الهيئة السعودية لتنظيم الكهرباء
SAUDI ELECTRICITY REGULATORY AUTHORITY

POWER QUALITY

RULES AND STANDARDS

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المستند النظامي

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مرجعية هذه الوثيقة

في حال وجود أي استفسارات أو ملاحظات فإن المرجع فيها إلى الإدارة العامة للشؤون الفنية

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دورة تحديث هذه الوثيقة

يتم تحديث هذه الوثيقة حسب الإجراءات المعتمدة في الهيئة وكذلك بما تقتضيه الحاجة.

لغة الوثيقة

تم إعداد هذه الوثيقة باللغة الإنجليزية

جدول ضبط النسخ	
رقم الإصدار	التاريخ
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الهدف:

تهدف هذه الوثيقة إلى تحديد القواعد والمعايير المتعلقة بجودة الطاقة الكهربائية، والتي يتعين على مقدمي الخدمة ومستخدمي الشبكة الكهربائية الالتزام بها.

الوثائق الرسمية ذات العلاقة بهذه الوثيقة:

- نظام الكهرباء الصادر بالمرسوم الملكي رقم (م / ٤٤) وتاريخ ١٦/ ٥/ ١٤٤٢ هـ
- تنظيم الهيئة السعودية لتنظيم الكهرباء الصادر بقرار مجلس الوزراء رقم (٢٦٣) وتاريخ ١٤٤٢/٠٥/١٤هـ
- اللائحة التنفيذية لنظام الكهرباء فيما يتعلق بمهمات الهيئة السعودية لتنظيم الكهرباء الصادرة بقرار مجلس إدارة الهيئة رقم (٠٢/٤٣) وتاريخ ١٤٤٣/٠٤/١٣هـ الموافق ٢٠٢٣/١١/١٨ م
- الكود السعودي لنقل الكهرباء المعتمد بقرار مجلس إدارة الهيئة رقم (٢٨/١٦/٠٣) وتاريخ ١٤٢٨/٠٦/٠١هـ
- كود التوزيع السعودي المعتمد بقرار مجلس إدارة الهيئة رقم (٢٩/١٨/٠٤) وتاريخ ١٤٢٩/٠٥/٠٢هـ
- لائحة ضبط وإثبات مخالفات أحكام نظام الكهرباء والفصل فيها، الصادرة بقرار مجلس إدارة الهيئة السعودية لتنظيم الكهرباء رقم (٠٢-٤٥-١) وتاريخ 1445/03/19هـ الموافق 2023/10/04م، والمعدّلة بموجب القرار رقم (٢-٦٠-٧-٢٠٢٥) وتاريخ 1446/11/21هـ الموافق 2025/05/19م.

Legal basis:

The Saudi Electricity Regulatory Authority (SERA) in exercise of its powers conferred under Article (4) of Electricity Law promulgated by the Royal Decree No. (M/44) on 16/5/1442 H, and Article (4) and (5) of SERA's Charter issued by the Council of Ministers resolution No. (263) on 14/5/1442 H amended by the Council of Ministers decision No. (918) dated 28/10/1445H, and article 18 of the Implementing Regulation of the Electricity Law related to the duties of SERA Issued by SERA's Board of Directors resolution No. (34/02), dated 13/04/1443H, SERA hereby issued the following Power Quality Rules and Standards.

NORMATIVE REFERENCES

The documents listed below serve as normative references for the Power Quality Rules and Standards and adhere to relevant standards and codes, including SAGC, SADC, SASO, IEC, and IEEE.

SADC – Saudi Arabian Distribution Code.

SAGC – Saudi Arabian Grid Code.

EN 50160 – Voltage characteristics of electricity supplied by public electricity networks.

IEC 61000-2-2– “Electromagnetic compatibility (EMC) - Environment – Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems”.

IEC TR 61000-2-8– “Electromagnetic compatibility (EMC) - Part 2-8: Environment – Voltage dips and short interruptions on public electric power supply systems with statistical measurement results”.

IEC 61000-3-3– “Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection".

IEC TR 61000-3-7– “Electromagnetic compatibility (EMC) - Part 3-7: Limits - Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems”.

IEC 61000-4-7 –"Electromagnetic compatibility (EMC) - Part 4-7: Testing and measurement techniques - General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto".

IEC 61000-4-15 –"Electromagnetic compatibility (EMC) - Part 4-15: Testing and measurement techniques - Flickermeter - Functional and design specifications".

IEC 61000-4-30 –"Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods”.

IEEE 1159 – IEEE Recommended Practice for Monitoring Electric Power Quality.

IEEE 1894 – IEEE Guide for Online Monitoring and Recording Systems for Transient Overvoltages in Electric Power Systems.

IEC/IEEE 60255-118-1 – Measuring relays and protection equipment - Part 118-1: Synchrophasor for power systems – Measurements.

IEEE C37-118 – IEEE Standard for Synchrophasor Measurements for Power Systems.

1. PURPOSE

The quality of electricity service is regulated through provisions that focus on three main areas: continuity of supply, commercial quality, and power quality. Continuity of supply pertains to the reliability of electricity delivery, which is measured by the frequency and duration of supply interruptions. Commercial quality involves the relationship between the service provider and consumers. It includes factors such as new connection processes, billing accuracy, service timelines, and complaint resolution. Power quality relates explicitly to the technical characteristics of the electricity supplied. This domain encompasses a variety of disturbances and deviations in the major electricity parameters, such as the voltage and frequency.

This document defines the Rules and Standards for Power Quality in the Kingdom of Saudi Arabia. It sets out several requirements for Power Quality management such as indicators, standards, monitoring, reporting, etc. as detailed in this document. The Power Quality Rules and Standards aim to enhance consumers satisfaction in matters related to power quality and to encourage licensees to ensure adequate standards and levels of power quality are in place.

