



## **Integration of Electric Vehicle Charging Systems (EVCS) to SEC LV and MV Distribution Network**

*Technical Specifications for the Connection of Unidirectional EVCS to the LV and MV Distribution Networks of SEC*

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## 1 SCOPE

This document provides a common set of requirements for Electrical Vehicle Charging Stations (EVCS) which intend to operate in parallel with the LV & MV distribution networks of the Saudi Electricity Company (SEC) in the Kingdom of Saudi Arabia. In this document, the Electrical Vehicle Charging Stations will be referred to as EVCS. The standards for connecting EVCS are not developed yet within international committees as the technology is still developing and some applications are yet under experiments, consequently, this document is an attempt to define technical rules and connection requirements for the sake of protecting and safeguarding the distribution network from Unidirectional EVCS, that are not able to inject nor reverse current towards the network. The document defines the following:

- Requirements to support the frequency and voltage stability of the power system when it is subject to disturbances.
- Requirements for the start-up, the operation, and the disconnection of the EVCS.
- Requirements to prevent the EVCS from causing disturbances and damages either to the distribution network or to the other Consumers connected to the same distribution network.

The present document is compatible with additional requirements set out by other national & international standards, network codes, or specific technical requirements of SEC, and which may apply to the connection of an EVCS. In particular The Saudi Arabian Distribution Code Updated Version: April 2021 (in this document referred to as “Distribution Code”).

The Distribution Code is applicable to all users of the distribution system and still represents the main technical document to refer to for the connection of a new Consumer or for the modification of the connection of an existing Consumer. The present Technical Standards shall apply in case the new installation (or modified one) includes an EVCS as defined in this document and shall be intended as an extension of the Distribution Code for what is not directly ruled by the code itself. For all the aspects not covered by the present document, reference shall be made to the Distribution Code.

It is not under the purpose of these standards to define technical rules for the off-grid operation of networks in isolated (e.g. rural) areas, where no part of SEC distribution network is involved. Unless otherwise explicitly specified, the requirements set forth by the present standards apply to new EVCS, i.e. to those EVCS which do not have already been approved by SEC at the date of publication of the standards.

Finally, even if it is not directly within the scope of the present standards, it is important to stress and remind the fundamental importance and necessity for these systems to be installed by certified and trained installers that are certified by both the national certification body and the manufacturers. As regards the Service Conditions, the equipment/material used for the EVCS shall be suitable for operating at their standard ratings under the usual service condition in the inland, desert, or coastal areas environment in the Kingdom of Saudi Arabia. Typical service conditions for the KSA are indicated in ANNEX B.

### DISCLAIMER

*If the SEC document conflicts with any of the Saudi standards or the national code in any clauses and conditions, the Saudi standard and national code prevail in this situation. At the time of the release of this document, there were no International references for the connection of EVCS to the distribution grid, hence this document is expected to evolve in parallel with the evolution of the technology.*

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## TECHNICAL STANDARDS FOR UNIDIRECTIONAL EVCS

### 1.1 Notice to users

This document is for use of employees of SEC, Consumers, Consultants, installers, and Contractors. Users of this guideline should consult all applicable laws and regulations. Users are responsible for observing or referring to the applicable regulatory requirements. SEC does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Users should be aware that this document may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. These Technical Standards at any point in time consist of the current edition of the document together with any amendments, corrigenda, or errata then in effect. All users should ensure that they have the latest edition of this document, uploaded on SEC website.

Finally, the user shall refer to Saudi Building Code –Chapter 722, as well as to applicable SASO Standards or International Standards mentioned in these SEC documents and adopted by SASO, unless differently indicated in other SEC documents.

### 1.2 SEC Limitation of Liability and Consumer's undertaking

SEC disclaims liability for any personal injury, property, or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the connection point. Consumers are responsible for observing or referring to the applicable laws and regulatory requirements.

It is the responsibility of the Consumer to determine that the interconnection equipment's specifications and confirmed performance satisfy the technical needs of the SEC system and are compatible with the present and any other applicable SEC standards. SEC standards are indispensable for EV application. All equipment in an installation connected to SEC system shall be designed, manufactured, tested, and installed in accordance with all applicable statutory obligations and shall conform to the relevant SEC standards current at the time of the connection of the installation to SEC system.

The Consumer shall comply with the following:

- Arrange all necessary requirements and systems to connect EVCS to SEC system including compliance with security and safety requirements and providing necessary equipment.
- Terms and conditions of offer to connection, connection agreement, connection conditions, and any other relevant requirement adopted by SEC.
- Not to conduct any action impacting the safety and efficiency of SEC system.
- All costs associated with the connection of an EVCS to SEC system shall be borne by the Consumer.
- If there is a risk to the safety and/or the security of the system and the public electricity network, SEC is entitled to either disconnect or require immediate disconnection of the EVCS from the network.

## 2 REFERENCE DOCUMENTS

- [1] The Saudi Arabian Distribution Code Updated Version: April 2021 (in this document referred to as “Distribution Code”)
- [2] The Saudi Arabian Grid Code, Electricity & Cogeneration Regulation Authority, Updated Version: April 2021 (in this document referred to as “Grid Code”)
- [3] The Saudi Building Code Electrical Requirements (SBC401)
- [4] SASO IEC 61000-3-2: Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current  $\leq 16$  A per phase)
- [5] SASO 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  $\leq 75$  A per phase
- [6] SASO IEC 61000-13-15: table -7. 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  $\leq 75$  A per phase
- [7] SASO IEC/TR 61000-3-15: Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network
- [8] Guidelines for Consumers and Integrators to Connect EV Charging System / Station to SEC Distribution Networks

### 3 TERMS AND DEFINITIONS

**Active power** – Active Power is the real component of the apparent power, expressed in watts or multiples thereof (e.g. kilowatts (kW) or megawatts (MW)). In the text, this will be generically referred to as P or P<sub>nom</sub> in the case of the nominal active power of equipment.

**Consumer/Eligible Consumer** – A person who has a Point of Connection that meets the requirements of these Regulations and the Connection Conditions between the Distribution System and the Consumer's Premises as defined in the Distribution Code.

**Distribution System / Network** – The system consists of electric lines, an electric plant, transformers, and switchgear and which is used for conveying electricity to final Consumers. It can be either a Medium or Low Voltage system, and for the scope of the present document and in accordance with international standards:

- A Low Voltage (LV) Distribution System is a network with a nominal voltage lower than 1kV AC or 1.5 kV DC. The LV Distribution System nominal voltages in KSA are 400/230V and 380/220V.
- A Medium Voltage (MV) Distribution System is a network with nominal voltage included in the range from 1kV AC up to 69 kV. The MV Distribution System nominal voltages in KSA are 13.8, 33kV, and 69 kV.

**Point of Connection PoC** – The physical point at which Consumer's Plant or apparatus is joined to the SEC Distribution System.

**EV Unit** – A group of devices that allow to the connection of an Electric vehicle to an EV charging System, together with all plant and apparatus and any step-up transformer which relates exclusively to the operation of that part of the same EV System. For the avoidance of doubt, in this document the generic term EV Unit will be considered equivalent to EV Charging System Unit.

**Absorbed Electricity** – Electricity that is drawn from the Distribution Network and consumed by the Consumer under one or more Accounts.

**Interface Protection (IP)** – The electrical protection required to ensure that either the EV Charger System and/or any EV charger Unit is disconnected for any event that could impair the integrity or degrade the safety and reliability of the distribution network.

**Inverter** – electric energy converter that changes direct electric current to single-phase or polyphase alternating current.

