCG: Part II B2(1)

- Load Flow Study
- Short Circuit Study
- Reactive Power Capability Test



Reactive Power Capability Test

CEA TSCG: Part II B2(1)

RE generators shall be capable of supplying dynamically **varying reactive power support** so as to maintain pf with in the limits **of 0.95 lagging to 0.95 leading** with a **voltage variation of $\pm 5\%$**

- PQ Capability for Voltage at PCC above 1pu (up to 1.05 pu) at various active power generation (0-100%)
- PQ Capability for Voltage at PCC below 1pu (upto 0.95 pu) at various active power generation (0-100%)
- V-Q curve at POI



Dynamic Study using RMS model (PSS/E), and EMT model (PSCAD/EMTDC)

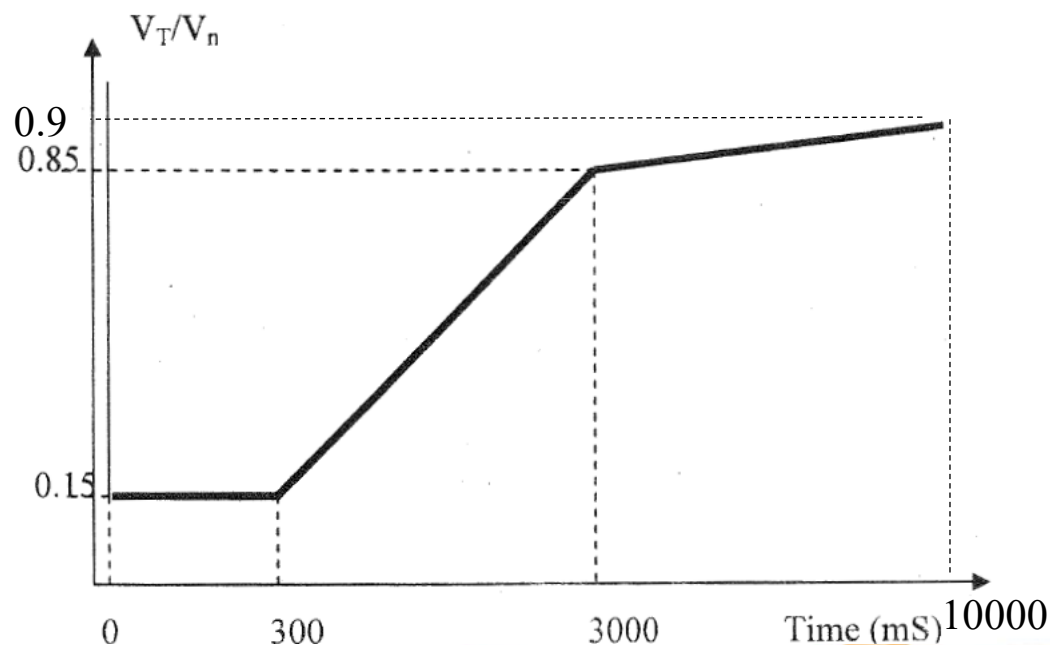
CEA TSCG: Part-II B2(1), B2(2), B2(3), B2(4)

- LVRT Test Response
- HVRT Test Response
- Operating Frequency Range Test
- Frequency Response Test
- Voltage Response Test
- Unbalanced faults



LVRT Test

The generating station connected to the grid, shall remain connected to the grid when voltage at the interconnection point on any or all phases dips up to the level depicted by the thick lines in the following curve, namely: — V_T : Actual Voltage; V_n : Nominal Voltage—



LVRT Test

- 3-ph impedance fault at POI for 3 sec (grid voltage is <0.85 pu during fault) – 100 % generation
- 3-ph impedance fault at POI for 3 sec (grid voltage is <0.85 pu during fault) – 50 % generation
- 3-ph impedance fault at POI for 3 sec (grid voltage is <0.85 pu during fault) – 25 % generation

- 3-ph impedance fault at POI for 300 msec (grid voltage is 0.15 pu during fault) – 100% Generation
- 3-ph impedance fault at POI for 300 msec (grid voltage is 0.15 pu during fault) – 50% Generation
- 3-ph impedance fault at POI for 300 msec (grid voltage is 0.15 pu during fault) – 25% Generation

- LVRT simulation case for 0.9pu – Continuous @ 100% generation
- LVRT simulation case for 0.9pu – Continuous @ 50% generation
- LVRT simulation case 0.9pu – Continuous @ 25% generation



HVRT Test

The generating station connected to the grid, shall remain connected to the grid when voltage at the interconnection point, on any or all phases (symmetrical or asymmetrical overvoltage conditions) rises above the specified values given below for specified time —

Over voltage (pu)	Minimum time to remain connected (Seconds)
$1.30 < V$	0 Sec (Instantaneous trip)
$1.30 \geq V > 1.20$	0.2 Sec
$1.20 \geq V > 1.10$	2 Sec
$V \leq 1.10$	Continuous

HVRT Test

- Rise in grid voltage is upto 1.1 pu – 100% generation
- Rise in grid voltage is upto 1.1 pu – 50% generation
- Rise in grid voltage is upto 1.1 pu – 25% generation

- Rise in grid voltage is up to 1.2 pu for 2 sec – 100 % generation
- Rise in grid voltage is up to 1.2 pu for 2 sec – 50 % generation
- Rise in grid voltage is up to 1.2 pu for 2 sec – 25 % generation

- Rise in grid voltage is up to 1.3 pu for 200 msec – 100% Generation
- Rise in grid voltage is up to 1.3 pu for 200 msec – 50% Generation
- Rise in grid voltage is up to 1.3 pu for 200 msec – 25% Generation



Operating Frequency Range

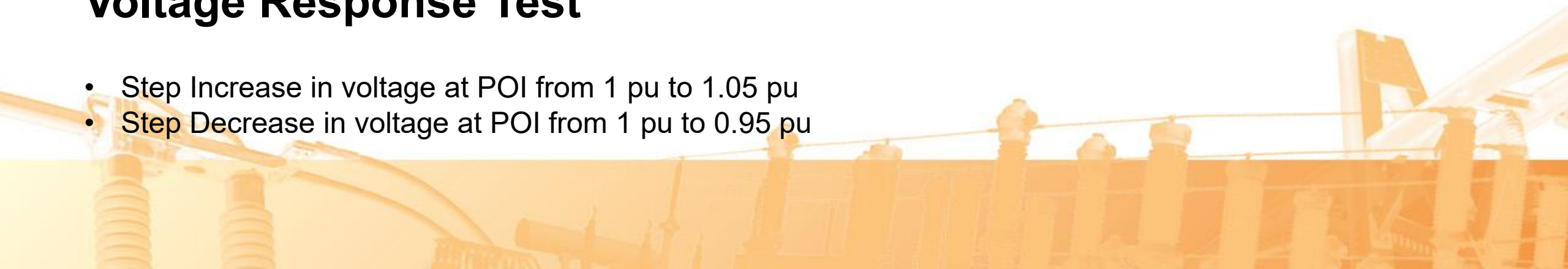
- Rated Active power generation between 49.5-50.5 Hz at POI voltage (0.95 pu, 1 pu, 1.05 pu)
- Stable power output between 47.5 Hz-52 Hz at POI voltage (0.95 pu, 1 pu, 1.05 pu)

Frequency Response Test

- Increase in grid frequency upto 50.5 Hz
- Decrease in grid frequency upto 49.5 Hz

Voltage Response Test

- Step Increase in voltage at POI from 1 pu to 1.05 pu
- Step Decrease in voltage at POI from 1 pu to 0.95 pu



Power Quality Study

CEA TSCG: Part-II B1(2) and IEEE519

Requirements with respect to Harmonics, Direct Current (DC) Injection and Flicker

- (i) The limits of voltage harmonics by the distribution licensee in its electricity system, the limits of injection of current harmonics by bulk consumers, point of harmonic measurement, i.e., point of common coupling, method of harmonic measurement and other related matters, shall be in accordance with the **IEEE 519-2022** standards, as amended from time to time.
- (ii) The Generating station **shall not inject DC current greater than 0.5 %** of the full rated output at the interconnection point.
- (iii) The generating station shall not introduce flicker beyond the limits specified in **IEC 61000**
- (iv) Measuring and metering of harmonics shall be a continuous process with meters complying with provisions of **IEC 61000-4-30 Class A**.

