

7.0 GENERATING FACILITY DESIGN AND OPERATING REQUIREMENTS FOR THE SYSTEM OF HYBRID INVERTERS, SOLAR PV ROOFTOP AND BATTERY WITH LOW VOLTAGE FEEDERS (ANNEX 07)

7.1 The protective function and requirements defined here are designed to protect CEB distribution system and not the system of hybrid inverters, solar PV rooftop and battery with low voltage feeders (Hereafter, it is named as the Generating Facility). A Producer shall be solely responsible for providing adequate protection for its Generating Facility and interconnection facilities. The Producer’s protective functions shall not impact the operation of other protective functions utilized on CEB’s distribution system in a manner that would affect CEB capability of providing reliable service to its customers.

7.2 **Generating facilities operating in parallel with CEB distribution system shall be equipped with the following protective functions** to sense abnormal conditions on CEB distribution system and cause generating facility to be automatically disconnected from CEB distribution system or to prevent the generating facility from being connected to CEB distribution system inappropriately.

7.2.1 CEB Distribution System Parameters are as follows;

a. Nominal Voltage	33 kV	11kV	400 V
b. System Highest Voltage	36 kV	12 kV	440 V
c. Rated fault current	25 kA	20 kA	20 kA
d. No. of Phases	3	3	3ph&Neutral
e. System Frequency	50Hz	50Hz	50Hz
f. Method of Earthing	Non-Effectively Earthed	Solidly Earthed	Solidly Earthed

7.2.2 Over and Under Voltage trip functions and over and under frequency trip functions.

7.2.3 A voltage and frequency sensing and time delay function to prevent the generating facility from energizing a de-energized distribution system circuit and to prevent the generating facility from reconnecting with CEB distribution system unless CEB distribution system service voltage is within

06% of the nominal supply voltage and frequency is within 47 Hz to 52 Hz and are stable for at least 3 minutes.

7.2.4 A function to prevent the generating facility from contributing to the formation of an Unintended Island and cease to energize the CEB system within half a second (0.5 second) of the formation of an unintended island.

7.2.5 The generating facility shall cease to energize CEB distribution system for faults on CEB distribution system circuit to which it is connected. (IEEE1547 – 4.2.1). The generating facility shall cease to energize CEB distribution circuit prior to reclosure by CEB distribution system equipment. (IEEE 1547-4.2.2)7.2.6 The generating facility shall be automatically disconnected from the CEB distribution network within half a second (0.5 second) when the CEB supply is intentionally or automatically switched off.

7.2.6 The generating facility should have an external back feed protection scheme to prevent any hazardous voltage or current back feed to CEB system during a power interruption by the hybrid solar PV installer. The external back feed protection scheme (Back up to the primary protection) shall be placed in between CEB meter and point of common coupling (PCC), closer to CEB meter through a separate isolation device for Type I & Type II as shown in the drawings attached with this document. An automatic phase failure relay shall be installed at external back feed protection scheme and the relay tripping signal shall be wired to the isolation device. Isolation device shall be a two-pole device for single phase connections and a four-pole device for three phase connections. Isolation device ‘Close’ and ‘Open’ status shall be clearly indicated via indication lamps. Further, grid power availability also shall be indicated via another indication lamp. During grid failure, operation of the isolation device (Open operation) shall be taken place within 0.5 seconds and once the grid status reinstates, close operation shall be taken place after 1 second relay detects grid availability. The producer shall be responsible for the proper function of the external back feed protection scheme. This protection scheme shall be operated and maintained by The Producer at its own cost and expenses.

7.2.7 The Producer should not change any of the settings stated above without the written permission from the CEB.

7.3 Suitable equipment required

The electrical installation of PV power supply system including AC modules shall comply with the latest edition of BS 7671 (IEE wiring regulations) & SLS 1680. Circuit breakers or other interrupting devices located at the point of common coupling, if needed, must be certified by CEB as suitable for their intended operation. This includes being capable of interrupting the maximum available fault current expected at their location.

Producer's generating facility and interconnection facilities shall be designed so that the failure of any one device shall not potentially compromise the safety and reliability of CEB distribution system.

The generating facility paralleling device shall be capable of withstanding 220% of the interconnection facility rated voltage (IEEE 1547 – 4.1.8.3). The interconnection facility shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE 1547 – 4.1.8.2.

7.4 Visible disconnect required

The producer shall furnish and install a ganged manually operated isolating switch near the point of common coupling (PCC) to isolate the generating facility from CEB distribution system. The device does not have to be rated for load break nor provide over current protection.

