



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

Additional Technical Requirements for the Connection of Bidirectional EVCS to the LV and MV Distribution Networks of SEC

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1 SCOPE

This is an integrative document to the connection standards issued for unidirectional EVCS entitled “Technical Specifications for the Connection of Unidirectional EVCS to the LV and MV Distribution Networks of SEC”. The scope of this document is to provide additional technical requirements that have to be respected for the connection of new bidirectional EVCS to protect the integrity and security of the distribution network and to guarantee the continuous delivery of quality of service in line with the requirements of the Distribution Code.

For the connection of the new bidirectional EVCS, all technical requirements established in the “Technical Specifications for the Connection of Unidirectional EVCS to the LV and MV Distribution Networks of SEC” have to be respected in addition to the requirements mentioned in this document in chapter 5. The standards for connecting bidirectional EVCS are not developed yet within international committees as the technology is still developing and some applications are yet under experiment. Nevertheless, this document is an attempt to develop a frame of technical requirements that aims at protecting the distribution network in the future when the integration of these systems becomes substantially high.

The requirements defined in this document shall be fulfilled regardless of the presence of loads in the Consumer’s installation. The document defines the following:

- Requirements for the equipment to be used for the interconnection of bidirectional EVCS with the distribution network.
- Requirements to support the frequency and voltage stability of the power system when it is subject to disturbances.
- Requirements to prevent the bidirectional EVCS from causing disturbances and damages either to the distribution network or to the other Consumers connected to the same distribution network.
- Requirements to prevent the bidirectional EVCS from operating in parallel with a portion of the distribution network which has been disconnected on purpose from the main power system.

All the technical requirements reported in this document are intended to reduce the impact of injecting power towards the grid, or when the bidirectional EVCS is in discharge mode. If the bidirectional EVCS is operated in charging mode reference shall be made in this case to the document [9], in this case, the bidirectional EVCS will operate similarly to the unidirectional EVCS.

It has to be noticed that the Distribution Code shall apply 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 the modification of the connection of an existing Consumer. The present Technical Standards shall apply in case the new installation (or modified one) includes a new bidirectional EVCS as defined in this document and shall be intended as an extension of the Distribution Code and of the “Technical Specifications for the Connection of Unidirectional EVCS to the LV and MV Distribution Networks of SEC” for what 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.

Finally, even if it is not directly within the scope of the present document, it is important to stress and remind the fundamental importance and necessity for these systems to use and assemble products in accordance with the national and international standards commonly used for the planning, design, installation, operation, and maintenance of bidirectional EVCS. As regards the Service Conditions, the equipment/material used for the EV Systems 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.

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

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 the Bidirectional EVCS to the distribution grid, hence this document is expected to evolve in parallel with the evolution of the technology.

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 ≤ 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 ≤ 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 ≤ 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 Systems / Stations to SEC Distribution Networks
- [9] Technical Specifications for the Connection of Unidirectional EVCS to the LV and MV Distribution Networks of SEC
- [10] IEC 15118: Communication interface protocol between Vehicle to Grid, it is also known as protocol SASO ISO 15118

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_{nom} in the case of the nominal active power of equipment.

Apparent power – Is the product of voltage (in Volt) and current (in Ampere). It is usually expressed in kiloVolt-Ampere (kVA) or MegaVolt-Ampere (MVA) and consists of a real component (Active Power) and an imaginary component (Reactive Power). In the text, this will be generically referred to as S or S_n in the case of the rated apparent power of equipment.

Auxiliary Supply Power – Electricity supply to auxiliary systems and services such as Interface Protection or circuit breaker and contactor opening coils.

Certified Vendor – An entity that is enrolled with SEC to design, install, operate and maintain an EV Charging System.

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 that 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, 380/220V, and 220/127V.
- A Medium Voltage (MV) Distribution System is a network with nominal voltage, ranging from 1kV AC up to 69 kV. The MV Distribution System nominal voltages in KSA are 13.8, 33kV, and 69kV.

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

Delay time (of a protection relay) – Indicates the minimum duration of a fault detected by the protection relay before the output of the protection relay is triggered.

EV Charging Pool – Assembly of electrically interconnected EV chargers with multiple charging ports and sockets. It can be found in public areas e.g. commercial malls and public parking areas.

EV Unit – A group of devices that allow connecting 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.

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.

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

Islanding - Situation where a portion of the distribution network, containing generating plants, becomes physically disconnected from the rest of the distribution network, and one or more generating plants maintain a supply of electrical energy to such an isolated part of the distribution network.

Main Meter - Is the bidirectional device installed at the Connection Point which measures the amount of electric energy exchanged (either in import or in export) by the Consumer with the distribution network.

Power factor (ϕ) – 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_{nom}.

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 can 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 – 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.

Bidirectional EVCS – refers to V2G technology which allows the power to flow in both directions from the grid toward the EV and vice versa and in this case, the charging station is considered as both generator and load.

4 GLOSSARY

The following acronyms and symbols are used throughout the document:

$\cos \varphi$	Power factor
WERA	Water & Electricity Regulatory Authority
IP (or I.P.)	Interface Protection
LOM	Loss Of Mains
LV	Low Voltage (namely 220/127 Vac or 380/220 Vac or 400/230 Vac)
LVRT	Low Voltage Ride Through
MV	Medium Voltage (namely 13.8kV or 33 kV)
P	Active power
P _{nom}	Nominal active power of the equipment
p.u. (or pu)	per unit
EV	Electric Vehicle
Q	Reactive Power
S	Apparent Power
S _n	Nominal Apparent Power
SEC	Saudi Electricity Company
V	Voltage
V _{nom}	Nominal Voltage

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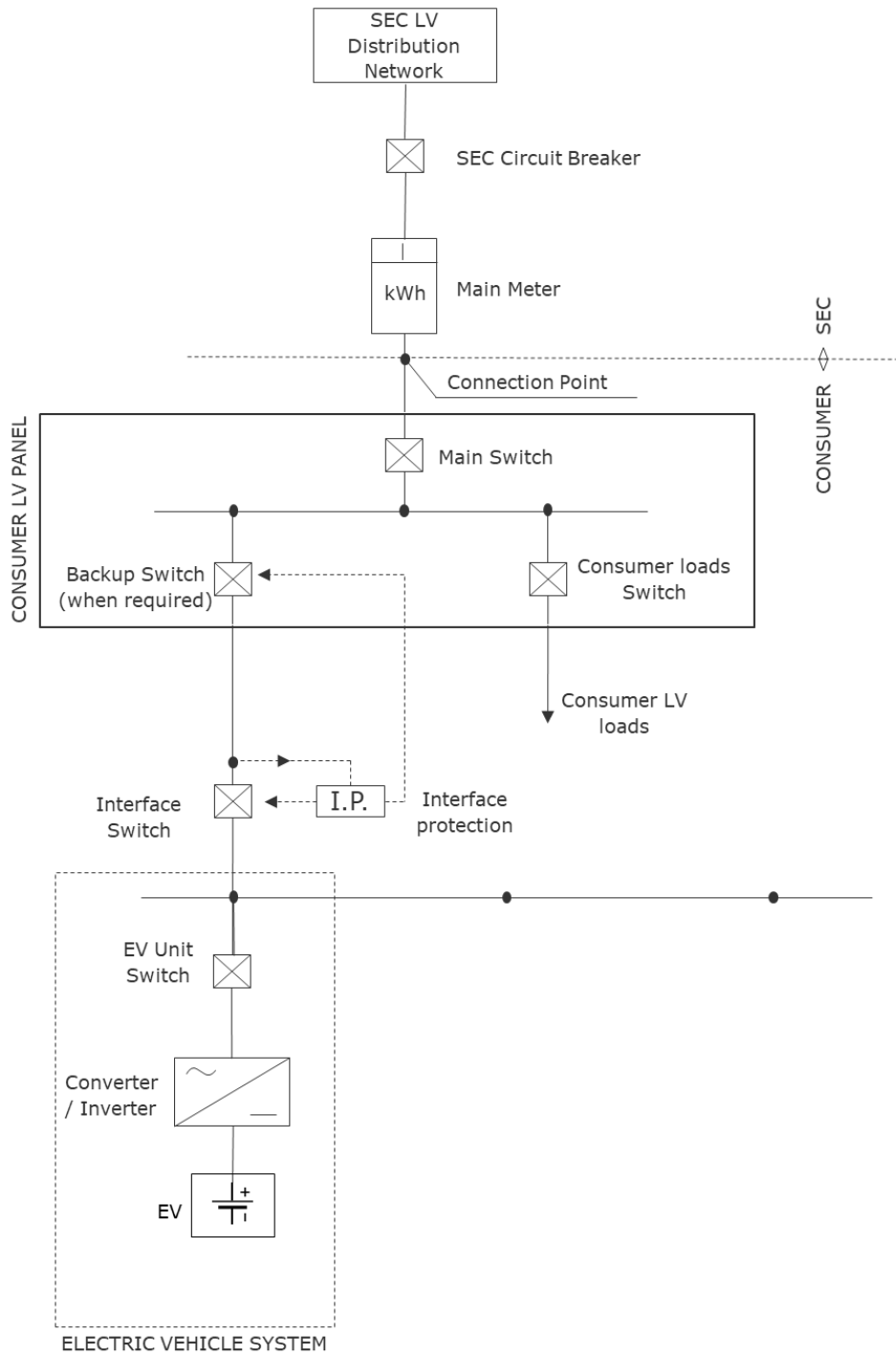
5.1 Connection schemes

The purpose of this section is to provide a general scheme for bidirectional EVCS that illustrates the main components necessary for connecting these systems. These schemes may differ from case to case but all illustrated components in this section shall be present in any design of bidirectional EVCS. Additional schemes are reported in Annex A which presents the typical equipment that is additionally required for Bidirectional EVCS and which shall be at least installed for a safe and reliable interconnection of an EVCS to the LV and MV distribution network, such as:

- Interface Protection, it's mandatory protection for the bidirectional EVCS which intends to monitor both the frequency and voltage of the network and intervene for the sake of protecting the distribution network from any disturbances.
- Interface Switch, operated by Interface Protection, shall be envisaged in the Consumer installation to separate the portion of it containing one or more EV Units from both the remaining part of the Consumer's installation containing only loads and SEC distribution network.

the ability of the Bidirectional EVCS to generate power shall not be affected at any time by random trappings of a protection device caused by a bad selectivity. For instance, if the IP protection trips due to a fault in the network, once the disturbance is cleared, no other device should prevent the Bidirectional EVCS from discharging power but the IP protection itself, hence, all components in the EVCS shall be ready to discharge towards the grid once the IP protection commands the reclosure of the IP switch.