This document outlines the roles and responsibilities of stakeholders and specifies the applicable standards, including acceptable limits, for monitoring both the power quality performance of service providers and the power quality disturbances caused by Users. It also establishes a reporting mechanism to SERA for the actual power quality introduced by service providers. Additionally, the document offers guidance on managing power quality complaints and the necessary corrective actions that service providers, or users, should take to enhance the performance of the system.

2. ABBREVIATIONS

AC	Alternating Current
CAPEX	Capital Expenditure
DSP	Distribution Service Provider
EHV	Extra High Voltage
FACTS	Flexible AC Transmission Systems
HV	High Voltage
HVDC	High-Voltage Direct Current
Hz	Hertz
IEC	International Electrotechnical Commission
LV	Low Voltage
MV	Medium Voltage
MW	Megawatt
n	Harmonics order
PMU	Phasor Measurement Unit
PQ	Power Quality
PQM	Power Quality Monitor
P_{lt}	Flicker Severity Index (long-term)
P_{st}	Flicker Severity Index (short-term)
RMS	Root Mean Square
SADC	Saudi Arabian Distribution Code
SAGC	Saudi Arabian Grid Code
SASO	Saudi Standards, Metrology and Quality Organization
SERA	Saudi Electricity Regulatory Authority
STATCOM	Static Synchronous Compensator
SVC	Static VAR compensator
THD	Total Harmonic Distortion
TSP	Transmission Service Provider

3. DEFINITIONS

3.1. The terms and expressions defined in the Electricity Law, its Implementing Regulations related to the duties of SERA, and the codes shall have the same meaning in this document unless the context requires otherwise.

3.2. The following terms and expressions, when used in this document, shall have the meanings given below unless the context requires otherwise.

Abnormal Operating Conditions – Include voltage sags, swells, transients, and interruptions that deviate from the normal operational parameters of the power system and affect the performance of electrical equipment [IEEE1159].

Back-to Back-Converter – is a high-voltage direct-current (HVDC) system with both ends in the same switchyard.

Battery Energy Storage System – Refers to the electrochemical storage facility, able to absorb and inject Active and Reactive Power from and to the network.

Connection Point – The electrical point of connection where the assets of a user are physically connected to the network.

Data Management Plan – Details the strategies for collecting, organizing, and analyzing power quality monitoring data. It covers aspects such as acquisition frequency, storage protocols, security measures, and methods for interpreting findings. Supports decision-making, regulatory compliance, and continuous improvement of power quality.

Designated User – Users whose loads or generation characteristics impact the power quality.

Directly-Connected Customers – Any User directly connected to the Transmission System, other than the Generator or Distribution Entities.

Distribution Code – The Saudi Arabian Distribution Code.

Distribution Service Provider – The legal entity licensed by SERA to practice electricity distribution and/or retail sale activities.

Distribution User – The term applied to persons or entities who are connected to the Distribution System, and the requirements of the Distribution Code apply.

Extra High Voltage – A voltage level equal to or exceeding 230 kV.

Emission Level – The level of a given electromagnetic disturbance emitted from a particular device, equipment, or system – In the context of this document, 'Emission' includes Harmonics, Unbalance and Flicker.

Flicker – Impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time [IEC 61000-4-30].

Frequency – Is defined as the number of complete cycles of an alternating current (AC) or voltage waveform that occur per second. It is measured in hertz (Hz) [IEC].

Generator – A legal entity licensed to engage in the production of electricity through a generating unit or generating station.

Grid Code – The Saudi Arabian Grid Code.

Harmonics – Voltages or currents at frequencies that are integer multiples of the fundamental frequency of the system.

High Voltage – A voltage level exceeding 69 kV and below 230 kV.

Implementation Plan – is a comprehensive structured document or strategy that outlines the steps, procedures, and resources required to successfully install, configure, and integrate power quality monitors into the network in alignment with this document requirements.

Implementing Regulation – Implementing Regulation of the Electricity Law Related to the Duties of the Saudi Electricity Regulatory Authority (SERA) Issued by the Saudi Electricity Regulatory Authority Board of Directors Resolution No. (02/43), dated 13/04/1443H, corresponding to 18/11/2021D.

Licensee – A Person holding a valid License or Exemption.

Low Voltage – A Voltage used for the supply of electricity, of nominal RMS value which does not exceed 1 kV.

Medium Voltage – A Voltage used for the supply of electricity, the nominal RMS value of which is greater than 1 kV and up to 69 kV.

Network – An electricity network of a Transmission Licensee or Distribution Licensee.

Normal operating conditions – refer to the conditions under which the system is expected to operate without experiencing any significant disturbances or deviations from its designed parameters.

Ownership Boundary – A boundary established and which is referenced in a connection agreement to determine the division of responsibility for assets between the service providers and a user.

Planning Level – Defines standards and criteria applied during the planning and design phases of the power system, guiding decisions related to network expansion, upgrades, and new installations to ensure long-term reliability, efficiency, and safety of the electrical infrastructure.

Power Quality Management Framework – Provides a framework for systematic monitoring and assessment of power quality in electrical systems. It defines measurement methodologies and outlines responsive actions to maintain compliance and ensure reliable power delivery.

Rapid Voltage Change – A quick transition in RMS voltage occurring between two steady-state conditions, and during which the RMS voltage does not exceed the dip/swell thresholds [IEC 61000-4-30].

Remedial Measurement – A measurement undertaken to verify whether identified power quality disturbance(s) have been resolved through implementing a Corrective Action Plan or not.

