PUNJAB STATE ELECTRICITY REGULATORY COMMISSION

Draft PSERC (Power Quality) Regulations, 2023

Explanatory Memorandum

The meteoric rise of non-linear loads such as power electronic converters, arc furnaces, electrolytic processes, inverters for distributed generation, traction load etc., are posing serious challenges for quality of power flow from generation to consumption points. Poor quality of power leads to premature failure or reduced/degraded performance of equipment. It also leads to increased system losses. Therefore, apart from the reliability i.e. continuous supply, the preference of the electricity consumers is now shifting towards quality power supply from the distribution licensees.

Clause (h) and (i) of sub-section (1) of Section 86 of the Electricity Act, 2003 conferred the powers to the State Electricity Regulatory Commission (SERC) for specifying the Grid Code and Standards with respect to quality, continuity and reliability of service by licensees. The relevant portion of section 86 of the Act is reproduced below;

Section 86. (Functions of State Commission): --- *(1) The State Commission shall discharge the following functions, namely:-*

(a)…

….

(*h) specify State Grid Code consistent with the Grid Code specified under clause (h) of sub-section (1) of section 79;*

(i) specify or enforce standards with respect to quality, continuity and reliability of service by licensees;

Further section 50 of The Electricity Act, 2003, sub-section (1) of section 57 read with clause (x) and (za) of sub-section (2) of section 181 conferred the powers to the SERC for specifying the Electricity Supply Code and the Standards of Performance for the Distribution licensees. The relevant provision is extracted as under:

Section 50. (The Electricity Supply Code): *The State Commission shall specify an Electricity Supply Code to provide for recovery of electricity charges, interval for billing of electricity charges, disconnection of supply of electricity for non-payment thereof, restoration of supply of electricity, tampering, distress or damage to electrical plant, electric lines or meter, entry of distribution licensee or any person acting on his behalf for disconnecting supply and*

removing the meter, entry for replacing, altering or maintaining electric lines or electrical plant or meter.

….

Section 57. (Consumer Protection: Standards of performance of licensee): *(1) The Appropriate Commission may, after consultation with the licensees and persons likely to be affected, specify standards of performance of a licensee or a class of licensees.*

The **Tariff Policy** notified on 28th January, 2016 by Ministry of Power provides as under:

*8.0 Supply of reliable and **quality power** of specified standards in an efficient manner and at reasonable rates is one of the main objectives of the National Electricity Policy. The State Commission should determine and notify the standards of performance of licensees with respect to quality, continuity and reliability of service for all consumers. It is desirable that the Forum of Regulators determines the basic framework on service standards. A suitable transition framework could be provided for the licensees to reach the desired levels of service as quickly as possible. Penalties may be imposed on licensees in accordance with section 57 of the Act for failure to meet the standards."*

Accordingly, the Commission specified Standard of Performance (SoP) in the Supply Code regulations along with compensation payable to consumers in case of violation of these standards by the distribution licensee. However most of the standards are related to time period prescribed for rendering various services by the distribution licensee to the consumers viz release of connection, attending supply related complaints, change of defective meter, transfer of title etc. Few power quality parameters like voltage fluctuation and reliability of supply have been specified but many other important PQ parameters have not been specified.

The Forum of Regulators (FOR) has been constituted under section 166(2) of the Electricity Act, 2003. As per Forum of Regulators Rules, 2005, one of the functions of the FOR is harmonization of regulations in power sector. Accordingly, a sub group of FOR was constituted to suggest measures to ensure reliable and quality power to consumers including drafting of Model Power Quality Regulations. The report of the sub group was endorsed by FOR in its 64th meeting held on 24.08.2018. FoR model regulations recommended various PQ parameters for inclusion in the regulations. These parameters are discussed along with the probable causes and effects on the electrical equipments or supply system as under:

(A) POWER QUALITY PARAMETERS

1.0 Harmonics

In an ideal power system, the voltage supplied to the consumers and the resulting current wave forms are sine waves. However, distortions are caused due to use of non-linear loads such as power electronic converters, arc furnaces, static VAR systems, inverters for distributed generation, etc. Nonlinear loads change the sinusoidal nature of the AC power current thereby resulting in the flow of harmonic currents in the ac power system. Presence of harmonics results in increased losses, overheating, relay malfunctioning and damage to insulation.