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Figure 1 - Schematic representation for the interconnection of a Bidirectional EVCS to SEC LV Distribution Network

¹ Another alternative is to use the EV unit switch as a backup switch and in this case the interface switch has to be an MCCB to protect the system against short circuit current.

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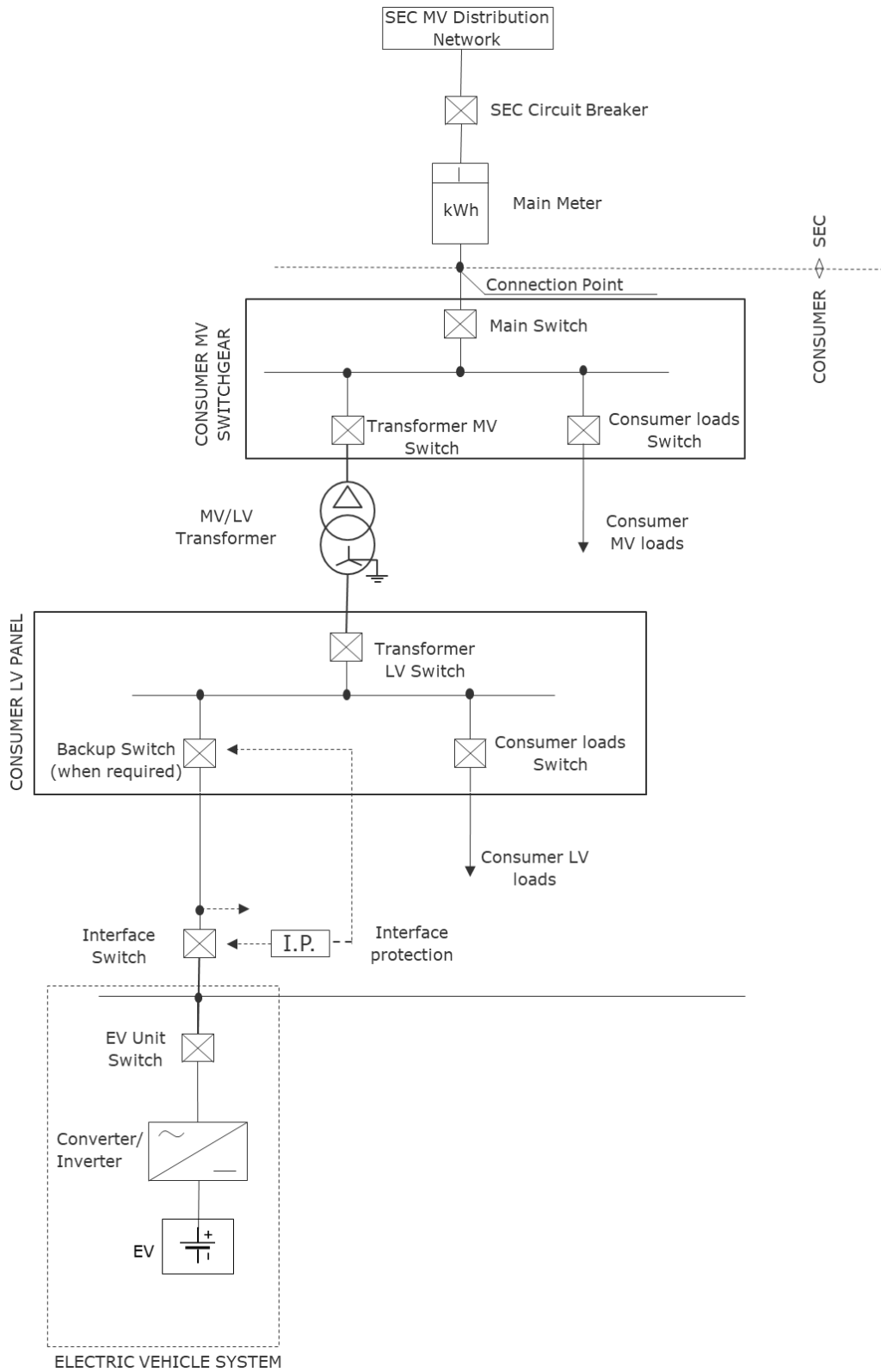


Figure 2 - Schematic representation for the interconnection of a Bidirectional EVCS to SEC MV Distribution Network (either 13.8 or 33kV)

5.2 Choice of Switches

The correct dimensioning and selection of the switch is the responsibility of the Bidirectional EVCS designer, the correct design shall ensure a safe operation and a performance aligned with the expectation of the technical requirements, for instance, a bidirectional EVCS connected to the MV Distribution Network and with the Interface Switch on the MV side of the plant (as shown in Figure 14 in ANNEX A), the Interface Switch shall consist of:

- three-pole withdrawable automatic circuit breaker operated by an Undervoltage release, or
- three-pole automatic circuit breaker operated by an Undervoltage release along with a line isolator (either upstream or downstream of the circuit breaker)

In any case, the circuit breaker shall be motorized, and allow automatic reclosure once the network disturbances that have led to the trip of the Interface Protection have been cleared. The consensus to the reclosure of the Interface Switch shall be given by the Interface Protection itself, which has then to sense the voltages on the network side (as represented in the Connection Schemes in Figure 13 and Figure 14 in Annex A) and not on the EVCS side of the Interface Switch. The reconnection duration to the distribution network after tripping can be classified for 2 reasons as reported in 5.5.2:

- Due to a fault in the network.
- Manual tripping of the EVCS.

For bidirectional EVCSs connected to the MV Distribution Network and with the Interface Switch on the LV side of the plant (see Figure 13 in ANNEX A) or for bidirectional EVCSs connected to the LV distribution network (see schemes from Figure 6 to Figure 14 in ANNEX A), the interface switch shall consist of either:

- motorized automatic circuit breaker or switch disconnecter operated by an Undervoltage release, or
- AC3 contactor operates on all the poles (i.e. phases and neutral).

In order to allow automatic reclosure once the network disturbances that have led to the trip of the Interface Protection have been cleared. The consensus to the reclosure of the Interface Switch shall be given by the Interface Protection itself, which has then to sense the voltages on the network side (as represented in the Connection Schemes, from Figure 6 to Figure 14) and not on the EVCS side of the Interface Switch. In case of loss of auxiliary supply power to the switchgear, a secure disconnection of the Interface Switch is required immediately.

The function of the Interface Switch can be combined with either the Main Switch or the EV Unit Switch in a single switching device². In case of a combination of these, the single combined switching device shall be compliant with both the requirements of the interface switch and of either the main switch or EV unit switch, according to the combination chosen.

² For connection schemes using a single main switch, the combination of the interface switch with the main switch will lead to the disconnection of the overall Consumer's facility when the interface switch is opened, that is a lack of supply will also affect the Consumer load.

5.3 Requirements for the frequency stability of the power system

5.3.1 Active power response for Bidirectional EVCSs in Discharging mode

When a Bidirectional EVCS operates in discharging mode, in other words injecting power towards the grid, the active power response shall match the requirements illustrated in the graph below in Figure 3. The reduction of active power is activated after 60.3 Hz threshold to allow the intervention of the primary reserve in the grid.

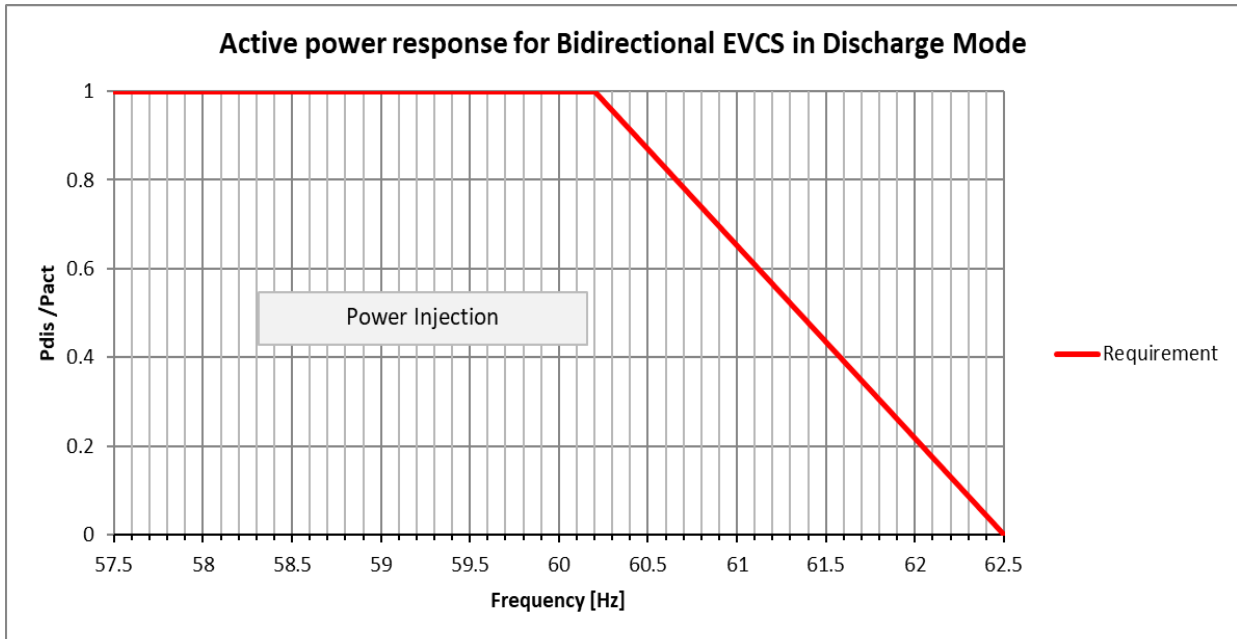


Figure 3 – Frequency regulation requirement for EVCS when discharging toward the grid

In these circumstances, the Bidirectional EVCS is acting as a generator and it shall reduce the active power injection towards the grid during over-frequency conditions. During under-frequency conditions though, the Bidirectional EVCS shall maintain the active power injection towards the distribution network. The amount of active power injection will depend on the amount of power stored inside the battery before the inversion of power flow and the number of EVs connected to the Charging Station.

