Ref. Ares(2026)6819642 - 08/07/2026

EUROPEAN
COMMISSION

Brussels, XXX
[…](2026) XXX draft

ANNEXES 1 to 3

**ANNEXES**

**to the**

**COMMISSION DELEGATED REGULATION**

**on establishing a network code on requirements for grid connection of generators and repealing Commission Regulation (EU) 2016/631**

# ANNEX I

Tables and Figures to be moved here

# ANNEX II

Tables and Figures to be moved here

# ANNEX III

## Certification Framework for V2G electric vehicles and V2G electric vehicle supply equipment (V2G EV and V2G EVSE)

This technical annex establishes the framework for the certification of components and systems of V2G electric vehicles (EV), V2G electric vehicle supply equipment (EVSE), and their bidirectional charging functionalities. It lays down the procedures and criteria required to demonstrate conformity with the technical requirements of this Regulation.

The certification framework is based on a functional split between EV and EVSE, allowing each to be assessed and certified individually.

Certificates of V2G EV and V2G EVSE, issued on the basis of certifications schemes in accordance with this Annex, shall be deemed to demonstrate the compliance of the V2G EV or V2G EVSE with the relevant requirements.

## 1. CERTIFICATION PROCESS AND FUNCTIONAL SPLIT

Certification shall follow a functional split between the mobile (EV) and stationary (EVSE) component within a V2G system. The EV and EVSE shall be certified individually, based on its contribution to grid code compliance.

The conformity assessment shall be based on test setups, configuration range, parameter sets and acceptance criteria defined in EN 50549-10:2022, with specific adaptations for V2G EV and V2G EVSE detailed in Chapters 5 and 6 of this Annex.

Certification shall be conducted by authorised certifiers accredited under EN ISO/IEC 17065 and recognised by the national affiliate of the European Cooperation for Accreditation (EA), in accordance with Regulation (EC) No 765/2008.

### 1.1. EVSE-Based Compliance

Where compliance with this Regulation is demonstrated by the V2G EVSE (AC or DC), the V2G EVSE manufacturer shall provide a country-specific certificate demonstrating compliance.

### 1.2. EV-Based Compliance

Where compliance is fulfilled by the AC V2G EV, the EV manufacturer shall demonstrate compliance with this Regulation through the Whole Vehicle type Approval (WVTA) framework.

In the case that a manufacturer seeks AC V2G EV certification prior to the WVTA framework becoming effective, the manufacturer may seek certification of compliance in accordance with this Annex from an Authorised Certifier.

Manufacturers shall provide a Union-wide certificate for all AC V2G EVs which are excluded from the WVTA.

## 2. V2G EV AND V2G EVSE FAMILIES

V2G EV or V2G EVSE certificates may be extended to include other products of a product family in the same certificate without repetition of tests if all of the conditions set out in points 2.1, 2.2 and 2.3 are met.

### 2.1. AC V2G EV family

The product ‘AC V2G EV System’ comprises the following components within the EV:

- Electronic converters within the AC V2G EV that ensure the power delivery from, or into, the AC V2G EV energy storage system to the connection point (i.e. the DC/AC converter).
- Low voltage electronic logic circuits within the AC V2G EV which controls the electronic converters and communicates with the AC V2G EVSE.

For the purposes of this Annex, an AC V2G EV system family means a group of AC V2G EV systems from the same manufacturer with equivalent characteristics to the representative system which has satisfactorily undergone conformance tests (certified system) of its electrical performance.

An AC V2G EV system shall be considered as part of an AC V2G EV system family if all of the following conditions are met:

- Electrical performance: The power conversion stage and filter circuitry of the AC V2G EV system shall be technically equivalent in design and control technology in regard to their electrical properties, and shall have a power range of between ±50% of the rated power (Pn) of the certified AC V2G EV system;
- Communication protocols: The AC V2G EV system shall operate the same software segments regarding the grid code compliance as that of the certified AC V2G EV system family;
- Control Algorithm: The grid code compliance segments of the control algorithm software implemented in the AC V2G EV system shall be the same as that of the certified AC V2G EV system family.

### 2.2. DC V2G EVSE family

For the purposes of this Annex, a DC V2G EVSE family means a group of DC V2G EVSE from the same manufacturer with specified characteristics in relation to a representative DC V2G EVSE which has undergone conformance tests (certified product) of its electrical performance. The specified characteristics shall be those in Chapter 4.