Clause(b) of section 73 of the Electricity Act, 2003 (The Act) conferred the powers to Central Electricity Authority (The Authority) to specify the technical standards for construction of electrical plants, electric lines and connectivity to the grid. Accordingly, as per the powers conferred under clause(b) of section 73 read with section 177 of the Act, the Authority notified CEA(Technical Standards for connectivity to the Grid) Regulations, 2007. These regulations have been further amended vide notification dated 06.02.2019. The paragraph 3 of part-IV of these regulations reads as under;

(3) Voltage and Current Harmonics. –

(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 519-2014 standards, as amended from time to time;

(ii) Measuring and metering of harmonics shall be a continuous process with meters complying with provisions of IEC 61000-4-30 Class A.

(iii) The data measured and metered as mentioned in sub-paragraph (ii) with regard to the harmonics, shall be available with distribution licensee and it shall also be shared with the consumer periodically.

(iv) ***The bulk consumer shall install power quality meter*** *and share the recorded data thereof with the distribution licensee with such periodicity as may be specified by the appropriate Electricity Regulatory Commission:*

Provided that ***the existing bulk consumer shall comply with this provision within twelve months from the date of commencement of the Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2018.***

(v) In addition to harmonics, periodic measurement of other power quality parameters such as voltage sag, swell, flicker, disruptions shall be done as per relevant International Electrotechnical Commission Standards by the distribution licensee and the reports thereof shall be shared with the consumer.

(vi) The distribution licensee shall install power quality meters in a phased manner within three years from the date of commencement of the Central Electricity Authority (Technical Standards for Connectivity to the Grid) (Amendment) Regulations, 2018 covering at least 33% of the 33 kV substations each year.

Further, Regulation 12 added vide notification dated 06.02.2019 reads as under:

12. Compliance of regulations.- *(1) The licensee shall ensure that before connectivity to the grid, all the provisions with regard to the connectivity specified under these regulations are complied with by the requester.*

(2) Before allowing connectivity to the requester, the compliance of the provisions laid down under sub-regulations (2), (3) and (5) of regulation 6 shall be verified by the licensee and the verification of compliance of provisions of other regulations shall be in the form of self-declaration in the proforma of connection agreement which shall be checked and verified by the concerned licensee on sample basis.

(3) ***The user may be disconnected from the Grid by the licensee for non-compliance of any provision of these regulations and any non-compliance of the provisions of these regulations shall be reported by the licensee or the State Load Dispatch Centre or the Regional Load Dispatch Centre, as the case may be, to the appropriate Commission****".*

Central Electricity Authority also notified CEA(Technical Standards for Connectivity below 33 kV) (Amendment) Regulations, 2019 vide notification dated 06.02.2019 and similar provisions have been made in Regulation 11 A of these regulations for system voltages below 33 kV. The relevant clauses of regulation 11 A are as under;

(1) ----------

(2) The limits of injection of current harmonics at the point of common coupling by the user, method of harmonic measurement and other such matters, shall be in accordance with the IEEE 519-2014 standards, as amended, from time to time.

(3) The measuring and metering of harmonics shall be a continuous process with power quality meters complying with the provisions of IEC 61000-4-30 Class A.

(6) The data measured and metered as mentioned in sub-regulation (5), shall be available with the distribution licensee and be shared with the consumer periodically.

(7) ***The applicant seeking connectivity at 11 kV or above shall install power quality meters*** *and share the recorded data thereof with the distribution licensee with such periodicity as may be specified by the appropriate Electricity Regulatory Commission:*

Provided that the user connected at 11 kV and above shall comply with the provision of this sub-regulation within twelve months from the date of commencement of the Central Electricity Authority (Technical Standards for Connectivity of the Distributed Generation Resources) Amendment Regulations, 2018.