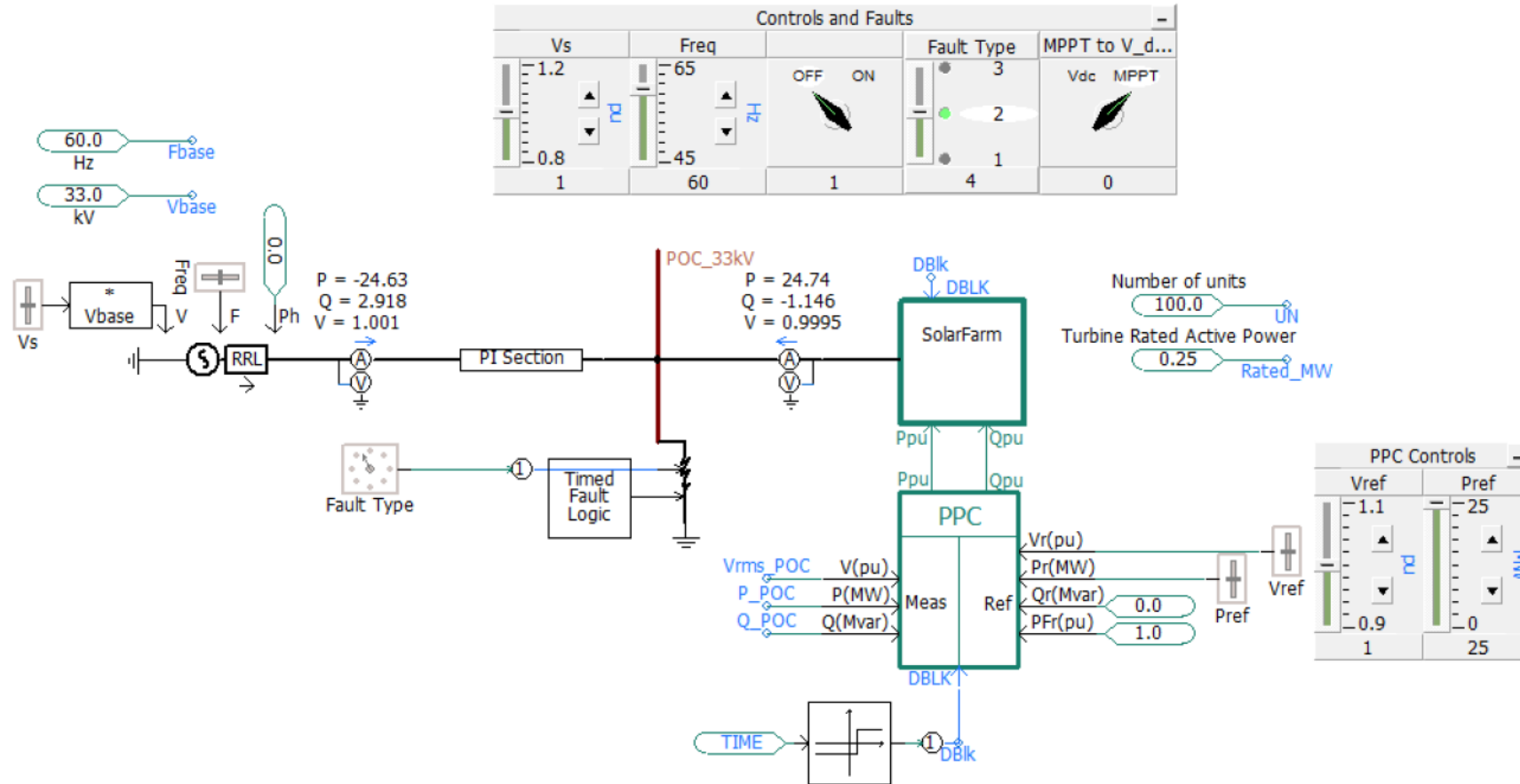
Data required for Study

- Plant SLD
- Cable Routing of the Plant
- Solar inverter data
- GTP of Solar IDT
- GTP of Power Transformer
- GTP of Cable
- PQ Capability Curve @ **48°C**

