

TECHNICAL SPECIFICATION



**Power quality management –
Part 1: General guidelines**

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TECHNICAL SPECIFICATION



**Power quality management –
Part 1: General guidelines**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.020

ISBN 978-2-8322-1061-4

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POWER QUALITY MANAGEMENT –**Part 1: General guidelines****FOREWORD**

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The text of this Technical Specification is based on the following documents:

Draft	Report on voting
8/1588/DTS	8/1602/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 63222 series, published under the general title *Power quality management*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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INTRODUCTION

With the development of smart grid and massive deployment of renewable energy, power quality issues have received attention not only from system operators and customers (especially with sensitive power quality loads) but also from market regulators with the demands to provide information on the actual power quality level. Power quality management of the grid is a systematic project which includes the whole process of planning, operation, assessment and mitigation. The characteristics of power supplier, load characteristics of power consumer and external environment will affect the power quality of the grid. This document focuses on the whole process management and is the general guideline for this series of standards.

Traditional electrified railways, steel mills and other non-linear loads are the main pollution sources of the power quality. In recent years, the new loads such as new energy and electric vehicles have brought new challenges to power quality management. The rapid popularization and application of high-tech precision technology has also put forward new requirements for high-quality power supply and consumption system.

Power quality is an important issue for electricity supply network operators, which needs to be handled at planning and operation stages. In order to achieve power quality target, reduce power quality impacts/losses and improve the economic efficiency of the system, power quality regulation and supervision of the operating power system is necessary, and a well-considered power quality planning before project implementation is also needed, such as system expansion, construction and grid connection of the distributed generation. Besides, the users at the end of power system should also be taken into consideration. Power quality problems can cause system instability, equipment abnormal operation and supply interruption. Power quality management is a method to avoid further power quality problems after project implementation.

The standard system in power quality management provides a technical basis for improving power management level and standardizing power quality industry and market. As the general guideline of the standard series, this specification summarizes the power quality indicators and assessment methods, and analyses the overall power quality level by monitoring assessment and predicted assessment. Monitoring system and field test are used to assess the power quality level at different nodes of the grid, and solve users' power quality complaints and other practical problems. Connection and monitoring points are reasonably selected to assess the power quality levels of the grid in operation stage, and it also contributes to the power quality mitigation. In addition, the economical assessment of power quality is regulated in the document. Power quality management use cases in different typical scenarios are shown in Annex A.

POWER QUALITY MANAGEMENT –

Part 1: General guidelines

1 Scope

This part of IEC 63222, which is a Technical Specification, is intended to provide provisions associated to the main use cases regarding recognized engineering practices applicable to power quality management in public electric power supply networks. It summarizes the operation in power quality management and investigates the current standards, for requirement of power quality assessment work, as well as to promote the development of power quality management best practices.

The power quality management domain groups use cases and associated power quality requirements common to network management, including customer support network operation, network and extension planning.

This document captures possible "common and repeated usage" of power quality management under the format of "use case". Use case implementations are given for information purpose only. This document derives the common requirement as provisions by further standardization activities, in terms of actors interacting with the given system. The interface requirement is considered for later standardization activities. The relationship of the stakeholders in power quality management, such as network operator, network user, etc., are discussed in the document. Table 1 highlights the domains and business use cases described.

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Table 1 – Content of IEC TS 63222-1

Domain	Content	Scope
Power quality monitoring assessment	Described with 5 business use cases 1) Manage power quality over the grid. 2) Manage power quality through distribution or transmission grid interfaces with another network. 3) Take into account power quality constraints in network operation. 4) Provide reports on network power quality. 5) Manage complaints on power quality over the network. Described with 5 system use cases 1) Assess power quality on the network. 2) Measure power quality on a specific point of the network. 3) Monitor power quality on the network. 4) Engineer a power quality provision. 5) Assess the emission limit related to power quality technical parameters in power system.	Continuous monitoring operation for public power grid
Power quality predicted assessment	Described with 4 business use cases 1) Manage power quality over the grid. 2) Take into account power quality constraints in connecting a user to the grid. 3) Take into account power quality constraints in network development. 4) Provide reports on network power quality. Described with 7 system use cases 1) Predict power quality impact of a construction work or maintenance. 2) Predict power quality impact of a new connection or network development. 3) Measure power quality on a specific point of the network. 4) Monitor power quality on the network. 5) Engineer a power quality provision. 6) Assess power quality on the network. 7) Assess the emission limit related to power quality technical parameters in power system.	Power quality assessment of new construction, reconstruction or expansion projects in the grid

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61000-3 (all parts), *Electromagnetic compatibility (EMC) – Part 3: Limits*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

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

IEC TS 61000-3-4, *Electromagnetic compatibility (EMC) – Part 3-4: Limits – Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A*

IEC TS 61000-3-5, *Electromagnetic compatibility (EMC) – Part 3-5: Limits – Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 75 A*

IEC TR 61000-3-6, *Electromagnetic compatibility (EMC): Limits-Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems*

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

IEC 61000-3-8, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 8: Signalling on low-voltage electrical installations – Emission levels, frequency bands and electromagnetic disturbance levels*

IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤ 75 A per phase*

IEC TR 61000-3-13, *Electromagnetic compatibility (EMC) – Limits – Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems*

IEC TR 61000-3-14, *Electromagnetic compatibility (EMC) – Assessment of emission limits for harmonics, interharmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems*

IEC 61000-4 (all parts), *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques*

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

IEC 61000-4-30:2015, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

IEC TR 61850-90-17:2017, *Communication networks and systems for power utility automation – Part 90-17: Using IEC 61850 to transmit power quality data*

IEC 61968-9:2013, *Application integration at electric utilities – System interfaces for distribution management – Part 9: Interfaces for meter reading and control*

IEC TS 62749: 2020, *Assessment of power quality – Characteristics of electricity supplied by public networks*

ISO 10002:2018, *Quality management – Customer satisfaction – Guidelines for complaints handling in organizations*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Terms and definitions

3.1.1

power quality

characteristics of the electricity at a given point on an electrical power system, evaluated against a set of reference technical parameters

[SOURCE: IEC 60050-617:2009, 617-01-05, modified – "electric current, voltage and frequencies" has been changed to "electricity"]

3.1.2

power quality indices

technical parameters characterizing the quality of electricity, measured at a given point, relevant for the assessment of the quality of the electricity delivered by a network operator

[SOURCE: IEC TS 62749:2020, 3.29]

3.1.3

nominal voltage

voltage by which a system is designated or identified

[SOURCE: IEC 61000-4-30:2015, 3.18]

3.1.4

voltage unbalance

in a polyphase system, a condition in which the RMS values of the phase voltages (fundamental component) or the phase angles between consecutive phases are not all equal.

Note 1 to entry: The degree of the inequality is usually expressed as the ratios of the negative- and zero-sequence components to the positive-sequence component.

Note 2 to entry: In this standard, voltage unbalance is considered in relation to 3-phase systems.

[SOURCE: IEC 60050-161:1990 161-08-09, modified – "phase voltages" has been changed to "phase voltages (fundamental component)", notes to entry have been added]

3.1.5

voltage deviation

difference between the supply voltage at a given instant and the declared supply voltage

3.1.6

flicker

impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

[SOURCE: IEC 60050-161:1990 161-08-13]

3.1.7**voltage dip**

a sudden reduction of the voltage at a point in an electrical system followed by voltage recovery after a short period of time from a few cycles to a few seconds.

[SOURCE: IEC 60050-161:1990, 161-08-10]

3.1.8**short interruption**

the disappearance of the supply voltage for a time interval whose duration is between two specified limits

Note 1 to entry: A short interruption is considered to be a reduction of the supply voltage to less than 1 % of the nominal voltage, with the lower limit of the duration typically a few tenths of a second, and its upper limit typically in the order of one minute (or, in some cases up to three minutes).

[SOURCE: IEC 60050-161:1990, 161-08-20]

3.1.9**harmonic component**

sinusoidal component of a periodic quantity having a harmonic frequency

[SOURCE: IEC 60050-551:2001, 551-20-07, modified – The note has been deleted]

3.1.10**harmonic frequency**

frequency which is an integer multiple greater than one of the fundamental frequency or of the reference fundamental frequency

[SOURCE: IEC 60050-551:2001, 551-20-05]

3.1.11**interharmonic component**

sinusoidal component of a periodic quantity having an interharmonic frequency

Note 1 to entry: For practical analysis, an approximation of the periodicity may be necessary.

[SOURCE: IEC 60050-551:2001, 551-20-08]

3.1.12**interharmonic frequency**

frequency which is a non-integer multiple of the reference fundamental frequency

[SOURCE: IEC 60050-551:2001, 551-20-06]

3.1.13**system operator****network operator**

party responsible for safe and reliable operation of a part of the electric power system in a certain area and for connection to other parts of the electric power system

[SOURCE: IEC 60050-617:2009, 617-02-09]

3.1.14**(power) network user****(power) system user**

party supplying electric power and energy to, or being supplied with electric power and energy from, a transmission system or a distribution system

[SOURCE: IEC 60050-617:2009, 617-02-07]

3.1.15 stakeholders

individual, group or organization that has an interest in an organization or activity

Note 1 to entry: Usually a stakeholder can affect or is affected by the organization or the activity.

[SOURCE: IEC 60050-904:2014, 904-01-10]

3.1.16 system average RMS variation frequency index SARFI

a power quality index that provides a count or rate of voltage dips, swells, and/or interruptions for a system.

[SOURCE: IEC TS 62749: 2020, 5.3.3.2]

3.1.17 distribution system operator

party operating a distribution system

[SOURCE: IEC 60050-617:2009, 617-02-10]

3.1.18 transmission system operator

party operating a transmission system

[SOURCE: IEC 60050-617:2009, 617-02-11]

3.2 Abbreviated terms

Abbreviations used in the text are defined in Table 2.

Table 2 – Abbreviations of IEC TS 63222-1

Abbreviation	Definition
PQ	Power Quality
BUC	Business use case
SUC	System use case
VSC	Voltage Source Converter
PCC	Point of Common Coupling
SCADA	Supervisory Control and Data Acquisition
SARFI	System Average RMS variation Frequency Index
FACTS	Flexible AC Transmission Systems
SVC	Static Var Compensator
STATCOM	Static Synchronous Compensator
UPS	Uninterrupted Power Supply
APF	Active Power Filter
DVR	Dynamic Voltage Restorer
LN	Logical Node
RVC	Rapid Voltage Change
RTC	Real Time Clock
EMC	Electromagnetic Compatibility
BESS	Battery Energy Storage system

4 Use cases list

4.1 List of business use cases and business roles of the domains

The business use cases list is not exhaustive, and it is likely to grow as new use cases come to light. The organisation of the use cases in the document and the links between them are shown in Figure 1. Annex A gives the details of use cases.

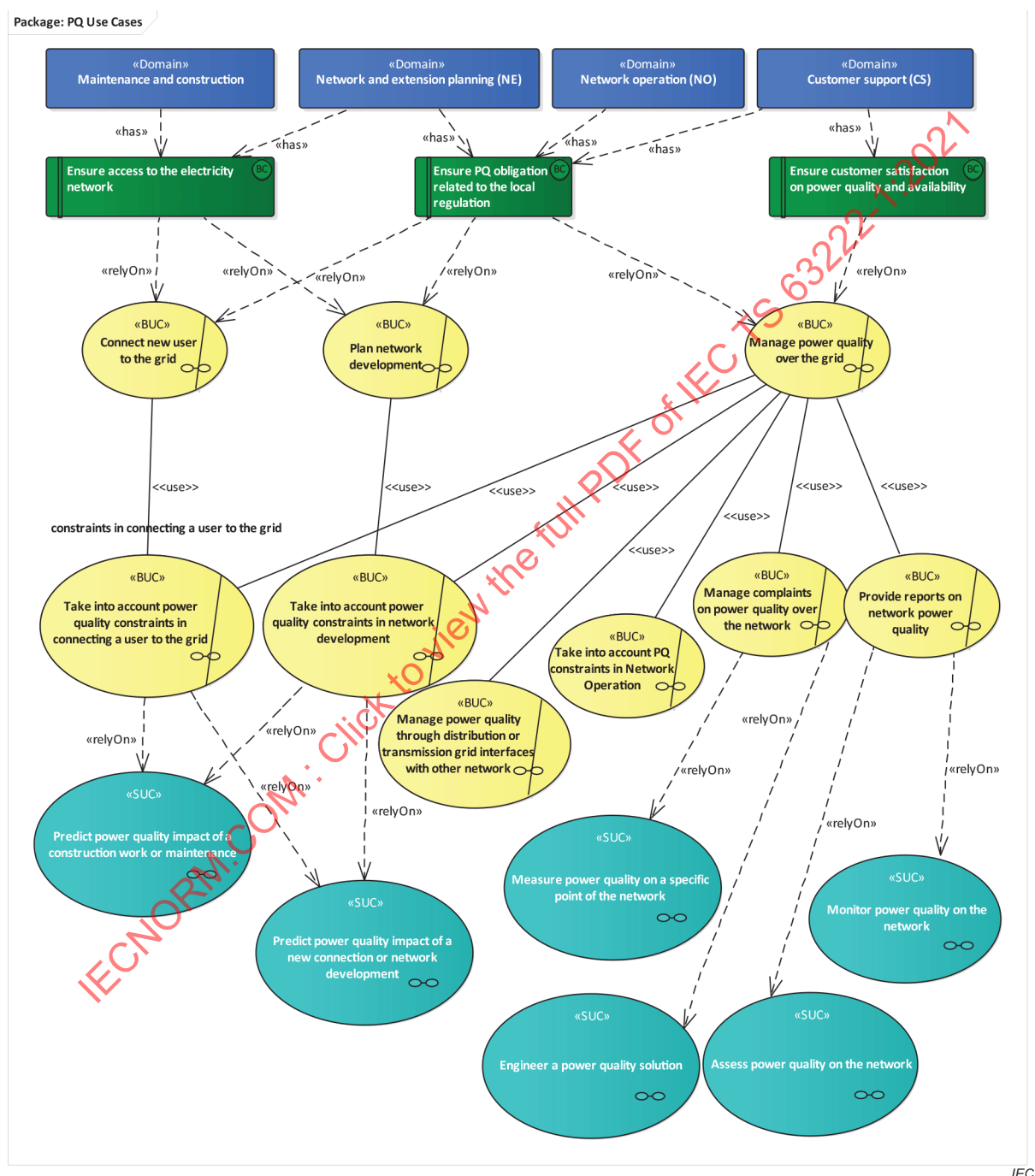


Figure 1 – Organisation of the use cases

Table 3 lists and provides a brief description of the business use cases that have been identified so far (they do not cover the entire domain business use cases). In Clause A.1, a part of business use cases is developed.

Table 3 – Lists of business use cases

Index of the business use case	Identified business use case	Associated domain	Brief description
UC63222-B001	Manage power quality over the grid	Customer support, Network operation, Network and extension planning	The business use case describes the system operator main processes to manage power quality disturbances for the reliability of the power system and ensures continuity and quality of the electrical energy provided to the grid users at their connection point to the grid.
UC63222-B002	Manage complaints on power quality over the network	Customer support, Network operation, Network and extension planning	The business use case describes the system operator main processes to resolve a power quality issue on a specific point of the network.
UC63222-B003	Provide reports on network power quality	Customer support, Network operation, Network and extension planning	The business use case describes the system operator main processes to retrieve, build, analyse power quality data and report on it for different commitments.
UC63222-B004	Take into account power quality constraints in connecting a user to the grid	Customer support, Network operation, Network and extension planning	New user is connected to the grid, which can meet the power quality of load and the grid.

Table 4 lists the business roles that have been identified so far in the business use cases provided in Clause A.2. This list is not exhaustive.

Table 4 – Business roles of IEC TS 63222-1

Business roles	Definition
System operator	Party responsible for safe and reliable operation of a part of the electric power system in a certain area and for connection to other parts of the electric power system. [SOURCE: IEC 60050-617:2009, 617-02-09]
Power quality complaints responsible	Party responsible for customer relationship and customer support on power quality issues on part of the electric power system in a certain area
Network operation responsible	Entity responsible for the planning, operation, maintenance, and the development in given areas of the electricity network
Grid user	Party connected to the grid and consuming and/or producing electricity. Grid users include consumers, producers, and prosumers
(Electricity) supplier	Party having a contract to supply electric power and energy to a customer [SOURCE: IEC 60050-617:2009, 617-02-08]
Conceding authority	Authority that owns (a part of) the distribution grid and delegates its operation to a distribution grid operator in a system where electricity distribution is operated as a concession. The conceding authority is usually a local authority or a municipality.
Regulator	Authority that is responsible for preparing or adopting regulations. [SOURCE: IEC 60050-901:2013, 901-03-11] May be responsible for exercising autonomous authority over electricity markets and the associated synchronous electricity grids. Equivalent to regulatory authority.
Grid user	Party connected to the grid and consuming and/or producing electricity. Grid users include consumers, producers, and prosumers. Equivalent to party connected to the grid.

4.2 List of system use cases and system roles

Table 5 lists the system use cases which have been identified so far to enable the business use cases described above to operate. The list is non-exhaustive and will be updated in future editions of IEC TS 63222-1. It should also be noted that business as usual functions have not been listed.