A DC V2G EVSE shall be considered part of an DC V2G EVSE family if all of the following conditions are met:

- Electrical Performance: The hardware and filter circuitry of the DC V2G EVSE shall be technically equivalent in design and control technology in regard to their electrical properties, and shall have a Pn between ±50%Pn of the certified DC V2G EVSE.
- Communication Protocols: The DC V2G EVSE shall operate the same software segments regarding grid code compliance as that of the certified DC V2G EVSE.
- Control Algorithm: The grid code compliance segments of the control algorithm software implemented in the DC V2G EVSE shall be the same as that of the certified DC V2G EVSE.

### 2.3. AC V2G EVSE family

For the purposes of this Annex, an AC V2G EVSE family means a group of AC V2G EVSE from the same manufacturer, with specified characteristics in relation to a representative AC V2G EVSE which has undergone conformance tests (certified product) of its electrical performance.

An AC V2G EVSE shall be considered part of an AC V2G EVSE family if all of the following conditions are met:

- Functional Equivalence: The AC V2G EVSE shall exhibit equivalent or comparable performance in terms of grid interface capabilities, including switching behaviour, protection coordination, and fault response, as the certified AC V2G EVSE certified and shall have a Pn of between ±50% Pn of the certified AC V2G EVSE.
- Communication Protocols: The AC V2G EVSE shall operate the same software segments regarding the grid code compliance as that of the certified AC V2G EVSE.
- Control Logic: The control logic implemented in the EVSE shall demonstrate equivalent behaviour in terms of timing, response characteristics and interaction with the AC V2G EV and grid operator as those of the certified AC V2G EVSE.

## 3. EV CERTIFICATION AND REUSABILITY

EV Certification shall be conducted on AC V2G EV Systems. Certified AC V2G EV Systems may be integrated into other vehicle models, forming an AC V2G EV system family, provided the integration does not alter the certified characteristics.

Certificates shall remain valid unless the relevant component is modified.

## 4. COMPLIANCE FRAMEWORK FOR NEW AND EXISTING EV AND EVSE COMBINATIONS

The certification framework shall enable interoperability as required by this Regulation between EVs and EVSE across the Union. Once an AC V2G EV is certified in accordance with this Annex, it shall be permitted to charge and operate bidirectional charging functionality throughout the Union. For AC and DC V2G EVs:

- New EVSE[1] shall provide unidirectional charging capabilities to all EVs which have compatible connectors.
- New EVSE shall provide bidirectional charging capabilities to all EVs compliant with this Regulation.
- Nothing in this Annex shall prevent existing EVSE from providing unidirectional charging capabilities for all compatible new and existing EVs.

Those requirements are summarised in Table 1:

[1] EV/EVSE combinations are all AC/AC or DC/DC; AC/DC interoperability is not required.

*Table 1: Compatibility of "existing" and "new" EV/EVSE combinations*

| | | EVSE | |
|---|---|---|---|
| | | **New** V2G EVSE | **Existing** V2G EVSE |
| EV | **New** V2G EV | **Compliance with NC RfG requirements** | RSO requirements* |
| | **Existing** V2G EV | RSO requirements* | RSO requirements* |

* the requirements of the relevant system operator (RSO) shall apply.

## 5. FUNCTION ALLOCATION BETWEEN EV AND EVSE AND COMMON REQUIREMENTS

### 5.1. DC connected EV and EVSE function allocation

In systems where a DC bidirectionally charging electric vehicle (DC V2G EV) is connected to the public electricity network via a DC electric vehicle supply equipment (DC V2G EVSE), all certification-relevant grid functions shall be implemented within the DC V2G EVSE.

Accordingly, only EVSE-based compliance as set out in point 1.1 applies.

The DC V2G EV shall remain connected and continue to transfer power in the case that the DC V2G EVSE deviates from the EV's target values in order to fulfil grid code requirements, provided this is still within the capability of the EV. This behaviour is expected to be part of the standardized functionality of the V2G EV.

For the purposes of certifying a DC V2G EVSE, a DC V2G EV reference test device[2], simulating a DC connected EV shall be used. This reference test device shall simulate the behaviour of a DC V2G EV and shall include the following capabilities:

- Reception and interpretation of relevant signals via digital communication protocols;
- A storage system or storage simulator capable of responding to control commands and supporting dynamic grid support functions during testing.