Residual Voltage – Minimum value of RMS voltage recorded during a voltage dip.

Renewable Energy Generation – A Generating Unit utilizing renewable resources such as solar thermal, solar PV, wind, geothermal, etc. for electricity production. If intended for self-consumption, it must adhere to the Regulatory Framework for Renewable Energy Generation for Self-Consumption.

Rise Time – the interval of time between the instants at which the instantaneous value of a pulse (transient) first reaches a specified lower value and then a specified upper value. Unless otherwise specified, the lower and upper values are fixed at 10 % and 90 % of the pulse magnitude.

Sensitive Consumer – Any Consumer obliged to provide a backup source for electricity in addition to other requirements according to Article Eight of the Electricity Law.

Service Provider – Distribution Service Provider or Transmission Service Provider.

Spectral Content – indication of the frequency content of a transient by way of classifying the transient.

Supply Voltage Unbalance – A Condition in a polyphase system in which the RMS values of the line voltages (fundamental component), and/or the phase angles between consecutive line voltages, are not all equal based on [IEC61000-4-30].

Total Harmonic Distortion – Is the ratio of the RMS value of the sum of all the harmonic components up to 50^{th} harmonic order to the RMS value of the fundamental component based on [IEC 61000-4-7].

Transient Overvoltage – Overvoltage with a duration of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped [IEEE 1159].

Transmission Service Provider – The legal entity licensed by SERA to practice electricity transmission activities.

Transmission User – The term applied to persons or entities who are Connected to the Transmission System, including generators, distribution entities and directly-connected customers. The requirements of the Grid Code apply.

User – In the context of this document, "User" means Transmission Users and Distribution Users.

Voltage Dip –Temporary reduction of the voltage magnitude at a point in the electrical system below a threshold [IEC 61000-4-30].

Voltage Level – The magnitude of the electrical potential difference between two points, measured in volts.

Voltage Swell –Temporary increase of the voltage magnitude at a point in the electrical system above a threshold [IEC 61000-4-30].

4. SCOPE AND APPLICATION

4.1. The provisions of this document are applicable to the following:

a. Service Providers.

b. Users.

4.2. This document applies to all voltage levels of Transmission and Distribution networks (Extra High Voltage, High Voltage, Medium Voltage and Low Voltage).

4.3. The scope of this document is to specify the main power quality requirements of electrical supply at the connection point between Service Providers or Service Providers and the Users.

4.4. This document outlines the criteria for Service Providers to measure, monitor, manage Power Quality complaints and report Power Quality parameters and indicators to SERA.

5. GENERAL PROVISIONS

5.1. Legal provisions

5.1.1. SERA is the final reference for the interpretation of any article or provision of this document or for any discrepancy between this document and any other regulatory documents.

5.1.2. The Governor shall exercise the duties and powers entrusted to SERA in this document, with the exception of those specifically assigned to SERA's Board. The Governor may delegate any of his duties and powers to whomsoever he deems fit.

5.1.3. Any violation of the requirements set forth in this document shall be deemed a breach of the provisions of the Electricity Law and shall be subject to the applicable penalties under the relevant laws and regulations.

5.1.4. As per article 18(2) of implementing regulation, Service Providers are required to provide written reports to SERA, explicitly detailing the outcomes related to each quality-of-service standard. If the Service Provider failed to meet one or more standards, they must provide an explanation for each unmet standard and outline the corrective actions they have implemented or intend to undertake to address the issue and remedy the failure. If SERA does not accept the explanation, Service Providers shall be subjected to legal actions as stipulated in article 18(2) of the implementing regulation.

5.1.5. In the event of suspected non-compliance with power quality requirements, SERA reserves the right to conduct an investigation, including on-site inspections and data audits. Service Providers shall fully cooperate with SERA during such investigations, providing all required information and access to relevant records and facilities. Any identified non-compliance shall be addressed promptly, and corrective actions shall be implemented as per the Corrective Action Plan outlined in this document.

5.2. General Compliance Obligations

5.2.1. Service Providers and Users shall comply with all applicable laws and regulations and adhere to the approved standards and codes and any other regulatory requirements approved by SERA.

5.2.2. Service Providers are subject to SERA's oversight, monitoring, and performance auditing, and must comply with the power quality parameters and boundaries specified in this document, as well as the compliance criteria set by SERA.

5.2.3. Service providers and Users shall comply with the regulations, standards, guidelines issued/ adopted and/or modified by SERA, that shall include the following:

a. Requirements for power quality within the context of this document.
b. Standards for all relevant power quality parameters as adopted and/or modified by SERA.
c. Power quality monitoring requirements specified by SERA.
d. Minimum reporting requirements specified by SERA.
e. Procedures for managing power quality complaints as specified by SERA.

5.2.4. All Users of the electrical network who are subject to the provisions of the approved Saudi Arabian Distribution Code and the Saudi Arabian Grid Code shall comply with the relevant requirements set forth therein, as well as with the requirements of this document. Residential consumers are exempt from the technical requirements stipulated in the Saudi Arabian Distribution Code and from the related provisions contained in this document.

5.3. Responsibility of Service Providers

5.3.1. Service Providers shall monitor and ensure compliance with PQ levels throughout the transmission and distribution networks according to this document.

5.3.2. Service Providers shall ensure that the power quality emissions from any User connected to the network are within the limits described in this document.

5.3.3. Service Providers shall address and mitigate power quality disturbances caused by network-related issues.

5.3.4. Service Providers shall handle the complaints related to power quality.

5.3.5. Service Providers shall establish an internal audit process for power quality to ensure compliance with the requirements of this document.