**Residual current device (RCD)** – is a sensitive safety device that switches off when the residual current exceeds the operating value of the device

**Premises** – Any occupied or unoccupied land, building, enclosure, or another place with a point of connection to the Distribution System.

**Power factor ( $\phi$ )** – under periodic conditions, the ratio of the absolute value of the active power P to the apparent power S.

**Rated active power** – Represents the sum of the nominal active power of all the EV Units which compose the EVCS; it is generally referred to as P<sub>nom</sub>.

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**Reactive power capability** – Defines the reserves of inductive/capacitive reactive power which can be provided by a generating system/unit. The reactive power capability usually varies with the active power and the voltage of the generating system/unit.

**Reactive Power** - Represents the imaginary component of the apparent power, usually expressed in kilovar (kVAR) or Megavar (MVAR).

**Switch** – Mechanical device capable of making, carrying, and breaking currents in normal circuit conditions and, when specified, in given operating overload conditions. In addition, it is able to carry, for a specified time, currents under specified abnormal circuit conditions, such as short-circuit conditions.

**THD (Total Harmonic Distortion)** – With reference to an alternating quantity, it represents the ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the fundamental component or the reference fundamental component.

**EVCS** – An electric vehicle charging station is equipment that connects an electric vehicle (EV) to a source of electricity to recharge electric cars, neighborhood electric vehicles, plug-in hybrids, or even electric trucks.

**Unidirectional EVCS** – it refers to the direction of the power flow which always will be from the grid toward the Electrical Vehicle and in this case, the charging station is considered a passive load.

## 4 GLOSSARY

The following acronyms and symbols are used throughout the document:

$\cos \varphi$	Power factor
WERA	Water & Electricity Regulatory Authority
LV	Low Voltage (namely 380/220 Vac or 400/230 Vac)
LVRT	Low Voltage Ride Through
MV	Medium Voltage (namely 13.8kV or 33 kV)
P	Active power
Pnom	Nominal active power of the equipment
p.u. (or pu)	per unit
EV	Electric Vehicle
Q	Reactive Power
S	Apparent Power
Sn	Nominal Apparent Power
SEC	Saudi Electricity Company
V	Voltage
Vnom	Nominal Voltage

## 5 TECHNICAL REQUIREMENTS FOR UNIDIRECTIONAL EVCS

### 5.1 General requirements

An EV Charging System which from hereinafter will be referred to as EVCS shall be connected to SEC Distribution Network, either in LV or MV, at an appropriate point, called Point of Connection. It is the responsibility of SEC to design a suitable process which determines the appropriate Connection Point and assesses the capacity of the network to host the connecting EVCS at that point whilst maintaining a stable, reliable, and economical operation of the system for all operating conditions. SEC responsibility is limited to upstream the Point of Connection of the EVCS.

According to the Distribution Code, if the results of such a process highlight that connecting EVCS is likely to cause the network to possibly operate outside of SEC statutory performance standards, SEC has the right to reject the connection application or to propose modifications (for example in terms of Connection Point and/or characteristics of the EVCS) or alternative solutions (for example in terms of network reinforcements) to enable the connection.

The Maximum Connected Capacity of the EVCS to be proposed by the Consumer will be determined in agreement with the specific clauses of WERA Regulations.

### 5.2 Connection schemes

All EVCS manufacturers have to ensure that the EVCS is designed in a way that respects the Saudi Distribution code and installation best practices. An EVCS shall be in compliance with the connection requirements of SEC, and especially shall meet the following requirements:

- The synchronization, operation, and disconnection of the System under normal network operating conditions, i.e. in the absence of faults or malfunctions, shall bear no consequences to the statutory power quality of the network.
- The protection schemes and settings needed for the EVCS shall be coordinated with those of the distribution network; they shall therefore be agreed upon between SEC and the Consumer or Manufacturers with the following purpose:
  - Faults and malfunctions within the EVCS shall not impair the normal operation of SEC distribution network. In particular, any faults including earth faults with leakage current internal to the EVCS installation will be detected and cleared below or at the connection point before any SEC protection operates.
  - The protection schemes of the EVCS shall be coordinated with those of the distribution network in order to operate properly in case of faults either within the EVCS or within the distribution network.

In order to satisfy the requirements of these standards, some schemes reported in this section present the typical equipment which shall be at least installed for a safe and reliable interconnection of an EVCS to the LV and MV distribution network respectively:

- The Main Switch shall be installed as close as possible to the Connection Point and shall be operated by a protection system in case of internal faults, in accordance with the Distribution Code <sup>1</sup>. If agreed with SEC, it is possible to install more than one main switch in order, for example, to have two separate circuits, one dedicated to the Consumer's loads and one dedicated to the EVCS.

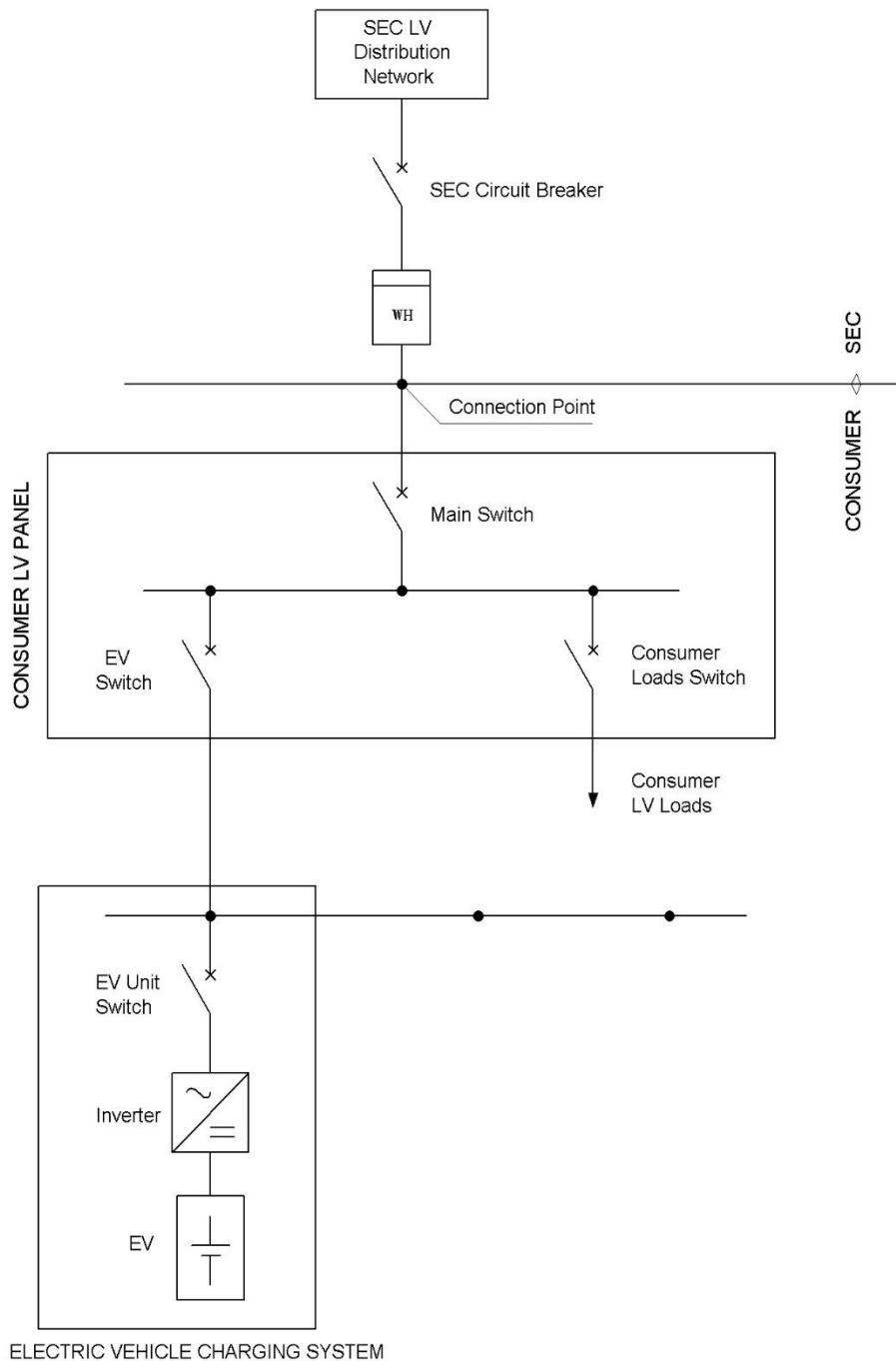
All EVCS overload and short circuit protections are provided in addition to the earth leakage protection.