Simulation Model

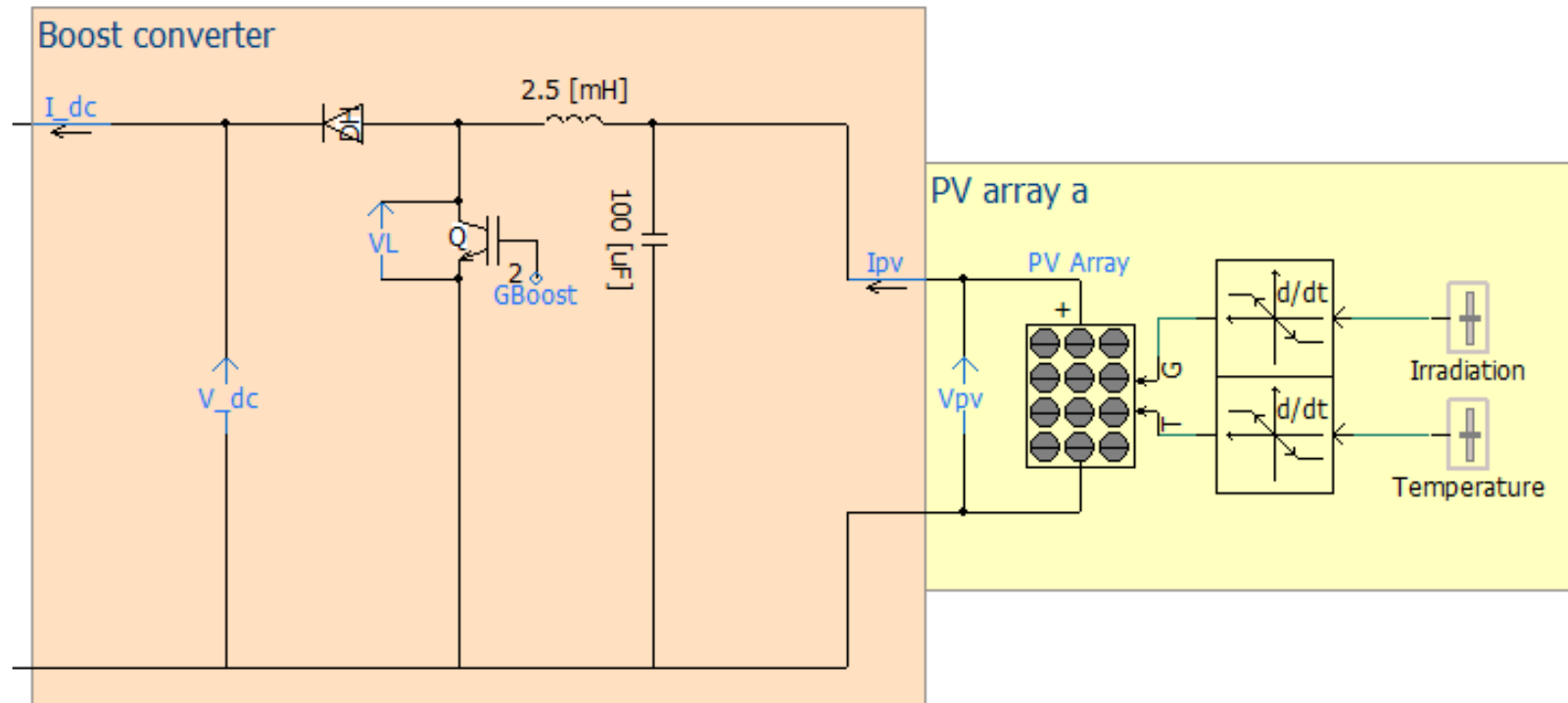


PSCAD/EMTDC Model



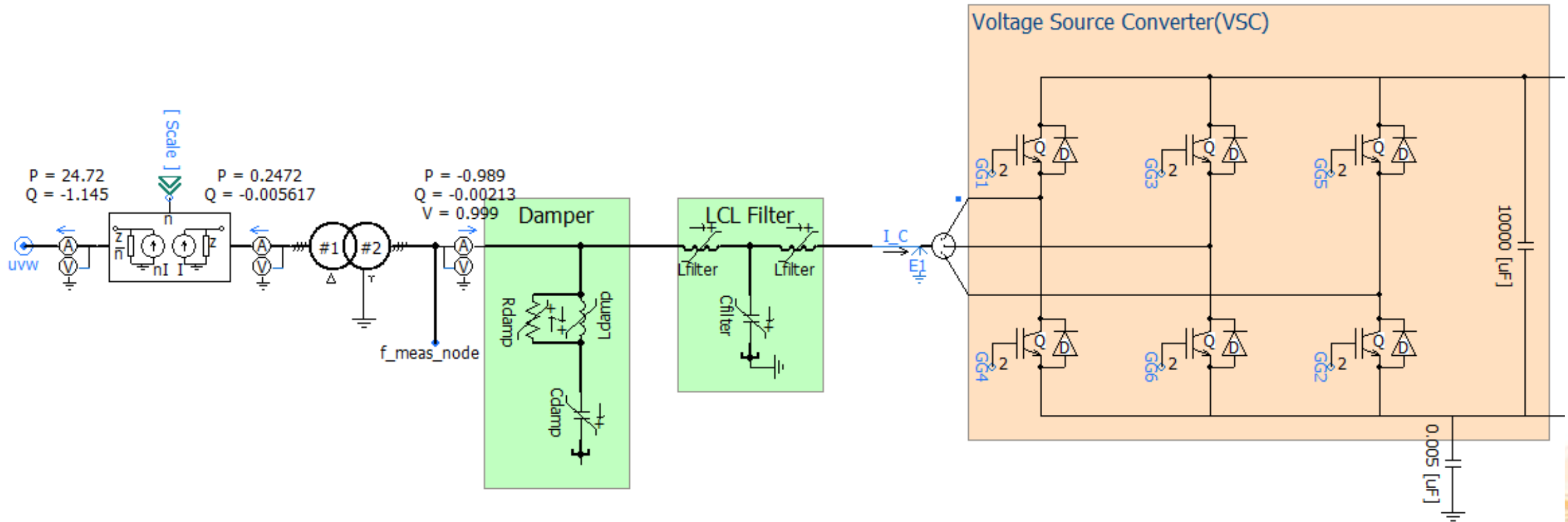
Solar Farm Model and equivalent Grid

PV Array along with Boost Converter



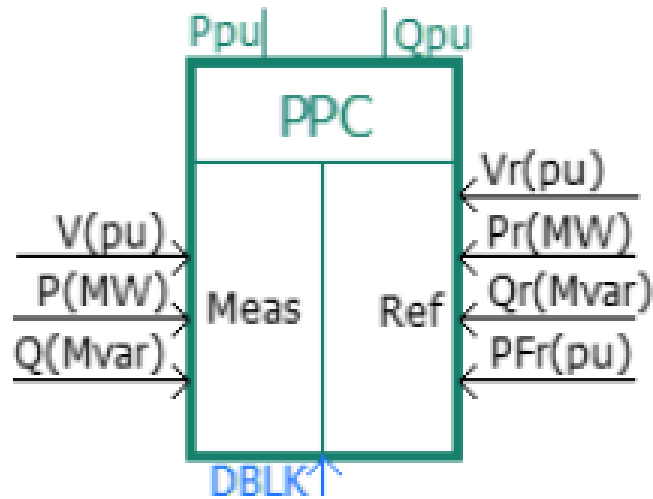
Photovoltaic source	
PV Array Parameters	
General	
PV array name (optional)	PVarray1
Number of modules connected in series per array	35
Number of module strings in parallel per array	130
Number of cells connected in series per module	35
Number of cell strings in parallel per module	1
Reference irradiation	1000
Reference cell temperature	25
Graphics Display	industry

Voltage Source Converter (Inverter Model)