Table 5 – Lists of the system use cases

Index of the system use case	Identified system use case	Brief description
UC63222-S001	Monitor power quality on the network	This system use case describes the structure composition, general workflow of power quality monitoring, and functional requirements of each layer system.
UC63222-S002	Measure power quality on a specific point of the network	This system use case describes the method for measurement and interpretation of results for power quality on a specific point of the network.
UC63222-S003	Assess the emission limit related to power quality technical parameters in power system	This use case provides methods to evaluate the emission limits for the installations and equipment. The co-ordination approach in the use case relies on individual emission levels being derived from the power quality level. It can be used as a tool when evaluating the emission limits for the installations and equipment.

Table 6 lists the system roles which have been identified so far. The list is non-exhaustive and will be updated in future editions of IEC TS 63222-1.

Table 6 – Lists of system roles

System roles	Description
Client	Functional unit that requests and receives services from a server [SOURCE: IEC 60050-732:2010, 732-01-13]
Monitoring terminal	A functional unit that observes and records, for analysis, selected activities within a switching system [SOURCE: IEC 60050-714:1992, 714-18-28]
Master station	The data station that has been designated by the control station to ensure data transfer to one or more slave stations [SOURCE: IEC 60050-721:1991, 721-19-12]

5 Provisions

5.1 Power quality assessment

5.1.1 General

Monitoring assessment and predicted assessment can be used for power quality assessment of public power grid and users connected to the grid. The power quality assessment of power supply connected to the grid can refer to monitoring assessment and predicted assessment. The relationship between the power quality assessment and use cases is given in Figure 2.

The significant changes can be detected by the following conditions:

- data analytics being developed for automatic detection of changes from the permanent measurements,
- customer complaints,
- operation mode adjustment information given by dispatching department,
- the access change information of customer given by the marketing department.

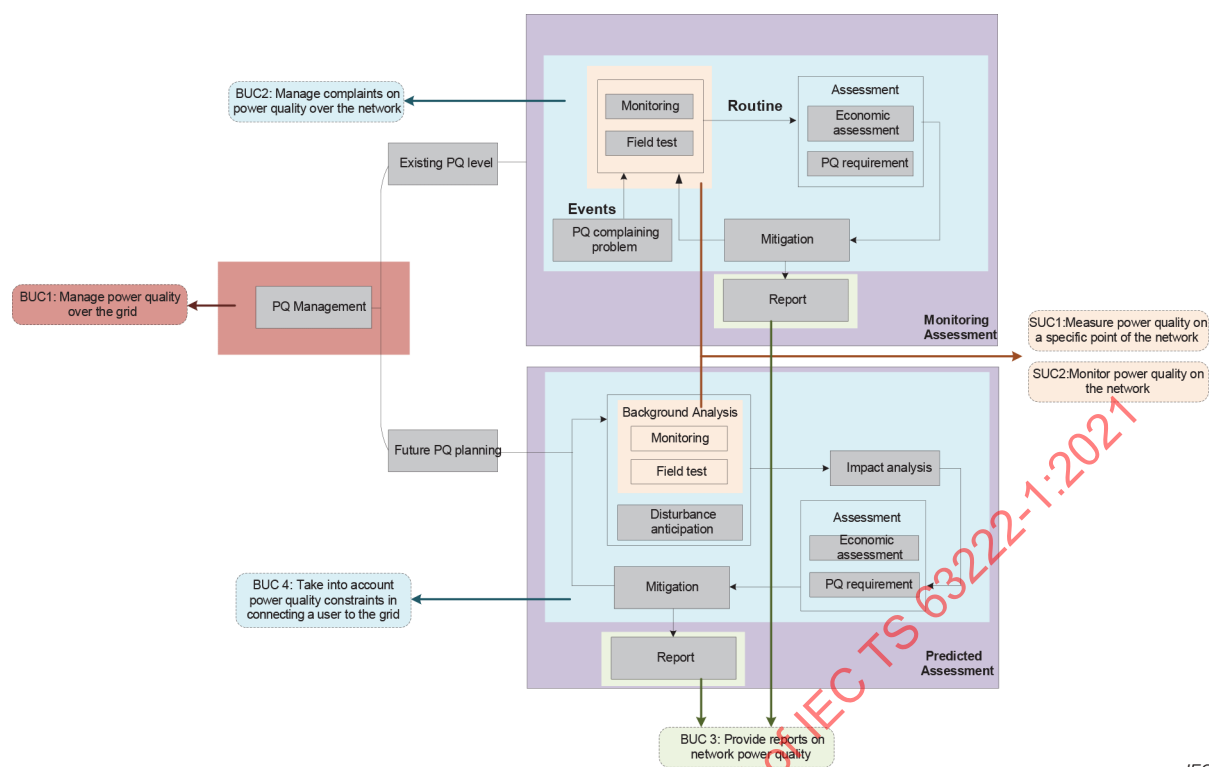


Figure 2 – Overview of the power quality management main functions

5.1.2 Monitoring assessment

The monitoring assessment should be used for the continuous monitoring of the existing grid. In addition, monitoring assessment can be used for power quality assessment of the key nodes in the network. It is also needed to analyse the actual power quality levels when receiving the power quality complaining from users.

Measuring equipment is used for field test to obtain power quality testing data. Measurement data is compared with the PQ characteristic value, judging whether it meets the standard requirements, and evaluates voltage qualification rate and grade as required. The main contents and requirements of power quality monitoring assessment report are listed in Annex B.

5.1.3 Monitoring assessment process

1) Object and range determination

Determine the assessment object and range according to the source and purpose of the assessment task.

2) System and equipment data collection

Collect the data of power system and equipment related to the assessment object, determine the monitoring assessment points and limits or levels of PQ indicators.

3) Monitoring plan formulation

Analyse the operation mode, equipment working condition and characteristics of production process of the assessment object, formulate monitoring plan.

4) Testing data obtaining

Select testing equipment, determine the appropriate measurement conditions, measurement time and measurement value, obtain testing data. The measurement should be carried out in the minimum (or smaller) operation modes of the power system and under the normal working condition of the assessment object. The monitoring period should include the maximum disturbance working period of the assessment object.

5) Data analysis

Process and make statistics of testing data, compare results with the limits or levels of PQ indicators, and analyse the respective PQ results of background or generated by users according to the actual situation to get the assessment conclusion.

6) Put forward mitigation suggestions

If the assessment results exceed PQ limits, mitigation suggestions shall be put forward.

7) Provide report

Provide monitoring assessment report. See Annex C for the main contents of the monitoring assessment report.

5.1.4 Predicted assessment

The predicted assessment shall be used for the power quality assessment of new construction, reconstruction or expansion projects in the planning feasibility study stage.

According to the relevant load data and system parameters, modelling, simulation or analysis of the assessment object is made to get power quality data. Assessment results are compared with the limit value of PQ indicators to determine whether it meets the standard requirements. The main contents and requirements of power quality predicted assessment report are listed in Annex C.

5.1.5 Predicted assessment process

1) Object and range determination

Determine the assessment object and range according to the source and purpose of the assessment task.

2) System and equipment data collection

Collect the data of power system and equipment related to the assessment object (if it is unable to provide, refer to the same type of equipment), and determine the assessment point and limits or levels of PQ indicators.

3) Assessment under prediction

According to the influence degree of the assessment object to the assessment indicator, the predicted assessment method is used. During the assessment, the minimum (or smaller) operation mode and maximum load level of the system in the year when the load is put into operation and the year when the capacity is reached shall be considered.

4) Provide report

Provide predicted assessment report. See Annex C for the main contents of the predicted assessment report.

5.1.6 Background description and analysis

The national standards of power quality mainly include voltage sag and short-term interruption, transient and temporary overvoltage, harmonic/interharmonic, voltage fluctuation and flicker, three-phase unbalance, voltage deviation and frequency deviation. Power quality data is obtained, mainly through the establishment of power grid and load simulation models and power quality monitoring equipment, from which the basic voltage/current data can be obtained.

In different areas, different requirements of power quality may be applied for planning purposes; the level should be under the planning level.

5.1.7 Disturbance anticipation

At the planning and designing stage of power quality interference source connected to power system, qualified organizations should be delegated to conduct disturbance evaluation.

PQ predictive evaluation should be based on a local evaluation process, and it is related to load type, load electrical characteristics and electrical parameters of the grid. The main parameters include the grid voltage level, system capacity, load capacity, power quality data, maximum active power and reactive power.

For the project whose predictive evaluation result is "exceeding PQ standard limit", the PQ control technical measures need to be taken, and the power quality monitoring terminal shall be installed synchronously.

5.1.8 Impacts analysis

PQ evaluation is divided into two methods: monitoring evaluation and predictive evaluation. The monitoring evaluation should meet the needs of the grid performance evaluation. The predictive evaluation should meet the requirements of various types of power quality interference sources and sensitive users connecting the grid planning.

5.2 PQ monitoring system

5.2.1 General

PQ monitoring indicators are those stated in IEC TS 62749, i.e. supply voltage deviations and fluctuations, flicker, three-phase voltage unbalances, system frequency deviations, harmonic voltages, interharmonics, dips and swells. For different application scenarios, one or more monitoring indicators can be selected for monitoring. As stated in that document, for assessing power quality monitoring periods should not be shorter than 1 week (168 h).

Sometimes, apart from the aggregated statistical values, the intermediate magnitudes are also very important. For instance, each 10-minute RMS value is the result of previous 200-millisecond and 3-second aggregations. Those magnitudes in shorter windows can be made available for either statistical analysis or even online measurements (e.g. through the SCADA).

When direct correlations with different sources are in mind, monitoring current might help enormously. For instance, by measuring drawn current by a customer, a direct correlation between these currents and voltage fluctuations at the PCC could be outlined. Last but not least, if a relevant customer is very important for the analysis of power quality problems during events and faults, it is necessary to record the current waveforms through the power quality monitoring device.

5.2.2 Monitoring points

The selection of optimal distribution points for power quality monitoring points should consider the following factors: technical factors and economic factors.

For the power supply system, power quality monitoring can be performed at the following monitoring points:

- important busbars and outlets of substations,
- DC receiver terminals and high- and low-voltage busbars affected by the substations,
- busbars and outlets that supply power to users of the interference source,
- power connection points,
- system substations (converter stations) busbars and outlets equipped with FACTS equipment (such as SVC, STATCOM, etc.),
- substation busbars and outlets with more serious oversubscription or more complaints from users in field tests,
- power supply to sensitive users, busbars and outlets,

- customer with equipment liable to cause more distortion than would be expected from a customer their size.

For users, power quality monitoring can be performed at the following monitoring points: the connection point to the utility grid, the input and/or output side of power quality control devices (such as UPS, APF, DVR, etc.), the connection of important sensitive devices and the incoming side of a typical power quality pollution source device.

5.2.3 Monitoring equipment

Power quality instrument- class A¹ should be selected when precise measurements are necessary, for example for contractual applications that may require resolving disputes, verifying compliance with standards, etc. Power quality instrument- class S² is recommended for statistical applications such as surveys or power quality assessment, possibly with a limited subset of parameters. Devices such as fault recorders, power meters, protection relays can be selected if the measurement methods conform to IEC 61000-4-30. Measurement instruments can be fixed or portable. The instrument measurement capability should be in accordance with the phenomena to be investigated.

5.2.4 Related information and communication system

The monitoring data should have a standard format in order to interact between different application systems and achieve full potential of the value of the power quality monitoring data. Monitoring equipment could be based on IEC 61850 (all parts) to achieve power quality data modelling and communication, and any application system could obtain power quality monitoring data from monitoring instruments through it. By using IEC 61850 (all parts), any calculated power quality magnitude can be associated to a LN, either specific (e.g., logical node for harmonics, logical node for flicker, etc.) or generic (e.g., logical node for generic measurements). Management of PQ events is also included in the standard through the logical node for power quality events and logical nodes for protection related functions (for waveform recording). Moreover, by using the logical nodes and interfacing and archiving, any PQ magnitude can be periodically stored and queried.

However, this approach seems very tight and lacks flexibility. Indeed PQ magnitudes are rarely used by the SCADA system, and this is not even conceivable in LV networks due to its complexity and unnecessary overhead on PQ devices. These devices are indeed simpler: they can be queried online for real-time visualisation by high-skilled personnel, but not by SCADA operators. In fact their main goal is to produce files with PQ measurements every n-minutes, synthetic description of events and waveform recording. This process can be easily yielded by these devices either in binary or text flat formats with little overhead (see Appendix 4-A in CIGRE/CIREN C4.112).

Moreover, it should be considered whether these data-centric approaches are really appropriate when dealing with thousands of devices. In contrast, edge-computing architectures are showing up, thus lowering communication, storage and processing needs in central locations. They just get rid of the legacy generation of files and rely on embedded databases with simple HTTP interfaces.

5.3 Economical assessment

5.3.1 General

The PQ economic evaluation is the basis for power grid and users to make investment decisions for power quality control. The assessment of the economics of power quality shall be based on a clear assessment of the required basic data and data collection methods firstly;

¹ Class A: This class is used where precise measurements are necessary, for example for contractual applications that may require resolving disputes, verifying compliance with standards, etc.

² Class S: This class is used for statistical applications such as surveys or power quality assessment, possibly with a limited subset of parameters.

then calculate the economic losses caused by various types of power quality disturbances for power users and distribution networks, and then evaluate the investment benefits of mitigation projects through economic benefit analysis.

5.3.2 Economical assessment of PQ provisions

5.3.2.1 PQ economic evaluation data type

PQ economic evaluation data type consists of: basic economic cost data for the economic evaluation of the power quality of electricity users and public distribution networks, power quality related monitoring data, equipment and system parameters.

5.3.2.2 Economic cost data

The economic data of power users includes: labour costs, equipment costs, product costs, material costs, inspection and test costs, energy and power costs, and contract default costs.

Distribution network economic cost data includes: electricity costs, labour costs, equipment costs, inspection and testing costs, contract default costs.

5.3.2.3 Power quality indicator data

The PQ indicator data includes: original power quality monitoring data; annual statistical results of event-based power quality data that cause economic losses; annual statistical values of continuous power quality indicators; annual fundamental voltage, operating power, and main measurement data of electrical equipment.

5.3.2.4 Equipment and system parameters

Equipment and system parameters include: electrical equipment rated parameters, electrical equipment test parameters, power supply system operating parameters.

5.3.2.5 Power quality economic evaluation data collection method

1) Data collection

Power users or public distribution networks shall collect basic economic cost data, relevant monitoring data, equipment and system parameters for power quality through monitoring, calculation and statistical methods, and provide data basis for conducting economic losses assessment of electrical energy.

The power quality data collection cycle is generally one year. The collected data should be true, accurate, and comprehensive, reflecting the operating conditions and production characteristics of power users and public distribution networks. During the data collection process, special attention should be paid to the analysis and collection of abnormal power quality data.

The power quality economic data collection work can be carried out according to the following steps:

- a) Collect equipment and system parameters before putting the electrical equipment into operation.
- b) Conduct power quality monitoring and collect power quality monitoring data.
- c) After the occurrence of power quality disturbance, combined with power quality disturbance phenomenon, consequences and characteristics, collect and calculate the basic data of various economic losses caused by the power quality disturbance.

See Annex D for more details on data collection.

- d) After completing the various types of economic losses caused by a single power quality disturbance and collecting and statistics, all types of economic losses shall be aggregated to obtain the economic losses of this power quality disturbance.

- e) After completing the above calculation of economic data of economic power quality and calculation of economic losses, statistical work on economic loss of power quality shall be carried out on a yearly basis.

2) Data forecast

For the systems that have not yet completed the preliminary design, or the system under different operating conditions and different mitigation programs to carry out power quality economic assessment, some of the data cannot be directly collected, and can be estimated by the following two methods:

- a) Simulation prediction method: This method is suitable for event-type power quality assessment, mainly including fault point method, Monte Carlo simulation method and critical distance method.
- b) Probabilistic analysis and prediction method: This method is suitable for the continuous power quality assessment. It mainly considers the uncertainty of the disturbance, introduces the random variable and the period probability density function, and uses the probabilistic analysis method to evaluate the cycle power quality indicators and their economics loss.

5.3.3 Economical assessment of unsatisfactory PQ objectives/results

5.3.3.1 Electric power users economic loss calculation method

According to the effects of power quality disturbances on power users, the economic losses of power users can be divided into economic activity interruption losses and economic activity uninterrupted losses, such as the poor quality of products. Generally, one year is taken as the statistical period to calculate the economic losses caused by power users in one year because of power quality problems, including the loss of economic activities and the uninterrupted loss of economic activities.

The loss of economic activity is divided into: loss of single economic activity interruption and annual loss of economic activity.

The uninterrupted loss of economic activity refers to the calculation of the uninterrupted economic losses of annual economic activities after calculating the annual economic losses that are caused by the above-mentioned various types of power quality disturbances.

5.3.3.2 Distribution network economic loss calculation method

In the power grid, some of the power quality disturbances are transient impact caused by specific events while others are long-term continuous impact. Thus the economic losses of power quality in distribution networks can be divided into losses caused by event-type disturbances and losses caused by continuous disturbances. The impact of various types of power quality indicators on the distribution network, sub-index statistical calculation of economic losses is taken in consideration. One year is generally taken as the statistical period to calculate the economic losses caused by the distribution network due to power quality problems within one year, including event-based power quality economic losses and continuous power quality economic losses.