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<sup>1</sup>For the definition of the requirements of the protection system against faults within the Consumers' installations, please refer to DCC4.2 in the Distribution Code

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- The EV Unit Switch shall be installed as electrically close as possible to the terminals of each EV Unit, for the protection and the connection/disconnection of that unit. For the protection issues, the recommendations and requirements of the Manufacturer of the equipment shall apply.

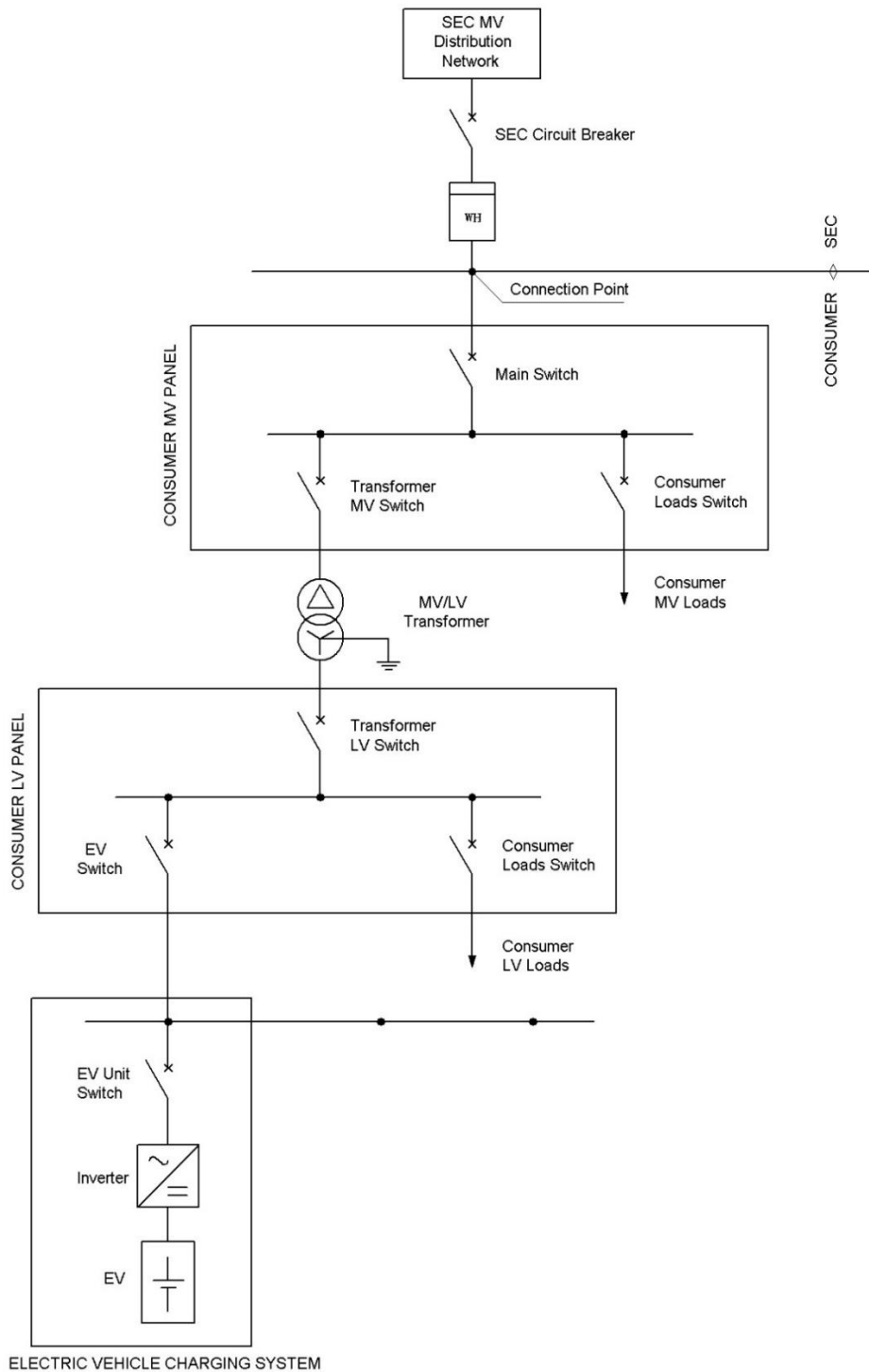


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**Figure 1 - Schematic representation for the interconnection of unidirectional EVCS to SEC LV Distribution Network**

<sup>2</sup> This is a general scheme that is not referring to any type of charging modes and is not illustrating the components placement. The purpose of this scheme is to illustrate only the main components needed in connecting the EVCS in LV network.

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**Figure 2 - Schematic representation for the interconnection of unidirectional EVCS to SEC MV Distribution Network (either 13.8 or 33kV)**

<sup>3</sup> This is a general scheme that is not referring to any type of charging modes and is not illustrating the components placement. The purpose of this scheme is to illustrate only the main components needed in connecting the EVCS in MV network.

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### 5.3 Choice of Switches

For each of the above-mentioned switches, the choice of the type to be installed (circuit breaker, contactor, disconnecting switch with fuses, etc.) shall be based on:

- The functions the switch shall carry out.
- The characteristics of the Consumer's installation.
- The characteristics of SEC Distribution Network at the Consumer's Connection Point.

Especially, the following criteria shall be adopted:

- the switches, panels, and switchgear shall be compliant with the requirements of the Distribution Code,
- the switch(es) of the EVCS shall be compliant with the Manufacturer's requirements, depending on the implemented technology.
- any switch shall have a breaking and making capacity coordinated with the rated values of the Consumer's installation, taking into consideration both the EVCS and the contribution to short circuits from the Distribution Network.
- the short time withstands current of the switching devices shall be coordinated with the maximum short circuit power at the Connection Point<sup>4</sup>.
- The entire electrical system from the EV unit up to the connection point shall be protected against earth leakage current.

All EVCS connected at the MV level shall be designed according to Saudi Arabian Codes, Regulations & Standards and in alignment with the requirements of the Distribution code and Distribution Planning Standards. When selecting a switch for MV connection, the above-mentioned considerations shall be applied. Additionally, the designer has to take into account the following aspects:

- The correct selection of equipment and components for MV connections that will withstand the network characteristics e.g. voltage level, short circuit level, etc.
- To guarantee that the selected components and elements will provide the expected performance in an efficient and safe manner
- The correct use of protections and settings for the transformer and all EVCS elements on both MV and LV sides.

All requirements for MV connection that are established within SEC's rules and regulations shall be respected for all EVCS technologies.