### 5.2. AC connected EV and EVSE function allocation

#### *5.2.1. General*

In systems where an AC bidirectionally charging electric vehicle (AC V2G EV) is connected to the public electricity network via an AC electric vehicle supply equipment (AC V2G EVSE), a clear function split as set out in Table 2 is required, to enable interoperability and an individual certification. Accordingly, EV based and EVSE based compliance as set out in Chapter 1 applies.

[2] The use of a reference test device ensures that the digital communication interface between the DC V2G EV and the DC V2G EVSE functions correctly. Therefore, full protocol stack certification of the digital communication is not required under this Annex.

### 5.2.2. *AC V2G EV capabilities*

### 5.2.3. *Common rules for individual certification*

1. For the individual certification of an AC V2G EV, an AC V2G EVSE reference test device[3] shall be used. This AC V2G EVSE reference test device shall transmit all relevant parameters via digital communication.

All other functions dedicated to the AC V2G EVSE in accordance with Table 2 shall be tested by the function specific test setup required by EN 50549-10:2022.

2. For the individual certification of an AC V2G EVSE, an AC V2G EV reference test device shall be used. This AC V2G EV reference test device shall provide the following capabilities:

   (a) Reception and correct interpretation of the national specific data set including a means to compare with the received parameters (e.g. an active power control curve);

   (b) A generator which is able to generate a stable unintentional island on a parallel resonant circuit with a quality factor equal to one;

   (c) A generator which is able to provide grid support functions.

   Where this test procedure is used a complete certification of the digital communication shall not be required.

   All other function dedicated to the AC V2G EV in accordance with Table 2 shall be tested by the function specific test setup required by EN 50549-10:2022.

3. If the rated power of the AC V2G EV differs from the rated power of the AC V2G EVSE, the AC V2G EV and the AC V2G EVSE shall apply the following rated power for all grid code functions:

   *Smax = Pmax = Min(PmaxEV, PmaxEVSE)* *(1)*

   *Maximum Consumption Capacity (MCC) = Min(MCCEV, MCCEVSE)* *(2)*

4. For the aspect of control accuracy, an AC V2G EV that is connected to an AC V2G EVSE with a lower rated power shall provide the relevant control accuracy.

   Example: AC V2G EV with 22 kW connected to an AC V2G EVSE with 11 kW: The AC V2G EV needs to comply with control accuracy requirements for an 11 kW AC V2G EV.

   In the case grid codes refer to $S_{max}$. and since an AC V2G EVSE is limited only by current, $S_{max}$ is equal to $P_{max}$ for the AC V2G EV.

5. There is no requirement for an AC V2G EV to be able to operate outside a power factor range of 0.90 underexcited to 0.90 overexcited.

6. Measurements of all relevant quantities, e.g. current, voltage, power etc, shall be RMS values measured over ten cycles, unless indicated otherwise in each module. Measurement of frequency shall be with a resolution of 10mHz. Active power measurement shall be evaluated as 1-minute averages.

---

[3] The use of a reference test device ensures that the digital communication between AC V2G EV and AC V2G EVSE functions correctly. Therefore, full protocol stack certification of the digital communication is not required under this Annex.

7. Although the LFSM requirements in point 6.4 explicitly cover both production and consumption cases, all other tests described for production shall be demonstrated also for consumption.

8. In the case where the AC V2G EV receives grid code related parameters outside of its certified ranges, the AC V2G EV shall not start any power output or shall ignore these parameters if already producing or consuming.

*5.2.4. AC V2G EV an AC V2G EVSE function split and certification module overview*

Table 2 provides an overview of the function split between AC V2G EV and AC V2G EVSE for both active power consumption (i.e. charging) and active power output (i.e. production). For each function the certification relevant details are shown in Chapter 6.

For bidirectional charging, the requirements summarised in Table 2 shall be demonstrated for both production (using $P_{max}$) and consumption (using MCC).

*Table 2: AC V2G EV and AC V2G EVSE function split and certification module overview*

| Grid Code Function | AC V2G EV<br>Bidirectional charging (V2G mode / consume and inject) | AC V2G EVSE<br>Bidirectional charging (V2G mode / consume and inject) | Remarks |
|---|---|---|---|
| **Local grid code requirements** | | | |
| Storage of local grid code parameter setting | - | X | Country specific certification of the AC V2G EVSE.<br>Transmission of parameters is dealt with in each line below. |
| Relevant System Operator data exchange interface | - | X | Country specific certification of the AC V2G EVSE.<br>Transmission of parameters is dealt with in respective lines below. |
| **Interface Protection 1)** | | | |
| The inclusion of relevant national interface protection. Typical requirements may include:<br>- Detection of abnormal voltage and frequency with single fault tolerance<br>- Interface Switch with singe fault tolerance 2)<br>- Storage of local interface protection events<br>- Digital input(s) (transfer trip, switch to narrow frequency band)<br>- Autotest | - | X | Country specific certification of the AC V2G EVSE |