Power Plant Controller

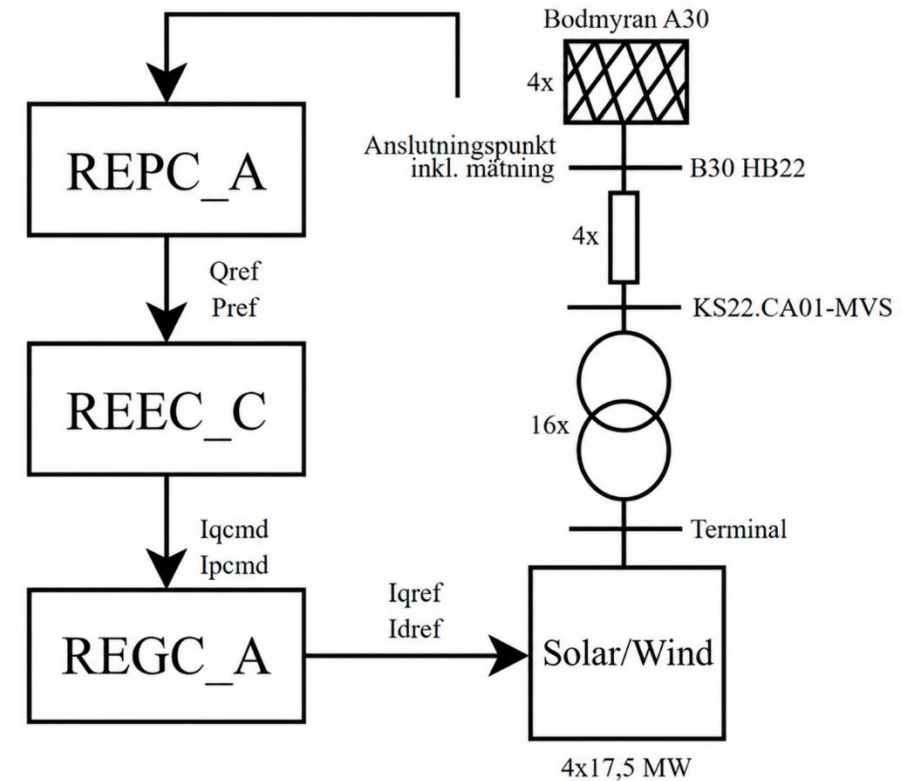
Input Parameter of PPC



Name	Caption	Type	Unit	Value
Scale	Number of Inverters	Integer	UN	
Sbase	MVA Rating of Single Inverter	Real	MVA	Rated_MW
con_mode	Reactive Power Control Mode	Choice		1
HVRT	HVRT Detection Threshold	Real	pu	1.15
LVRT	LVRT Detection Threshold	Real	pu	0.85
Pmax	Pmax	Real	pu	1
Pmin	Pmin	Real	pu	0
Qmax	Qmax	Real	pu	0.6
Qmin	Qmin	Real	pu	-0.6

WECC- PSS/E Model

- Power Plant Controller Model (REPC_A)
- Electrical Control Model (REEC_C)
- Converter Model (REGC_A)



Overview of an equivalent dynamic simulation model in PSS/E.

WECC- PSS/E Model

REPC_A → REEC_C

The REPC model represents the centralized, automatic control system at the plant level. It generates high-level control commands that are distributed to each individual inverter unit of the solar/wind plant.

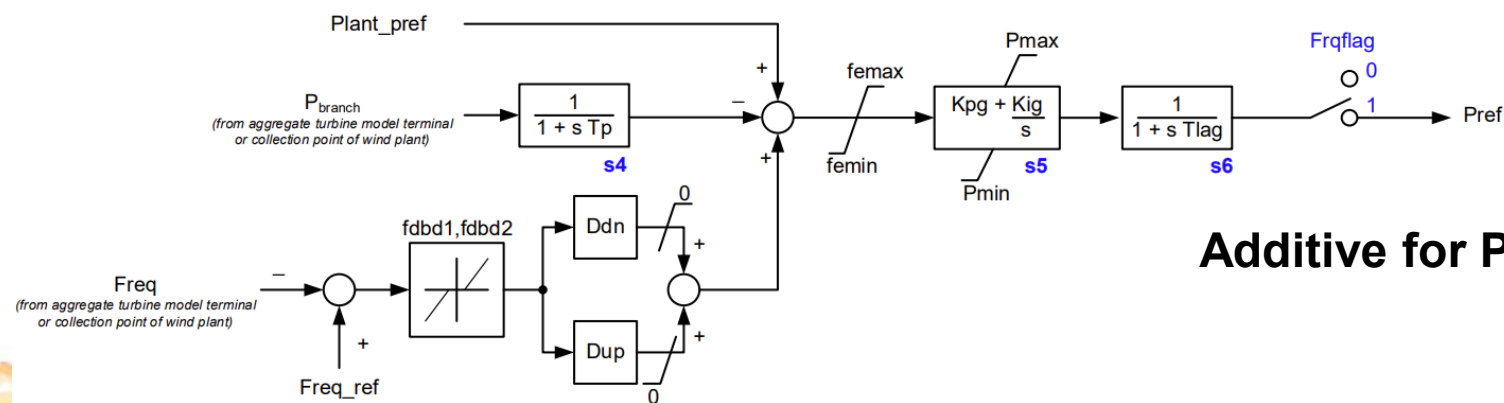
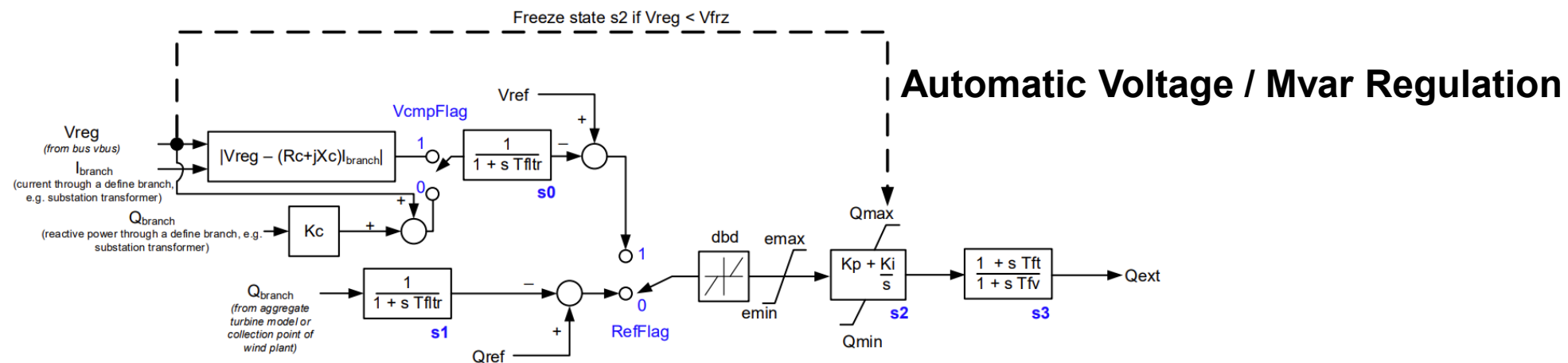
REEC_C → REGC_A

The REEC model represents the automatic control system within each individual inverter unit.

REGC_A → Networks

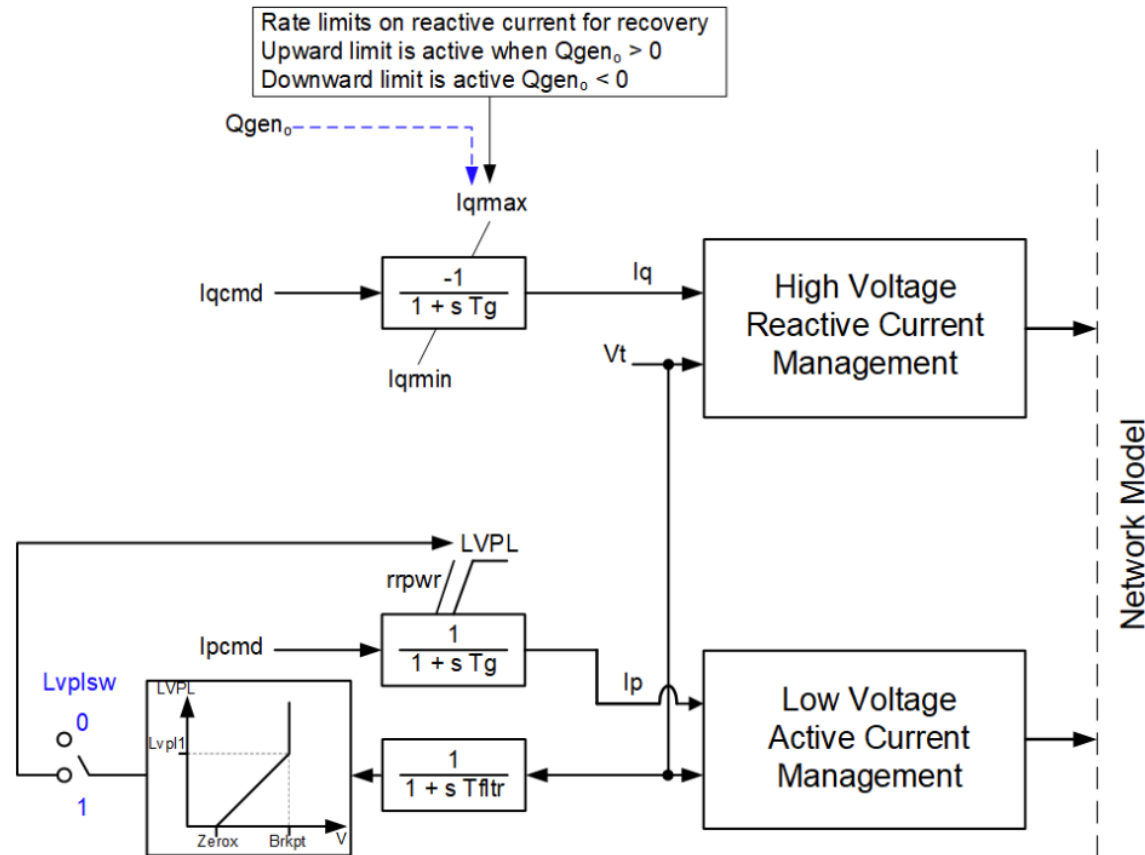
REGC_A model represents the electrical interface between the inverter unit and the power grid. It acts as a power source. Modern inverters use internal current control loops that regulate their output current precisely. Therefore, their mains-fed power can be represented as a power source in the simulation software.