### 5.4 Operating ranges

All types of EVCSs shall be capable of remaining connected to the Distribution Network and of operating stably, as specified in this document, for voltage ranges for the time periods specified in the tables below, regardless of the type and settings of the protection systems:

**Table 1: Voltage operating range**

Voltage range at the Connection Point	Operation Requirement
90-110% Nominal Voltage	Continuous

<sup>4</sup> Information about the maximum prospective short-circuit level of SEC distribution networks is reported in DCC4.5.1 of the Distribution Code.

## TECHNICAL STANDARDS FOR UNIDIRECTIONAL EVCS

EVCSs shall be capable of remaining connected to the Distribution Network and of operating stably, as specified in Table 2 for frequency ranges for the time periods specified in the table below, regardless of the type and settings of the protection systems.

**Table 2: Frequency operating range**

Below Nominal Frequency (Hz)	Above Nominal Frequency (Hz)	Operation Requirement
58.8 – 60.0	60.0 – 60.5	Continuous
57.5 – 58.7	60.6 – 61.5	for a period of 30 minutes
57.0 – 57.4	61.6 – 62.5	for a period of 30 seconds

### 5.5 Immunity against disturbances

#### 5.5.1 Low Voltage Ride Through (LVRT) capability

EVCS shall contribute to the stability of the overall power system providing immunity towards dynamic voltage changes, especially those due to faults on the higher voltage level networks. The requirements below apply to all kind of disturbances (1ph, 2ph, and 3ph faults) and are independent of the type of EVCS. Therefore, whether the EVCS will stay connected or not will also depend on settings in other equipment e.g. Inverter, MCCBs, etc.

An EVCS with a Maximum Connected Capacity greater than 22kW shall be capable to stay connected to the distribution network as long as the voltage at the Connection Point remains above the voltage-time diagram of Figure 3. The p.u. voltage shall be calculated with respect to the nominal voltage at the Connection Point. For three-phase generating systems, the smallest phase-to-phase voltage shall be evaluated. The compliance to such LVRT requirements shall apply to all equipment that might cause the disconnection of the EVCS as mentioned previously.

After the fault is cleared and the voltage returned within the voltage normal operating range (see 5.4), the pre-disturbance operating conditions (active & reactive power) shall be recovered as fast as possible and with a tolerance of  $\pm 10\%$  of the EVCS rated power.

If not explicitly mentioned by SEC, the 22kW threshold shall be constantly updated and revised in accordance with the needs of the distribution network and the technology evolution. Consumers, contractors, and consultants shall ensure the acquisition of the latest version of this document.

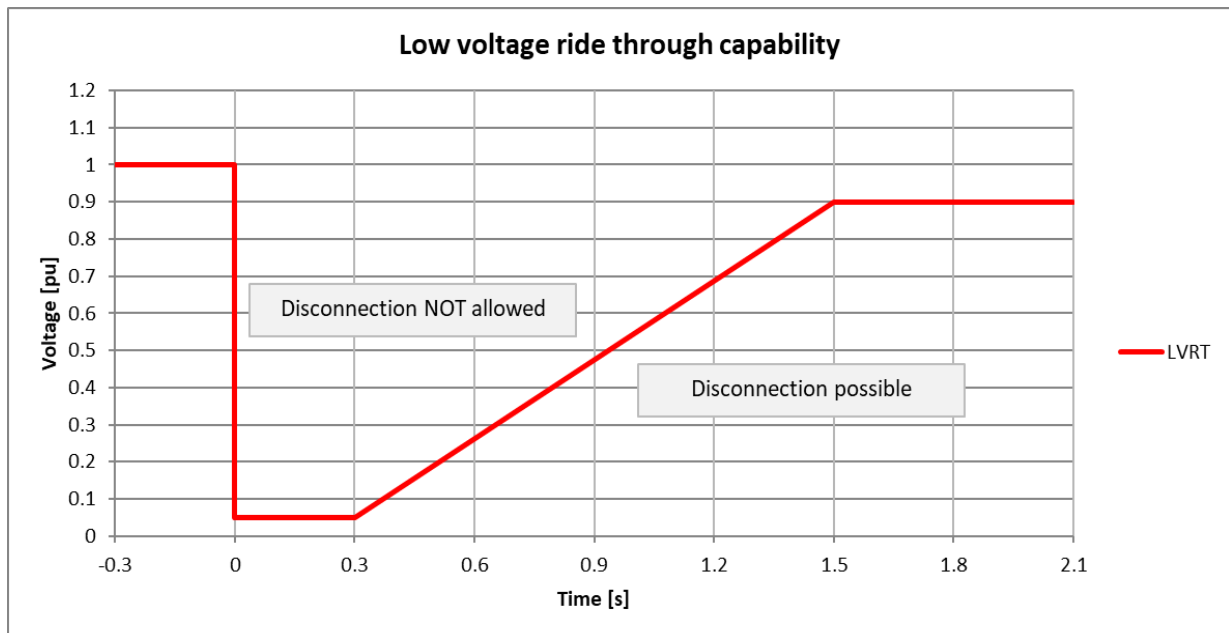


Figure 3 - LVRT characteristic for all EVCS above 22kW

## 5.6 Requirements for the frequency stability of the power system

With the increased penetration of EVCS, it becomes essential the contribution to frequency control in various ways. These features and functionalities must be embedded within the charging station and used only with an indication from SEC whenever needed.

### 5.6.1 Active power response for EVCSs

EVCSs when operating in charging mode or absorbing power from the grid shall have the capability to reduce the charging active power in the case under frequency conditions. So even if this kind of system is only absorbing power from the grid (referred to as V1G technology), it can yet regulate the absorbed power according to the frequency variation by means of the available technology.

On the other hand, the EVCS must continue the absorption of power from the grid to charge the Electric Vehicle during over-frequency violations. The below curve illustrates the active power regulations performed by EVCS above 22 kW in both under and frequency conditions. If not explicitly mentioned by SEC, the 22kW threshold shall be constantly updated and revised in accordance with the needs of the distribution network and the technology evolution. Consumers, contractors, and consultants shall ensure the acquisition of the latest version of this document in order to be up to date with the latest requirements.