5.3.3.3 Economic evaluation method

1) Life-cycle cost analysis (LCC)

The life cycle cost (LCC) is the present value of the life cycle cost of the power quality control equipment. It is applicable to the comparison of alternative solutions when the effects of different solutions are basically the same. When the life cycle is equal, scheme with the smallest LCC value is the optimal mitigation scheme; when the life cycle is not equal, the annual value of LCC should be used, and the scheme with the smallest annual value is the optimal.

2) Net present value method (NPV)

Net present value indicates the annual cash flow during the life cycle of a project, which is the sum of the current cash flows of each year discounted to the present value at the beginning of the construction period at a certain discount rate.

Net present value method is based on the calculation of the NPV value of different power quality management schemes. The evaluation criteria are: The solution with a net present value not less than zero is a viable option. Since the NPV value cannot reflect the efficiency of the initial investment, when there is no capital constraint, the larger the NPV value, the better; when the funds are in short supply, the internal rate of return method (IRR method) should be used for evaluation.

3) Payback period method (PB)

The payback period is calculated from the start of construction of the mitigation plan and the time required for the recovery of the net cash flow of the mitigation plan for all investments.

The payback period method is based on the calculation of the payback period for different power quality management options. Its evaluation criteria is: the investment recovery period is less than the basic investment recovery period as a feasible plan, the shortest investment recovery period is the optimal plan, and the anti-risk ability is strong. The general PB method is only used as an assistant decision method.

4) Internal rate of return method (IRR)

Internal rate of return method refers to the discount rate when the present value of the net cash flow related to the project capital is equal to zero within the calculation period of the mitigation plan. It is the profit rate of the project investment and reflects the efficiency of investment use.

Internal rate of return method is based on the internal rate of return (IRR) calculation of different power quality management schemes. The evaluation criterion is that the internal rate of return greater than the benchmark rate of discount is considered to meet the requirements of investment interests; the maximum IRR is the optimal management scheme.

The economic evaluation method of power quality management scheme recommends the above four methods. In actual situation, one or more methods could be selected for evaluation according to the need, and other methods are not excluded for evaluation.

5.4 PQ requirement

According to different conditions, the power quality assessment of public power grid evaluates power supply voltage deviation, frequency deviation, harmonic voltage, voltage fluctuation and flicker, three-phase voltage unbalance, inter harmonic, etc.

The power quality assessment of the users connected to the power system evaluates power supply voltage deviation, harmonic voltage, harmonic current, voltage fluctuation and flicker, three-phase voltage unbalance, negative sequence current, frequency deviation and inter harmonic as required.

5.5 Mitigation/Trouble shooting

5.5.1 Total requirements

On the basis of meeting the requirements of the general users connected to the power system, attention should be paid to power quality problems caused by interference source users, and the principles of prevention, pollution and governance should be followed, and the public power environment should be maintained.

PQ mitigation measures can be divided into: harmonic mitigation, reactive power management, three-phase unbalance mitigation, voltage deviation mitigation, voltage sag and short-term interruption mitigation, voltage fluctuations and flicker mitigation, switching transients and temporary overvoltage mitigation.

5.5.2 Power quality mitigation scheme

5.5.2.1 Harmonic mitigation scheme

Harmonic mitigation includes active filtering and passive filtering. The principle of mitigation is local mitigation of harmonic sources, ensuring that the harmonic current of the PCC point connected to the grid is lower than the national limit value.

The mitigation methods can be implemented either on the grid side or on the load side. The main way to control harmonic pollution is to install a filter device at the harmonic source to absorb harmonic current, including active filter and passive filter. Active power filter (APF) is fed into the power network with the same harmonic current amplitude, the same phase and the opposite direction, so that the total harmonic current of the system is zero and the harmonic current can be compensated in real time. It is suitable for filtering the $2N$ times (N is a natural number which can be 1,2,3...) harmonics at the same time. Or select 2 specific harmonics within 50 times harmonics to compensate. The passive filter uses the combination of inductance, capacitance and resistance to form a single tuned filter, a double-tuned filter, a high-pass filter circuit, which can filter one or more harmonics. The most common passive filter structure is the series of inductors and capacitors, which can form a low impedance bypass for the main subharmonics.

5.5.2.2 Reactive power control scheme

The reactive power compensation measures mainly include capacitor compensation, static var compensator (SVC), static var generator (STATCOM, SVG), and the principle of mitigation should be reactive load local compensation, reducing the line loss caused by reactive power flowing in the power grid to minimize the loss of the power grid.

The shunt capacitor bank can be switched in parallel by a mechanical contact device to fix the capacitor bank on the power supply bus, and the inductive reactive power generated by the electric equipment in power system can be compensated by increasing the capacitance appropriately. In order to avoid the oscillation of the power supply system caused by the switching process, the reactor and capacitor are usually used in series, and the impedance of the compensation loop is inductive relative to the load at the harmonic frequency point, thus eliminating the harmonic oscillation caused by the capacitance of the circuit. At the same time, it has the function of limiting the inrush current.

Static var compensator (SVC) usually uses a thyristor control capacitor or reactor to connect the power supply bus, and the reactive power compensation is realized by changing its equivalent capacitance or equivalent inductance.

The static synchronous compensator/static Var Generator (SVG) is generally composed of a voltage source converter connected in parallel to the power supply bus, and the phase and amplitude of the output current of the AC side of the converter are adjusted by adjusting the phase and amplitude of the output voltage at the AC side of the converter. It absorbs or emits reactive current to meet the load requirement and realizes the purpose of dynamic reactive power compensation.

5.5.2.3 Voltage unbalance mitigation scheme

Voltage unbalance mitigation includes passive unbalanced mitigation, active unbalanced mitigation, and unbalanced load transfer mitigation.

The active unbalanced regulator is equivalent to four-wire SVG. It can dynamically treat the three-phase unbalanced current of the load. By detecting the unbalanced current of the system in real time, the system can be compensated by the opposite unbalance current and the system can reach the state of three-phase balance. Active unbalance control can achieve continuous regulation.

The passive unbalanced regulator adjusts the unbalanced current by adjusting the number of capacitors connected between phase and phase and between phase and zero line. Passive unbalance control cannot achieve continuous regulation and zero order unbalance control.

The unbalanced load transfer mitigation uses the fast switching to realize the three phase load redistribution and adjustment.

5.5.2.4 Voltage deviation mitigation scheme

Voltage deviation mitigation includes adjusting the operating mode of the power grid, OLTC and series voltage regulation, adopting reactive power compensation, balancing three-phase loads, controlling active power and power factor, adding generators battery energy storage system etc., to meet the requirements of relevant standards.

5.5.2.5 Voltage dips and short interruptions mitigation scheme

The mitigation methods can be implemented either on the grid side or on the load side.

On the grid system, it is recommended to evaluate the SARFI index and implement measures to reduce the index to be in line with IEC 61000-4 series standard. A study on area of vulnerability is recommended to be conducted for new supply applications.

There are three categories for load side voltage dip protection for industries with critical loads:

- control system protection,
- equipment protection,
- whole plant protection.

At the load side, voltage dips mitigation includes purchasing equipment that meet/exceed the IEC standard, dynamic voltage restorers, static UPS, Dynamic UPS, dip proofing system, BESS, etc.

Short interruptions can be mitigated by installing either a static UPS or a dynamic UPS.

5.5.2.6 Voltage flicker and fluctuations mitigation scheme

Voltage flicker and fluctuations mitigation include erection of dedicated lines to connect large-volume impact load users to higher voltage power supply systems, installation of fast-response static var compensators, or static var generators to dynamically compensate for load fluctuations.

Annex A (normative)

Use case

A.1 Business use cases

A.1.1 BUC 1: Manage power quality over the grid

A.1.1.1 Description of the use case

A.1.1.1.1 Name of use case

Use case identification		
ID	Area(s)/Domain(s)/Zone(s)	Name of use case
1	Customer support (CS), Network operation (NO), Network and extension planning (NE)	Manage power quality over the grid

A.1.1.1.2 Scope and objectives of use case

Scope and objectives of use case	
Scope	Power quality management of electricity transmitted and distributed on the grid to the grid users, either producer or consumer. Customer premises power quality issues and management processes are not in the scope, only power quality at the network user connection point is considered.
Objective(s)	Ensure that power quality requirements have been defined and power quality is within acceptable limits at all times. Power quality requirements concerns (IEC TS 62749) • frequency deviation, • supply voltage deviation, • voltage unbalance (positive, negative and zero voltage consequences), • harmonic and interharmonic voltages, • flicker (voltage fluctuation), • supply interruption, • voltage dips and swells, • rapid voltages changes (RVC).
Related business case(s)	Ensure customer satisfaction on power quality and availability Ensure PQ obligation related to the local regulation

A.1.1.1.3 Narrative of the use case

Narrative of use case
Short description
This business use case describes the system operator main processes to ensure continuity and quality of the electrical energy provided to the grid users at their connection point to the grid. Power quality issues on electrical grids operated by the system operator can take several forms such as: • frequency deviation, • supply voltage deviation, • voltage unbalance (positive, negative and zero voltage consequences), • harmonic and interharmonic voltages, • flicker (voltage fluctuation), • supply interruption due to faults on the operated network, faults on a higher voltage network, supply interruptions due to maintenance or construction work or major outstanding events (natural or accidental), • voltage dips and swells (short or long increase or decrease compared to acceptable threshold), • rapid voltages changes (RVC).
Complete description
The system operator main power-quality processes are organised in three scenarios depending on the state of the grid concerned by power quality issues, each of them using one or several dedicated business use cases. <u>Summary of use case</u> • Manage power quality in network planning (extension or reinforcement) <u>Description:</u> The objective is to ensure that while planning a network extension, the system operator can certify that power quality will meet power quality requirements at all times, in the network extension and also in other parts of the network connected to it. The power quality of the grid and disturbance emission of the equipment should be taken into account to ensure the reliability of the power quality. This scenario covers the case of a network extension or reinforcement used as provision for power quality issue resolution on a network area. • Manage power quality in customer support <u>Description:</u> The objective is to ensure that power quality at a grid user connection point meets power quality requirements at all times through managing • dedicated contracts with grid users including special power quality commitments and monitoring, • treatment of customer (grid user) complaints on power quality issues, • management of connection of the grid user to the grid (connection requirements, dedicated work or extension, ...), • monitoring of the PQ at connection points. • Manage power quality during construction, network operation and maintenance work (before, during and after) <u>Description:</u> The objective is to ensure that while conducting network construction or maintenance work or network operation, power quality will stay within acceptable limits for grid users, in the network extension if any and also in other parts of the network.

A.1.1.2 Use case conditions

Use case conditions
Assumptions Power quality requirements have been defined: Power quality limits can be defined by - the regulation, - the standardization, - the grid user through specific contracts for network access, - the system operator in accordance with network operation constraints. NOTE Those limits exist for security reasons, for performance of industrial processes and use of electricity.
Prerequisites /

A.1.1.3 Further information to the use case for classification/mapping

Classification information
Relation to other use cases <<BUC>> Manage power quality through distribution or transmission grid interfaces with other network <<BUC>> Take into account power quality constraints in connecting a user to the grid <<BUC>> Take into account power quality constraints in network development <<BUC>> Provide reports on network power quality <<BUC>> Manage complaints on power quality over the network <<BUC>> Take into account PQ constraints in Network Operation
Level of depth High-level
Prioritisation /
Generic, regional or national relation General
Nature of the use case BUC
Further keywords for classification Power Quality, Manage PQ

A.1.2 BUC 2: Manage complaints on power quality over the network

A.1.2.1 Description of the use case

A.1.2.1.1 Name of use case

Use case identification		
ID	Area(s)/Domain(s)/Zone(s)	Name of use case
1	Customer support (CS)	Manage complaints on power quality over the network

A.1.2.1.2 Scope and objectives of use case

Scope and objectives of use case	
Scope	Exchanges between the grid user and the network operator on managing a power quality complaint on the electricity transmitted and distributed on the grid to the grid user either producer or consumer. It can concern: • frequency deviation, • supply voltage deviation, • voltage unbalance (positive, negative and zero voltage consequences), • harmonic and interharmonic voltages, • flicker (voltage fluctuation), • supply interruption, • voltage dips and swells, • rapid voltages changes (RVC). NOTE Customer premises power quality issues can appear in complaints as it is sometimes difficult to identify the causes and root causes of a power quality issue. It is part of the scope as analyses of the complaint will help sort upstream-connection- point power-quality issues from downstream ones.
Objective(s)	Resolve power quality issue on a specific point of the network
Related business case(s)	Ensure customer satisfaction on power quality and availability

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A.1.2.1.3 Narrative of the use case

Narrative of use case	
Short description	
In order to resolve a power quality issue on a specific point of the network, several steps have to be performed: • Register the grid user complaint information. • Identify the power quality commitments potentially unfulfilled and the network events correlated. • If potentially the power quality issue can be reproduced, measure the power quality on the specific point of the network. • Assess the power quality issue (causes, root cause, etc.). • Propose a power quality solution.	
Complete description	
<u>Summary of use case</u> • Register the grid user complaint information <u>Description:</u> Through customer relationship management processes and tool, register the grid user complaint information such as: – grid user contact information, – nature of the power quality issue (supply interruption, voltage threshold, harmonics, etc.), – grid user observations (producing process abnormal interruption, equipment malfunction, etc.), – context (dates, load configuration), – potential data measured. The grid user complaints can be provided directly to the system operator or through secondary actors (supplier). • Identify the network events potentially correlated <u>Description:</u> Identify the power quality commitments potentially unfulfilled and identify the network events potentially correlated to the power quality issue. Those events may have been measured, monitored or extrapolated through statistical analyses or network simulations. • Measure power quality on the specific point of the network <u>Description:</u> Measure the power quality at the network user connection point or any relevant point of the network. • Assess the power quality issue <u>Description:</u> In order to assess a power quality issue on a specific point of the network and identify its causes and root cause, the assessment should list: – the standard values or the commitment values as indicated by contract or regulation recommended or/indicative values, – the measure or monitoring conditions associated with, – measurement methods or statistical analysis methods, It should be noted that there are some gaps between the standards, contracts and regulation, thus the measurement and assessment also need to conform to the contracts and regulation. The assessment is made over a minimum period of time depending on the phenomenon observed. • Propose and/or engineer power quality solutions <u>Description:</u> Decide and deploy power quality solutions such as – network development, – balance settings, – modify grid user connection, – modify transformer tap changer position, – modify network operation plan, – client desensitization. Check power quality on the specific point of the network after the solutions are deployed.	