WECC Model REPC_A





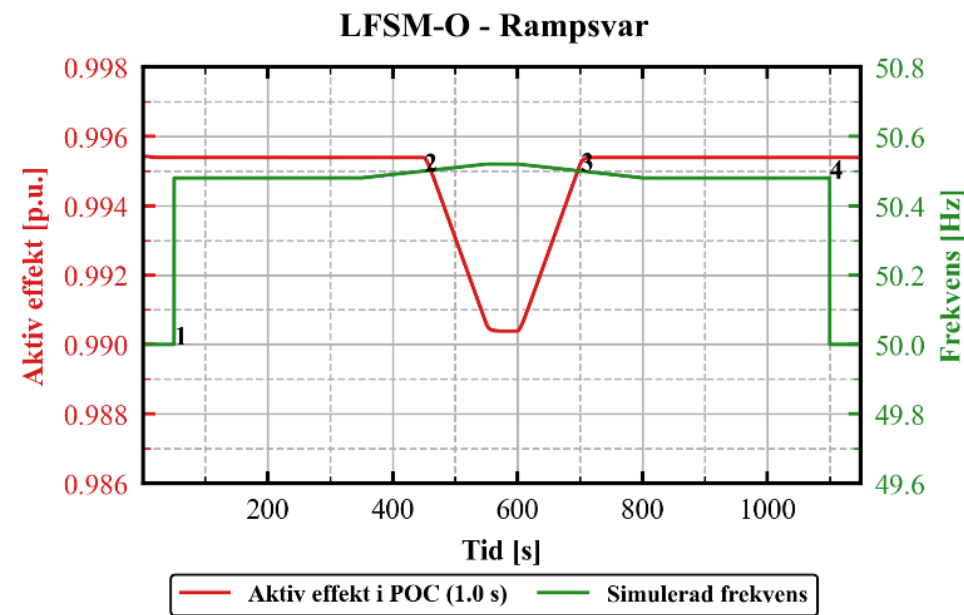
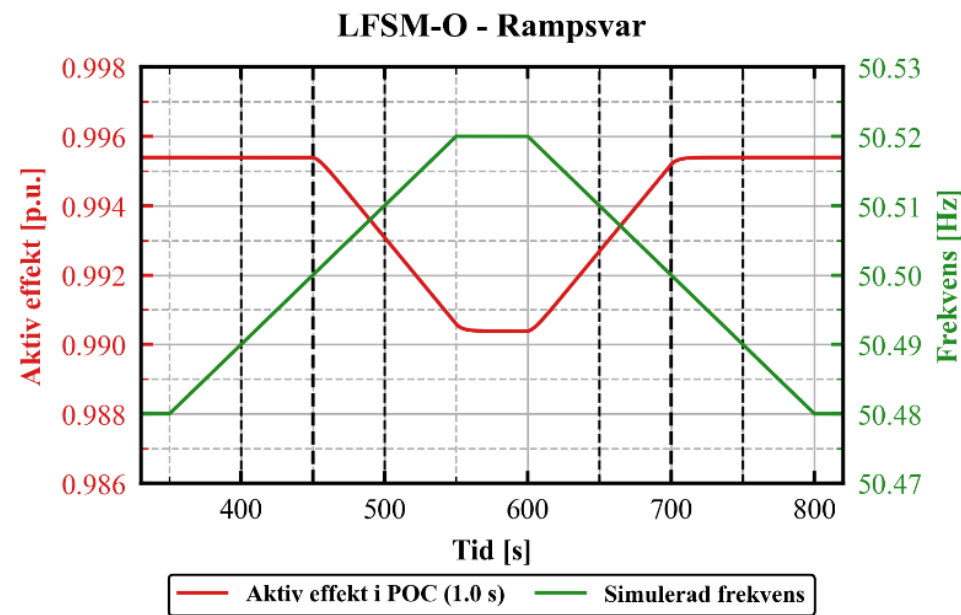
WECC Model REGC_A