TECHNICAL STANDARDS FOR UNIDIRECTIONAL EVCS

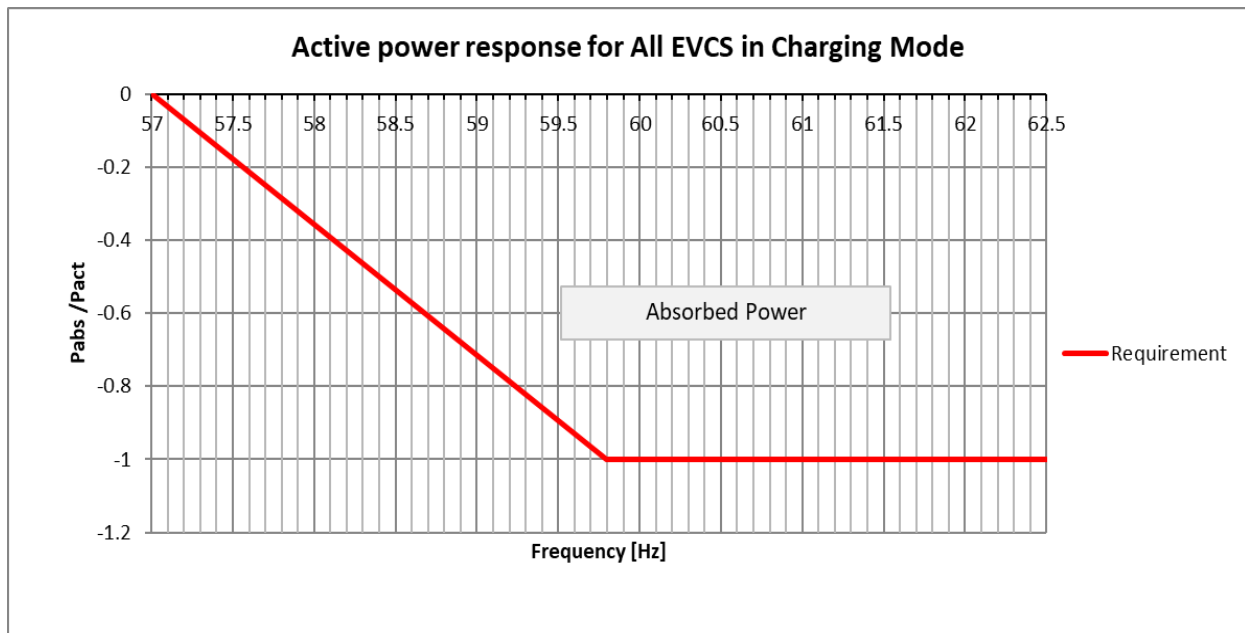


Figure 4 – Frequency regulation requirement for EVCS above 22kW

It must be clarified that the absorbed power depends on the status of the battery charging before the under-frequency incident. The reduction in the active power absorption is activated after 59.8 Hz threshold to allow the intervention of the primary reserve in the grid.

The reduction of the absorption of active power under frequency conditions with the reduction slop settings between 2% and 8% in steps of a maximum of 1 %; if not explicitly specified by SEC, the reduction slop shall be set to 3.83%.

## 5.7 EV Charger requirements for the voltage stability of the power system

### 5.7.1 Reactive power capability

When voltage and frequency at the Connection Point are within their normal operating ranges, EVCS shall be able to provide reactive power in any operating point within the boundaries of the reactive power capability curves defined in Figure 5<sup>5</sup>.

Based on this capability, the EVCS will be able to either generate/absorb reactive power to/from the Distribution Network, in order to provide voltage support at the PoC, for any of the values of active power absorbed by the EVCS.

The Rectangular area is required for inverters included in EVCS whose Maximum Connected Capacity is greater than 22 kW. It shall be capable of either generating or absorbing reactive power Q within the area. This requirement might be extended to all types of EVCS in the future, based on the needs of the distribution network.

The following extreme working points can be singled out:

- Set Point A: The EV charger can charge the EV vehicle for 100% of the capacity and it is controlled to support the voltage with 33% of the rating capacity in Mvar by absorbing the necessary reactive power and operating at a power factor 0.95 Lag.

<sup>5</sup> The active power 1 p.u. shall refer to the nominal active power value of the EVCS: at 1 p.u. of active power, the reactive power capability of an EVCS corresponds to a power factor varying between 0.95 leading (inductive reactive power absorbed) to 0.95 lagging (inductive reactive power generated).

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- Set Point O: The EVCS is completely dedicated to the charging mode. It is power factor 1.
- Set Point B: The EVCS can charge the EV vehicle for 100% of the capacity and generate the necessary reactive power by 33% of the rating capacity in Mvar, operating at a power factor 0.95 Lead.
- Set Point C: The EVCS do not charge the EV vehicle and it is controlled to increase the voltage by generating 100% of the rating capacity in Mvar. It is a power factor 0.0, the EVCS works as a shunt compensation device.
- Set Point D: The EVCS do not charge the EV vehicle and it is controlled to reduce the voltage by absorbing 100% of the rating capacity in Mvar. It is a power factor 0.0, the EVCS works as a shunt compensation device.

Accuracy of the EVCS required Q shall always be as good as technically feasible and error shall not exceed 10% of  $S_n$ .

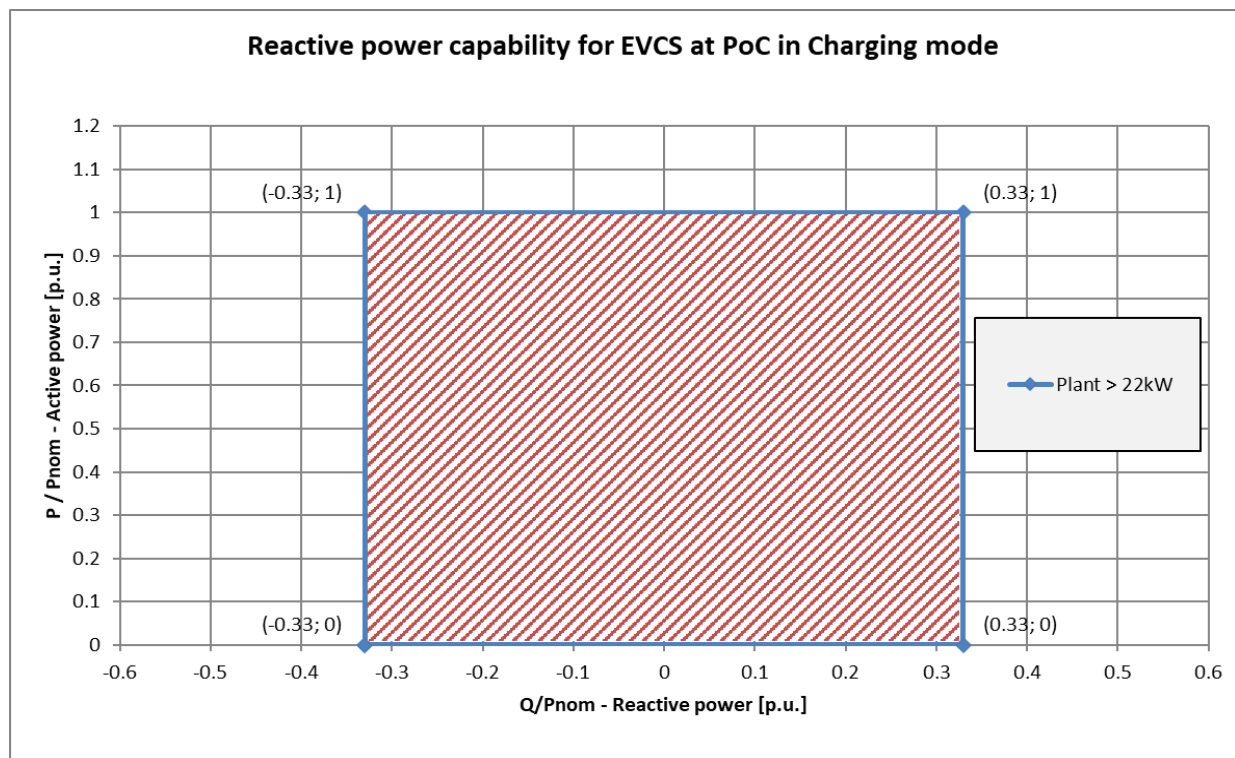


Figure 5 - Reactive power capability for EVCSs above 22kW in charging mode

### 5.7.2 Reactive power control modes

EVCS above 22kW shall be capable of operating in the control modes stated below, within the limits of its reactive power capability and as expressed in detail in 5.7.1:

- fixed Q: the reactive power is controlled in order to have a fixed value;
- fixed  $\cos \varphi$ : the reactive power is controlled in order to have a fixed power factor;
- $\cos \varphi (P)$ : the reactive power is controlled in order to have a power factor function of the actual active power delivery;
- $Q=f(V)$ : the reactive power is controlled as a function of the local voltage, according to a characteristic curve.

The above control modes are exclusive; only one mode may be active at a time. The activation, deactivation, and configuration of the control modes shall be field adjustable. It is the responsibility of SEC to communicate to the EVCS's owner which of the above-mentioned reactive power control mode

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shall be activated, depending on the needs of the distribution network and depending on the outcome of the technical assessment. Based on the analysis conducted by SEC, it shall be communicated to the consumer the desired control mode and this shall be mentioned clearly during commissioning and in the connection agreement.