5.3.6. Distribution Service Providers are required to develop criteria and selection methodology for designated users whose load or generation characteristics affect or are expected to affect the power quality, e.g. data centers, electric vehicle charging stations, railway and metro, factories, etc. DSPs must provide SERA with the criteria and selection methodology for review and approval.

5.3.7. Service Providers shall install power quality monitors at all identified locations specified in Section 7. This installation should align with the PQ monitoring implementation plan, subject to approval by SERA, to ensure continuous observability of relevant PQ indicators and maintain power quality in their supply area.

5.3.8. The costs related to the PQ monitors, as well as all associated expenses, will be borne by the Service Provider.

5.3.9. The Service Provider shall provide the User, upon request, with information about the power quality level in their network area, allowing these Users to proactively enhance their power quality measures against the current level.

5.3.10. Service Providers are required to regularly submit reports to SERA as outlined in section 8 and upon request by SERA, detailing compliance with the stipulations outlined in this document.

5.3.11. Each Service Provider shall compile additional internal standards, policies, and procedures to comply with the requirements of this document. This shall include, but not be limited to, the following:

a. Definition of User categories.
b. Implementation plan for PQ monitor installations.
c. Data management plan.
d. PQ management framework.
e. Management of consumers' complaints.
f. Internal PQ auditing procedure.

5.4. Responsibilities of Users

5.4.1. Users shall design and operate their equipment and facilities at Connection Points in compliance with the emission levels specified in this document to prevent adverse effects on the network or other Users.

6. POWER QUALITY APPLICABLE STANDARDS

6.1. A power quality disturbance exists when there is a deviation from the standards as specified in this section.

6.2. The limits specified in this document for PQ parameters are considered as a compatibility level and shall apply only under normal operating conditions.

6.3. Under normal operating conditions, the compliance criteria will be based on international standards and practices, such as IEC 61000-4-30 and EN 50160. Additionally, SERA will consider PQ field assessments that arise from the implementation of this document, advancements in emerging technologies, evolving policies and regulations, and the continuous development of the electricity sector when establishing and updating these criteria.

6.4. All PQ parameters outlined in the [IEC61000-4-30] standard that are not specifically listed in this section must be measured and recorded. SERA may request this data if deemed necessary.

6.5. Standard for Voltage Variation:

6.5.1. The transmission and distribution voltage levels shall be as defined in SAGC and SADC as shown in Annex 1.

6.5.2. Under normal operating conditions, voltage variations in the transmission and distribution systems, as well as at all connection points shall not exceed ±5% of the nominal voltage, based on SAGC and SADC.

6.5.3. The voltage shall be measured on RMS basis and evaluated for each 10-minute period with measurements undertaken over a period of at least [1 week] based on [IEC 61000-4-30].

6.6. Standard for Frequency:

6.6.1. The Transmission System shall have a nominal frequency of 60 Hz and shall be maintained within the limits of 59.9 Hz and 60.1 Hz under normal operating conditions based on the SAGC.

6.6.2. The frequency on parts of the Distribution System not interconnected by the Transmission System, either permanently or temporarily, shall have a nominal frequency of 60 Hz and shall be maintained within the limits of 59.9 Hz and 60.1 Hz under normal operating conditions based on the SADC.

6.6.3. Frequency shall be measured and evaluated for each 10-second period with measurements undertaken over a period of at least [1 week] based on [IEC 61000-4-30].

6.7. Standard for Voltage Harmonics

6.7.1. Total Harmonic Distortion (THD) is the ratio of the root mean square of the harmonic content, including the harmonic components (n = 2, 3, 4 ...up to 50) and it is expressed as a percentage of the fundamental frequency.

6.7.2. The standard for THD and individual harmonics in the transmission and distribution systems, as well as at all connection points shall be as defined in SAGC and SADC as shown in Annex 1.

6.7.3. THD and individual harmonics shall be measured in accordance with [IEC 61000-4-7] and evaluated with measurements taken at 10-minute intervals over a period of at least [1 week] based on [IEC 61000-4-30].

6.8. Standards for Supply Voltage Unbalance

6.8.1. The supply voltage unbalance in the transmission system for the EHV and HV levels shall not exceed 1% at the Connection Point based on SAGC.

6.8.2. The supply voltage unbalance in the distribution system shall not exceed 1% at the Connection Point in the MV level based on SADC and 2% at the Connection Point in the LV level based on [IEC 61000-2-2].

6.8.3. Supply voltage unbalance shall be measured on RMS basis and evaluated for each 10-minute period with measurements undertaken over a period of at least [1 week] based on [IEC 61000-4-30].

6.9. Standards for Flicker

6.9.1. The short-term flicker P_{st} is measured over a period of 10 minutes, as described in [IEC 61000-4-15].

6.9.2. The long-term flicker P_{lt} is calculated from twelve (12) P_{st} values over an interval of 2 hours, as described in [IEC 61000-4-15]

6.9.3. In the Transmission System, the maximum short-term flicker P_{st} should be below 0.8 and long-term flicker P_{lt} should be below 0.6, based on SAGC (for EHV and HV levels).

6.9.4. In the Distribution System, for LV levels the maximum short-term flicker P_{st} should be below 1, and the long-term flicker P_{lt} should be below 0.8 based on [IEC 61000-2-2]. Additionally, for MV levels the maximum short-term flicker P_{st} should be below 0.9, and the long-term flicker P_{lt} should be below 0.7 based on [IEC 61000-3-7].

6.9.5. Flicker shall be evaluated over a measurement period of at least one week based on [IEC 61000-4-30].

6.10. Standard for Rapid Voltage Change

6.10.1. A rapid voltage change shall be measured based on [IEC 61000-4-30].

6.10.2. In the Transmission System, the rapid voltage change shall not exceed 1%-3% of the nominal voltage level (for EHV and HV levels) based on SAGC, these limits depend on the number of such changes in a given time period.