5.3.2 Remote limitation of Active power injection

Bidirectional EVCS with a Maximum Connected Capacity greater than 22 kW shall be equipped with an interface (input port) that is able to receive, from a remote-control center, an instruction requiring the reduction of the active power output. The reduction of active power shall be carried out as fast as possible and with an accuracy greater than 5% of the nominal active power of the EVCS.

SEC shall have the right to specify further requirements in terms of equipment, communication protocol, information to be exchanged, and/or time of execution, which allows integration of such features into the control systems of its distribution network and which allows remotely limiting the active power output of the Bidirectional EVCS connected to its network.

5.4 EVCS requirements for the voltage stability of the power system

5.4.1 Active Power reduction at increasing voltage

In order to avoid disconnection due to overvoltage protection, a Bidirectional EVCS is allowed to reduce its apparent power input (active and/or reactive power) as a function of the rising voltage at the Point of Connection if it was discharging the power toward the grid. The implemented logic can be chosen by the Manufacturer/Certified Vendor. Nevertheless, the implemented logic shall not cause steps or oscillations in the power output of the system.

5.4.2 Reactive current injection during a fault

The provision of reactive current during a fault is currently not required for EVCSs. Such a feature might be introduced in the future and only for MV-connected Bidirectional EVCS, in a scenario of a growing penetration level of Bidirectional EVCS and a decreasing short circuit power of the power system of the KSA.

5.4.3 Reactive power capability

Bidirectional EVCS will have the ability to operate in both charging and discharging modes, and consequently, a different capability is introduced for these particular systems. The following extreme working points can be singled out for Bidirectional EVCS:

- Set Point A: The EVCS can charge the connected EV 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 of 0.95 Lag.
- 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 connected EV for 100% of the capacity and generate the necessary reactive power by 33% of the rating capacity in Mvar, operating at a power factor of 0.95 Lead.
- Set Point C: The EVCS discharge the stored power in the connected EV for 100% (in case fully charged) of the rated capacity and it produces the necessary reactive power by generating 33% of the rating capacity in Mvar. It operates in this case at a power factor of 0.95 leading, the EVCS works as a generator in this case.
- Set Point D: The EVCS discharge the stored power in the connected EV for 100% (in case fully charged) of the rated capacity and it absorbs the necessary reactive power by absorbing 33% of the rating capacity in Mvar. It operates in this case at a power factor of 0.95 lagging, and the EVCS works as a generator in this case.

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

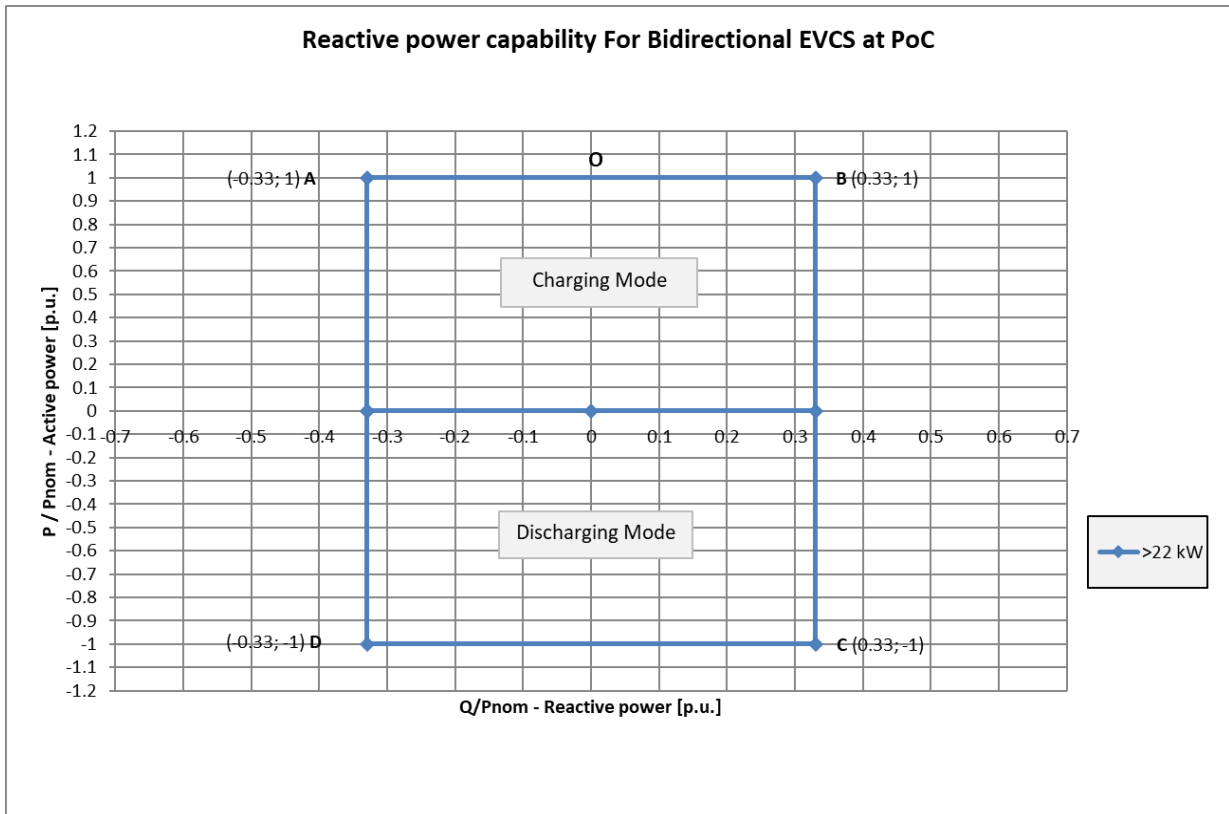


Figure 4 - Reactive power capability

5.4.4 Reactive power control modes

5.4.4.1 Power related control mode

The power related control mode $\cos \varphi$ (P) controls the $\cos \varphi$ 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 5.4.3 shall be configurable within the control systems of the EVCS; a change in active power output results in a new $\cos \varphi$ set point according to the characteristic.

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

In Charging mode:

- C $P = 0 P_{nom}$ $\cos \varphi = 1$
- D $P = 0.5 P_{nom}$ $\cos \varphi = 1$
- E $P = P_{nom}$ $\cos \varphi = 0.95$ Lag
- F $P = P_{nom}$ $\cos \varphi = 0.95$ Lead

In Discharging mode:

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

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

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The response to a new $\cos \varphi$ 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 5.4.3.

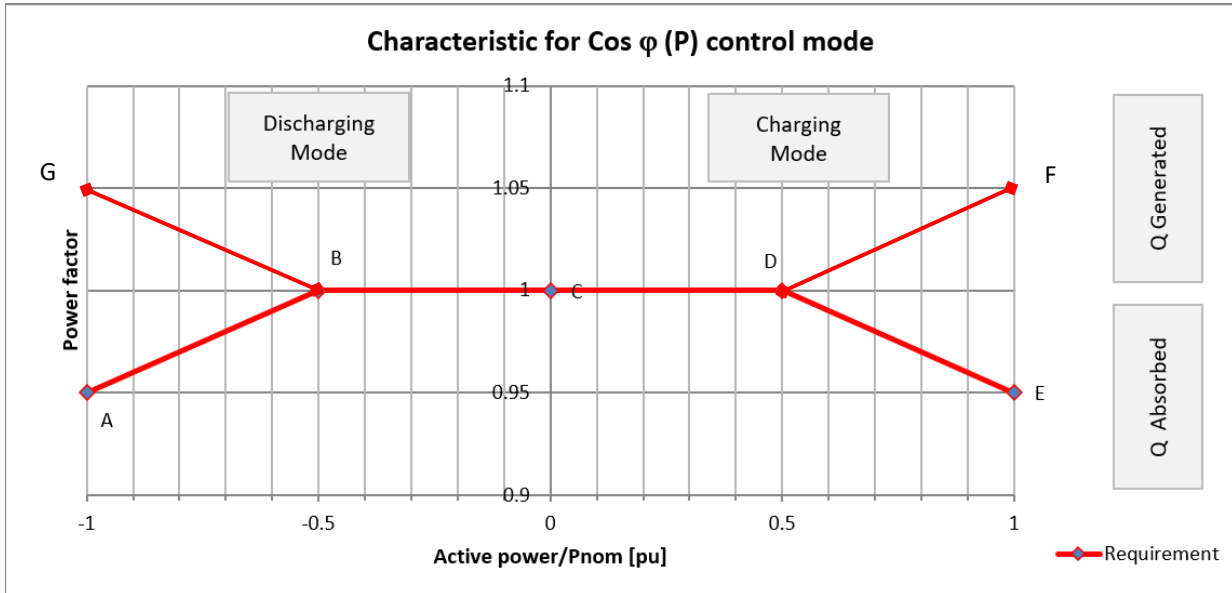


Figure 5 - Characteristic for $\cos \varphi$ (P) control mode

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

5.5 Requirements for the management of the power system

5.5.1 Remote disconnection

A Bidirectional EVCS with a Maximum Connected Capacity greater than 11 kW³ shall be equipped with a logic interface (input port) in order to disconnect from the network following an instruction received at its interface.