Simulation Results

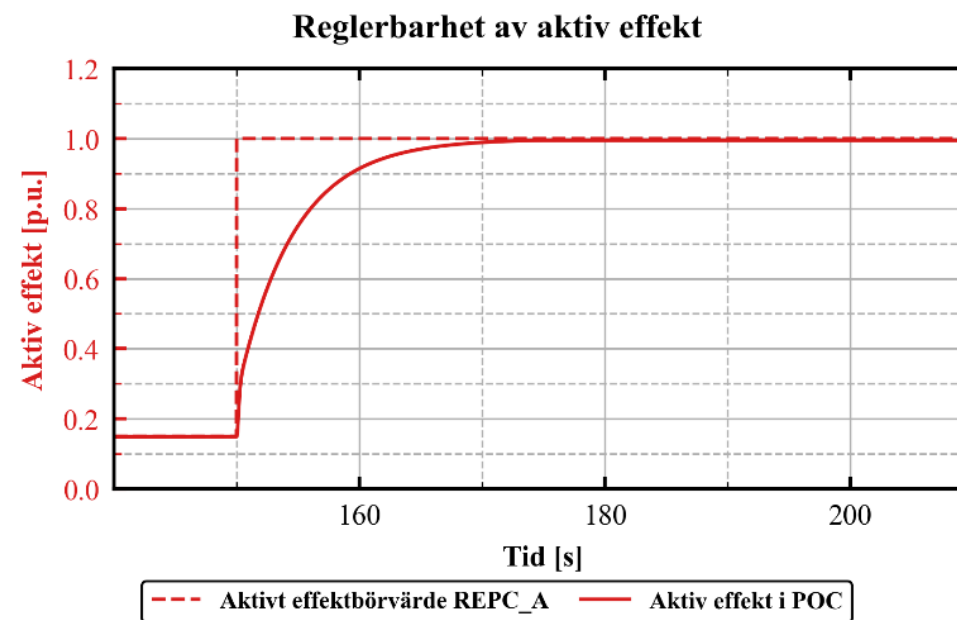
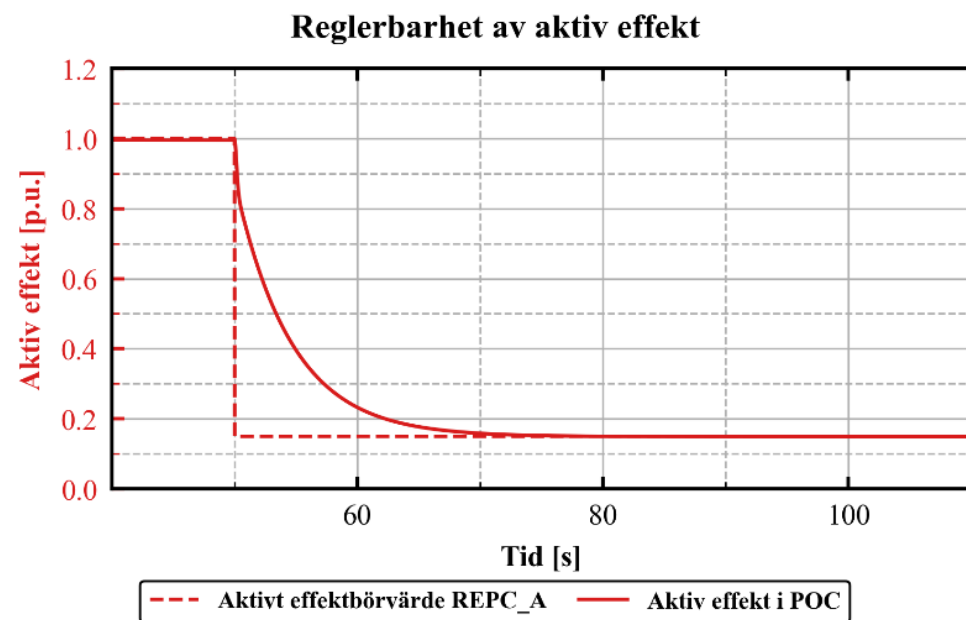


Simulation of Frequency Ramp



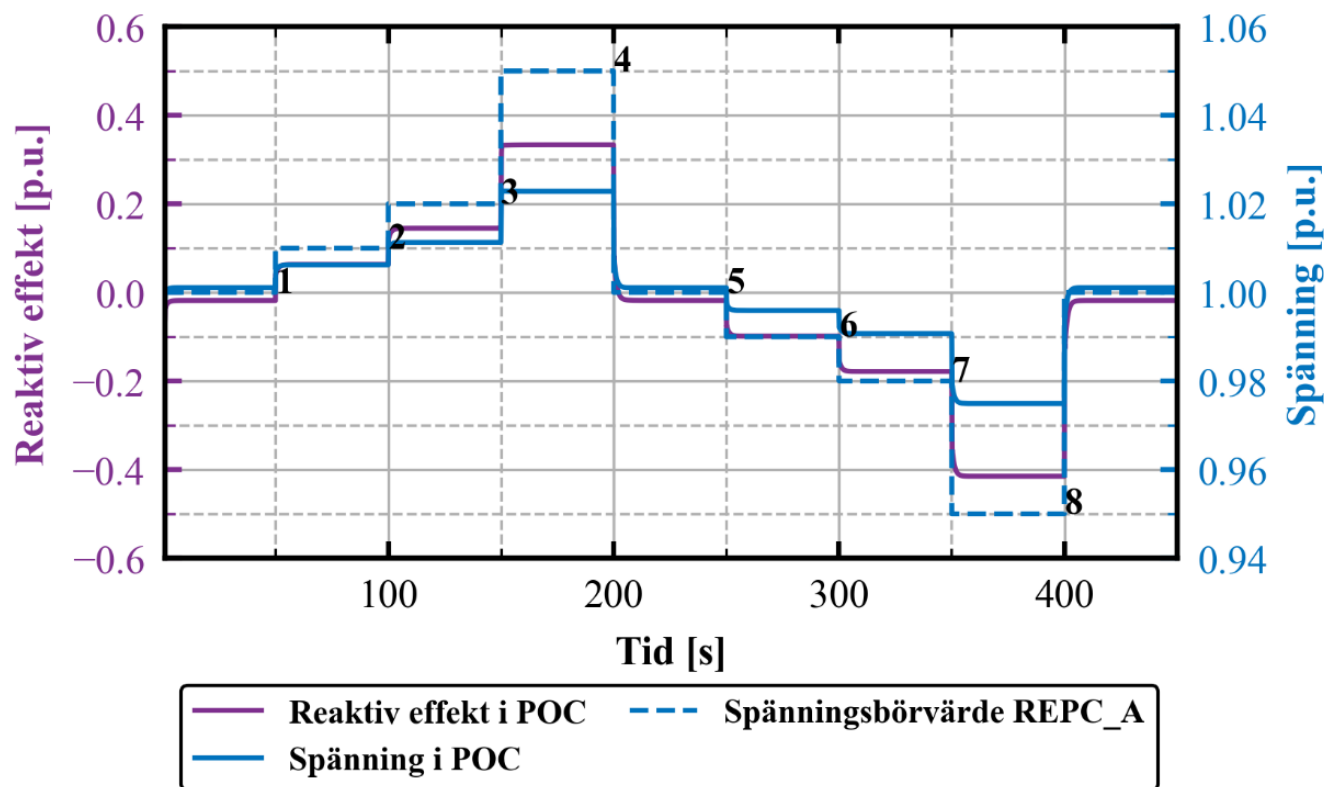
Acceptance criteria	Analysis	Approved [YES/NO]
The frequency ramp tests show that the active power starts to change when the frequency is outside the frequency deadband and stops changing when the frequency is inside the frequency deadband. An acceptance of 10 mHz deviation is accepted, i.e. the frequency deadband is accepted to be between 0.49–0.51 Hz.	The response in active power comes after the frequency crosses the dead band, i.e. 50.5 Hz, and according to the set statics.	YES