A.1.2.1.4 Use case chart Key performance indicators (KPI)

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
1	Mean response time	ISO 10002:2018	Resolve power quality issue on a specific point of the network
2	Satisfaction rate	ISO 10002:2018	Resolve power quality issue on a specific point of the network

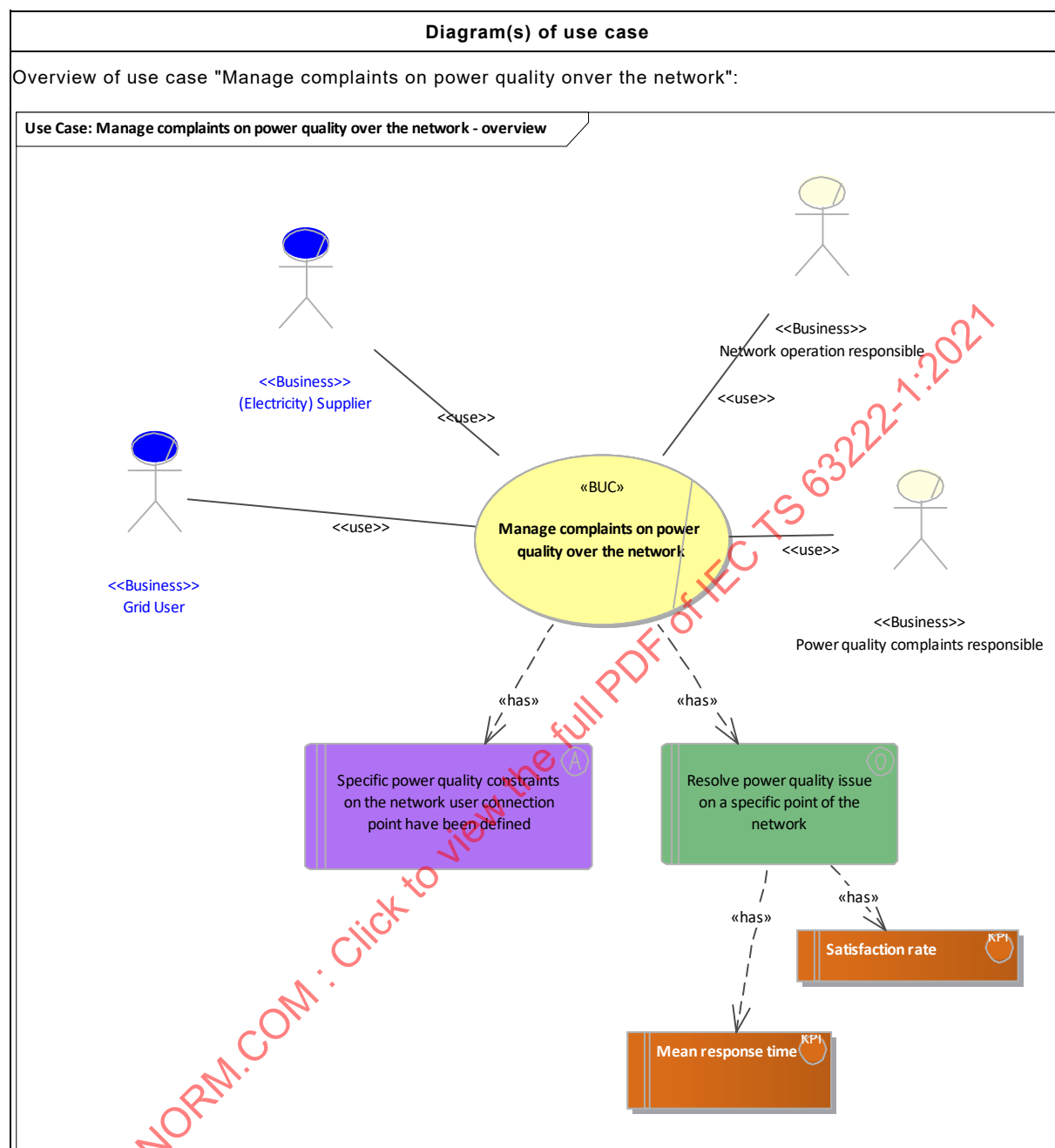
A.1.2.1.5 Use case conditions

Use case conditions	
Assumptions	
1	Specific power quality constraints on the network user connection point have been defined: On both sides of the network user connection point commitments and responsibilities concerning power quality shall be defined.
Prerequisites	
/	

A.1.2.1.6 Further information to the use case for classification/mapping

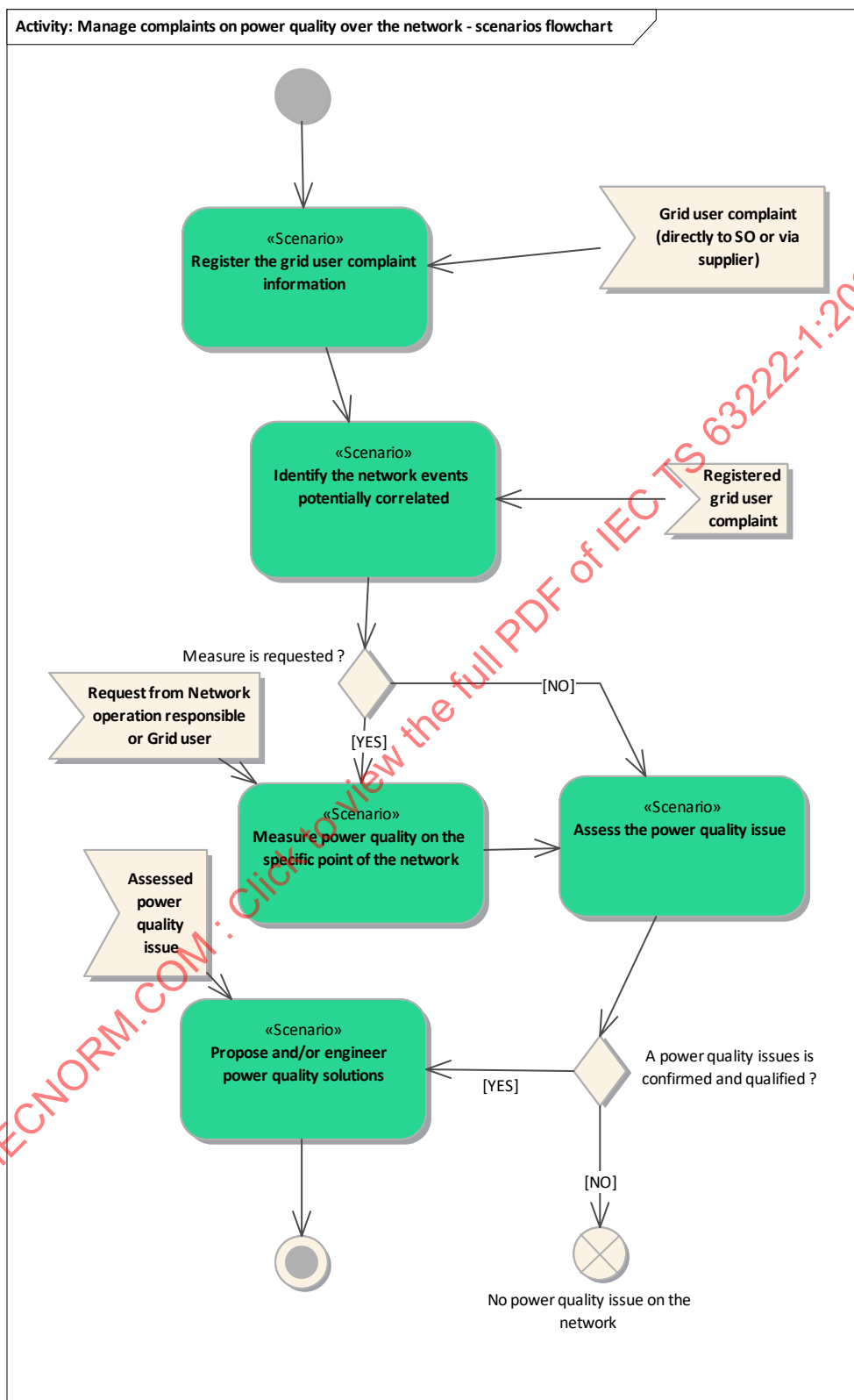
Classification information	
Relation to other use cases	
<<BUC>> Manage power quality over the grid <<SUC>> Engineer a power quality solution <<SUC>> Measure power quality on a specific point of the network	
Level of depth	
High-level use case	
Prioritisation	
/	
Generic, regional or national relation	
Generic	
Nature of the use case	
BUC	
Further keywords for classification	
Power quality, Network operation, Customer support	

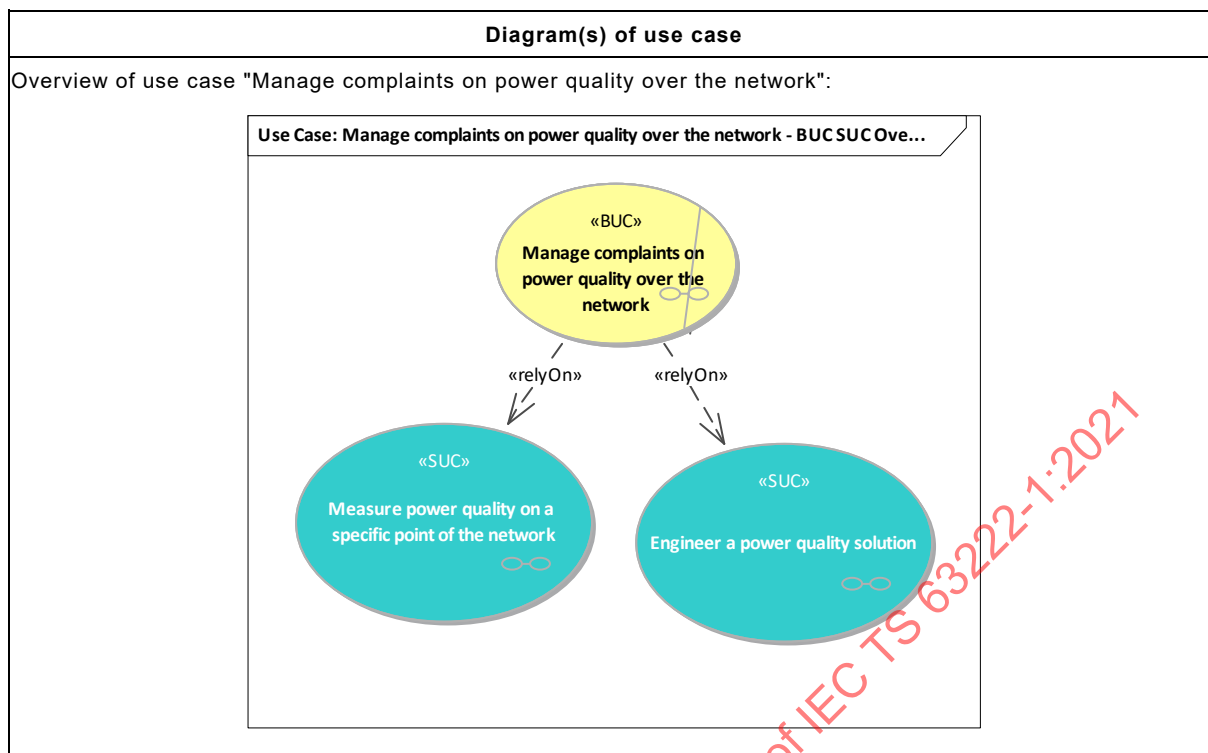
A.1.2.2 Diagrams of use case



Diagram(s) of use case

Scenarios flow chart of use case "Manage complaints on power quality over the network"





A.1.2.3 Technical details

A.1.2.3.1 Actors

Actors			
Grouping (e.g. domains, zones)		Group description	
/		/	
Actor name	Actor type	Actor description	Further information specific to this use case
Power quality complaints responsible	Business	Party responsible for customer relationship and customer support on power quality issue on part of the electric power system in a certain area	
Network operation responsible	Business	Entity responsible for the planning, operation, maintenance, and the development in given areas of the electricity network. See definitions of distribution system operator, transmission system operator.	
Grid user	Business	A party connected to the grid and consuming and/or producing electricity. Grid users include consumers, producers, and prosumers. Equivalent to party connected to the grid.	
(Electricity) Supplier	Business	Party having a contract to supply electric power and energy to a customer.	

A.1.2.3.2 References

References						
No.	Reference type	Reference	Status	Impact on use case	Originator / organisation	Link
1	Technical Specification	• IEC TS 62749:2020	Published	/	IEC	/
2	International Standard	• IEC 61000-4-30:2015	Published	/	IEC	/

A.1.2.4 Step by step analysis of use case – Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Register the grid user complaint information	Through customer relationship management processes and tool, register the grid user complaint information such as: • grid user contact information, • nature of the power quality issue (supply interruption, voltage threshold, harmonics, etc.), • grid user observations (producing process abnormal interruption, equipment malfunction, etc.), • context (dates, load configuration), • potential data measured. The grid user complaints can be provided directly to the system operator or through secondary actors (supplier).	Power quality complaints responsible	Grid user complaint (directly to SO or via supplier)	/	/
2	Identify the network events potentially correlated	Identify the power quality commitments potentially unfulfilled and identify the network events potentially correlated to the power quality issue. Those events may have been measured, monitored or extrapolated through statistical analyses or network simulations.	Network operation responsible	Registered grid user complaint	/	/
3	Measure power quality on the specific point of the network	Measure the power quality at the network user connection point or any relevant point of the network. A measurement instrument may be required.	Network operation responsible	Request from network operation responsible or grid user	/	/
4	Assess the power quality issue	In order to assess a power quality issue on a specific point of the network and identify its causes and root cause, the assessment should list: • the standard values or the commitment values as indicated by contract or regulation recommended or indicative values, • the measure or monitoring conditions associated with, • measurement methods or statistical analysis methods. The assessment is made over a minimum period of time depending on the phenomenon observed.	Network operation responsible	/	/	/

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
5	Propose and/or engineer power quality solutions	Decide and deploy power quality solutions such as • network development, • balance settings, • modify grid user connection, modify transformer tap changer position, • modify network operation plan, • client desensitization. Check power quality on the specific point of the network after the solutions are deployed.	Network operation responsible	Assessed power quality issue	/	/

A.1.3 BUC 3: Provide reports on network power quality

A.1.3.1 Description of the use case

A.1.3.1.1 Name of use case

Use case identification		
ID	Area(s)/Domain(s)/Zone(s)	Name of use case
1	Customer support (CS), Network operation (NO), Network and extension planning (NE)	Provide reports on network power quality

A.1.3.1.2 Scope and objectives of use case

Scope and objectives of use case	
Scope	Reporting on power quality of the electricity transmitted and distributed on the grid to the grid users, either producer or consumer based on data measured, statistical analysis or simulated data. This reporting can apply to grid user connection points, on one point, on a specific area or on the whole network. It can apply also to TSO-DSO or DSO-DSO interfaces.
Objective(s)	Comply with contractual and regulatory commitments on network power quality management
Related business case(s)	Ensure PQ obligation related to the local regulation Ensure customer satisfaction on power quality and availability

A.1.3.1.3 Narrative of the use case

Narrative of use case	
Short description	
Reporting and assessment on power quality against standards can be required by regulatory authorities, other network operators or grid users for survey, compliance with connection agreement, compliance with quality regulation, or benchmarking. This business use case describes the system operator main processes to retrieve, build, analyse power quality data and report on it for different commitments.	
Complete description	
The system operator main power-quality reporting processes are split in 3 main activities, each of them using one or several System use cases.	
<u>Summary of use case</u> Retrieve power quality data from the field <u>Description:</u> The objective is to retrieve the data measured on the field by power-quality dedicated instruments, equipment dedicated to other purposes (network operation, metering, etc.) or coming from monitoring systems. The data should be post-processed to obtain valid statistical indices. Build power quality data from statistical analysis and network simulations <u>Description:</u> The objective is to build complementary power quality data using - statistical analysis based on cross-referencing measures and monitoring data with non-power quality data (topology, weather, network events, etc.) to complete existing data, - network simulation used to extrapolate data on parts of the network where it is not available or to assess the impact on power quality of network operation or maintenance and construction work. Analyse power quality data and build a report on it <u>Description:</u> The objective is to analyse power quality data on different criteria depending on the reporting needs (target, commitments, etc.), criteria examples: - number or ratio of grid users impacted, - causes and root causes, - network location/extent of the power quality issue, - power quality interruption indices: SAIDI, SAIFI.	

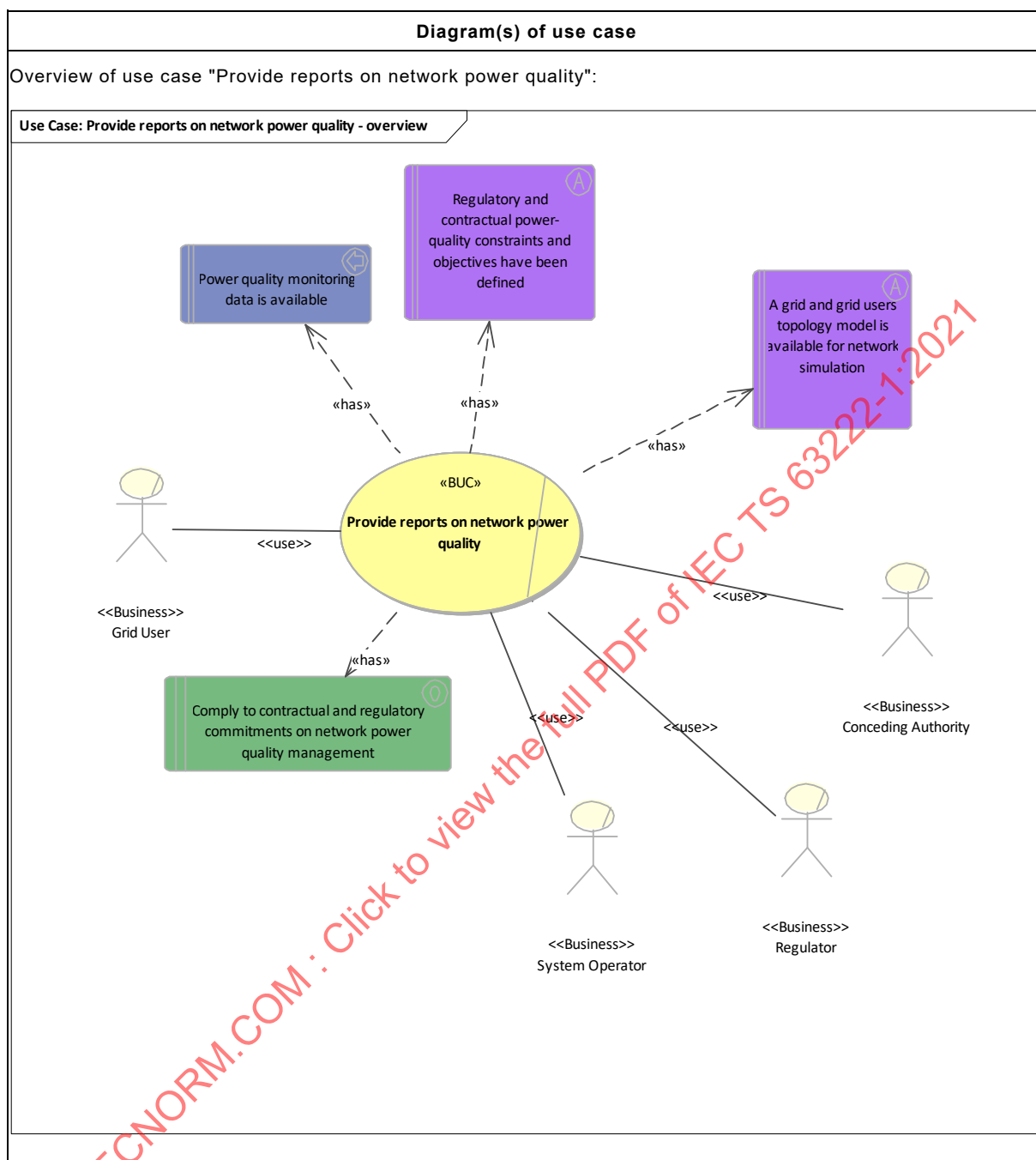
A.1.3.1.4 Use case conditions

Use case conditions	
Assumptions	
1	Regulatory and contractual power-quality constraints and objectives have been defined.
2	A grid and grid users topology model is available for network simulation.
Prerequisites	
1	Power quality monitoring data is available.