6.10.3. In the Distribution System, the rapid voltage change for MV level shall not exceed 3%-5% of the nominal voltage level based on [IEC TR 61000-3-7] and for LV level shall not exceed 3.3%-6% of the nominal voltage level based on [IEC 61000-3-3], these limits depend on the number of such changes in a given time period.

6.11. Standard for Voltage Dip

6.11.1. A voltage dip occurs when there is a sudden decrease in the voltage level to less than 90% with a duration from 0.5 cycles up to 1 min based on [IEC 61000-4-30] and [IEC TR 61000-2-8].

6.11.2. Voltage dips shall be measured on ½ cycle RMS basis based on [IEC 61000-4-30] with measurements undertaken over a minimum period of one year.

6.11.3. Voltage dips shall be classified according to their depths and durations. Although several tables with different duration and depth intervals are available in the literature, the classification in Annex 1 adapted from standard [IEC TR 61000-2-8] shall be used unless others are specified to the service providers by SERA.

6.12. Standard for Voltage Swell

6.12.1. A voltage swell occurs when there is a sudden increase in the voltage level to more than 110% with a duration from 0.5 cycles up to 1 min based on [IEC 61000-4-30] and [IEEE 1159].

6.12.2. Voltage swells shall be measured on ½ cycle RMS basis with measurements undertaken over a minimum period of one year, based on [IEC 61000-4-30].

6.12.3. Voltage swell shall be classified in accordance with the standard [IEEE 1159] in terms of the magnitude and duration of the voltage swell and shall be reported according to the Table in Annex 1.

6.13. Standard for Transient Overvoltage

6.13.1. The measurement of transient overvoltage changes shall be followed as in the [IEEE 1894] and shall be undertaken for a period of at least [1 year].

6.13.2. Voltage transient shall be classified in accordance with the standard [IEEE 1159] in terms of the magnitude and duration of the transient overvoltage, according to Tables in Annex 1.

7. MONITORING AND MEASUREMENT REQUIREMENTS

7.1. The Service Provider shall carry out monitoring of power quality in order to detect the presence of disturbances. PQ monitors shall be installed at required locations in the network to measure power quality levels against defined standards.

7.2. PQ monitors shall be certified for Class A criteria as per the [IEC 61000-4-30] standard. They must have sufficient sampling capabilities to accurately capture and analyze all power quality parameters. The monitors shall be calibrated in accordance with the manufacturer's specifications, calibration certificate from an independent calibrating agency accredited by the Saudi Accreditation Center.

7.3. The Service Provider shall carry out two types of power quality monitoring namely (1) Permanent monitoring and (2) Temporary monitoring, as described below in this section.

7.4. For each measurement carried out under permanent or temporary monitoring, the Service Provider shall collect power quality measurement data and shall store this data in electronic format for a period of a minimum of five years. SERA shall have the right to carry out audits of these data.

7.5. All PQM shall be installed on the Service Provider's networks or at the User's connection point at the Service Provider ownership boundary.

7.6. The duration of instrument connection for power quality assessment will be specified by SERA in coordination with Service Providers as follows:

a. **Type P**: Long-term permanent sites with fixed PQ monitors.

b. **Type R:** Short-term and rotating between sites with portable PQ monitors. These PQM shall be installed as per purpose for the temporary installation.

c. **Type I:** Investigation sites with portable PQ monitors. These PQM shall be installed for at least one week (8 consecutive days) as per [IEC 61000-4-30] or one full cycle of the plant / network operation under consideration. The cycle should take both network cyclical performance and plant operational cycles into account as per [IEEE1159].

7.7. Service Providers must remotely collect all measurements from PQM (Type P and Type R), using appropriate and secure communication means and

platforms. In addition, the platform shall process, analyze, and present the data according to industry best practices. SERA is entitled to access the platform all the time.

7.8. Permanent Monitoring

7.8.1. Implementing permanent monitoring (Type P) of power quality indicators is crucial for ensuring regulatory compliance, promptly identifying deviations, analyzing faults, and maintaining a reliable electrical supply.

7.8.2. Service Providers shall install PQ monitors with upgraded Phasor Measurement Unit (PMU) functionality in accordance with the latest IEC/IEEE 60255-118-1, IEEE C37-118 and other related standards. These monitors shall be deployed across transmission and distribution networks to ensure continuous measurement of power quality and PMU parameters (PQ/PMU combined functionalities “devices” shall be counted and allocated during the selection process of PQ locations).

7.8.3. The locations and sites to be monitored by the Service Provider at each voltage level and/or connection point are provided in Table 1 below.

Table 1: Sites to be monitored by the Service Provider (Permanent Monitoring)

Sites to be Monitored	Voltage Level	PQM Locations	Responsibility(1)	Note
Two Voltage Levels Substations	EHV/HV or EHV/ MV or HV/MV	At primary and secondary side of All transformers	TSP	All Transformers in Substations
Three Voltage Levels Substations	EHV/ HV/ MV	At HV side of all Transformers At MV side of all Transformers	TSP	All Transformers in Substations
Generator	EHV	All Incomers from Generator	TSP	All Generators Connected to Transmission Substations
	HV			