### 5.7.2.1 Fixed control modes

When operated with fixed Q or fixed  $\cos \phi$  control mode, the EV Unit shall control the reactive power or the  $\cos \phi$  of its output according to a set point set in the control system of the EVCS. If not explicitly specified by SEC, the default set point values shall be 0 for fixed Q control mode and 1 for fixed  $\cos \phi$  control mode.

For an EVCS with a Maximum Connected Capacity greater than 22 kW, the EVCS shall also be able to receive the set-point or a disconnection instruction from a remote control center in accordance with the provisions set forth in 5.8.3.

### 5.7.2.2 Power-related control mode

The power-related control mode  $\cos \phi (P)$  controls the  $\cos \phi$  of the output as a function of the active power output. A character with a minimum and maximum value and three connected lines according to Figure 6 shall be configurable within the control systems of the EVCS; a change in active power output results in a new  $\cos \phi$  set point according to the characteristic.

The parameters A, B, and C shall be field adjustable, and their settings are the responsibility of SEC. If not explicitly specified by SEC, these parameters shall be set as indicated below:

- A  $P = 0 P_{nom}$   $\cos \phi = 1$
- B  $P = 0.5 P_{nom}$   $\cos \phi = 1$
- C  $P = P_{nom}$   $\cos \phi = 0.95$  Lag
- C'  $P = P_{nom}$   $\cos \phi = 0.95$  Lead

where  $P_{nom}$  is the active nominal power of the EV Unit.

The response to a new  $\cos \phi$  set point value shall be as fast as technically feasible after the new value of the active power is reached. The accuracy of the control to each set point shall be in accordance with the requirements of 5.7.1.

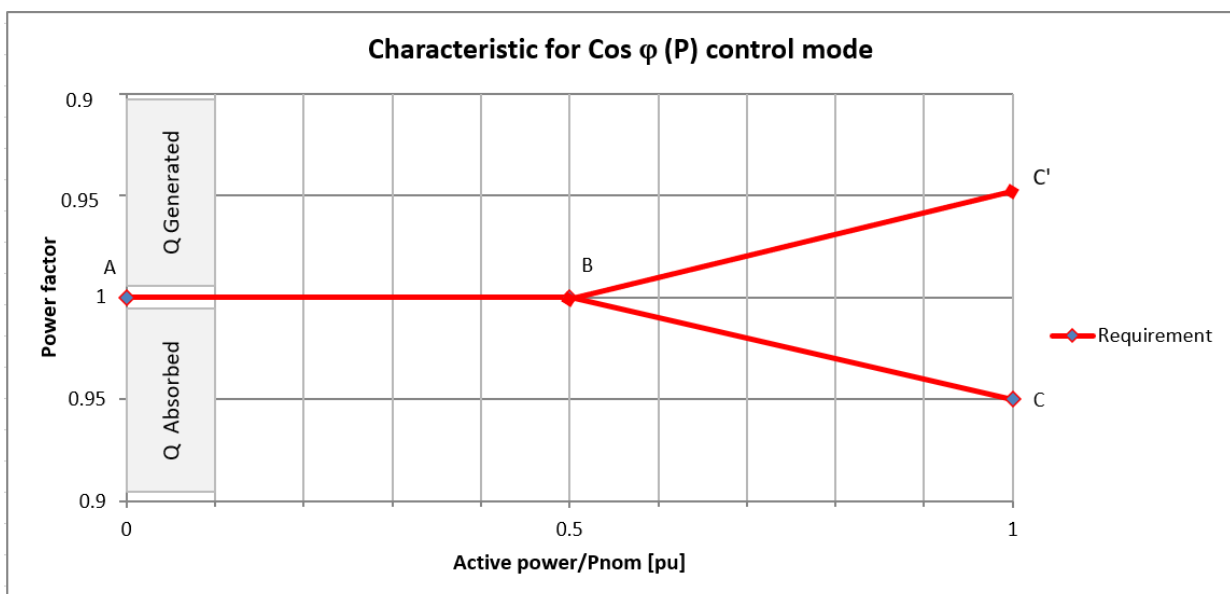


Figure 6 - Characteristic for  $\cos \phi (P)$  control mode

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The implementation of lock-in and lock-out voltage level shall be configurable, each in the range 90% to 110% of the nominal voltage at the Connection Point: the contribution is activated when the voltage at the Connection Point exceeds the lock-in voltage and is deactivated when the voltage at the Connection Point drops below the lock-out voltage. When the contribution is not activated, the EVCS shall be controlled with a unity power factor ( $\cos \varphi = 1$ ).

### 5.7.2.3 Reactive power support as a function of the voltage $Q(V)$

For EVCSs with a Maximum Connected Capacity greater than 22 kW, for such control mode, a characteristic with a minimum and maximum reactive power value and three connecting lines according to Figure 7 shall be configurable. It is SEC responsibility to communicate the parameters to be configured in case this support is required from EVCSs.

The values shall be assigned with the following criteria; therefore, the parameter ranges available in the inverter shall not limit this setting:

- $Q_{max}$  and  $-Q_{max}$  correspond to the capability curve boundaries as per Figure 5 (e.g.  $0.33 P_{nom}$ , where  $P_{nom}$  is the nominal power of the EV Unit)
- $V_2 < V_{nom} < V_3$

Possible default values can be the following unless differently agreed with SEC:

$$V_1 = 0.9 V_{nom}$$

$$V_4 = 1.1 V_{nom}$$

$$V_2 = 0.95 V_{nom}, V_3 = 1.05 V_{nom}$$

where  $V_{nom}$  is the nominal Voltage at the PoC.