A.1.3.1.5 Further information to the use case for classification/mapping

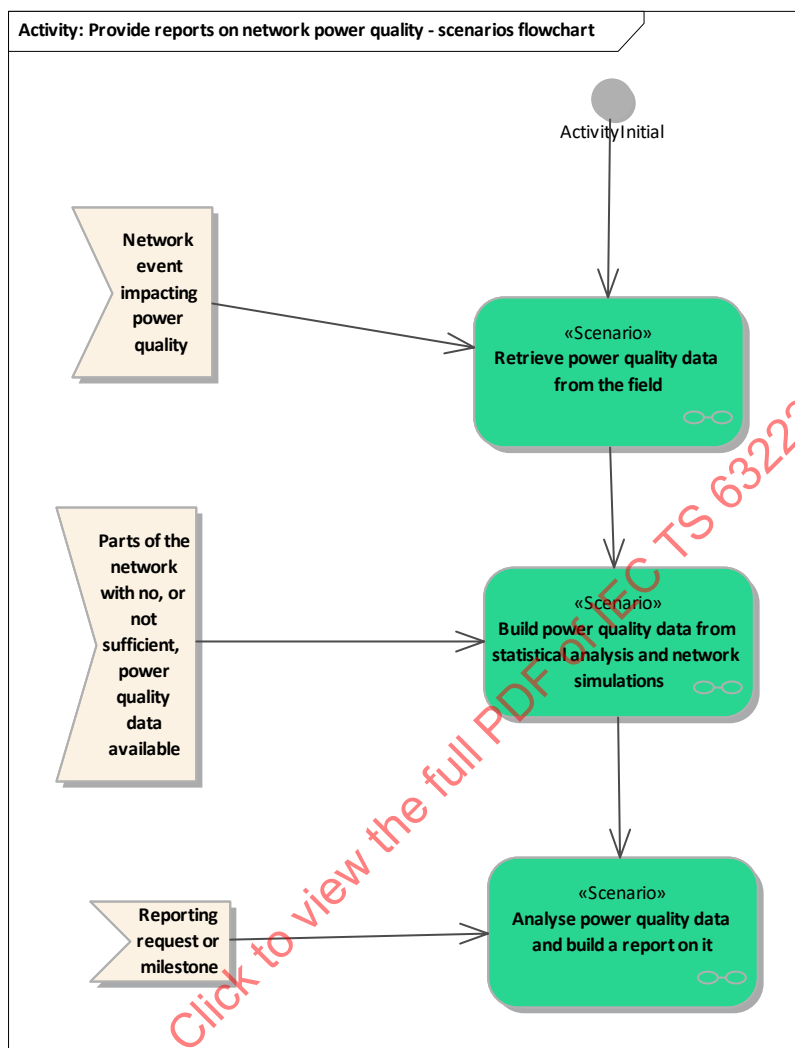
Classification information
Relation to other use cases
<<BUC>> Manage power quality over the grid <<SUC>> Assess power quality on the network <<SUC>> Monitor power quality on the network
Level of depth
/
Prioritisation
/
Generic, regional or national relation
/
Nature of the use case
BUC
Further keywords for classification
Power Quality, Reporting, Monitoring

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A.1.3.2 Diagrams of use case

Diagram(s) of use case

Scenarios flowchart of use case "Provide reports on network power quality":



A.1.3.3 Technical details**A.1.3.3.1 Actors**

Actors			
Grouping (e.g. domains, zones)		Group description	
/		/	
Actor name	Actor type	Actor description	Further information specific to this use case
Conceding authority	Business	Authority that owns (a part of) the distribution grid and delegates its operation to a distribution grid operator in a system where electricity distribution is operated as a concession. The conceding authority is usually a local authority or a municipality.	/
Regulator	Business	Authority that is responsible for preparing or adopting regulations. May be responsible for exercising autonomous authority over electricity markets and the associated synchronous electricity grids. Equivalent to regulatory authority. [SOURCE: Based on IEC 60050-901:2013, 901-03-11]	/
Grid user	Business	A party connected to the grid and consuming and/or producing electricity. Grid users include consumers, producers, and prosumers. Equivalent to party connected to the grid.	/
System operator	Business	Party responsible for safe and reliable operation of a part of the electric power system in a certain area and for connection to other parts of the electric power system. [SOURCE: IEC 60050-617:2009, 617-02-09]	/

A.1.3.3.2 References

References						
No.	Reference type	Reference	Status	Impact on use case	Originator / organisation	Link
1	Technical Specification	• IEC TS 62749:2020	Published	/	IEC	/
2	International Standard	• IEC 61000-4-30:2015	Published	/	IEC	/
3	Technical Report	• IEC TR 61850-90-17:2017	Published	/	IEC	/
4	International Standard	• IEC 61968-9:2013	Published	/	IEC	/

A.1.3.4 Step by step analysis of use case – Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Retrieve power quality data from the field	The objective is to retrieve the data measured on the field by power-quality dedicated instruments, equipment dedicated to other purposes (network operation, metering, etc.) or coming from monitoring systems	System operator	Network event impacting power quality	/	Measure or monitoring data are stored
2	Build power quality data from statistical analysis and network simulations	The objective is to build complementary power quality data using - statistical analysis based on cross-referencing measures and monitoring data with non-power quality data (topology, weather, network events, etc.) to complete existing data, - network simulation used to extrapolate data on parts of the network where it is not available or to assess the impact on power quality of network operation or maintenance and construction work.	System operator	Parts of the network with no, or not sufficient, power quality data available	/	Built power quality data available
3	Analyse power quality data and build a report on it	The objective is to analyse power quality data on different criteria depending on the reporting needs (target, commitments, ...), criteria examples: - number or ratio of grid users impacted, - causes and root causes, - network location/extent of the power quality issue, - power quality interruption indices: SAIDI, SAIFI.	System operator	Reporting request or milestone	Power quality data is available	Reporting is available

A.1.4 BUC 4: Take into account power quality constraints in connecting a user to the grid

A.1.4.1 Description of the use case

A.1.4.1.1 Name of use case

Use case identification		
ID	Area(s)/Domain(s)/Zone(s)	Name of use case
1	Customer support (CS), Network operation (NO), Network and extension planning (NE)	Take into account power quality constraints in connecting a user to the grid

A.1.4.1.2 Scope and objectives of use case

Scope and objectives of use case	
Scope	The power quality assessment process for new user connection to grid. It can concern: • frequency deviation, • supply voltage deviation, • voltage unbalance (positive, negative and zero voltage consequences), • harmonic and interharmonic voltages, • flicker (voltage fluctuation), • supply interruption, • voltage dips and swells, • rapid voltages changes (RVC).
Objective(s)	New user is connected to the grid, which can meet the power quality of load and the grid. New user is connected to the grid according to the process. The power quality of the grid and the new users meet the standard's requirement.
Related business case(s)	Manage power quality over the grid Provide reports on network power quality

A.1.4.1.3 Narrative of the use case

Narrative of use case
Short description
In order to connect new user to the grid, several steps have to be performed: • If the new user meets the relevant requirements, the load can be allowed to connect to the grid directly. • Evaluate new user power quality disturbance emission and the pre-existing harmonic voltage amplification. • Install appropriate mitigation equipment for new user with excessive power quality emission.
Complete description
• New user automatic acceptance <u>Description:</u> New users with small amount of power quality disturbance can be allowed to connect to the grid directly. Detailed evaluation is no longer required. In order to be automatically accepted, the user's load specific parameters should satisfy conservative criteria according to stage 1 of IEC TR 61000-3-6, IEC TR 61000-3-7, IEC TR 61000-3-13, IEC TR 61000-3-14: – voltage level, – capacity, – short circuit capacity. The parameters should be controlled in a certain range. In different areas, specific requirements may be applied. • Evaluation of new user disturbance emission <u>Description:</u> The new user's load shall adhere to the power quality disturbance emission limits by performing a detailed power quality analysis and submitting a report to the system operator. • Installation of mitigation equipment <u>Description:</u> If the new user's calculations do not conform to the power quality management, the economic rationality of different mitigation equipment may be evaluated through testing, monitoring, simulation or evaluation or other technical measures. Afterwards, the installation of appropriate mitigation equipment, such as dynamic compensation equipment, etc., is selected and connected to the power grid. For sensitive users, if the background power quality does not meet the requirements, add special power supply line power supply, or install mitigation device.

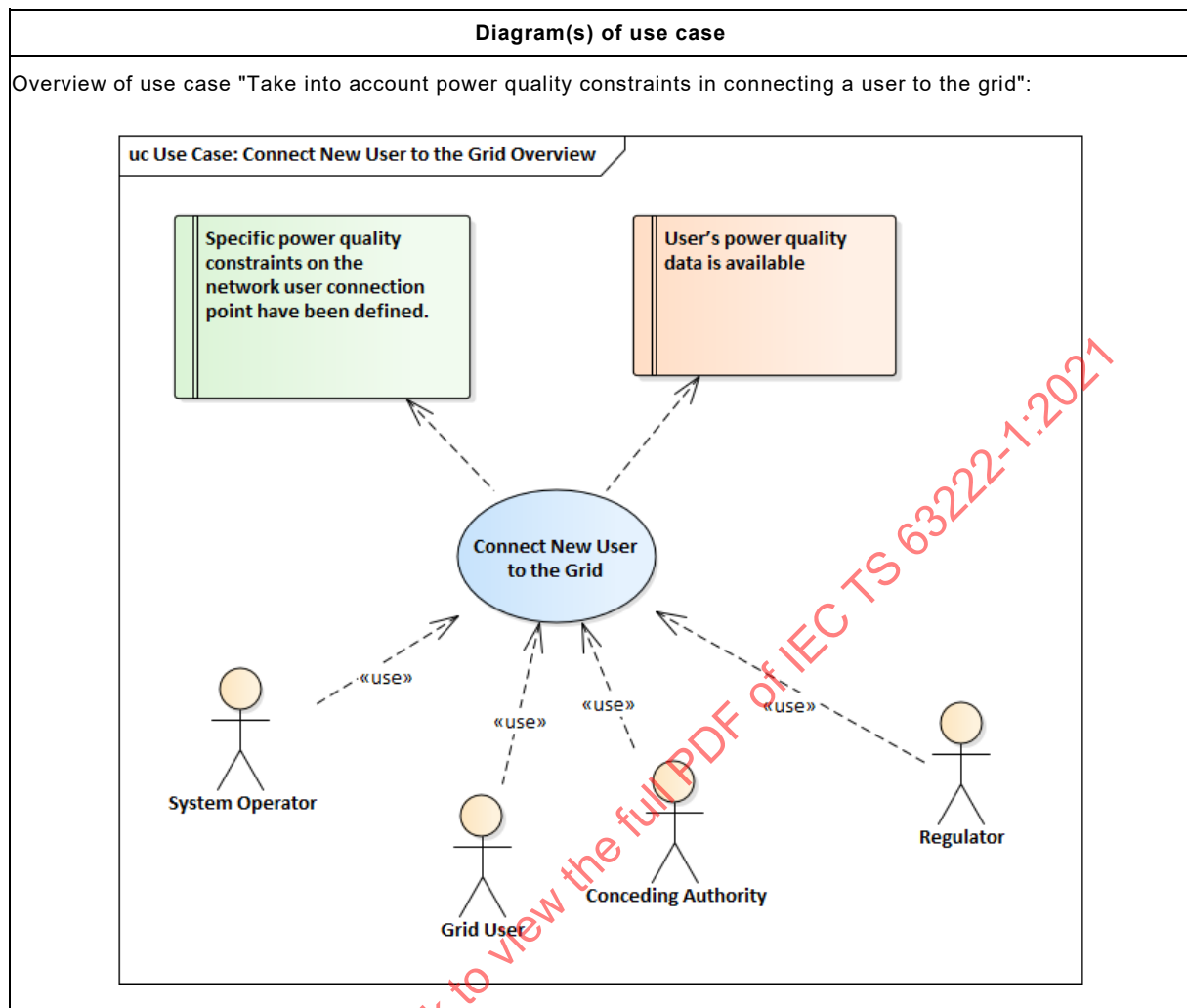
A.1.4.1.4 Use case conditions

Use case conditions	
Assumptions	
1	Specific power quality constraints on the network user connection point have been defined.
Prerequisites	
1	User's power quality data is available.

A.1.4.1.5 Further information to the use case for classification/mapping

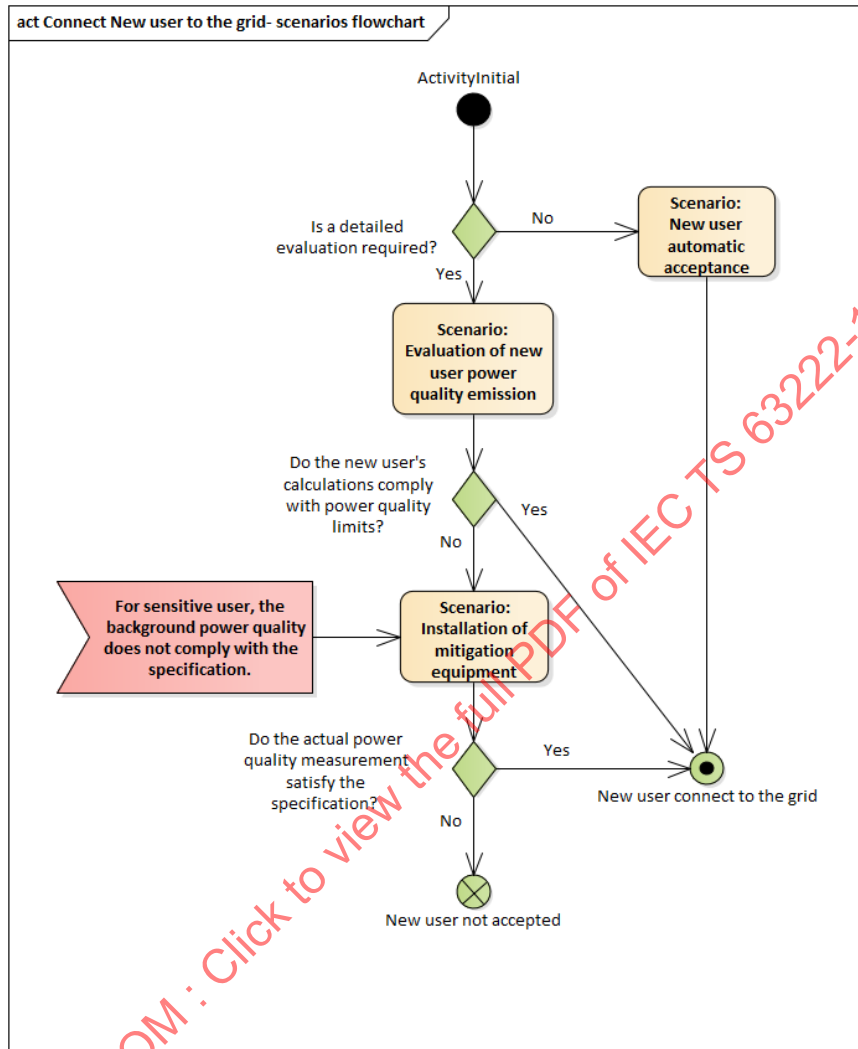
Classification information	
Relation to other use cases	
<<BUC>> Manage power quality over the grid	
<<BUC>> Provide reports on network power quality	
<<SUC>> Measure power quality on a specific point of the network	
Level of depth	
/	
Prioritisation	
/	
Generic, regional or national relation	
/	
Nature of the use case	
BUC	
Further keywords for classification	
Power Quality, Reporting, New user	

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A.1.4.2 Diagrams of use case

Diagram(s) of use case

Scenarios flowchart of use case "Take into account power quality constraints in connecting a user to the grid":



A.1.4.3 Technical details**A.1.4.3.1 Actors**

Actors			
Grouping (e.g. domains, zones)		Group description	
/		/	
Actor name	Actor type	Actor description	Further information specific to this use case
Regulator	Business	Authority that is responsible for preparing or adopting regulations. May be responsible for exercising autonomous authority over electricity markets and the associated synchronous electricity grids. Equivalent to regulatory authority. [Source: Based on IEC 60050-901:2013, 901-03-11]	/
Grid user	Business	A party connected to the grid and consuming and/or producing electricity. Grid users include consumers, producers, and prosumers. Equivalent to party connected to the grid.	/
System operator	Business	Party responsible for safe and reliable operation of a part of the electric power system in a certain area and for connection to other parts of the electric power system. [SOURCE: IEC 60050-617:2009, 617-02-09]	/