| | | | |
|---|---|---|---|
| Means to detect islanding situation (loss of supply network) | - | Country specific certification of the AC V2G EVSE | |
| **Grid Code Function** | **AC V2G EV**<br>**Bidirectional charging (V2G mode / consume and inject)** | **AC V2G EVSE**<br>**Bidirectional charging (V2G mode / consume and inject)** | **Remarks** |
| **(Re-)connection after tripping of Interface Protection** | | | |
| Automatic reconnection after tripping of the interface protection | X | X | Verify the abilities of the AC V2G EV and the AC V2G EVSE as set out in point 6.2. |
| **Starting to generate electrical power** | | | |
| Starting to generate electrical power | X | X | Verify the abilities of the AC V2G EV and the AC V2G EVSE as set out in point 6.2. |
| **Active Power Control** | | | |
| Active power limitation for distribution grid security | X | X | Verify the abilities of the AC V2G EV and V2G EVSE as set out in point 6.3. |
| Active response to frequency deviation (P(f)) | X | X | Verify the abilities of the AC V2G EV and AC V2G EVSE as set out in point 6.4. |
| Voltage related active power reduction (P(U)) | X | X | Verify the abilities of the AC V2G EV and AC V2G EVSE as set out in point 6.5. |

| Grid Code Function | AC V2G EV<br><br>Bidirectional charging (V2G mode / consume and inject) | AC V2G EVSE<br><br>Bidirectional charging (V2G mode / consume and inject) | Remarks |
|---|---|---|---|
| **Reactive Power Control** | | | |
| Voltage related control mode (Q(U)) | X | X | Verify the abilities of the AC V2G EV and AC V2G EVSE as set out in point 6.6. |
| Power related control mode (cos φ (P), Q(P)) | X | X | Verify the abilities of the AC V2G EV and AC V2G EVSE as set out in point 6.7. |
| Setpoint control modes (Q setpoint, cos φ setpoint) | X | X | Verify the abilities of the AC V2G EV and AC V2G EVSE as set out in point 6.8. |
| **EMC and power quality** | | | |
| Harmonic emissions | X | X | Verify the ability of the AC V2G EV and the AC V2G EVSE to limit harmonic emissions as set out in point 6.10. |
| Flicker and voltage fluctuations | X | X | Verify the abilities of the AC V2G EV and the AC V2G EVSE to limit flicker and voltage fluctuations as set out in point 6.10. |
| DC injection (differential mode) prevention | X | X | Verify the ability of the AC V2G EV to limit DC injection as set out in point 6.11. |

| Grid Code Function | AC V2G EV<br><br>Bidirectional charging (V2G mode / consume and inject) | AC V2G EVSE<br><br>Bidirectional charging (V2G mode / consume and inject) | Remarks |
|---|---|---|---|
| **Immunity to disturbances** | | | |
| Immunity to under-voltage ride through (UVRT) and over-voltage ride through (OVRT) | X | X | a.) UVRT: Verify the immunity of the AC V2G EV and V2G EVSE against undervoltage fault-ride-through as set out in point 6.9.1.<br>b.) OVRT: Verify the immunity of the AC V2G EV and AC V2G EVSE against over-voltage ride through as set out in point 6.9.2. |
| Immunity to frequency variation (ROCOF immunity) | X | X | Verify the immunity to frequency variations of AC V2G EV and AC V2G EVSE as set out in point 6.12. |
| Immunity to phase jump | X | X | Verify immunity to phase jumps of the AC V2G EV and AC V2G EVSE as set out in point 6.13. |
| **Operating range** | | | |
| Normal operating range frequency, voltage | X | X | Verify the ability of the AC V2G EV and the AC V2G EVSE to operate in the frequency and voltage ranges as set out in point 6.14.1 and 6.14.2.1. |
| Voltage support during faults and voltage steps / UVRT and OVRT operating range | X | X | Verify the abilities of the AC V2G EV and the AC V2G EVSE to provide voltage support during faults and voltage steps as set out in point 6.14.2.2. |

[1] Interface protection including islanding detection are completely solved within the electrical installation. National grid codes define the detailed interface protection concepts, i.e. if a dedicated interface protection function needs to be provided in the AC V2G EVSE or within the upstream installation.