In accordance with the provisions set forth in 5.8.3 in the document [9], SEC shall have the right to specify further requirements in terms of equipment, time of execution, communication protocol, and/or data to be exchanged, to integrate such features into the control systems of its distribution network, and to allow the remote disconnection of the Bidirectional EVCS connected to its network.

5.5.2 Connection conditions

After the disconnection of EVCS due to reasons not linked to the stability of the network, the bidirectional EVCS is allowed to reconnect to the network and to start to absorb or inject 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)
- Frequency range $59.5 \text{ Hz} \leq \text{Frequency} \leq 60.05 \text{ Hz}$ (in discharging mode)
- Voltage range $95\% V_{nom} \leq \text{Voltage} \leq 105\% V_{nom}$ (V_{nom} = nominal voltage at the PoC)

³ Remote disconnection is not applicable when EV is installed under the previous meter (Residential).

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- Minimum observation time 30s.

5.5.3 Automatic reconnection after tripping

After the trip of the interface protection due to violations in the network, a Bidirectional EVCS is allowed to reconnect to the network only if 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);
- Frequency range $59.5 \text{ Hz} \leq \text{Frequency} \leq 60.05 \text{ Hz}$ (in discharging mode);
- Voltage range $95\% V_{nom} \leq \text{Voltage} \leq 105\% V_{nom}$ (V_{nom} = nominal voltage at the PoC);
- Minimum observation time 300s.

After reconnection, the Bidirectional EVCS shall return to its target active power value with a variable rate not greater than 10% P_{nom}/min , where P_{nom} is the nominal active power of the EVCS.

5.5.4 Interface Protection

As mentioned previously, interface protection is a voltage and frequency protection that's intention is to protect the grid from any violations that might be caused by the power injected into the grid. Therefore interface protection is mandatory to be installed only for Bidirectional EVCS. The purpose of the interface protection is to:

- disconnect the Bidirectional EVCS from the Distribution Network in the following cases
 - the Distribution Network (or the feeder) to the EVCS is connected to de-energized from the main source of supply. De-energisation can be performed automatically due to protection system operation or manual/electrical disconnection. Electrical/manual disconnection in the Distribution Network can happen either remotely by SEC SCADA system or by local switching.
 - the voltage and frequency at the Connection Point are out of the normal operating ranges as defined in 5.4 in [9].
- prevent the Bidirectional EVCS, when generating power, to cause over-voltages in the distribution network it is connected to.

It should be noted that it is not the purpose of the interface protection to:

- disconnect the bidirectional EVCS from the Distribution Network in case of faults within the Consumer's installation; for such issues, the requirements for the connection of passive customers shall apply (refer to Distribution Code);
- prevent damages to the Consumer's equipment (EV charging units or loads) due to faults/incidents (e.g. short circuits) in the Distribution Network or on the Consumer's installation; for such issues, the recommendations and requirements of the manufacturers of the equipment shall apply.

The interface protection shall be a dedicated device(s) that acts on the interface switch. For a Bidirectional EVCS with a Maximum Connected Capacity smaller than or equal to 22 kW, it is permitted to integrate interface protection and the interface switch (see for example Figure 6 in ANNEX A).

For a Bidirectional EVCS with a Maximum Connected Capacity greater than 22 kW, the interface protection shall additionally act on another switch (backup switch) in case the interface switch fails to operate (see for example Figure 13 in ANNEX A). The backup switch may consist of a dedicated switch or

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an already existing switch⁴. When the backup switch is triggered because the interface switch has failed to open, only manual reclosure shall be possible⁵.

For a Bidirectional EVCS with a Maximum Connected Capacity greater than 22 kW, the power supply of the interface protection shall include an uninterruptible power supply. The loss of the auxiliary voltage on either the interface protection or on the EVCS's control system shall trigger the interface switch without delay.

The protection functions required in the Interface Protection are the following:

- Undervoltage [27]
 - One threshold [27<] in the range [20%; 100%] of the nominal voltage at the Connection Point is adjustable by steps of 5%, and delay time in the range [0.1s;100s] is adjustable in steps of 0.1s;
 - One threshold [27<<] in the range [0%; 100%] of the nominal voltage at the Connection Point is adjustable by steps of 5%, and delay time in the range [0.1s;5s] is adjustable by steps of 0.05s.
- Overvoltage [59]
 - One threshold [59>] in the range [100%; 120%] of the nominal voltage at the Connection Point is adjustable by steps of 1%, and delay time in the range [0.1s;100s] is adjustable in steps of 0.1s;
 - One threshold [59>>] in the range [100%; 130%] of the nominal voltage at the Connection Point is adjustable by steps of 1%, and delay time in the range [0.1s;5s] is adjustable by steps of 0.05s.
- Over-frequency [81>]
 - One threshold [81>] in the range [60Hz; 63Hz] is adjustable by steps of 0.1Hz, and delay time in the range [0.1s;100s] is adjustable in steps of 0.1s;
 - One threshold [81>>] in the range [60Hz; 63Hz] is adjustable by steps of 0.1Hz, and delay time in the range [0.1s;5s] is adjustable in steps of 0.05s;
- Under-frequency [81<]
 - One threshold [81<] in the range [57Hz; 60Hz] is adjustable by steps of 0.1Hz, and delay time in the range [0.1s;100s] is adjustable in steps of 0.1s;
 - One threshold [81<<] in the range [57Hz; 60Hz] is adjustable by steps of 0.1Hz, and delay time in the range [0.1s;5s] is adjustable in steps of 0.05s;
- Loss Of Mains (Anti-Islanding):

for the Loss Of Mains (LOM) protection function, a wide variety of approaches can be used: besides the passive observation of voltage and frequency, other active and passive methods are available and used to detect unintentional islanding situations. The present document does not intend to specify the method to be used to achieve the goal but rather its efficacy; for such a reason, the only requirement on LOM protection is that the protection function shall be tested in accordance with SASO IEC 62116 or other equivalent standards, which provides procedures to evaluate the performance of islanding prevention measures used with utility-interconnected Solar PV Systems.

Appropriate settings shall be applied to the interface protection and shall ensure the correct tripping of the Bidirectional EVCS under specific conditions. The settings shall be chosen so that, in case a fault within the distribution network triggers the network protection systems (which in turn disconnects the

⁴ It is anyway recommended not to use the main switch as back-up switch since it could lead to the disconnection of the overall Consumer's facility in the case the interface switch fails to open, with the consequence of the power supply also being removed to Consumer's loads.

⁵ The reasons are that it is required that the plant maintenance operator first acknowledges and checks the reasons why the interface switch failed to open, then remedies the technical issues and finally resumes operation.

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faulty feeder), all bidirectional EVCSs with Interface protection are disconnected before the attempt of reclosure in the MV distribution network takes place.

ANNEX B proposes default settings for 27, 59, and 81 protection functions. Such settings shall be applied to the Interface Protection of a Bidirectional EVCS only in case no other settings have been explicitly specified and communicated by SEC.

Moreover, the Interface Protection shall have at least two configurable digital inputs which may be used in the future⁶ by SEC for transfer trips, remote tripping, or any other function that may be necessary to increase the capacity of the distribution networks to host Bidirectional EVCS while keeping an acceptable level of reliability and security.

⁶ In a scenario of growing penetration level of Bidirectional EVCS in the distribution networks of the KSA

6 COMPLIANCE

The Consumer shall ensure that bidirectional 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 bidirectional EVCS which 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 bidirectional 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. CONNECTION SCHEMES FOR BIDIRECTIONAL EVCS









The schemes proposed in this Annex show examples of possible cases of connection of bidirectional EVCSs to either LV or MV Distribution Network of SEC, to summarize in single line diagrams the clauses on the connection as presented in this document, in particular in 5.1 and 5.2 Different arrangements may be used if previously agreed with SEC. These schemes have to be combined with the general scheme of the installation, for the feeding of the Consumer's loads.