(8) In addition to harmonics, periodic measurement of other power quality parameters such as voltage sag, swell, flicker, disruptions shall be done by the distribution licensee as per relevant IEC standard and the reports thereof shall be shared with the consumer.

Further, Regulation 15 inserted vide notification dated 06.02.2019 reads as under;

15. Compliance of regulations. - (*1) It shall be the responsibility of concerned licensee to ensure that before connectivity to the grid, all the provisions with regard to the connectivity stipulated in these regulations are complied with by the applicant.*

(2) The user may be disconnected from the grid by the licensee for non-compliance of any provision of these regulations, under report by the licensee to the appropriate Electricity Regulatory Commission.".

From the above, it is evident that as per CEA Regulations, which are applicable to all distribution licensees and all consumers connected at 11 kV and above, 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 519-2014 standards, as amended from time to time. Further in case of non-compliance of the provisions of connectivity to the grid by the consumer, the connection can be disconnected under intimation to the Commission.

The Institute of Electrical and Electronics Engineers (IEEE) has specified the "Recommended Practice and Requirements for Harmonic Control in Electric Power Systems" through IEEE 519-2014. Para 1.2 of the IEEE standards defines purpose as under;

1.2 Purpose

This recommended practice is to be used for guidance in the design of power systems with nonlinear loads..---------

This recommended practice should be applied at interface points between system owners or operators and users in the power system. The limits in this recommended practice are intended for application at a point of common coupling (PCC) between the system owner or operator and a user, where the PCC is usually taken as the point in the power system closest to the user where the system owner or operator could offer service to another user. Frequently for service to industrial users (i.e., manufacturing plants) via a dedicated service transformer, the PCC is at the HV side of the transformer. For commercial users (office parks, shopping malls, etc.) supplied through a common service transformer, the PCC is commonly at the LV side of the service transformer.

The limits represent a shared responsibility for harmonic control between system owners or operators and users. Users produce harmonic currents that flow through the system owner's or operator's system which lead to voltage harmonics in the voltages supplied to other users. The amount of harmonic voltage distortion supplied to other users is a function of the aggregate effects of the harmonic current producing loads of all users and the impedance characteristics of the supply system. Harmonic voltage distortion limits are provided to reduce the potential negative effects on user and system equipment. Maintaining harmonic voltages below these levels necessitates that

– All users limit their harmonic current emissions to reasonable values determined in an equitable manner based on the inherent ownership stake each user has in the supply system and

–Each system owner or operator takes action to decrease voltage distortion levels by modifying the supply system impedance characteristics as necessary.

Regarding harmonic measurement, para 4 of IEEE standard provides as under;

Harmonic measurements

For the purposes of assessing harmonic levels for comparison with the recommended limits in this document, any instrument used should comply with the specifications of IEC 61000-4-7 and IEC 61000-4-30.

2.0 Voltage Variations or Voltage Fluctuations–

It is defined as a cyclic variation of the voltage envelope or series of random voltage changes, the magnitude of which does not normally exceed the specified voltage ranges. These variations can be caused by static frequency converters, cyclo-converters, arc furnaces, rolling mill drives, main winders and large motors during starting, etc. Voltage fluctuations may cause nuisance tripping due to mal-operation of relays and contactors and unwanted triggering of UPS units to switch to battery mode. It may stress electrical and electronic equipment causing detrimental effects that may disrupt production processes with considerable financial loss.

3.0 Voltage Unbalance

It is a condition in a poly-phase system in which the root mean square (rms) values of the line-to-line voltages (fundamental component), or the phase angles between consecutive line voltages, are not equal. The sources of unbalanced voltages are due to malfunctioning of equipment, mismatched transformer taps and impedances, blown capacitor fuses, open-delta regulators, or open-delta transformers. It can also be caused by uneven single-phase load distribution among the three phases. Unbalanced systems indicate the existence of a negative sequence component of supply voltage, which is harmful to all poly-phase loads, especially three-phase induction machines. It can cause an over-load on induction machines and malfunctioning of frequency converters. Voltage unbalance can create a current unbalance which can be 6 to 10 times the magnitude of voltage unbalance. In turn, current unbalance produces heat in the motor windings which degrades motor insulation causing progressive performance deterioration and permanent damage to the motor.