Active Power Set Point Change



Voltage Controllability

AVR - Stegsvar, online

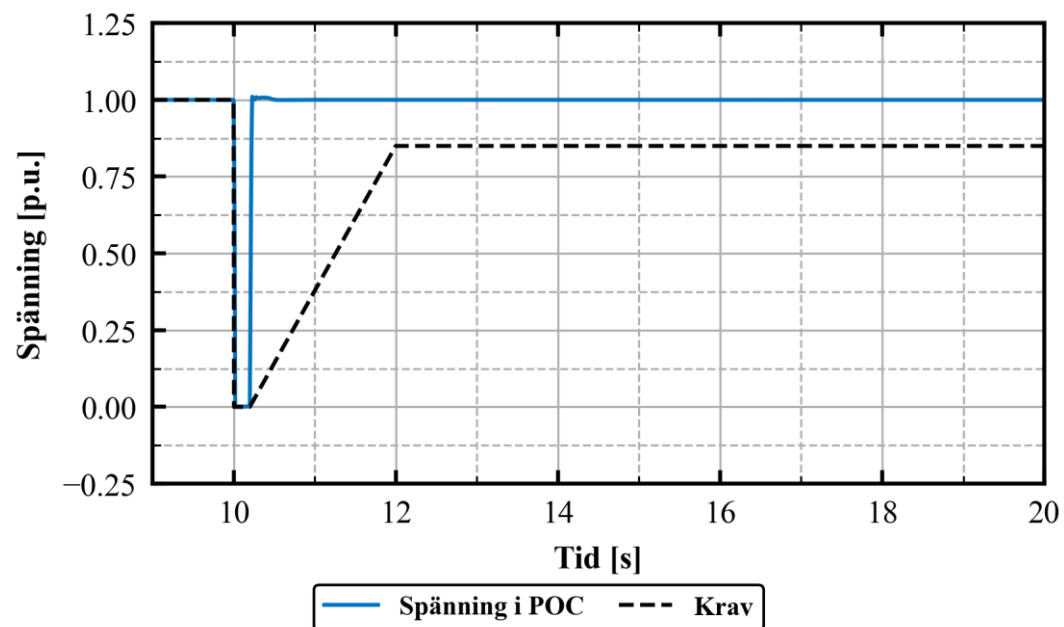


Step	Vref_change_pu	V_pu	Qmeas	Qmeas_pu	Xc
1	100% → 101%	100,6%	+4,4	+0,063	6,0%
2	101% → 102%	101,1%	+10,1	+0,145	6,1%
3	102% → 105%	102,3%	+23,3	+0,333	8,3%
4	105% → 100%	100,1%	-1,3	-0,018	6,0%
5	100% → 99%	99,6%	-6,9	-0,099	6,0%
6	99% → 98%	99,1%	-12,5	-0,178	5,9%
7	98% → 95%	97,5%	-29,1	-0,415	5,8%
8	95% → 100%	100,1%	-1,3	-0,018	6,0%

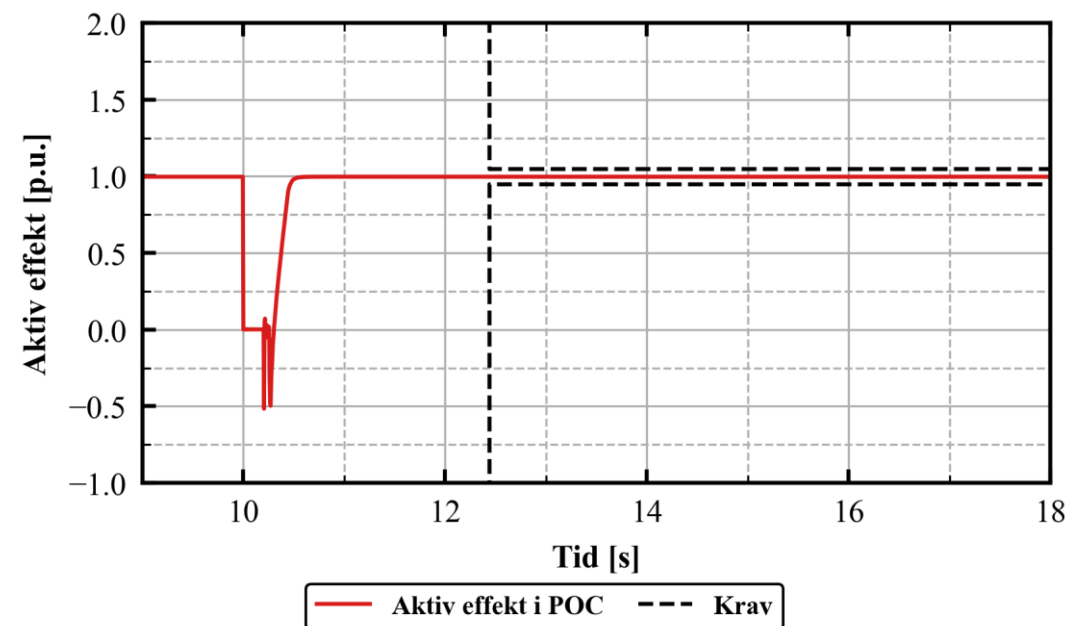
Simulation of voltage stages with $X_c = 2\%$ (here $X_c = 6\%$)

Active Power Recovery after Failure

Feltålighet - 3-fas fel



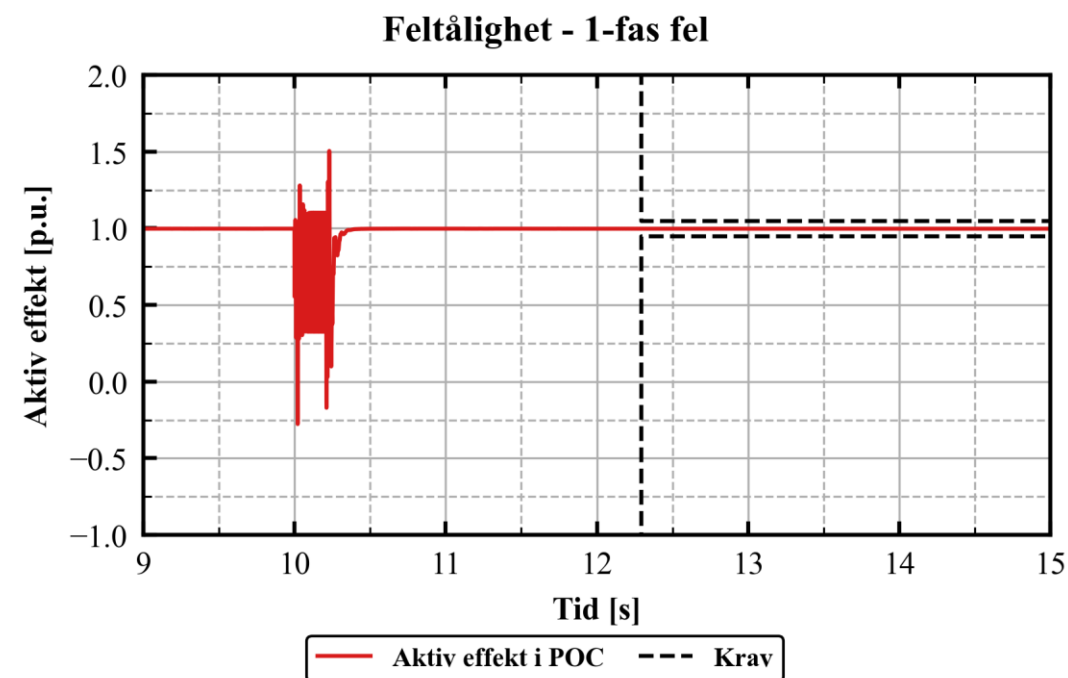
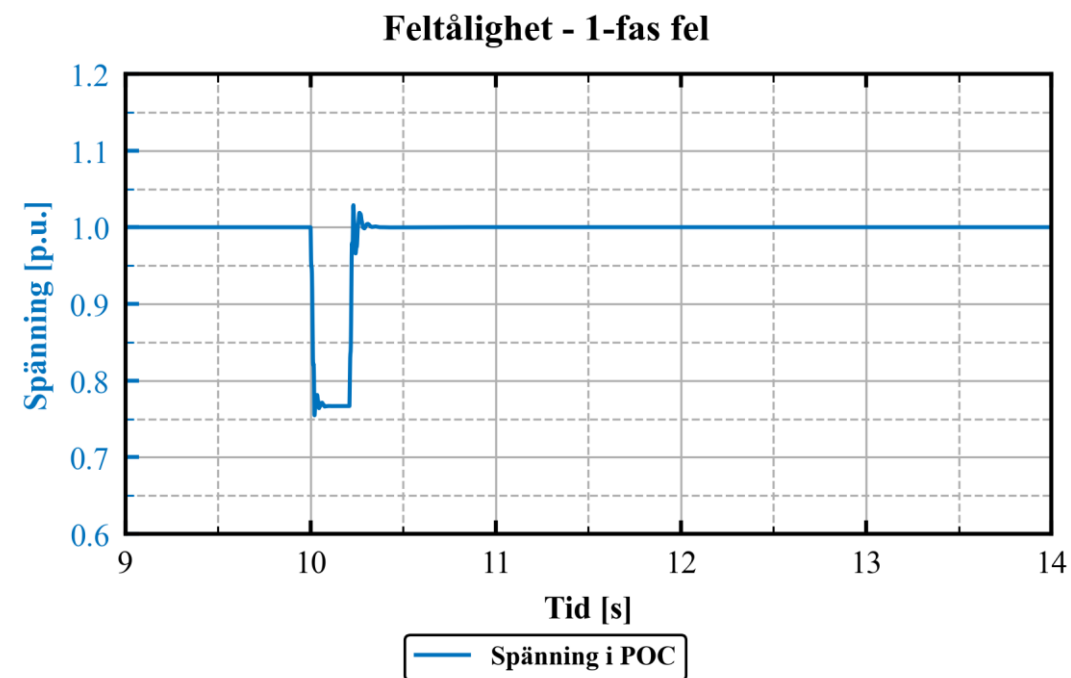
Feltålighet - 3-fas fel