The cases presented in the following are here listed:

Figure	Distribution Network (LV/MV)	Maximum Connected Capacity of the EVCS
6	LV	< 22kW
7	LV	> 22kW and ≤ 50kW
8	LV	> 22kW and ≤ 50kW
9	LV	> 50kW and ≤ 200kW
10	LV	> 50kW and ≤ 200kW
11	LV	> 200kW and ≤ 2 MW
12	LV	> 200kW and ≤ 2 MW
13	MV	≥ 2MW and ≤ 25 MW
14	MV	≥ 2MW and ≤ 25 MW

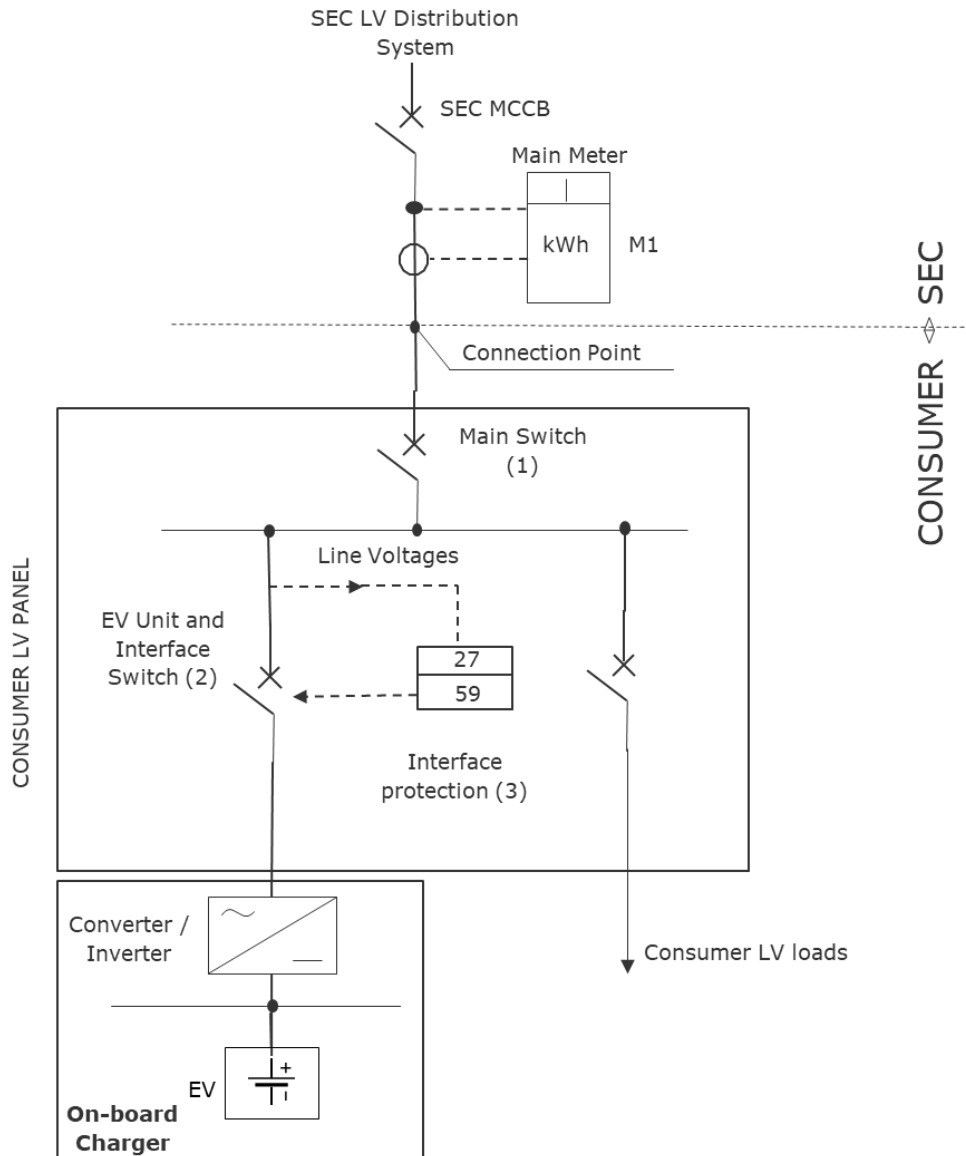
ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

The meaning of the symbols used in the single-line diagrams is explained hereinafter:

LEGEND	
	SWITCH (CIRCUIT BREAKER OR CONTACTOR)
	CURRENT TRANSFORMER (CT)
	POTENTIAL TRANSFORMER (PT)
	LOAD
	Converter / Inverter
	EV
	POWER TRANSFORMER
	Meter / Smart Meter

ANSI SYMBOLS FOR PROTECTIONS	
27	UNDERVOLTAGE PROTECTION
59	OVERVOLTAGE PROTECTION
81	UNDERFREQUENCY (81<), OVERFREQUENCY (81>) PROTECTION
LOM	LOSS OF MAINS PROTECTION
50	INSTANTANEOUS OVERCURRENT PROTECTION
51	IDMT OVERCURRENT PROTECTION
50N/51N	EARTH FAULT CURRENT PROTECTION

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS



NOTES:

(1) Automatic Circuit Breaker

(2) Motorized Automatic Circuit Breaker / Switch Disconnecter or AC3 Contactor operated by Undervoltage release In case an AC3 Contactor is used, an additional Automatic Circuit Breaker / Switch Disconnecter with:

Overload Protection

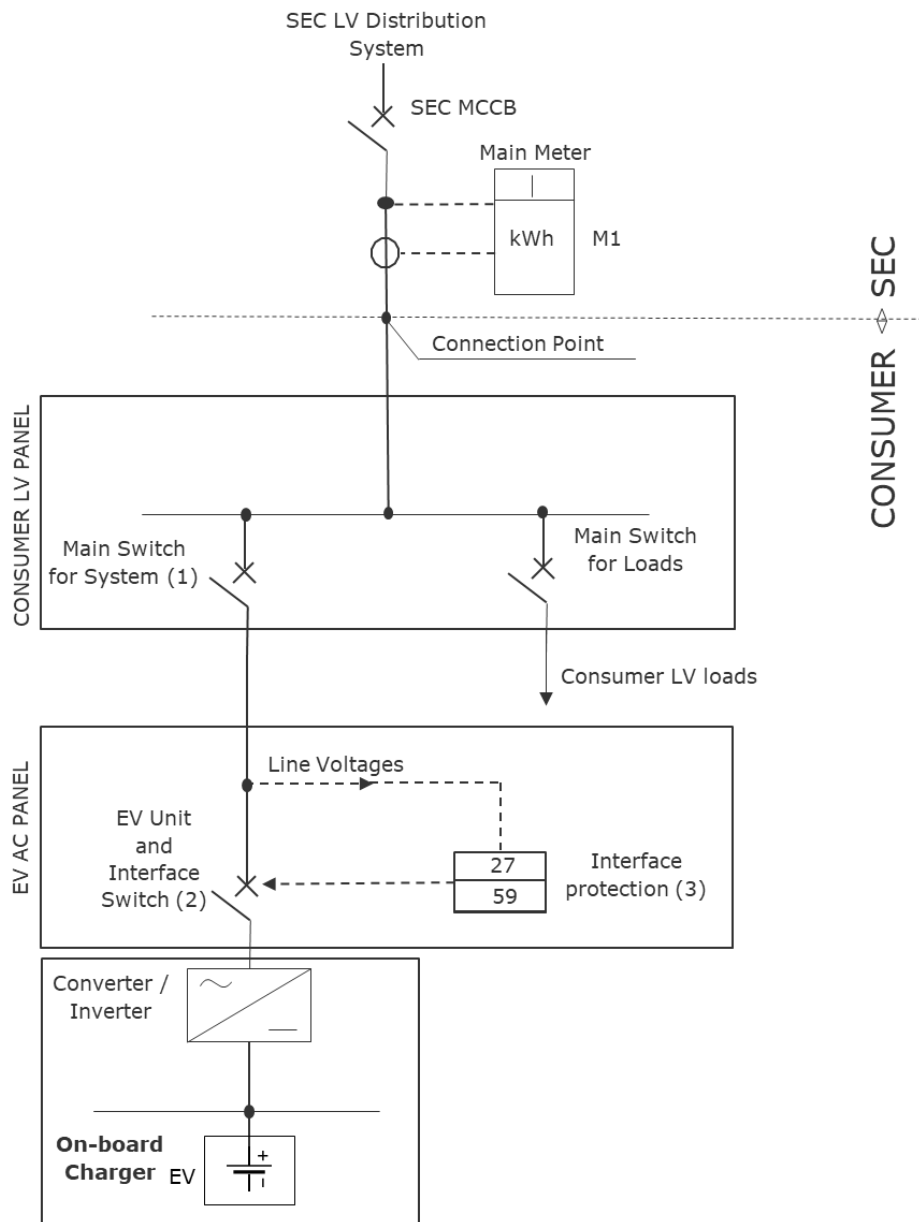
Short Circuit Protection

Protection against electric shock (RCD) is needed for the protection of the circuit

(3) Auxiliary power supply from a UPS

Figure 6: LV Connection Scheme – Bidirectional EVCS with Maximum Connected Capacity $\leq 22\text{kW}$