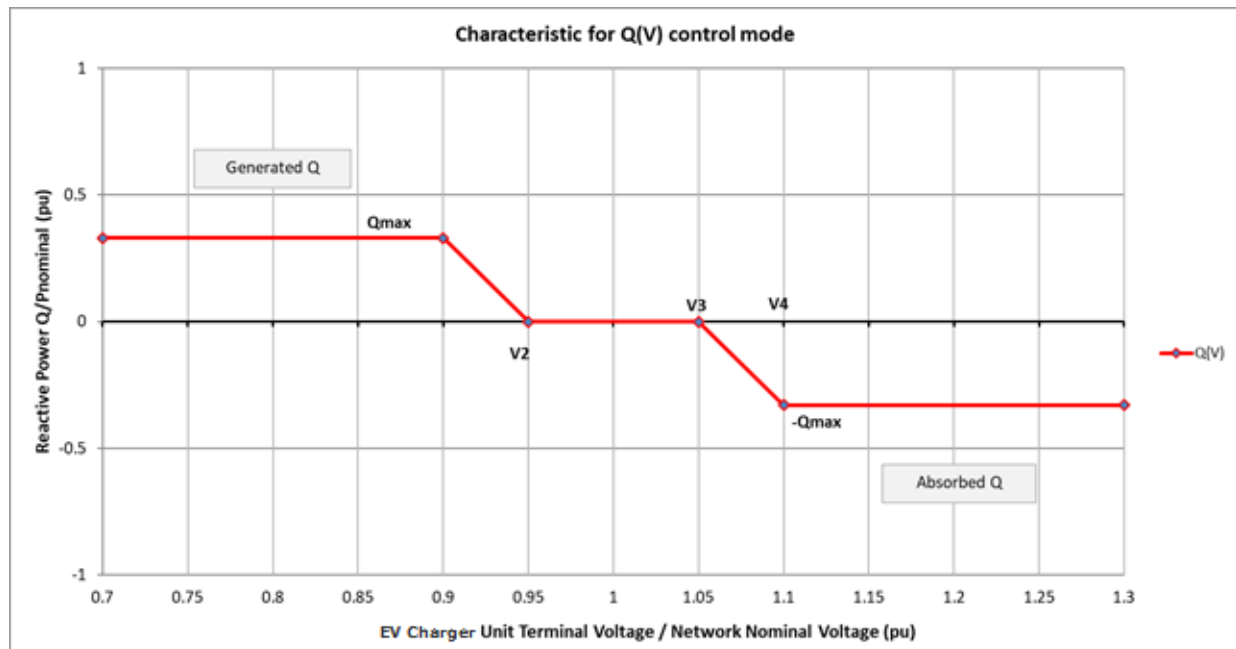


Figure 7 - Characteristic for  $Q(V)$  control mode

All the above control modes might be extended in the future to all types of EVCS when their share in the distribution grid increases. If not explicitly mentioned by SEC, the 22kW threshold shall be constantly updated and revised in accordance with the needs of the distribution network and the technology evolution. Consumers, contractors, and consultants shall ensure the acquisition of the latest version of this document.

## 5.8 Requirements for the management of the power system

### 5.8.1 Connection conditions

After the disconnection of An EVCS due to reasons not linked to the stability of the network, the EVCS is allowed to be reconnected to the network and to start to absorb electrical power due to normal operational start-up, when the voltage and frequency are within the following range for at least the observation time:

- Frequency range  $59.95 \text{ Hz} \leq \text{Frequency} \leq 60.05 \text{ Hz}$  (in charging mode);
- Voltage range  $95\% V_{nom} \leq \text{Voltage} \leq 105\% V_{nom}$  ( $V_{nom}$ = nominal voltage at the Connection Point);
- Minimum observation time 30s.

After the connection, an EVCS shall follow its target active power absorption value with a variation rate not greater than 10%  $P_{nom}/\text{min}$ , where  $P_{nom}$  is the nominal active power of the EVCS. The target active power absorption will depend on the number of EV units connected to the EVCS and the status of the batteries in each EV unit.

### 5.8.2 Protection and Control Ranking Priority

All EVCSs shall be designed and manufactured in a way that respects the priority ranking for the protections provided in this section. The purpose of the priority ranking is to avoid the conflict between 2 or more functions that have to be implemented at the same time. For instance, if there is an internal fault within the EVCS and at the same time there is an over-frequency problem in the network that indicates that the EVCS that was absorbing power from the network shall maintain its operation and stay connected.

In this case which of the 2 functions should prevail over the other? According to the below priority ranking the internal fault inside an EVCS has priority and the disconnection shall take place. the protection and control devices of an EVCS shall be organized in accordance with the following priority ranking (from highest to lowest):

1. Protection of the EV Units
2. Protection against faults within the Consumer's installation
3. Protection of the distribution network
4. Remote disconnection
5. Active power response to frequency variations
6. Remote limitation of active power
7. Remote reactive power control modes
8. Local reactive power control modes

To better achieve this level of protection, it is necessary that the EVCS includes the needed equipment and protection devices in order to perform as expected by these regulations. The components may vary from one manufacturer to another, however, all EVCS connected to the distribution network shall behave in a similar way when facing certain events. Some of the mandatory equipment and protection are reported in Table 3.

**Table 3: List of required equipment and settings**

Equipment	Protection purpose	Settings
Main Switch	Is needed to protect against short circuits and overcurrent	Case by case based on the short circuit power at PoC

## TECHNICAL STANDARDS FOR UNIDIRECTIONAL EVCS

RCD	Needed to protect against earth leakage current	the current of the RCD shall meet with the condition $I_d < 50/R_E$ where $R_E$ is the earthing resistance of the installation.
Power Management System PMS	Regulation of absorbed power	Automatically operated when frequency drops below 59.8 Hz
Control System	Communication with EV and DSP	A communication protocol to be developed
Battery Management System BMS	Identify the needed volt and current that can absorb.	Automatically activated based on battery status and if network voltage is outside the normal operating range 90-110%

### DISCLAIMER

*The ultimate goal of this equipment and setting is to protect the distribution network in a scenario of high integration of EVCS, this requirement will evolve hand in hand with the network needs and with the technology evolutions, as a consequence, these requirements will be in a continuous update and revision.*

### 5.8.3 Monitoring, remote control, and information exchange

Currently, all EVCSs have a smart communication system that can communicate with both network operators and EV units if the communication structure and protocols are defined. Adequate information concerning the Consumers connected to the Distribution Networks is a prerequisite for enabling SEC to maintain the stability, reliability, and security of its networks. SEC needs to have a continuous overview of the state of the network, which may require, in some cases, updated information on the operating conditions of the EVCSs connected to its Distribution Networks, as well as the possibility to communicate with these plants in order to direct the operational instructions set forth by the provisions of the present document.

Such requirements are usually needed in case of a growing penetration level of the EVCSs in distribution networks of a certain size; they may also be introduced in the framework of other initiatives dedicated, for example, to the optimization of the control performances of the network.

An EVCS with a Maximum Connected Capacity greater than 11 kW shall therefore have provision for bi-directional communication exchange which can be used for the exchange of information with SEC. Once actually needed for the operation of the network, in accordance with a cost/benefit approach, SEC shall have the right to specify additional requirements concerning especially:

- data, which shall be collected and sent to SEC in real-time or periodically, related to the operating conditions of the EVCS.
- operational instructions sent by SEC which shall be executed by the EVCS; such instructions shall be compliant with the requirements indicated in the present standards.
- Communications channels and protocols to be used for the above requirements.

If technically possible, SEC may take advantage of already existing communication channels, such as smart metering infrastructure, in order to facilitate the integration of the monitoring activities into its ICT architecture and reduce the costs of implementation.

### 5.8.4 Power factor

Any installations containing an EVCS of any size shall comply with the power factor limits, as measured at the Connection Point, indicated in the Distribution Code<sup>6</sup> (amended to date). This requirement can also be achieved by operating with the most suitable set point within the capability curves introduces in

<sup>6</sup> Specifically DPC2.4

## TECHNICAL STANDARDS FOR UNIDIRECTIONAL EVCS

chapter 5.7 for EVCS above 22kW, for EVCS smaller than 22kW further measures might be needed if violations in power factor were detected.

### 5.8.5 Power quality

#### 5.8.5.1 Voltage deviation

Under normal operating conditions, the connection and operation of an EVCS shall not cause the voltage at its Connection Point and at the Connection Point of any other Consumers connected to the same Distribution Network, to vary from the system-rated voltage by more than  $\pm 5\%$ .

The values of the voltages will then range in the following intervals as specified in the Distribution Code:

**Table 4: Voltage range under normal operating conditions for the different voltage levels**

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

As regards the LV distribution network and voltage levels, ANNEX A describes the different configurations of SEC power systems which can be found, with explanations of the different voltage levels.

#### 5.8.5.2 Rapid voltage changes

Connection and disconnection of an EVCS from the distribution networks shall not give rise to voltage variations exceeding 3% of the system-rated voltage at the Connection Point.

#### 5.8.5.3 Harmonic and inter harmonic voltages

Harmonic and inter harmonic voltages at the Connection Point of an EVCS connected to the MV Distribution Network shall not exceed the limits of the planning levels specified in the Saudi Arabia Distribution Code (SADC) Harmonics section "DPC2.3 Harmonics".