Symmetrical Fault : 3 Phase fault for 200ms

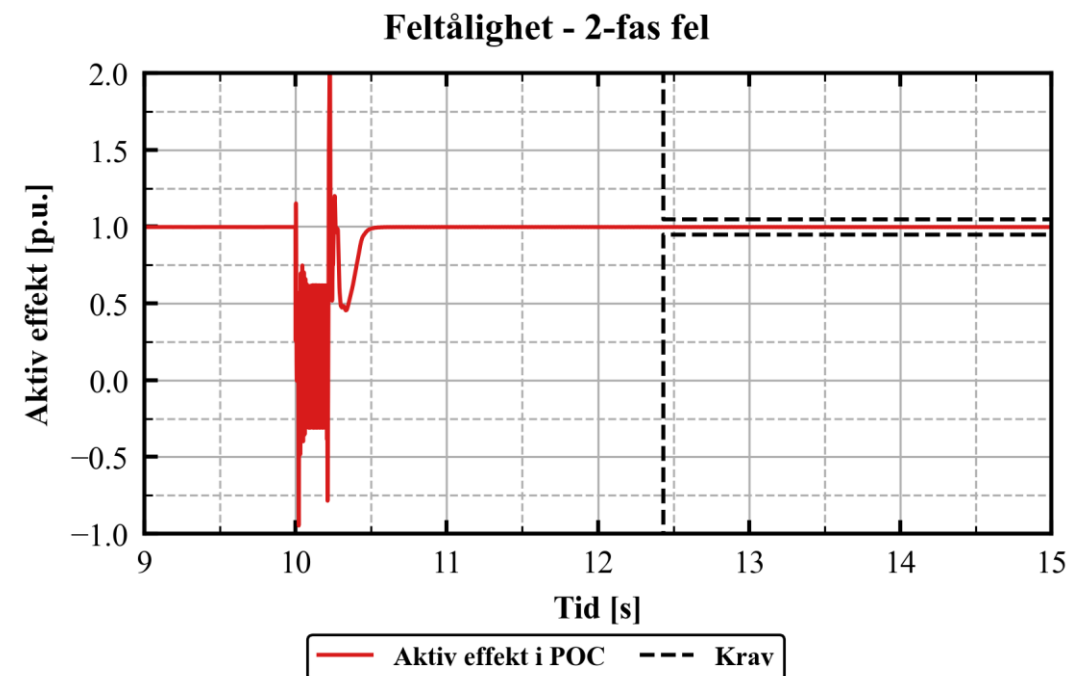
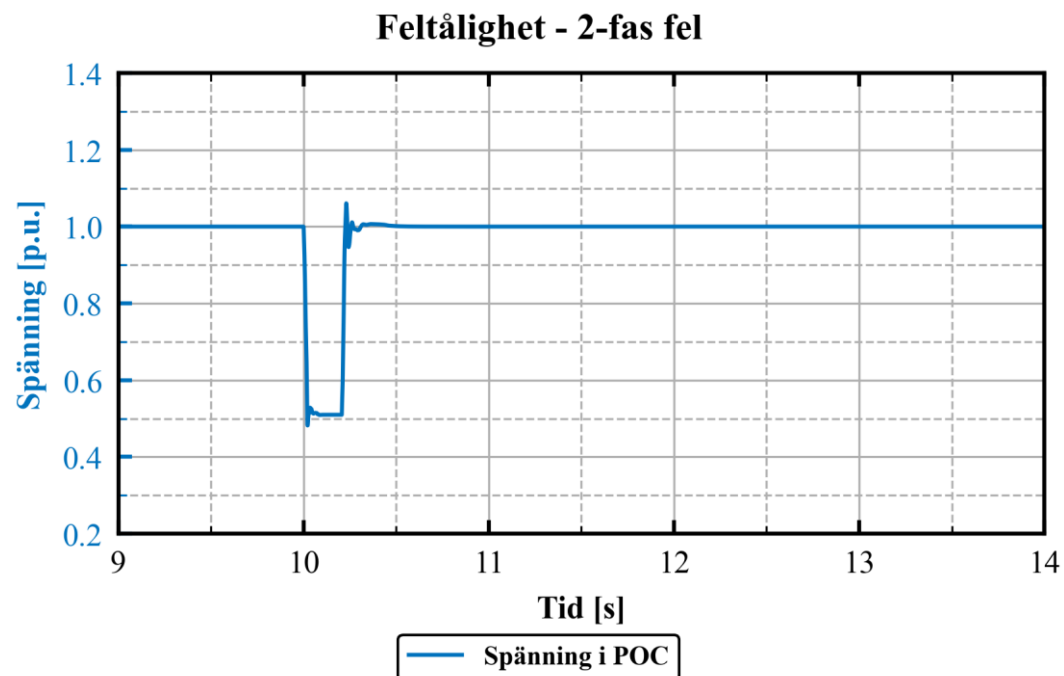


Active Power Recovery after Failure



A Symmetrical Fault : 1 Phase to ground fault for 200ms

Active Power Recovery after Failure



A Symmetrical Fault : 2 Phase fault for 200ms



IEEE519-2022 : Harmonics Distortion Limit

Voltage Distortion Limits

Bus Voltage at Point of Common Coupling (PCC)	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
1kV	5.0	8.0
1kV to 69 kV	3.0	5.0
69kV to 161kV	1.5	2.5
161kV & above	1.0	1.5

Harmonic Current Distortion Limits (for Voltage > 161kV)

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics) ^{a, b}						
I_{sc}/I_L	$3 \leq h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h \leq 50$	TDD
$< 25^c$	1.0	0.5	0.38	0.15	0.1	1.5
$25 < 50$	2.0	1.0	0.75	0.3	0.15	2.5
≥ 50	3.0	1.5	1.15	0.45	0.22	3.75

Thank you!



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