A.1.4.3.2 References

References						
No.	Reference type	Reference	Status	Impact on use case	Originator / organisation	Link
1	International Standard	IEC 61000-4-30:2015	Published	/	IEC	/
2	Technical Specification	IEC TS 62749:2020	Published	/	IEC	/
3	Technical Report	IEC TR 61000-3-6	Published	/	IEC	/
4	Technical Report	IEC TR 61000-3-7	Published	/	IEC	/
5	Technical Report	IEC TR 61000-3-13	Published	/	IEC	/
6	Technical Report	IEC 61000-3-14	Published	/	IEC	/

A.1.4.4 Step by step analysis of use case – Overview of scenarios

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	New user automatic acceptance	New users with small amount of power quality disturbance can be allowed to connect to the grid directly. Detailed evaluation is no longer required. In order to be automatically accepted, the user's load parameters should satisfy the criteria: - voltage level, - capacity, - short circuit capacity. The parameters should be controlled in a certain range. In different areas, specific indicators may be applied.	System operator	/	New user connects to grid	/
2	Evaluation of new user power quality emission	The new users shall adhere to the power quality disturbance threshold by performing a detailed power quality analysis and submitting a report to the system operator.	System operator	/	New user cannot directly connect to grid	/
3	Installation of mitigation equipment	If the new user doesn't meet the requirements, the economic rationality of different mitigation equipment shall be evaluated through testing, monitoring, simulation and evaluation and other technical measures. The installation of appropriate mitigation equipment, such as dynamic compensation equipment etc., shall be selected and connected to the power grid. For sensitive users, if the background power quality does not conform to the specification, add special power supply line power supply, or install mitigation device.	System operator	For sensitive users, the background power quality does not conform to the specification.	The new user's calculations do not conform to the power quality management.	/

A.2 System UCs

A.2.1 SUC1: Measure power quality on a specific point of the network

A.2.1.1 Description of the use case

A.2.1.1.1 Name of use case

Use case identification		
ID	Area(s)/Domain(s)/Zone(s)	Name of use case
1	Customer support (CS), Network operation (NO), Network and extension planning (NE)	Measure power quality on a specific point of the network

A.2.1.1.2 Version management

Version management				
Version No.	Date	Name of author(s)	Changes	Approval status
1	2020-05-12	Miao Huiyu	Creation	/
2	2020-05-27	Simon Issard	Update model	/

A.2.1.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	The use case defines the methods for measurement and interpretation of results for power quality on a specific point of the network. Measurement methods are described in terms that give reliable and repeatable results, regardless of the method's implementation. The considered power quality parameters include but are not limited to: • frequency deviation, • supply voltage deviation, • voltage unbalance (positive, negative and zero voltage consequences), • harmonic and interharmonic voltages, • flicker (voltage fluctuation), • supply interruption, • voltage dips and swells, • rapid voltages changes (RVC).
Objective(s)	The power quality of the special point in the power grid is measured accurately, and the data is stored. On a specific point of the network, measure and log relevant power quality events. Observe, measure and log all the relevant power quality events (power outage, faults, etc.) on a specific point of the network such as grid user connection point, network interfaces, key nodes.
Related business case(s)	/

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A.2.1.1.4 Narrative of use case

Narrative of use case	
Short description	
For each parameter measured, there are two classes (A and S). For each class, measurement methods and appropriate performance requirements are included. Class A is used where precise measurements are needed. Class S is used for statistical application. Users shall select the class based on the applications. Power quality measurement data and investigation of specific point to the network are useful for analysis (Emphasis should be focused on the measurement of current which is invaluable in determining sources/causes of power quality disturbances, since it can help to determine if the cause of the problem is upstream or downstream of the measuring instrument in IEC 62749:2020 5.1)	
Complete description	
Measuring power quality on a specific point is organised in five scenarios, depending on the state of the grid concerned by power quality issues, each of them using one or several dedicated system use cases. <u>Summary of use case</u> Determine the organization of the measurement <u>Description:</u> The electrical quantity to be measured may be either directly accessible, as is generally the case in low voltage systems, or accessible via measurement transducers. The measurement chain usually contains measurement transducers, measurement unit and evaluation unit. Determine the electrical values to be measured <u>Description:</u> Measurements can be performed on single-phase or polyphase supply systems. Depending on the context, it may be necessary to measure voltage between phase conductor and neutral (line-to-neutral) or between phase conductors (line-to-line) or between phase conductors or neutral and earth (phase-to-earth, neutral-to-earth). Phase-to-phase instantaneous values can be measured directly or derived from instantaneous phase-to-neutral measured values. Current measurements can be performed on each conductor of supply systems, including the neutral conductor and the protective earth conductor. Aggregate measurement over time intervals <u>Description:</u> The basic measurement time interval for parameter magnitudes (supply voltage, harmonic, interharmonics and unbalance) shall be a 10-cycle time interval for a 50 Hz power system or 12-cycle time interval for a 60 Hz power system. The 10/12-cycle values are then aggregated over additional intervals. The commonly used time intervals are 150/180-cycle interval, 10 min interval, 2 h interval. Measurement aggregations shall be performed using the square root of the arithmetic mean of the squared input values. The 10/12-cycle measurement shall be re-synchronized at every RTC 10 min tick in Class A. Resynchronization with the 10 min tick is permitted but not required in Class S. Manage real time clock (RTC) uncertainty <u>Description:</u> RTC uncertainty is defined relative to coordinated universal time. In Class A, the RTC uncertainty shall not exceed ± 20 ms for 50 Hz or 16,7 ms for 60 Hz. In Class S, the uncertainty shall not exceed ± 5 s per 24 h period. The performance can be achieved, for example, through a GPS receiver, or through reception of transmitted radio timing signals. When synchronization by an external signal becomes unavailable, the RTC tolerance shall be better than ± 1 s per 24 h period. Trigger and flag measurement <u>Description:</u> Flagging is triggered by dips, swell and interruption. Once triggered, all measurement channels shall be opened to record the transient waveform and effective values. Values, such as frequency, voltage deviation, voltage unbalance, harmonics and interharmonics shall be flagged when trigger event happens.	

A.2.1.1.5 Use case conditions

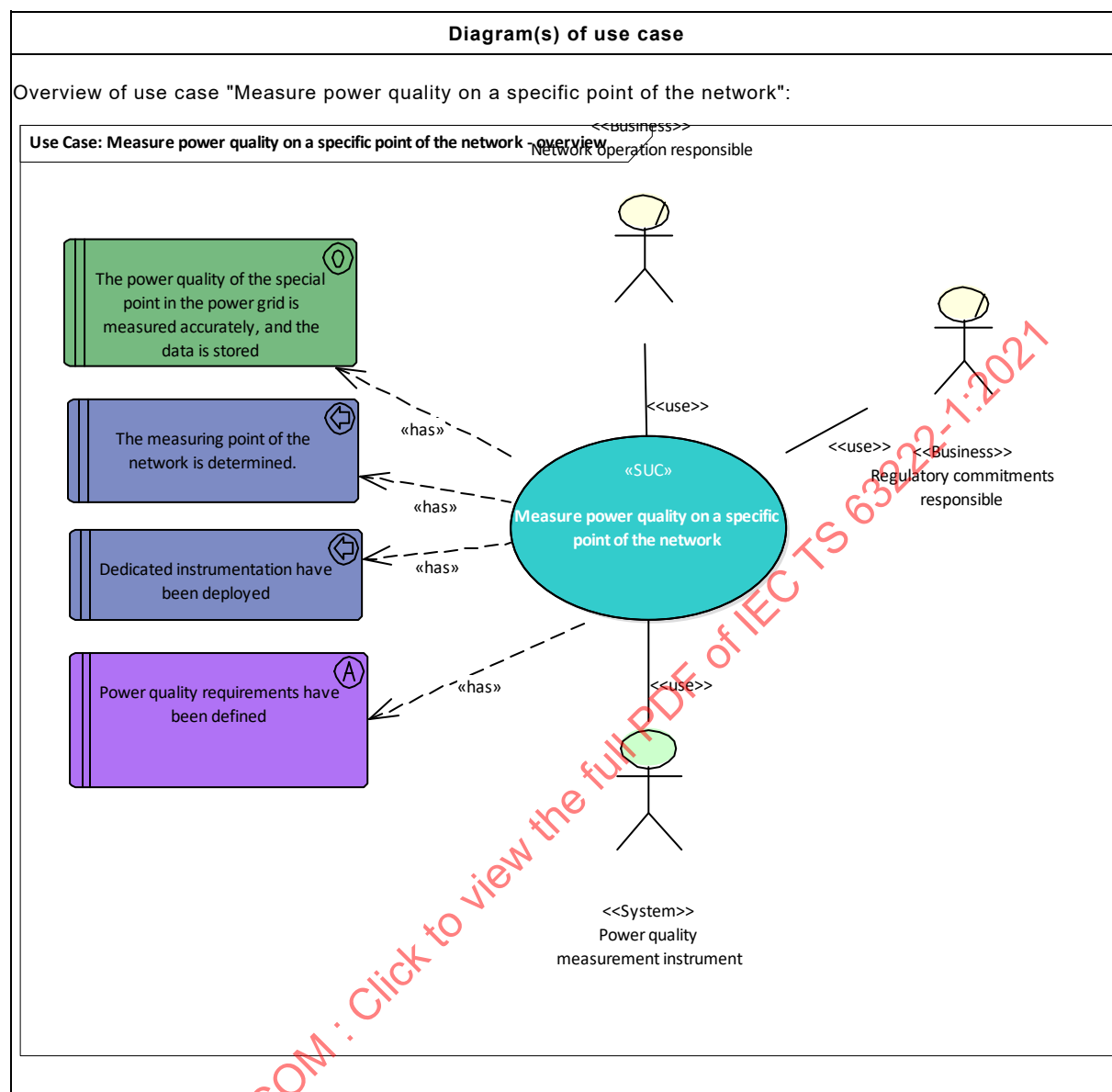
Use case conditions	
Assumptions	
1	Power quality requirements have been defined.
Prerequisites	
1	Dedicated instrumentation has been deployed: On the selected point of the network, instruments to measure relevant power quality data have been installed.
2	The measuring point of the network is determined.

A.2.1.1.6 Further information to the use case for classification/mapping

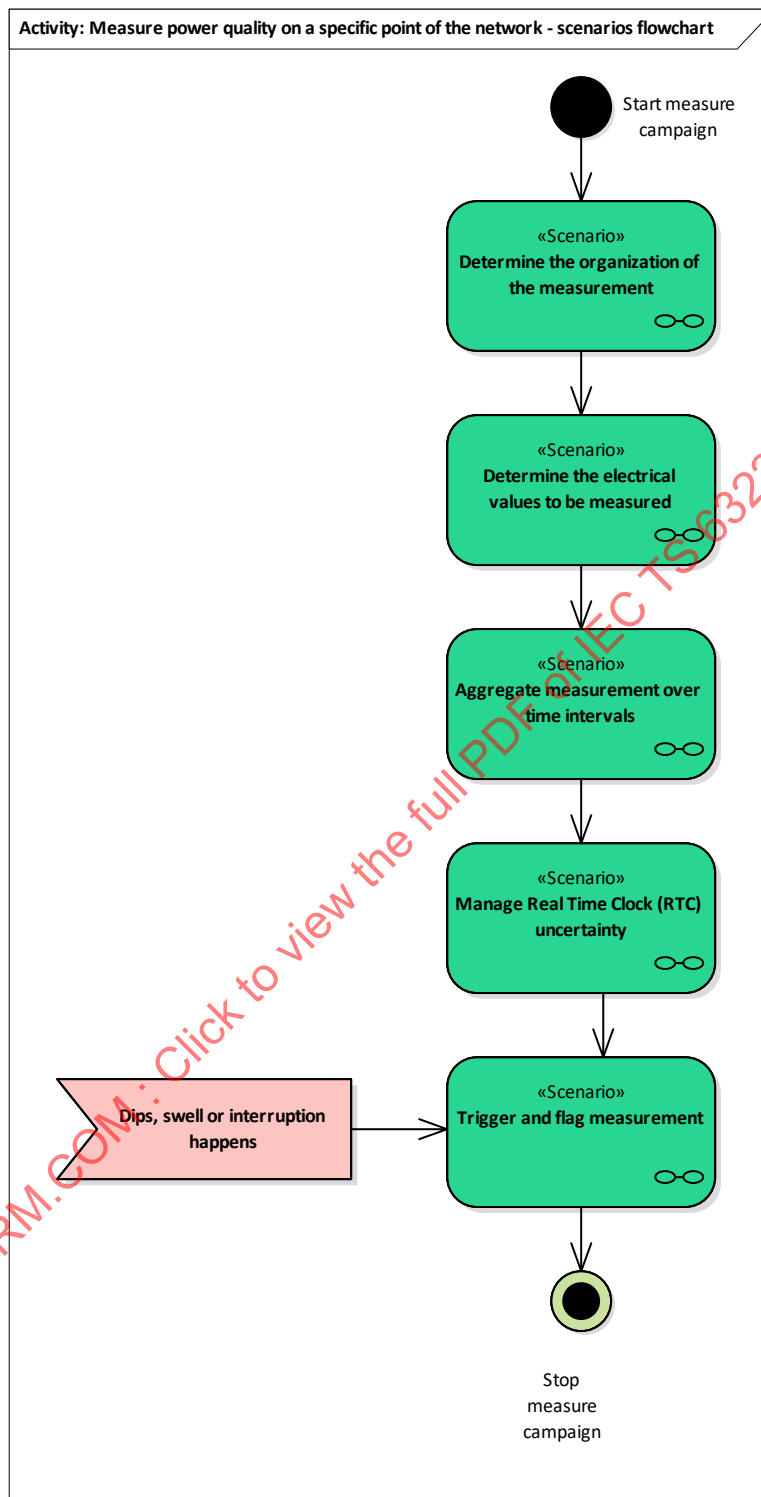
Classification information
Relation to other use cases
<<BUC>> [] Manage complaints on power quality over the network
Level of depth
/
Prioritisation
/
Generic, regional or national relation
Generic
Nature of the use case
SUC
Further keywords for classification
Power quality, Manage PQ, Monitor, Measurement

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A.2.1.2 Diagrams of use case



Scenarios flowchart of use case "Measure power quality on a specific point of the network":



A.2.1.3 Technical details

A.2.1.3.1 Actors

Actors			
Grouping (e.g. domains, zones)		Group description	
/		/	
Actor name	Actor type	Actor description	Further information specific to this use case
Onsite power quality measurement instrument	System	/	/
Mobile power quality measurement instrument	System	/	/
Power quality measurement instrument	System	/	/
Power quality complaints responsible	Business	Party responsible for customer relationship and customer support on power quality issues on part of the electric power system in a certain area	/
Network operation responsible	Business	Entity responsible for the planning, operation, maintenance, and the development in given areas of the electricity network. See definitions of distribution system operator, transmission system operator.	/
Regulatory commitments responsible	Business	/	/

A.2.1.3.2 References

References						
No.	Reference type	Reference	Status	Impact on use case	Originator / organisation	Link
1	International Standard	IEC 61000-4-30:2015	Published	/	IEC	/
2	International Standard	IEC 61000-4-15	Published	/	IEC	/
3	Technical Specification	IEC TS 62749:2020	Published	/	IEC	/