### DISCLAIMER

*The above technical requirements are meant to protect the distribution and transmission network from a fast-growing connection of EVCS. These requirements will be activated upon request from SEC and based on the network conditions and assessment. Due to the fast evolution of the network and the EV technology, these requirements might be updated based on the network needs, hence, its important for all stakeholders including manufacturers, consumers and contractors to acquire the latest update of this document which includes the latest requirements.*

## 6 COMPLIANCE

The Consumer shall ensure that its EVCS complies with the requirements defined in the present standards throughout the overall lifetime of the facility.

The Consumer shall notify to SEC of any incident, failure, or planned modification of its EVCS that may affect the compliance with the requirements defined in the present standards.

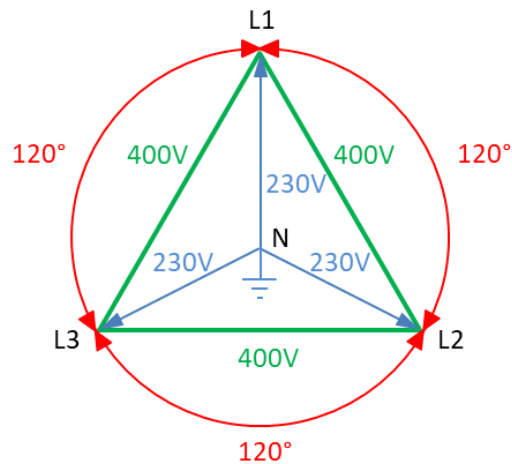
The Consumer shall provide SEC with all the documents, studies, and measurements useful to demonstrate the compliance of its EVCS to the requirements defined in the present standards.

If deemed necessary, SEC shall have the right to request the Consumer to carry out additional tests or studies with the scope to demonstrate the compliance of the EVCS with the provisions of the present document. Such activities may be requested not only during the connection process, but at any time throughout the lifetime of the EVCS, and more specifically after any failures, modifications, or replacements of any equipment that may have an impact on the compliance of the System with the present standards.

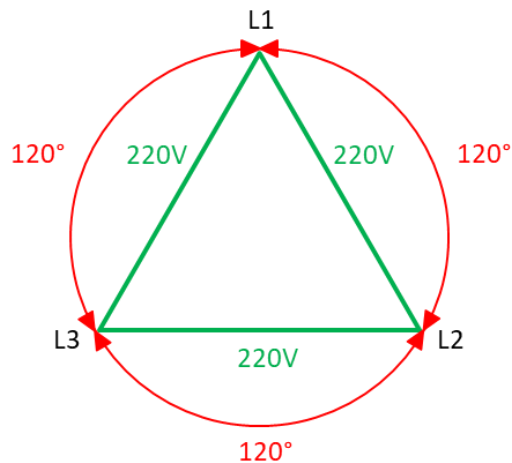
## ANNEX A. CONFIGURATION OF LV DISTRIBUTION SYSTEMS OF SEC

The AC power can be distributed to Consumers in the following possible ways in the LV Distribution Network of SEC. This will have to be considered in the choice of the equipment for EVCSs connected to the LV network, however, it is not expected the connection of EVCS to the old voltage level at 127V:

- 1) Three-phase four wires 400/230 Vac configuration



- 2) Three-phase three wires 220 Vac configuration



## TECHNICAL STANDARDS FOR UNIDIRECTIONAL EVCS

### ANNEX B. SERVICE AND ENVIRONMENTAL CONDITIONS FOR OUTDOORS INSTALLATIONS

Following table lists service conditions in the inland, desert, or coastal areas environment in the Kingdom of Saudi Arabia, to which EVCS will expose to if installed outdoors:

Altitude above mean sea level (msl):	a. up to 1000m (normal) b. above 1000m (as required)
Ambient Temperature (Outdoor):	Minimum: -5 °C Maximum: 55 °C Monthly average of the hottest month: 40 °C Yearly average: 30 °C
Ambient Temperature (Indoor):	Air-conditioned buildings: 25 °C Buildings where no air-conditioning is provided: 40 °C
Ambient ground temperature:	40 °C
Maximum relative humidity:	100%
Temperature of exposed surfaces due to solar radiation:	75 °C
Soil thermal resistivity one (1) meter and below:	2.0 °C.m/W
Maximum earthquake frequency/severity:	Zone 2 (U.S. Build Code)
Soil condition– General:	Corrosive. Widespread salt deposits.
Ground water table level:	Varies from deep to very near the surface
Soil pH:	7.0 – 8.5
Salt concentrations (typical) Sulphates (SO <sub>3</sub> ), by weight: 0 – 10 % Chlorides (as NaCl), by weight:	0 - 5%
Contamination level: Equivalent Salt Deposit Density (ESDD) in a period of any six:	0.3 to 0.5 mg/cm <sup>2</sup>
Average hydrogen sulphide in the atmosphere:	40 Mg/m <sup>3</sup> (0.03 ppm)
Soil salinity:	0 to 140 g/m <sup>3</sup> (0 to 100000 ppm)
Average rainfall per year:	150 mm
Maximum wind velocity:	150 km/h
Approximate highest density solar radiation average over the summer months	1000 W/m <sup>2</sup>
Isokeraunic level: (average / maximum / above 1000m):	10 /15 / 50 storm days/year

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#### TECHNICAL STANDARDS FOR UNIDIRECTIONAL EVCS

- 1) All equipment/material and accessories for EVCS shall be designed for satisfactory operation/performance based on the above (Indoor or Outdoor) service conditions.
- 2) All outdoor equipment enclosures/material shall be weatherproof, all metal parts shall be corrosion and/or abrasion-resistant, and the degree of protection shall be at least IP54 as per SASO standards.

## ANNEX C. APPLICABLE STANDARDS FOR EVCS COMPONENTS

Along with the Technical Standards for the Connection described in the current document, all the components of EVCSs shall comply with the applicable SASO standards which are listed in this Annex, according to the component they apply to.

This will ensure that components and equipment used in EVCSs in the Kingdom of Saudi Arabia fit with a minimum set of technical characteristics that give the necessary quality and avoid the use of unfit or unreliable material in EV projects.

The list includes the standards issued by SASO at the time of publication of this document. However, standards may be subject to future revisions, amendments, or extensions and it will be the user's care to find the latest published versions and utilize them. In all cases, the user should always comply with SASO technical regulations for EVs.

- [1]: SASO GSO IEC 62196: Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles.
- [2]: SASO IEC 61000-3-2: Electromagnetic compatibility (EMC)
- [3] IEC 15118: Road vehicles -- Vehicle to grid communication interface
- [4] SASO IEC 62196 -2: Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles - Part 2: Dimensional compatibility and interchangeability requirements for AC pin and contact-tube accessories
- [5] SASO IEC 61851: Electric vehicle conductive charging system
- [6] SASO IEC 62477-1: Safety requirements for power electronic converter systems and equipment - Part 1: General
- [7] SASO IEC 60364: Low-voltage electrical installations –Part 1: Fundamental principles, assessment of general characteristics, definitions
- [8] ISO 17409: Electrically propelled road vehicles — Connection to an external electric power supply — Safety requirements
- [11] SASO IEC 62368-1: Audio/video, information and communication technology equipment
- [12] SASO IEC 60529: Corrigendum 1 - Amendment 2 - Degrees of protection provided by enclosures (IP Code)
- [13] SASO IEC 61439-7: Low-voltage switchgear and control gear assemblies - Part 7: Assemblies for specific applications such as marinas, camping sites, market squares, electric vehicle charging stations
- [14] SASO IEC 62262: Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
- [15] SASO IEC 62477-1: Safety requirements for power electronic converter systems and equipment - Part 1: General
- [16] IEC 15118: Communication interface protocol between Vehicle to Grid, it is also known as protocol ISO 15118