Renewable Energy Generation	EHV HV MV	All Incomers from Renewable Energy Generation	TSP	All Renewable Energy Generation Connected to Substations
Battery Energy Storage System	EHV HV MV	All Incomers from Battery Energy Storage System	TSP	All Battery Energy Storage Systems Connected to Substations
FACT Devices (SVC or STATCOM)	EHV HV	At the upper voltage side of the SVC or STATCOM Transformer	TSP	All FACTS Devices
HVDC Link	EHV	All Incoming lines to each Terminal Substation	TSP	All HVDC links Substations
Back to Back Converter	EHV	All Incoming lines from Back-to-Back Converter Substation	TSP	All Back-to-Back Converter Substation
Directly-Connected Customer	EHV HV	All Incoming lines to Directly-Connected Customer	TSP	All Directly-Connected Customer Connection Points
MV Feeders Outgoing from Substations	MV	Outgoing MV feeders	DSP	20% of the Outgoing MV feeders from Substations (2)
Sensitive Consumers	MV	Connection Point	DSP	All Connection Points

Renewable Energy Generation for Self-Consumption	MV	Connection Point	DSP	All Connection Points of Renewable Energy Generation with capacity of 2 MW and above
	LV			
Designated User	LV	Connection Point	DSP	All Connection Points where the network is likely to be affected by PQ disturbances or variations originating from the designated user site
	MV			

Note:

(1) Installing, maintaining, operating, and reporting.

(2) The DSP is responsible for developing the criteria and methodology for assessing and selecting feeders and for submitting the criteria along with the list of selected feeders to SERA for review.

7.9. Temporary Monitoring

7.9.1. The purpose of temporary monitoring (**Type R**) is to evaluate the compliance with the requirements and address transient issues promptly, allowing for effective corrective actions to be implemented.

7.9.2. It is the responsibility of the Service Provider to determine the location and quantity of sites across all operating areas to be monitored at each voltage level and/or connection point for temporary monitoring (**Type R**).

7.9.3. The Service Provider shall carry out temporary PQ monitoring (**Type I**). Measurements shall be taken during a period of at least 1 week (based on IEC standards) at the connection point or if it is not available - at a convenient location close to the connection. The minimum measurement duration may be reduced or increased, depending on considerations such as the operational cycle of the User plant. Deviations from the IEC minimum duration of 1 week shall be evaluated on a case-by-case basis.

7.9.4. These measurements (**Type I**) shall be undertaken under various circumstances and needs such as:

a. Upon receiving a power quality complaint.
b. Troubleshooting.
c. For which Remedial Measurements are to be undertaken.

7.9.5. Temporary monitoring (**Type R or Type I**) and measurement of power quality may also be requested by SERA for specific situations, such as network disturbances, equipment failures, troubleshooting, complaints, or other exceptional events. Service Providers shall cooperate with SERA in facilitating temporary monitoring activities, providing necessary access, and sharing relevant information.

8. POWER QUALITY REPORTING

8.1. The Service Provider shall prepare and submit to SERA a Quarterly and Annual PQ Performance Reports, providing a comprehensive overview of its power quality management, performance and compliance during the reporting period. For urgent and pressing matters and upon a direct request from SERA, service providers shall submit immediately the required PQ data and measurements.

8.2. All data and information included in the PQ Performance Reports submitted to SERA shall be verified and audited by Service Provider prior to submission .

8.3. All power quality data shall be presented in a clear and structured format, ensuring transparency and ease of interpretation. The PQ Performance Reports should cover all parameters and indicators specified in section 6.

8.4. The PQ Performance Reports shall be in the format defined by SERA and shall contain at least the following:

a. PQ measurement plans.
b. Measurements undertaken categorized by type of monitoring, voltage level, and operating region.
c. Results per measurement.
d. Proof of traceability of calibration of all PQ monitors.
e. Number of Corrective Action Plans and status per plan (resolved or pending).
f. PQ performance summary and 5-year trends for the system and per operating region.
g. Compliance Assessment with Power Quality Standards.
h. Event Analysis and Impact Assessment.
i. Abnormal events and data excluded from the assessment, including the justification for each abnormal event.
j. PQ Complaints and Resolution.
k. Other relevant information.

8.5. The PQ Performance Reports shall include an evaluation of the Service Provider's compliance with the stipulated power quality limits and standards. Any instances of non-compliance should be clearly identified, accompanied by

a detailed account of corrective actions taken, including remedial measurements.

8.6. Investments made to enhance power quality, along with improvement plans, should be highlighted. The Quarterly and Annual Performance Reports should outline infrastructure upgrades, technological implementations, and any other initiatives aimed at continual enhancement.

8.7. The Service Provider shall draw insightful conclusions from the presented data and offer meaningful recommendations for future improvements in power quality management.

9. MANAGEMENT OF POWER QUALITY COMPLAINTS

9.1. Upon receiving a power quality complaint, the Service Providers shall verify and confirm that the complaint is associated with Power Quality parameters specified in this document.

9.2. All power quality complaints shall be investigated using existing measurement tools. If these tools do not identify the issue, a temporary PQM shall be installed, unless permanent monitoring is deemed necessary.

9.3. Service Providers shall take the actions required to resolve a power quality issue in a reasonable period as specified in the procedures for handling consumers' complaints approved by SERA for quality of the electricity service complaints.

9.4. The power quality complaint is considered resolved in the case if the power quality measurement conducted under the Remedial Measurement referred to in section 7, does not identify any power quality disturbance originating from the network.

9.5. The Service Providers are obligated to bear the cost of PQ verification.

9.6. The Service Provider shall maintain a system to register and process complaints in line with the KPI Manual (Key Performance Indicators for Electricity and Desalination Industry in the Kingdom of Saudi Arabia). The KPIs for C3 (Frequency of Complaints) shall include a separate category for power quality complaints.