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

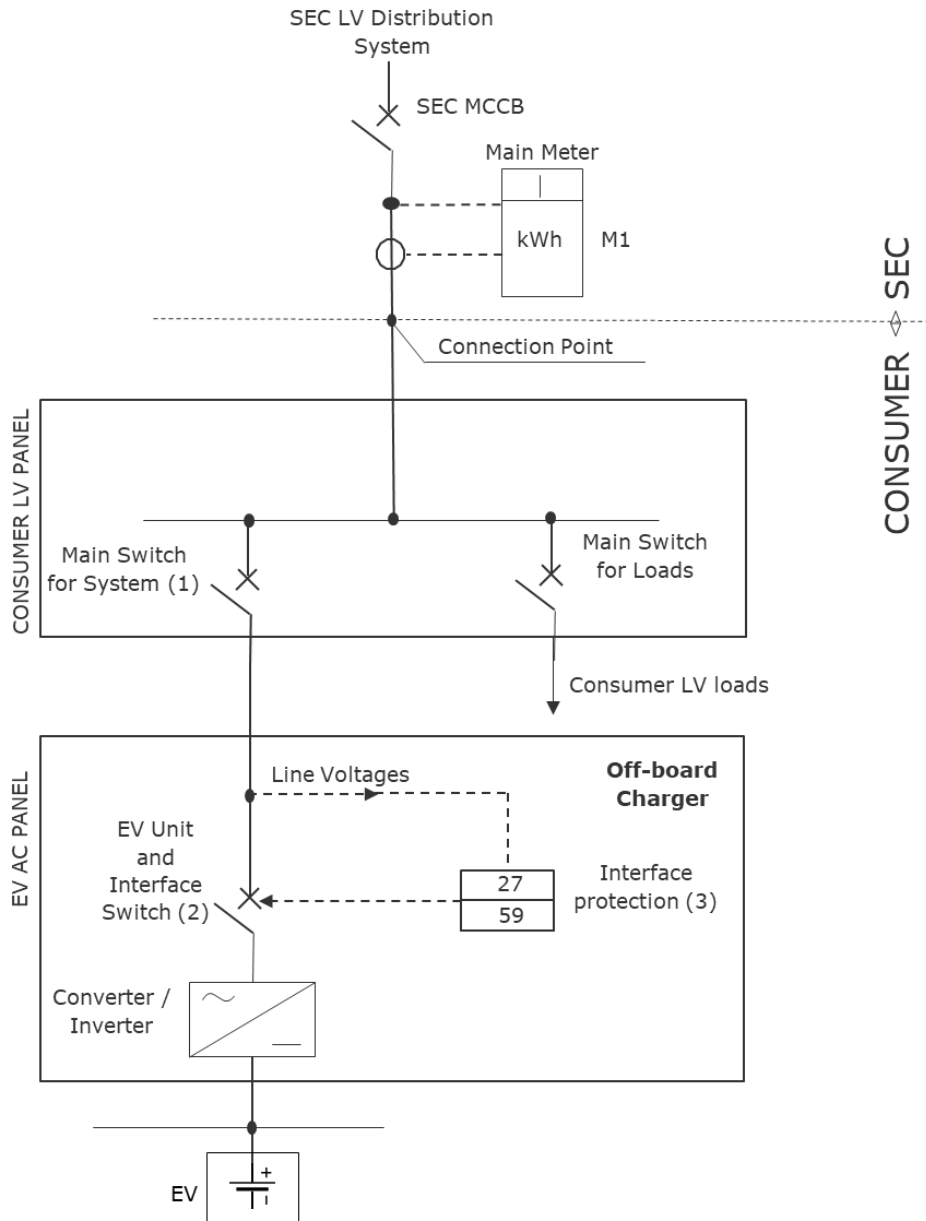


NOTES:

- (1) Automatic Circuit Breaker / Switch Disconnecter with:
 - Overload Protection
 - Short Circuit Protection
 - Protection against electric shock (RCD)
- (2) Motorized Automatic Circuit Breaker / Switch Disconnecter or AC3 Contactor operated by Undervoltage release
- (3) Auxiliary power supply from a UPS

Figure 7: LV Connection Scheme – Bidirectional EVCS with a maximum capacity between 22 kW and 50 kW three-phase system.

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

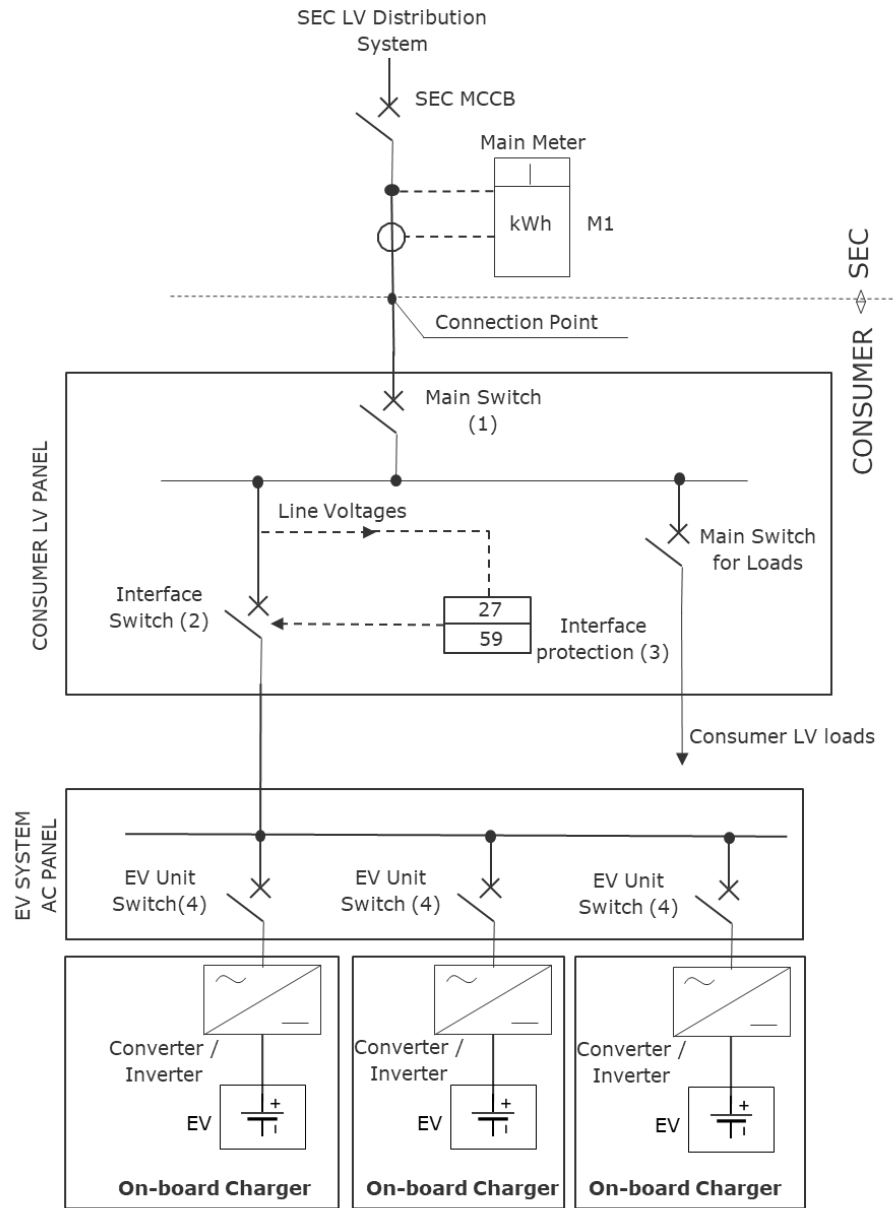


NOTES:

- (1) Automatic Circuit Breaker / Switch Disconnecter with:
 - Overload Protection
 - Short Circuit Protection
 - Protection against electric shock (RCD)
- (2) Motorized Automatic Circuit Breaker / Switch Disconnecter or AC3 Contactor operated by Undervoltage release
- (3) Auxiliary power supply from a UPS

Figure 8: LV Connection Scheme – Bidirectional EVCS with a maximum capacity between 22 kW and 50 kW three-phase system with an off-board inverter for DC FAST.

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

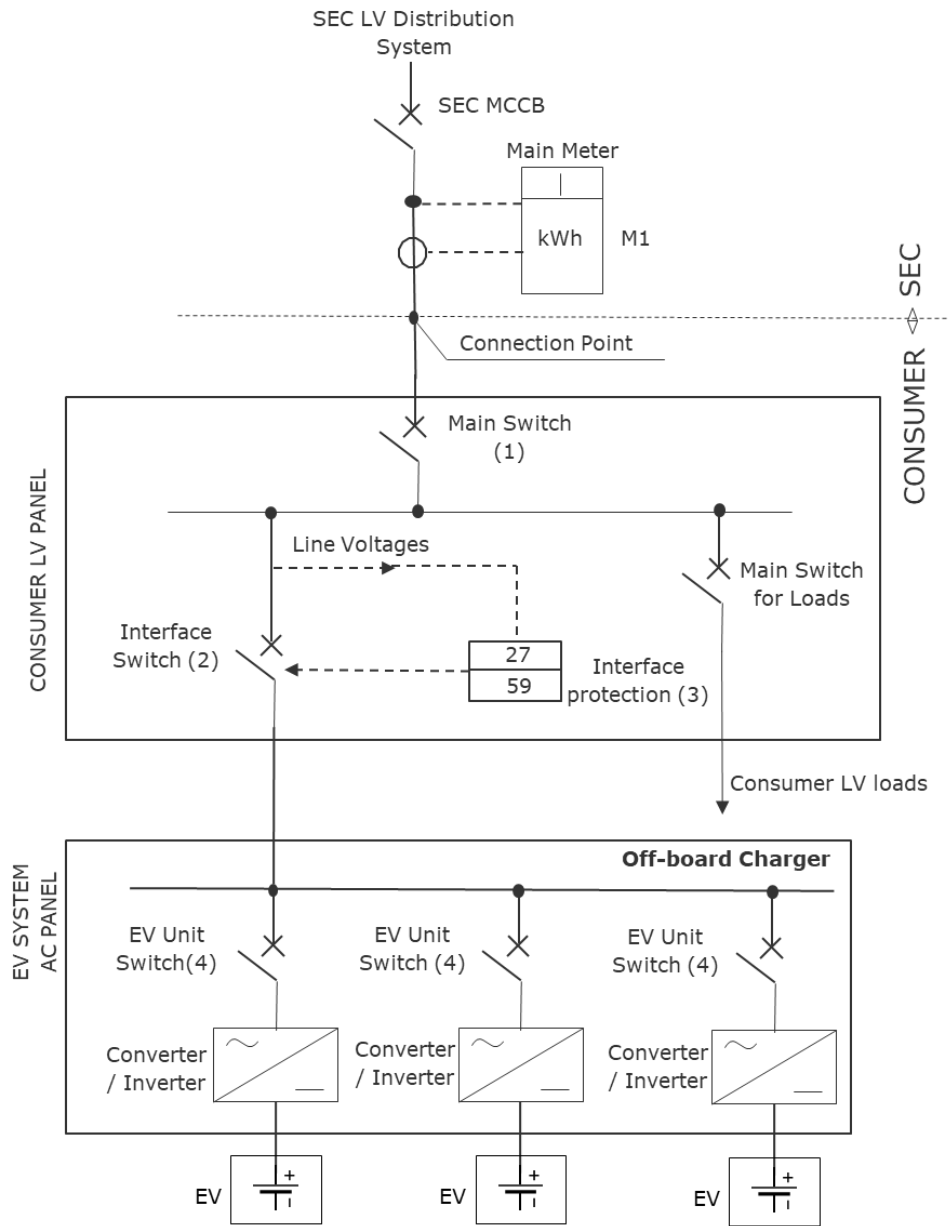


NOTES:

- (1) Automatic Circuit Breaker
- (2) Motorized Automatic Circuit Breaker / Switch Disconnecter operated by Undervoltage release, with:
 - Overload Protection
 - Short Circuit Protection
 - Protection against electric shock (RCD)
- (3) Auxiliary power supply from a UPS
- (4) Automatic Circuit Breaker or Switch Disconnecter

Figure 9: LV Connection Scheme – Bidirectional EVCS with a maximum capacity between 50 kW and 200 kW Multiple mode 3 AC EV Units.