The device must:

- a. Allow visible verification that separation has been accomplished. (This requirement may be met by opening the enclosure to observe contact separation)
- b. Include marking or signage that clearly open and closed positions.
- c. Be capable of being reached quickly and conveniently 24 hours a day by CEB personnel for construction, maintenance, inspection, testing or reading, without obstacles or without requiring those seeking access to obtain keys, special permission, or security clearance even when the isolating equipment is consumer's property.
- d. Be secured in a weather-proof enclosure and capable of being locked in the open position prevent unauthorized or accidental closing.
- e. Be clearly marked on the submitted single line diagram and its type and location approved by CEB prior to installation. If the device is not adjacent to the PCC, permanent signage must be installed at a CEB approved location providing a clear description of the location of the device.

7.5 Drawings: Prior to parallel operation or momentary parallel operation of the generating facility, CEB shall approve the Producer's protective function and control diagrams. Generating facilities equipped with protective function and control scheme previously, approved by CEB, may satisfy this requirement by reference to previously approved drawings and diagrams certified by a Designer / Contractor and a Chartered Electrical Engineer (Inspection & Testing) following the formats given in Annex 3 and Annex 4.

- 7.6 The output voltage wave form of the Generating Facility shall be of 50 Hz, with a sinusoidal wave form.
- 7.7 The Total Demand Distortion (TDD) and individual harmonic current distortion limits as a percentage of the minimum of rated current of the inverter and current of 85% of PV panel capacity at PCC should be as follows.

Individual harmonic order h	h<11	11<h<17	17<h<23	23<h<35	35<h	TDD
Allowable Limit (%)	4	2	1.5	0.6	0.3	5

Even harmonics are limited to 25% of the odd harmonic limits above.

Table 1: Current Harmonic Limits

- 7.8 If the Generating Facility uses a direct current (dc) generator, it should use an inverter to convert the dc to ac, complying with the TDD for current and individual harmonic limits as in table 1.
- 7.9 Total Demand Distortion shall be measured as follows,
- a. Disconnect the customer house and EPS/UPS load.
 - b. Open disconnection switch inside the meter enclosure.
 - c. Connect current probes and voltage probes of the power quality analyser to AC Isolator of the inverter.
 - d. Open AC isolator of the inverter
 - e. Close the disconnection switch, referred in b. above
 - f. Log 10 minute-average of Voltage THD% for 30 minutes.
- Note:** measured Voltage THD% during first 30 minutes must be below 2.5%. If this utility side Voltage THD% is more than 2.5%, utility must take action to reduce it to a value below 2.5%.
- g. After 30 minutes, Close the AC isolator of the inverter referred in d. above in order to connect the inverter to Utility supply.
 - h. Check the inverter, which must be turned on.
 - i. After the inverter is turned on, log 10 minute-average of Voltage THD%, current THD%, current TDD%, harmonic current distortions (2nd – 50th order) and Output Power for 4 hours, preferably (10:00 hrs -14:00 hrs).
 - j. During the testing period in i. above, after 3 hours, disconnect solar PV DC isolator and continue the test for remaining period at least for an hour. The TDD should be calculated during last segment of the test (without PV

panels), taking the minimum of rated current of the inverter and rated current of the battery into consideration.

7.10 95th percentile short time (10 min) harmonic currents should be less than the values given in Table 1.

7.11 Testing procedure for the external back feed protection scheme.

An external back feed protection isolation device is provided externally as a backup protection to the inbuilt back feed protection. The operation of the device shall be done automatically. Compliance shall be determined by relevant circuit diagram inspection and carrying out following tests/inspection based on IEC 62040-1 Clause 5.1.4 and Annex 1.

- a. Phase Failure Relay manufacturing standard conformity IEC standard or equivalent acceptable standard.
- b. Automatic reset capability of Phase Failure Relay.
- c. Functionality test during disconnection of CEB supply (from the breaker/fuse cutouts at the meter). Isolation device shall operate (Close to Open) within 0.5 seconds after the disconnection.
- d. Functionality test during reconnection of CEB supply (from the breaker/fuse cutouts at the meter). Isolation device shall operate (Open to Close) 1 second after the reconnection.
- e. Functionality test of Indication lamps of the Isolation device status and CEB supply status.

7.12 The inverters used for interconnection shall be only those which complied with SLS 1680:2020

7.13 The Producer should not change any of the settings stated in section 7.0 without the written permission from the CEB.

7.14 The Power Quality measurement at the Point of Common Coupling (PCC) shall be as follows;

Power quality measurement shall be complied with (IEEE 519 – 2014) IEC 61400-21. Emission of inter- harmonic currents from the power electronic converter up to 2 kHz and of current distortions above 2 kHz up to 9 kHz during operations shall be stated. The individual inter-harmonic currents below 2 kHz and the current distortions in the range 2 kHz up to 9 kHz shall be given as ten-minute average data for each frequency at the output power giving the maximum individual inter-harmonic current or current distortion.

7.15 Flicker Standard applicable: As per IEC 61000-3-7.

7.16 A compliance Inspection, including the harmonics measurements at the commissioning shall be performed by CEB as in Annex 5 & test results shall be documented in Annex 6.