10. CORRECTIVE ACTION FOR POWER QUALITY DISTURBANCE

10.1. The Service Provider shall evaluate whether a power quality disturbance exists for every measurement performed under permanent or temporary monitoring. All identified power quality disturbances must be recorded and included in the reports, as outlined in section 8.

10.2. If any power quality disturbance occurs during a given measurement that causes or may cause an impact on the system's performance or on the delivery of electricity service, the Service Provider shall develop a Corrective Action Plan.

10.3. This plan shall outline the timeframe, steps and procedures intended to be taken to resolve the failure.

10.4. The Service Provider shall promptly implement the Corrective Action Plan, focusing primarily on the operational and/or maintenance actions necessary to rectify the failure.

10.5. After the complete implementation of the Corrective Action Plan, the Service Provider shall carry out a Remedial Measurement at the given location followed by Remedial Completion Report that shall set out the steps and procedures that have been undertaken to address and resolve the issue.

10.6. Any investment requirements identified in the Corrective Action Plan shall be incorporated into the Investment Plan accompanied by the necessary justifications, which will be reviewed by SERA as part of the regular CAPEX review process.

10.7. If the Service Provider fails to record and report power quality disturbances as outlined in section 8, or if these reports indicate the Service Provider’s failure to meet one or more power quality standards without making reasonable efforts to rectify the situation, SERA reserves the right to enforce the provisions of clause 5.1.4.

10.8. Users operating outside the limits specified in this document shall rectify the situation immediately or within a timeframe agreed with the Service Provider, and in cases of persistent non-compliance, shall be subject to the provisions of the Electricity Codes and their associated documents.

ANNEX 1

TABLES OF APPLICABLE POWER QUALITY STANDARDS

Table 2: Standard Voltage levels and variations defined in the Grid Code

Nominal Voltage	Limits
110 kV	±5%
115 kV	±5%
132 kV	±5%
230 kV	±5%
380 kV	±5%

Table 3: Standard Voltage levels defined in the Distribution Code

Nominal Voltage	Lowest Voltage	Highest Voltage
220 / 127 V	209 / 120V	231 / 134V
380 / 220 V	360 / 209V	400 / 231V
400 / 230 V	380 / 218.5V	420 / 241.5V
13.8kV	13.1kV	14.5kV
33kV	31.4kV	34.7kV
69kV	65.5kV	72.5kV

Table 4: Non-standard Voltage levels defined in the Distribution Code

Nominal Voltage	Lowest Voltage	Highest Voltage
11kV	10.45kV	11.55kV
34.5kV	32.78kV	36.23kV

Table 5: Standard for Total Harmonic Distortion

Nominal Voltage	Individual harmonic (%) n ≤ 50	Total Harmonic Distortion THD (%)
380 kV	1.0%	1.5%
230 kV		
132 kV		
115 kV		
110 kV		
33 kV-69 kV	See Tables 5-7	3.0%
11 kV & 13.8 kV		4.0%
230-400 V		5.0%
127-220 V		5.0%

Table 6: Individual Harmonic planning level limits for LV Distribution Systems up to 1kV (maximum continuous individual Harmonic distortion expressed in % of voltage at fundamental frequency)

Odd Harmonics (Non-multiple of 3)		Odd Harmonics (Multiple of 3)		Even Harmonics	
Order n	Harmonic Voltage %	**Order n**	Harmonic Voltage %	**Order n**	Harmonic Voltage %
5	7.4	**3**	5	**2**	1.5
7	5.5	**9**	1.5	**4**	0.9
11	3.5	**15**	0.4	**6**	0.7
13	3	**21**	0.3	**8**	0.6
17	2.3	**>21**	0.2	**10**	0.5
19	2			**>12**	0.4
23	1.7				
25	1.5				
>25	(38.5/n-0.27)				

Table 7: Individual Harmonic planning level limits for voltage levels >1kV and ≤35kV of the Distribution System (maximum continuous individual Harmonic distortion expressed in % of voltage at fundamental frequency)

Odd Harmonics (Non-multiple of 3)		Odd Harmonics (Multiple of 3)		Even Harmonics	
Order n	Harmonic Voltage %	**Order n**	Harmonic Voltage %	**Order n**	Harmonic Voltage %
5	6.3	**3**	4	**2**	1.5
7	4.4	**9**	1.2	**4**	0.8
11	2.7	**15**	0.3	**6**	0.6
13	2.3	**21**	0.2	**8**	0.5
17	1.7	**>21**	0.2	**10**	0.5
19	1.5			**12**	0.4
23	1.2			**14**	0.4
25	1.1			**16**	0.3
>25	(32.3/n)-0.2			**>16**	(2.5/n)+0.2

Table 8: Individual Harmonic planning level limits for voltage levels >35kV and ≤69kV of the Distribution System (maximum continuous individual Harmonic distortion expressed in % of voltage at fundamental frequency)

Odd Harmonics (Non-multiple of 3)		Odd Harmonics (Multiple of 3)		Even Harmonics	
Order n	Harmonic Voltage %	**Order n**	Harmonic Voltage %	**Order n**	Harmonic Voltage %
5	4.1	**3**	2	**2**	1.1
7	2.9	**9**	1	**4**	0.6
11	1.9	**15**	0.3	**6**	0.5
13	1.6	**21**	0.2	**8**	0.4
17	1.2	**>21**	0.2	**10**	0.4
19	1.1			**12**	0.3
23	0.9			**14**	0.3
25	0.8			**16**	0.3
>25	20.4/n			**>16**	1.9/n+0.16

Table 9: Classification of Voltage Dips

	Duration						
Residual Voltage	**0.5 cycles <Δt≤ 1 cycle**	**1 cycle <Δt≤ 5 cycles**	**5 cycles <Δt≤ 30 cycles**	**30 cycles <Δt≤ 60 cycles**	**60 cycles <Δt≤ 180 cycles**	**180 cycles <Δt≤ 1200 cycles**	**1200 cycles <Δt≤ 3600 cycles**
85-90%							
70-85%							
40-70%							
10-40%							

Note: The shaded cells shall contain the number of dips recorded with respect to their classification.