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

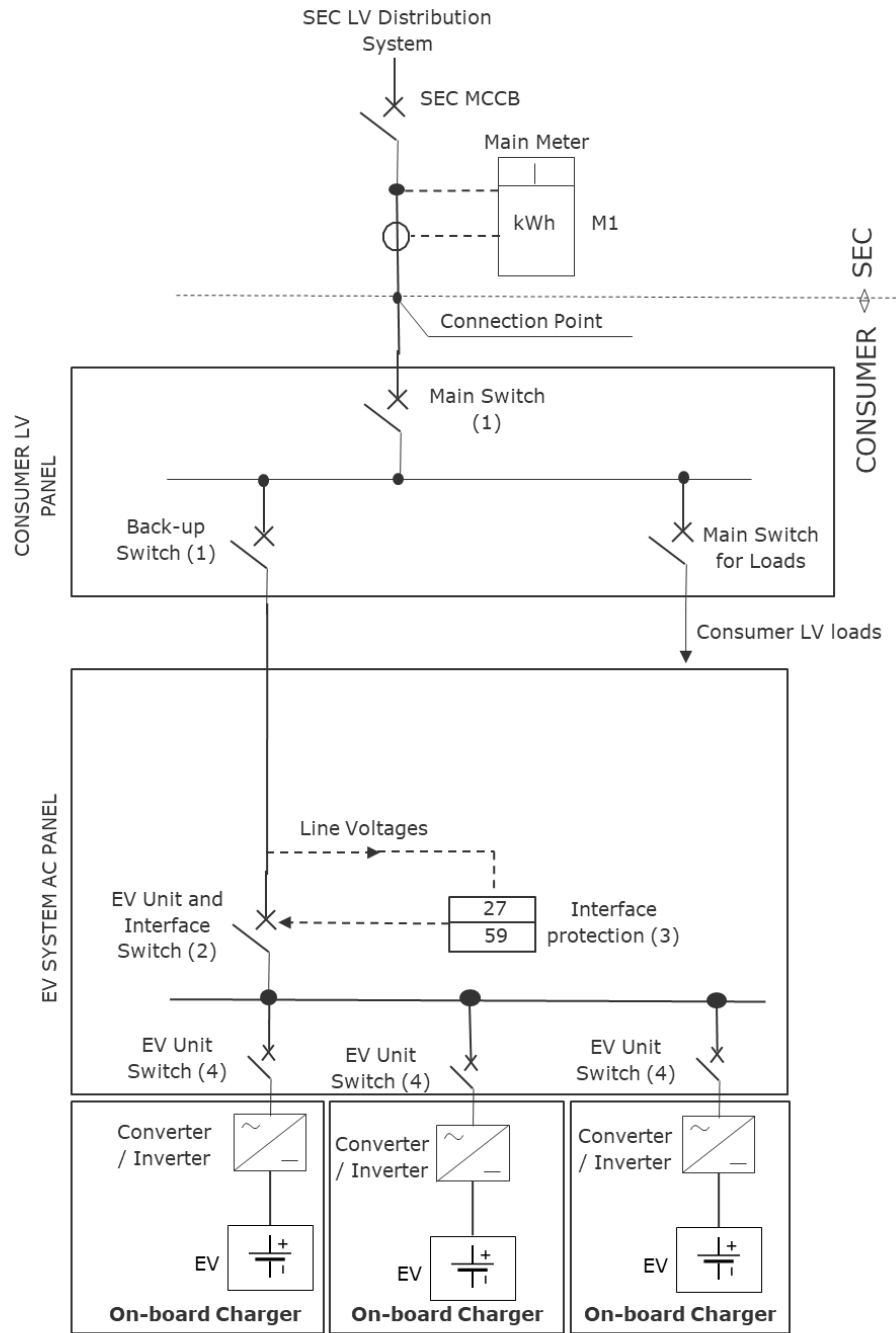


NOTES:

- (1) Automatic Circuit Breaker
- (2) Motorized Automatic Circuit Breaker / Switch Disconnecter operated by Undervoltage release, with:
Overload Protection
Short Circuit Protection
Protection against electric shock (RCD)
- (3) Auxiliary power supply from a UPS
- (4) Automatic Circuit Breaker or Switch Disconnecter

Figure 10: LV Connection Scheme – Bidirectional EVCS with a maximum capacity between 50 kW and 200 kW Multiple EV Units.

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

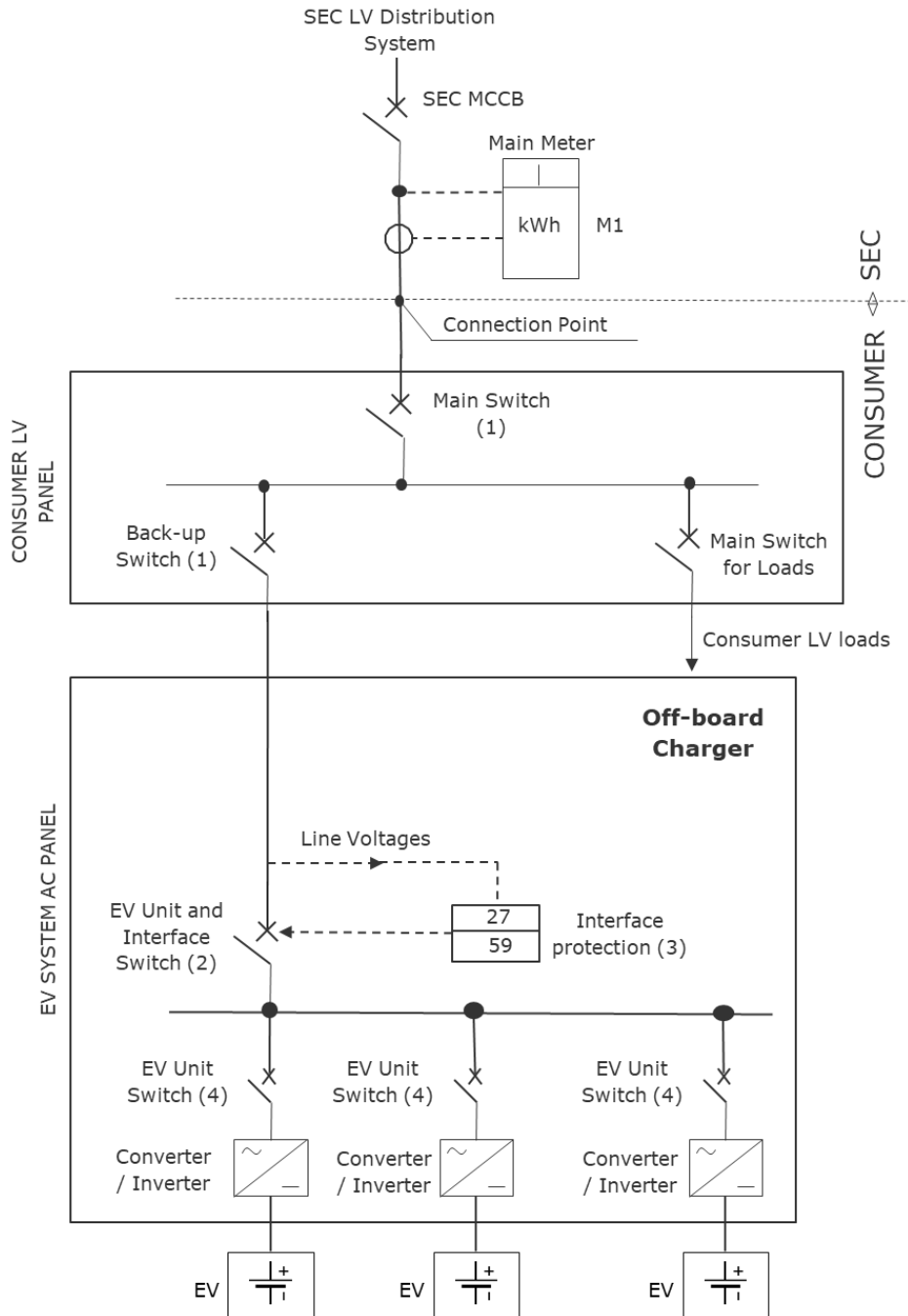


NOTES:

- (1) Automatic Circuit Breaker / Switch Disconnecter with: Overload Protection, Short Circuit Protection, Protection against electric shock (RCD)
- (2) Motorized Automatic Circuit Breaker / Switch Disconnecter operated by Undervoltage release
- (3) Auxiliary power supply from a UPS
- (4) Automatic Circuit Breaker or Switch Disconnecter

Figure 11: LV Connection Scheme – Bidirectional EVCS with Maximum Connected Capacity between 200kW and ≤ 2 MW – Multiple AC EV Units

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS



NOTES:

- (1) Automatic Circuit Breaker / Switch Disconnector with: Overload Protection, Short Circuit Protection, Protection against electric shock (RCD)
- (2) Motorized Automatic Circuit Breaker / Switch Disconnector operated by Undervoltage release
- (3) Auxiliary power supply from a UPS
- (4) Automatic Circuit Breaker or Switch Disconnector