A.2.1.4 Step by step analysis of use case

A.2.1.4.1 Overview of scenarios

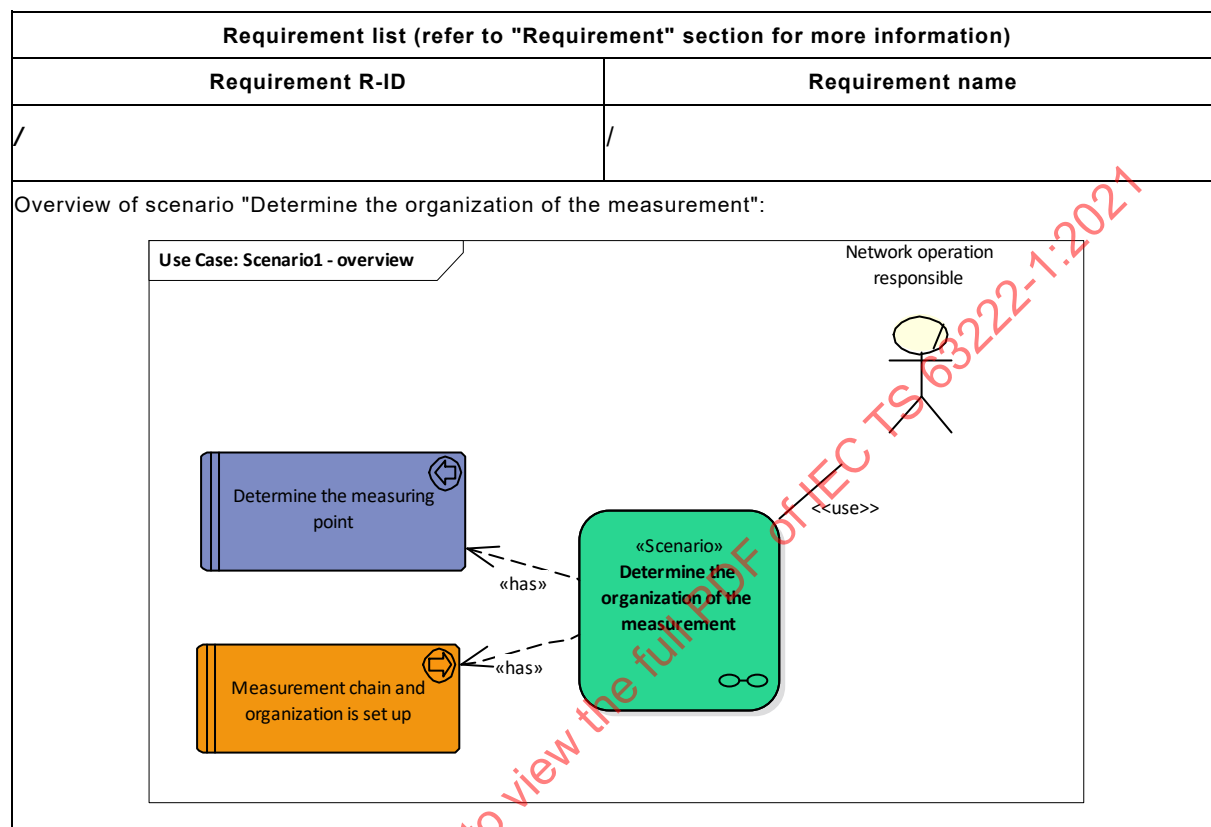
Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Determine the organization of the measurement	The electrical quantity to be measured may be either directly accessible, as is generally the case in low voltage systems, or accessible via measurement transducers. The measurement chain usually contains measurement transducers, measurement unit and evaluation unit.	/	/	Determine the measuring point	Measurement chain and organization is set up

Scenario conditions						
No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
2	Determine the electrical values to be measured	Measurements can be performed on single-phase or polyphase supply systems. Depending on the context, it may be necessary to measure voltage between phase conductor and neutral (line-to-neutral) or between phase conductors (line-to-line) or between phase conductors or neutral and earth (phase-to-earth, neutral-to-earth). Phase-to-phase instantaneous values can be measured directly or derived from instantaneous phase-to-neutral measured values. Current measurements can be performed on each conductor of supply systems, including the neutral conductor and the protective earth conductor.	/	/	Determine the organization of the measurements and the measured power quality value. Determine the measuring point	Electrical measurements to perform are defined (voltage/current, phases, etc.)
3	Aggregate measurement over time intervals	The basic measurement time interval for parameter magnitudes (supply voltage, harmonic, interharmonics and unbalance) shall be a 10-cycle time interval for 50 Hz power systems or 12-cycle time interval for 60 Hz power systems. The 10/12-cycle values are then aggregated over additional intervals. The commonly used time intervals are 150/180-cycle interval, 10 min interval, 2 h interval. Measurement aggregations shall be performed using the square root of the arithmetic mean of the squared input values. The 10/12-cycle measurement shall be re-synchronized at every RTC 10 min tick in Class A. Resynchronization with the 10 min tick is permitted but not required in Class S.	/	/	Determine the electrical measurement to perform. Determine the measuring point. Determine the organization of the measurements and the measured power quality value.	Electrical measures are aggregated
4	Manage real time clock (RTC) uncertainty	RTC uncertainty is defined relative to coordinated universal time. In Class A, the RTC uncertainty shall not exceed ± 20 ms for 50 Hz or $\pm 16,7$ ms for 60 Hz. In Class S, the uncertainty shall not exceed ± 5 s per 24 h period. The performance can be achieved, for example, through a GPS receiver, or through reception of transmitted radio timing signals. When synchronization by an external signal becomes unavailable, the RTC tolerance shall be better than ± 1 s per 24 h period.	/	/	Electrical measurements are aggregated	/
5	Trigger and flag measurement	Flagging is triggered by dips, swell and interruption. Once triggered, all measurement channels shall be opened to record the transient waveform and effective values. Values, such as frequency, voltage deviation, voltage unbalance, harmonics and interharmonics shall be flagged when trigger event happens.	/	Dips, swell or interruption happen	RTC uncertainty is managed. Electrical measurement are aggregated.	/

A.2.1.4.2 Steps – Scenarios

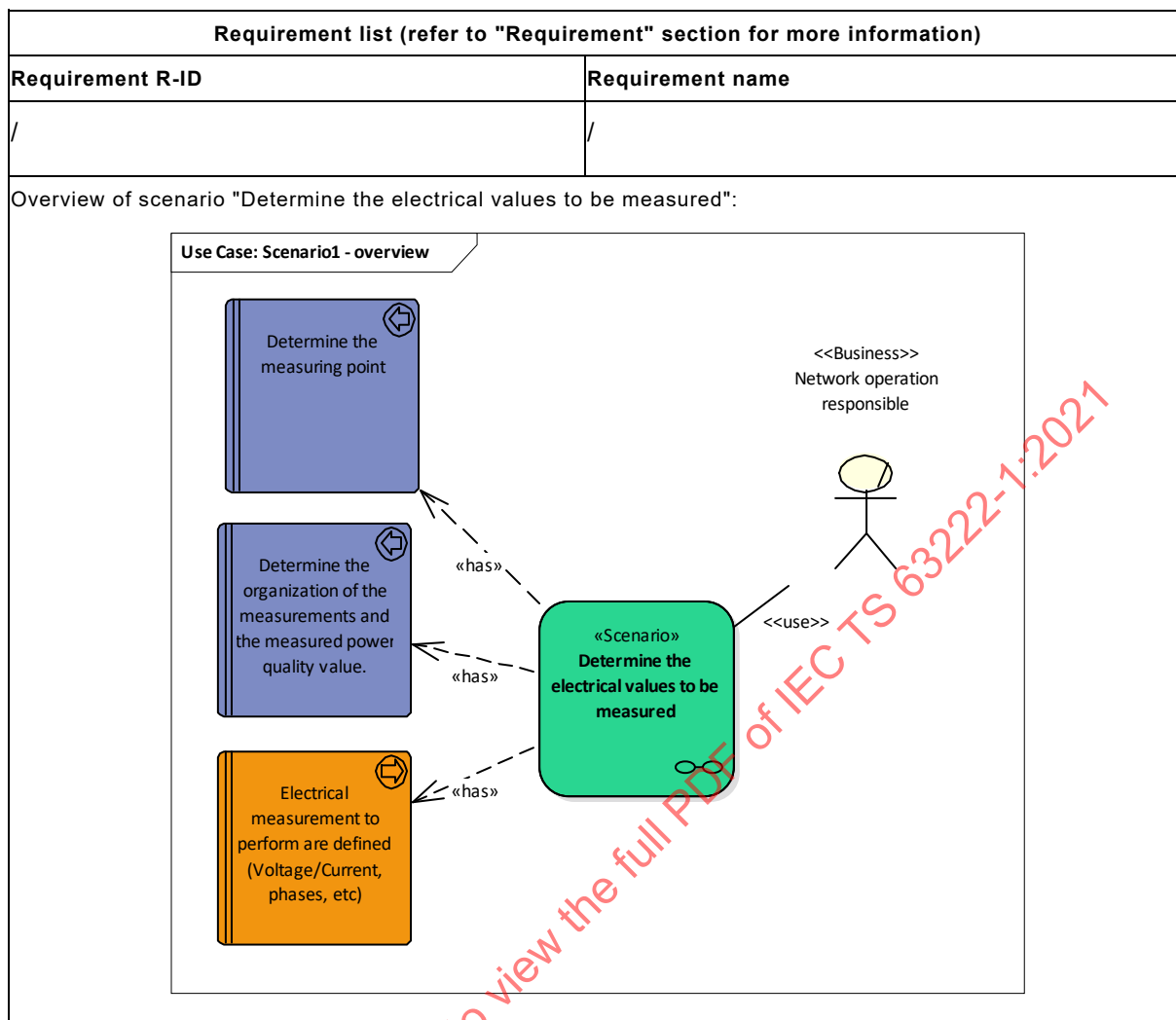
- **Determine the organization of the measurement**

The electrical quantity to be measured may be either directly accessible, as is generally the case in low voltage systems, or accessible via measurement transducers. The measurement chain usually contains measurement transducers, measurement units and evaluation units.



- **Determine the electrical values to be measured**

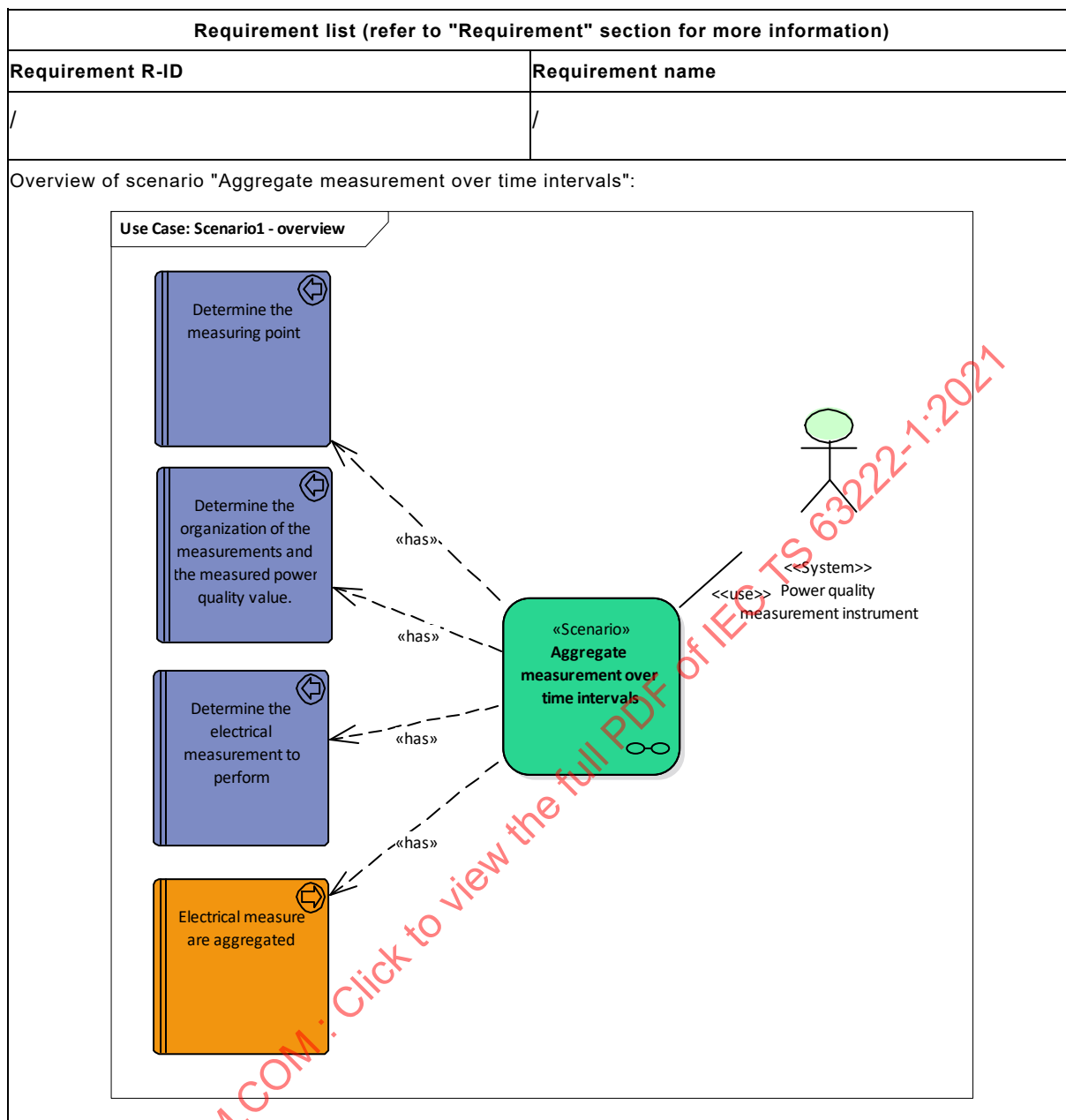
Measurements can be performed on single-phase or polyphase supply systems. Depending on the context, it may be necessary to measure voltage between phase conductor and neutral (line-to-neutral) or between phase conductors (line-to-line) or between phase conductors or neutral and earth (phase-to-earth, neutral-to-earth). Phase-to-phase instantaneous values can be measured directly or derived from instantaneous phase-to-neutral measured values. Current measurements can be performed on each conductor of supply systems, including the neutral conductor and the protective earth conductor.



- **Aggregate measurement over time intervals**

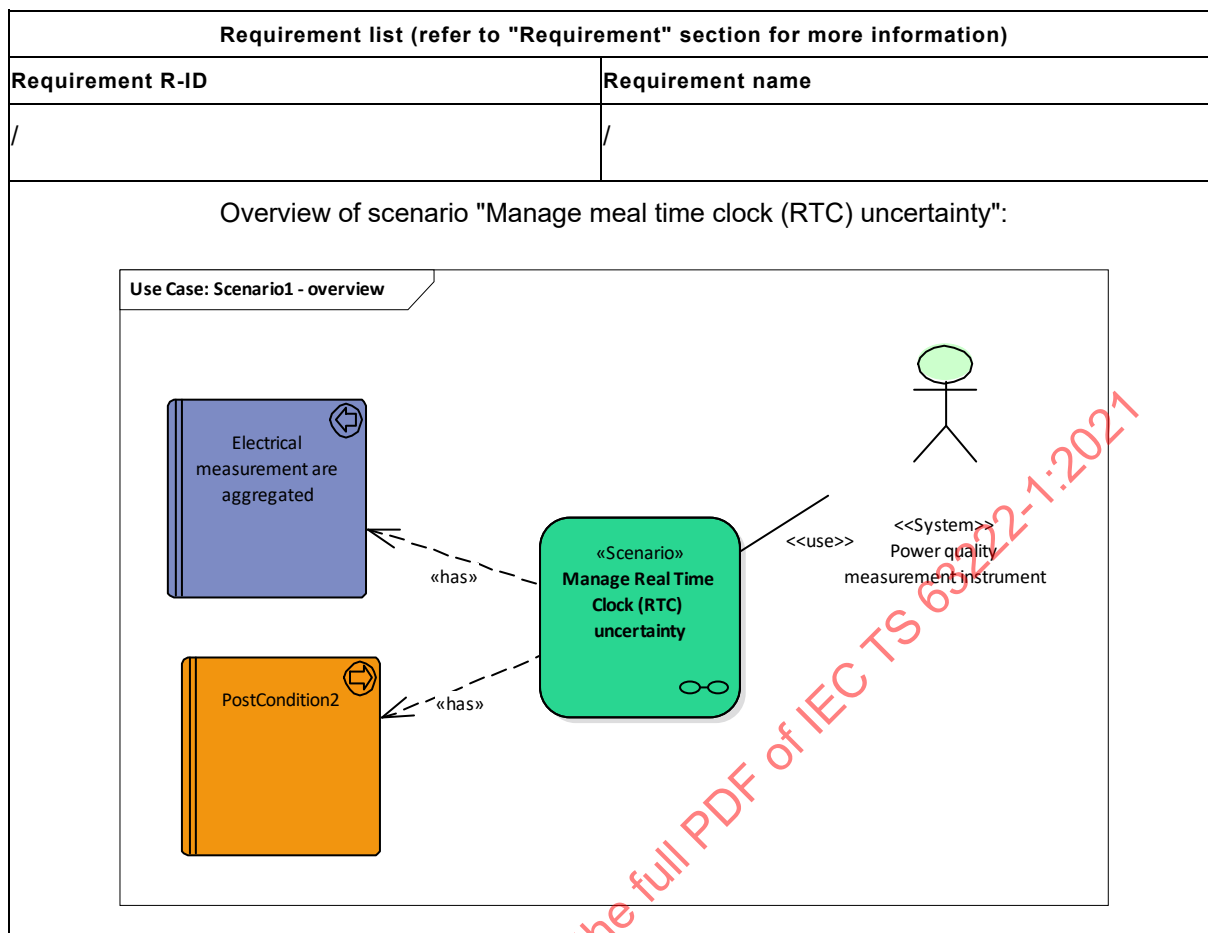
The basic measurement time interval for parameter magnitudes (supply voltage, harmonic, interharmonics and unbalance) shall be a 10-cycle time interval for 50 Hz power systems or 12-cycle time interval for 60 Hz power systems. The 10/12-cycle values are then aggregated over additional intervals. The commonly used time intervals are 150/180-cycle interval,

10 min interval, 2 h interval. Measurement aggregations shall be performed using the square root of the arithmetic mean of the squared input values. The 10/12-cycle measurement shall be re-synchronized at every RTC 10 min tick in Class A. Resynchronization with the 10 min tick is permitted but not required in Class S.