Table 10: Classification of Voltage Swell

	Duration						
Residual Voltage	**0.5 cycles <Δt≤ 1 cycle**	**1 cycle <Δt≤ 5 cycles**	**5 cycles <Δt≤ 30 cycles**	**30 cycles <Δt≤ 60 cycles**	**60 cycles <Δt≤ 180 cycles**	**180 cycles <Δt≤ 1200 cycles**	**1200 cycles <Δt≤ 3600 cycles**
110%< **Swell Voltage** <120%							
Swell Voltage ≥ 120%							

Note: The shaded cells shall contain the number of swells recorded with respect to their classification.

Table 11: Classification of Impulsive Voltage Transient

	Risetime		
Peak Voltage	**5 ns**	**1 µs**	**0.1 ms**
120% < V_p ≤ 150%			
150% < V_p ≤ 200%			
200% < V_p ≤ 400%			
Vp > 400%			

Note: The shaded cells shall contain the number of impulsive voltage transient recorded with respect to their classification.

Table 12: Classification of Oscillatory Voltage Transient

	Spectral Content		
Peak Voltage	**< 5 kHz**	**5 - 500 kHz**	**0.5 - 5 MHz**
120% < V_p ≤ 150%			
150% < V_p ≤ 200%			
200% < V_p ≤ 400%			
V_p > 400%			

Note: The shaded cells shall contain the number oscillatory voltage transient recorded with respect to their classification.

ANNEX 2

FLOW CHART OF CORRECTIVE ACTION FOR PQ DISTURBANCE

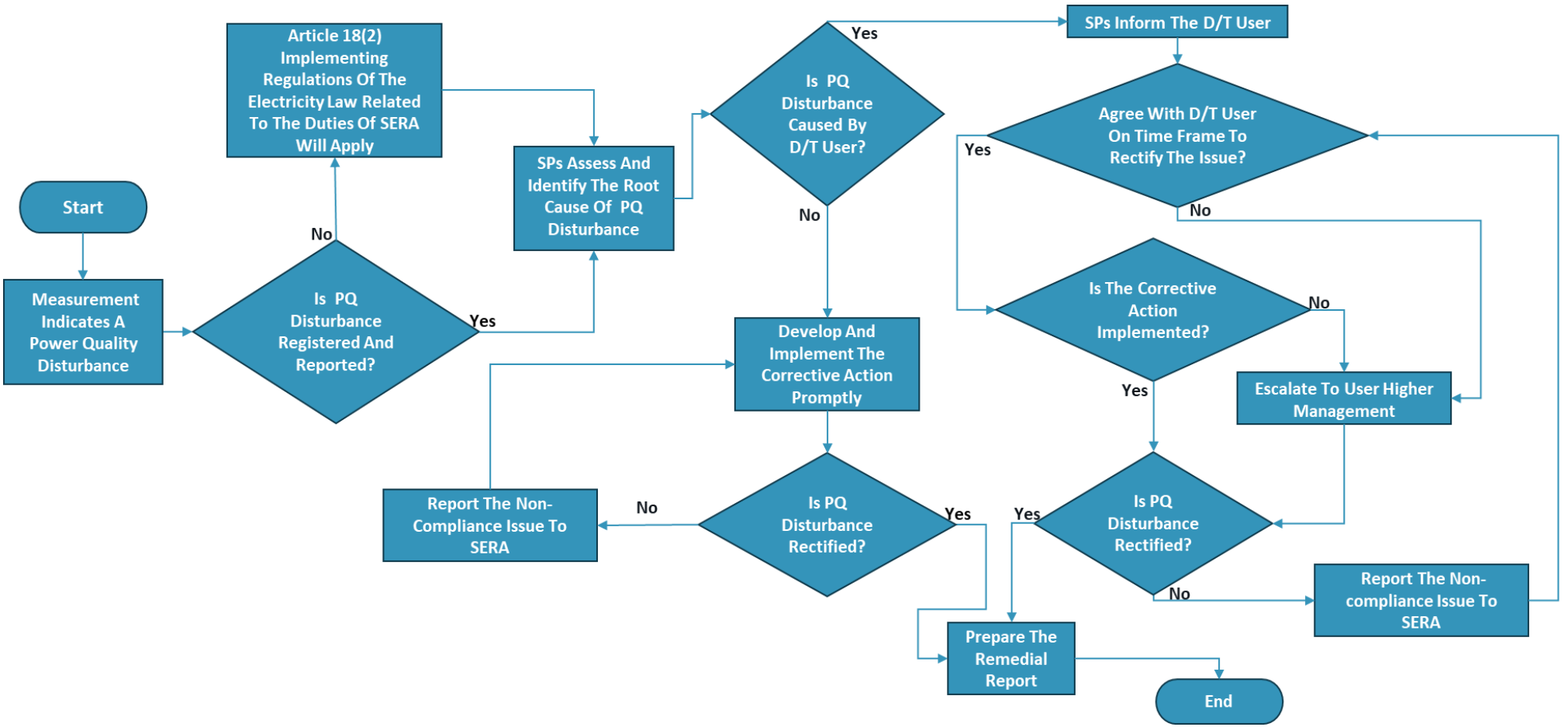


Figure 1: Flowchart of Corrective Action for PQ Disturbance

الهيئة السعودية لتنظيم الكهرباء

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