Figure 12: LV Connection Scheme – Bidirectional EVCS with Maximum Connected Capacity between 200kW and ≤ 2MW – Multiple EV Units offboard charging station

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

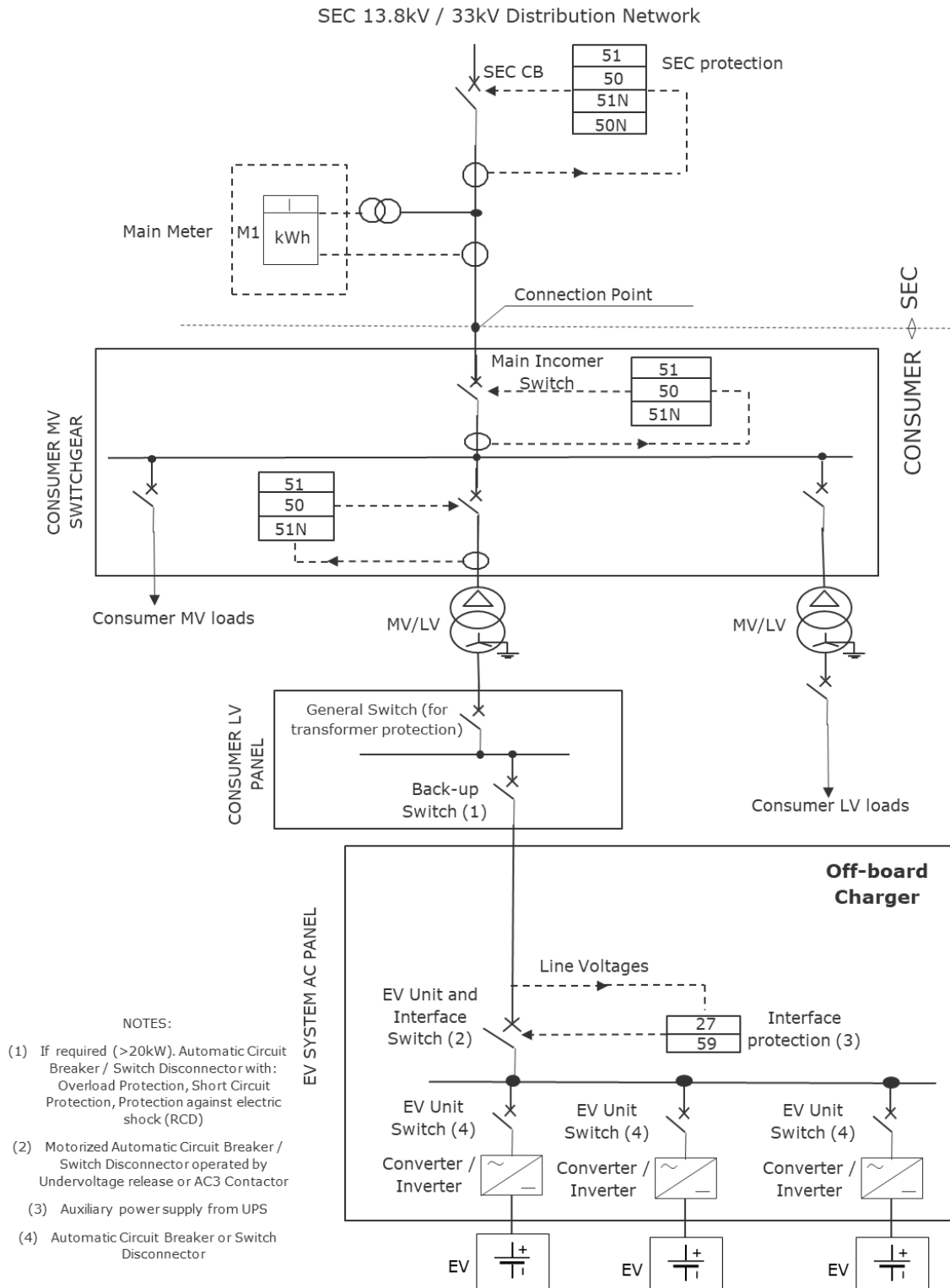
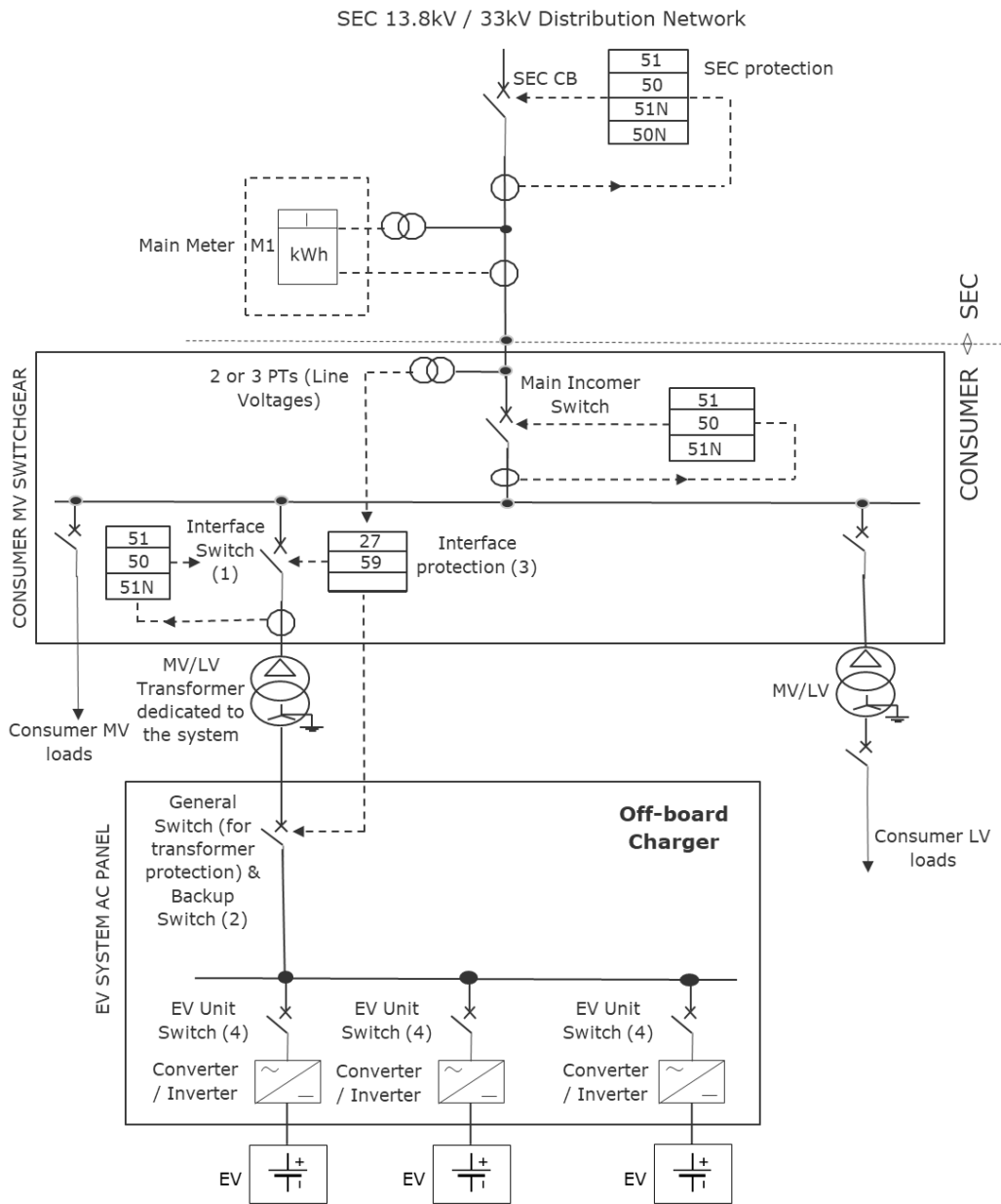


Figure 13: MV Connection Scheme – Bidirectional EVCS with Maximum Connected Capacity between 2 MW and 25 MW–Multiple EV Units with external and unique Interface Protection internal to the Bidirectional EVCS

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS



NOTES:

- (1) Motorized Automatic Circuit Breaker operated by Undervoltage release, with: Overload Protection (51), Phase Protection (50), Earth Protection (51N)
- (2) Automatic Circuit Breaker / Switch Disconnecter with: Overload Protection, Short Circuit Protection, Protection against electric shock (RCD)
- (3) Auxiliary power supply from a UPS
- (4) Automatic Circuit Breaker or Switch Disconnecter

Figure 14: MV Connection Scheme - Interface Protection on the LV side Bidirectional EVCS with Maximum Connected Capacity > 2MW and 25 MW– Multiple EV Units with external and unique Interface Protection on the MV side

ANNEX B. DEFAULT SETTINGS OF INTERFACE PROTECTION

The following table reports the default settings to be implemented in the Interface Protection of Bidirectional EVCS when no other settings have been communicated by SEC.

Table 1: Default settings for the protection functions for Bidirectional EVCS

Protection function	Settings	
	Threshold	Time delay
27<	90% Nominal Voltage	1.5 s
27<<	40% Nominal Voltage	0.8 s
59>	110% Nominal Voltage	3 s
59>>	120% Nominal Voltage	0.2 s
81>>	62.5 Hz	0.1 s
81<	57.5 Hz	4 s
81<<	57 Hz	0.1 s
50	DT: current setting 7 pu	0.15 s
51	SI, current setting 1.2 pu	time dial 0.1s
50N	DT: 0.8PU A	0.0 s
51N	SI, current setting 0.1 pu	time dial 0.1 s

ANNEX C. APPLICABLE STANDARDS FOR EVCSS 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)

ADDITIONAL TECHNICAL REQUIREMENTS FOR BIDIRECTIONAL EVCS

- [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 SASO ISO 15118