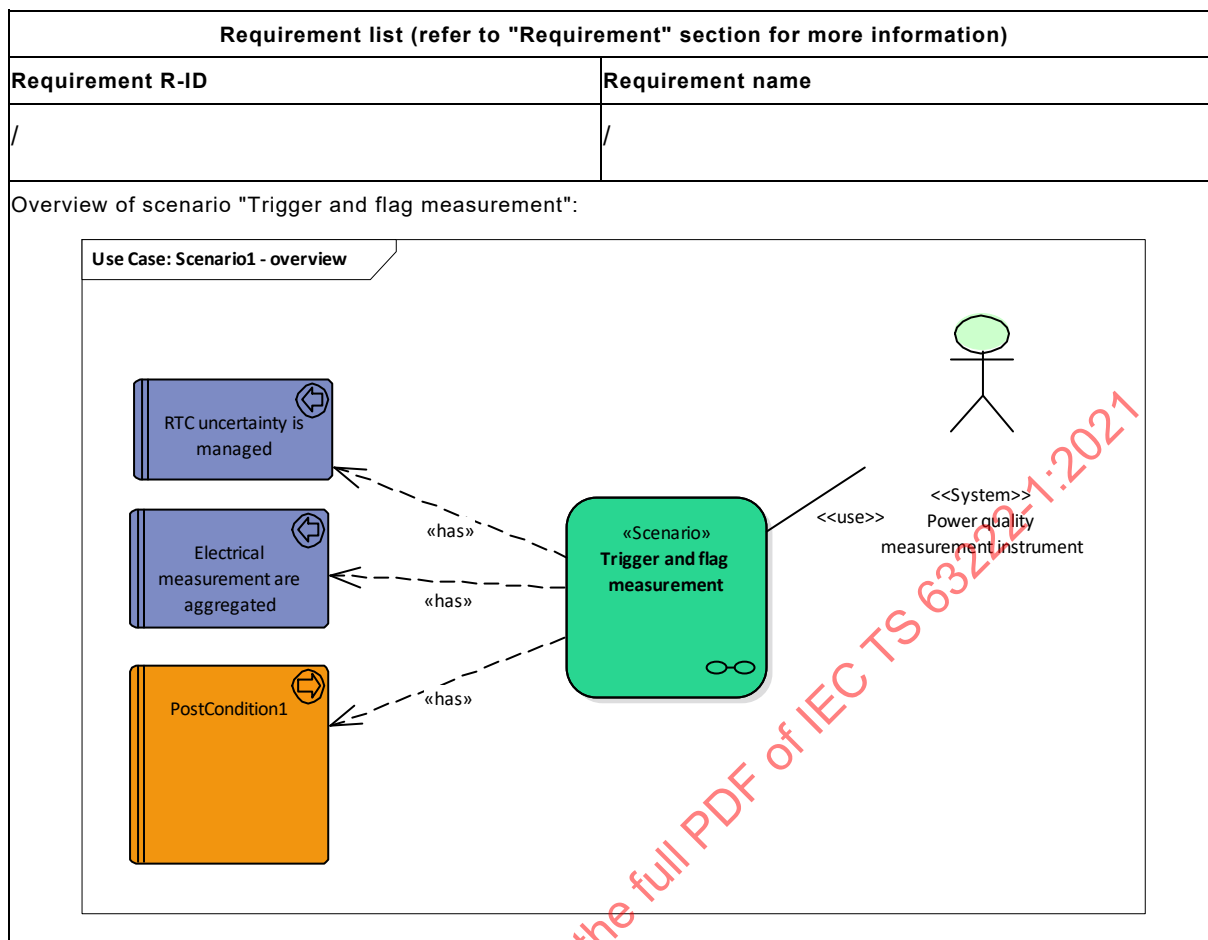
- **Manage real time clock (RTC) uncertainty**

RTC uncertainty is defined relative to coordinated universal time. In Class A, the RTC uncertainty shall not exceed ± 20 ms for 50 Hz or 16,7 ms for 60 Hz. In Class S, the uncertainty shall not exceed ± 5 s per 24 h period. The performance can be achieved, for example, through a GPS receiver, or through reception of transmitted radio timing signals. When synchronization by an external signal becomes unavailable, the RTC tolerance shall be better than ± 1 s per 24 h period.



- **Trigger and flag measurement**

Flagging is triggered by dips, swell and interruption. Once triggered, all measurement channels shall be opened to record the transient waveform and effective values. Values, such as frequency, voltage deviation, voltage unbalance, harmonics and interharmonics shall be flagged when trigger event happens.



A.2.2 SUC2: Monitor power quality on the network

A.2.2.1 Description of the use case

A.2.2.1.1 Name of use case

Use case identification		
ID	Area(s)/Domain(s)/Zone(s)	Name of use case
1	Customer support (CS), Network operation (NO), Network and extension planning (NE)	Monitor power quality on the network

A.2.2.1.2 Version management

Version management				
Version No.	Date	Name of author(s)	Changes	Approval status
1	2020-05-12	Miao Huiyu	Creation	/
2	2020-05-27	Simon Issard	Modelisation update	/

A.2.2.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Power quality monitoring equipment terminal, communication, monitoring master station and client
Objective(s)	Define the structure composition, general workflow of power quality monitoring, and functional requirements of each layer system in order to measure and log relevant power quality events on the network. In the background, observe, measure and log all the relevant power quality events on parts or whole network such as: power outage, faults, etc..
Related business case(s)	/

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A.2.2.1.4 Narrative of use case

Narrative of use case
Short description
Power quality monitoring system is set in a distributed structure. A complete monitoring system includes monitoring equipment layer, service layer and client layer. The monitoring equipment layer, service layer and client layer are connected by the communication network. Different monitoring systems realize data exchange through the interconnection of service layers. The power quality monitoring system selects a monitoring point and determines the description and analysis method. The system uses the power quality monitoring terminals installed on the grid side or the user side to collect the field data, which is then transmitted back to the master station on the client layer. The system monitors power quality on multiple locations and provides reports on network power quality.
Complete description
The power quality monitoring processes are organised in four scenarios depending on the state of the grid concerned by power quality issues, each of them using one or several dedicated system use cases.
<u>Summary of use case</u>
• Power quality monitoring equipment operation <u>Description:</u> The equipment layer has a power quality monitoring function, which consists of a monitoring unit and an adaptor unit. Data exchange between the equipment layer and the service layer should be carried out in a unified format according to the communication protocol. Each monitoring terminal shall have a fixed network address. The equipment measures the voltage and current to calculate and monitor the power quality. It should have the following functions: – accurate measurement, – communication and interface, – statistics, recording and storage, – capturing and recording for emergencies. • Data transmission between monitoring terminal and service station <u>Description:</u> The monitoring equipment, service station and client communicate by a unified communication protocol. Different monitoring systems realize data exchange through the interconnection of service layer. The real-time data report and statistical data report are periodically uploaded to the master station. The incident report is uploaded immediately. The file service data is uploaded according to the master station request. • The power quality monitoring service layer operation <u>Description:</u> power quality service layer (master station) consists of communication server, data server, web server, application server, management workstation, etc. It has the functions of monitoring data collection, management and analysis, system maintenance, authority management, etc. It is the link of data interaction between equipment layer and client layer. The objectives of the service layer include but are not limited to: – synchronous collection and real-time transmission of distributed data, data sharing of heterogeneous platforms, processing massive data and network information services, – ensuring the integrity, accuracy and consistency of the power quality data, – meeting the compatibility requirements of software, hardware and the interconnection between systems. • Client layer receiving the power quality reports <u>Description:</u> After the data collecting in the monitoring equipment layer and the analysis in the service layer, the client layer accesses the service layer and receives the power quality reports by a unified communication protocol. The client layer also has monitoring data access, browsing, query and other features. The reports should follow the following requirements: – accurately describe the power quality on the network, – evaluate the overall power quality of the network and indicate the system performance of the system, – identify the power quality pollution source, as the reference for the equipment maintenance.

A.2.2.1.5 Key performance indicators (KPI)

Key performance indicators			
ID	Name	Description	Reference to mentioned use case objectives
1	Number of outage	/	Define the structure composition, general workflow of power quality monitoring, and functional requirements of each layer system
2	Duration of outage	/	Define the structure composition, general workflow of power quality monitoring, and functional requirements of each layer system

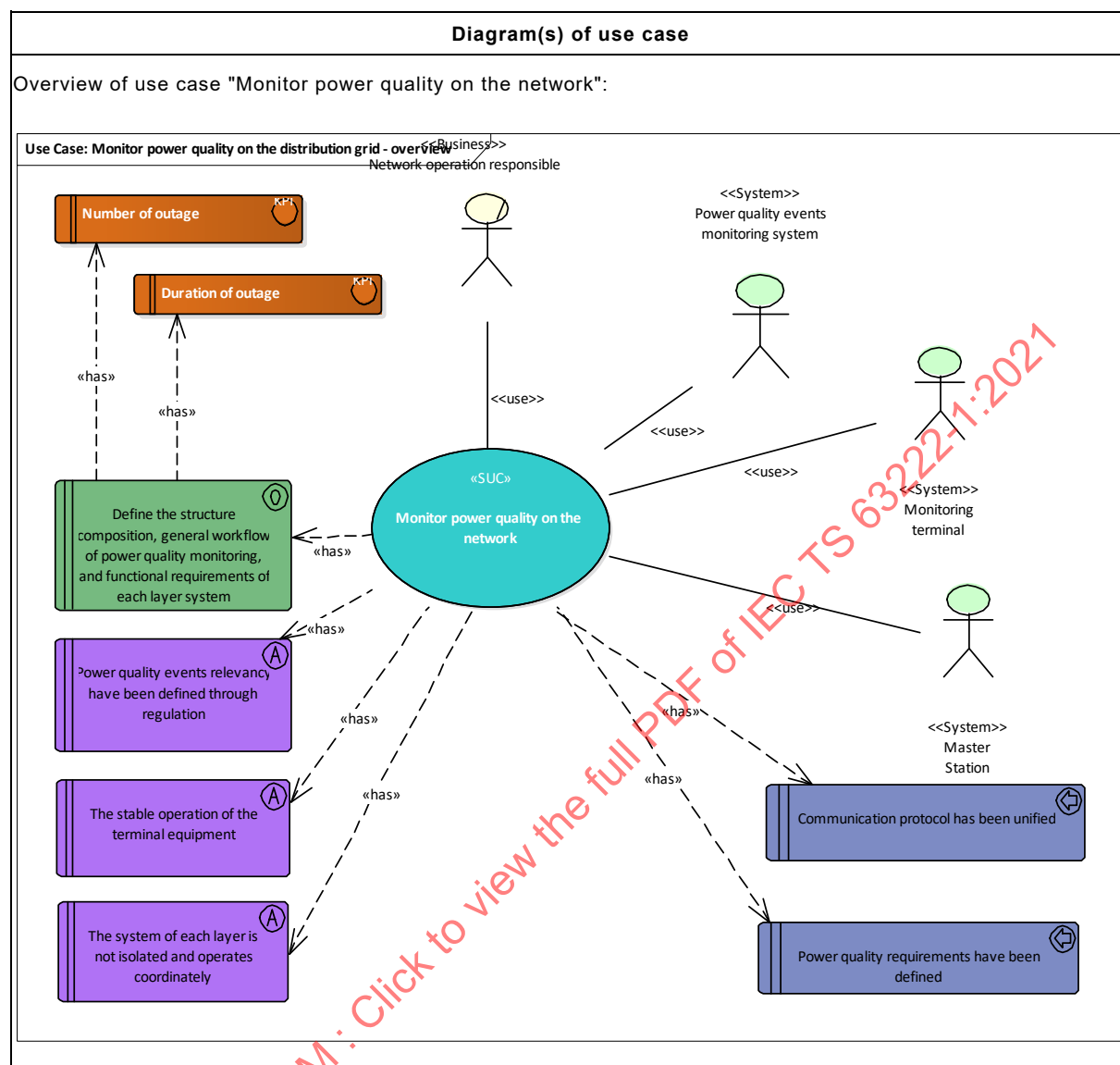
A.2.2.1.6 Use case conditions

Use case conditions	
Assumptions	
1	Power quality events relevancy has been defined through regulation: The power quality events that the network operator shall monitor have been defined by regulations or contracts.
2	The stable operation of the terminal equipment
3	The system of each layer is not isolated and operates coordinately.
Prerequisites	
1	Communication protocol has been unified.
2	Power quality requirements have been defined.

A.2.2.1.7 Further information to the use case for classification/mapping

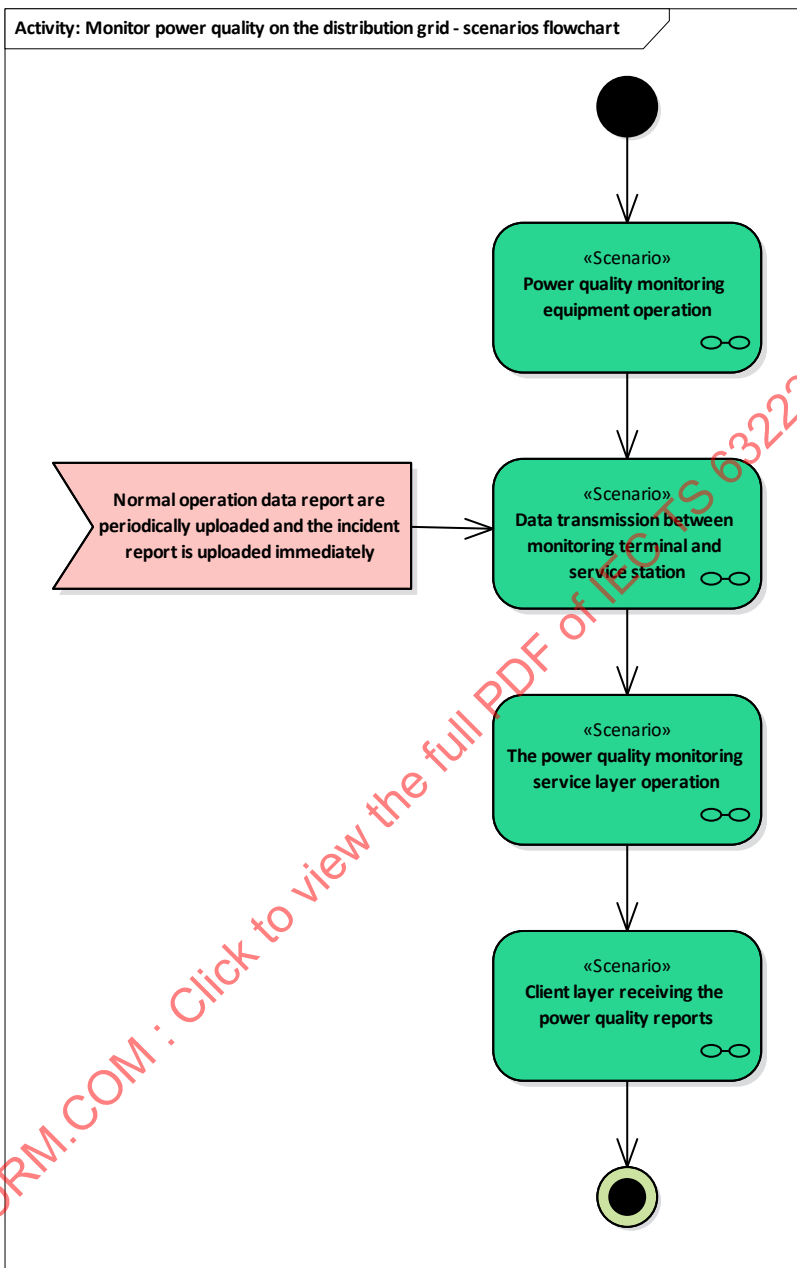
Classification information
Relation to other use cases
<<BUC>> [] Provide reports on network power quality
Level of depth
High level
Prioritisation
/
Generic, regional or national relation
Generic
Nature of the use case
SUC
Further keywords for classification
Power Quality, Manage PQ, Monitor

A.2.2.2 Diagrams of use case



Diagram(s) of use case

Scenarios flowchart of use case "Monitor power quality on the network":



A.2.2.3 Technical details

A.2.2.3.1 Actors

Actors			
Grouping (e.g. domains, zones)		Group description	
/		/	
Actor name	Actor type	Actor description	Further information specific to this use case
Power quality events monitoring system	System	A unit that monitors the access, browse and query of power quality data. it connects to the service layer through the network. Functional unit that requests and receives services from a server [SOURCE: IEC 60050-732:2010, 732-01-13]	/
Network operation responsible	Business	Entity responsible for the planning, operation, maintenance, and the development in given areas of the electricity network. See definitions of distribution system operator, transmission system operator.	
Monitoring terminal	System	A functional unit that observes and records, for analysis, selected activities within a switching system [SOURCE: IEC 60050-714:1992, 714-18-28]	/
Master station	System	The data station that has been designated by the control station to ensure data transfer to one or more slave stations [SOURCE: IEC 60050-721:1991, 721-19-12]	/

A.2.2.3.2 References

References						
No.	Reference type	Reference	Status	Impact on use case	Originator / organisation	Link
1	International Standard	IEC 61000-4-30:2015	Published	/	IEC	/
2	Technical Specification	IEC TS 62749:2020	Published	/	IEC	/