4.0 Voltage Sag (dip)

It is a condition in which the voltage at the supply terminals goes down below 90% of the nominal voltage for a duration of 10ms and upto & including 1 min. Common sources of sag are the starting of large induction motors and system faults. Sags can happen due to an overloaded circuit, malfunction of a transformer's tap changer, breakers connecting a large

inductive load to the grid or a disconnected capacitor bank. Also, arc furnaces initially take large amperes to produce high temperatures causing voltage sag. Voltage sag results in malfunction of equipment/ relays and contactors, under voltage tripping, loss of efficiency of motors and intermittent reduction of light illumination etc.

5.0 Voltage Swell (rise)

It is a condition in which the voltage at the supply terminals exceeds 110% of the nominal voltage for a duration of 10ms and upto & including 1 min. Over-voltage could be the result of connecting a capacitor bank or disconnecting a large inductive load. Other sources of voltage swells are line faults and incorrect transformer tap changer settings in the sub-stations. It also occurs due to transfer of loads from one source to another. Voltage swell results in malfunction of an equipment, insulation failure, intermittent increase in light illumination, tripping of relays and contactors etc.

6.0 Flicker

It is the impression of uncomfortable visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates rapidly with time. It is caused under certain conditions by voltage fluctuations resulting in change of the luminance of lamps. Quantitatively, it may be expressed as the change in voltage over nominal voltage expressed as a percent. The main cause of these effects is fast switching operations of industrial processes and electrical appliances connected to the supply system. Flicker is considered the most significant effect of rapid voltage fluctuations because it can affect the production environment by causing personnel fatigue and lower work concentration levels.

7.0 Supply Voltage Interruptions

It is a condition in which the voltage at the supply terminals is lower than 5% of the nominal voltage. It may be long or sustained interruption if duration is longer than 3 min. and short interruption if duration is up to and including 3 min. Reasons behind interruptions could be power system faults (short- circuits), equipment failures and/or failure of the control equipment. Long power interruptions are a problem for all users, but many operations e.g. continuous process operations, multi-stage batch operations, digital data processing semiconductor fabrication etc. are very sensitive to even very short interruptions. The sustained interruptions are calculated in terms of System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI).

(B) MEASUREMENT & EVALUATION TECHNIQUES OF PQ PARAMETERS

Mal-operation of end-use equipment caused by poor PQ is a common problem. However, it is not easy to identify whether the cause of poor power quality is at the utilities end or at the users end. Systematic procedures for power quality Measurement & Evaluation **(**M&E) at each end is necessary to understand the actual causes of power quality problems and to design effective countermeasures. Installing measurement equipment can help managers/supervisors determine if disturbances are coming from the supply side or are being generated at the consumer end. IEC 61000-4-30 specifies the class of PQ monitoring equipment and their utility. For overall performance of the system where continuous monitoring is required, Class-A monitors are used for better and precise measurements. Class-A monitors are used for Compliance Monitoring and for System Performance monitoring where a dispute between two stakeholders is required to be settled.

After issue of Model PQ Regulations, Bureau of Indian Standards issued Indian Standards for Distribution System Supply Voltage" i.e IS 17036:2018 in October, 2018. Keeping in view Bureau of Indian Standards IS 17036:2018, the Model PQ Regulations framed by FoR, Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007, as amended from time to time, CEA (Technical Standards for connectivity below 33 kV) Amendment Regulations, 2019, IEEE 519-2014 standards, other relevant Standards and the implementation issues including measuring instruments/analysis etc., the Power Quality Regulations have been drafted.

Draft PSERC (Power Quality) Regulations, 2023 are enclosed as Annexure-A. The comments/suggestions/objections from all the stakeholders are solicited under Sub-section (3) of Section 181 of the Electricity Act, 2003 read with Rule 3 of the Electricity (Procedure for Previous Publication) Rules, 2005 on the draft regulations.