[2] For certification of the single fault tolerance of the interface switch, a single disconnection device shall be considered sufficient if the following requirements are met:

- short circuit withstand capability (without welding) is coordinated with the upstream short-circuit capability of the electrical installation.
- mirror contact or equivalent is provided for end-of-life detection.

In the case of welded contact detection, the AC V2G EVSE the AC V2G EV shall be triggered to provide at least simple separation which is defined in the applicable product standards.

[3] Not currently enabled in standards.

## 6. CERTIFICATION MODULES

### 6.1. Verification of applying a dedicated active and reactive power control hierarchy by an V2G EV/EVSE combination

If different requirements on the AC V2G EV and associated AC V2G EVSE interfere with each other, the following hierarchy in descending order shall be applied by an AC V2G EV:

1. *Self-protection;*
2. *Voltage support during faults and voltage steps (see point 6.14.2.2);*
3. *The lower value of: remote control command on active power limitation for distribution grid security and LFSM-O (see point 6.4);*
4. *LFSM-U (see point 6.4);*
5. *Reactive power (Q(U), cos φ (P), Q(P), Q setpoint, cos φ setpoint) (see points 6.6, 6.7, 6.8) and P(U) (see point 6.5) controls;*
6. *Other control commands on active power setpoint for e.g. market, economic reasons, self-consumption optimisation.*

Only one reactive power control mode may be activated at a time.

Interface protection (including active islanding detection) shall be handled by the AC V2G EVSE. The AC V2G EVSE shall switch off independently from the AC V2G EV in the case of an interface protection event or in the case of an unintended island.

Compliance for the AC V2G EV is checked by the documentation of the design approach by the manufacturer and including, as appropriate, the inspection of the control algorithms of the control unit or by tests for which different test setups in accordance with EN 50549-10:2022 need to be combined.

### 6.2. Verification of automatic reconnection after tripping and starting to generate electrical power by an AC V2G EV and AC V2G EVSE

In the case of reconnection after tripping of the interface protection or in the case of starting to generate electrical power, the active power generated by AC V2G EV shall not exceed a specified gradient expressed as a percentage of Pmax per minute with an accuracy of 5% of Pmax. If no gradient is specified, the default setting is 10% Pmax/min. The range of the gradient shall be limited to a value between 6% – 3000% Pmax/min.

To apply the specified behaviour, the AC V2G EVSE shall calculate the required power ramp over time and shall send the limit active power values over digital communication.

*Compliance for the AC V2G EVSE shall be checked by setting the applicable parameters at the input terminals of the AC V2G EVSE and comparing with the received power ramp over time within the AC V2G EV reference test device.*

The AC V2G EV shall cease or reduce the received active power limit values within a maximum of 5 seconds.

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.10 adding an AC V2G EVSE reference test device that can provide the power ramp over time.*

Beside parametrization as defined by the relevant system operator, the AC V2G EVSE shall control the (re)connection process depending on the voltage and frequency bands as well as the observation time as set out in Article 19.

*For these functions of the AC V2G EVSE, country specific certification shall apply.*

### 6.3. Verification of applying active power limitation by an AC V2G EV and AC V2G EVSE

An AC V2G EV and AC V2G EVSE shall be capable of carrying out the active power output reduction to the respective limit within an envelope of not faster than 0.66% Pmax/ s and not slower than 0.33% Pmax/ s with an accuracy of 5% of Pmax as set out in point 5.2.

To apply the specified behaviour, the AC V2G EVSE shall:

1. Be capable of receiving active power limitation remotely by the relevant system operator. The active power limitation values shall be adjustable in the complete operating range from $P_{max}$ to minimum regulating level. The adjustment of the limit value shall be possible with a maximum increment of 10% of $P_{max}$.
2. Calculate the required power ramp over time and shall send the limit active power values by digital communication. If the AC V2G EVSE is configured to receive an active power limitation by an external source, the AC V2G EVSE shall forward the limitation by digital communication within a processing time of 4 seconds.

The AC V2G EVSE processing time starts on receiving the setpoint from an external source, and ends when the setpoint is sent via digital communication.

*Compliance for the AC V2G EVSE shall be checked by measurement of the processing time.*

The AC V2G EV shall cease or reduce the received active power limit values within a maximum of 5 seconds.

Digital communication may take up to 1 second.

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.10 adding an AC V2G EVSE reference test device that can provide the active power limitation.*

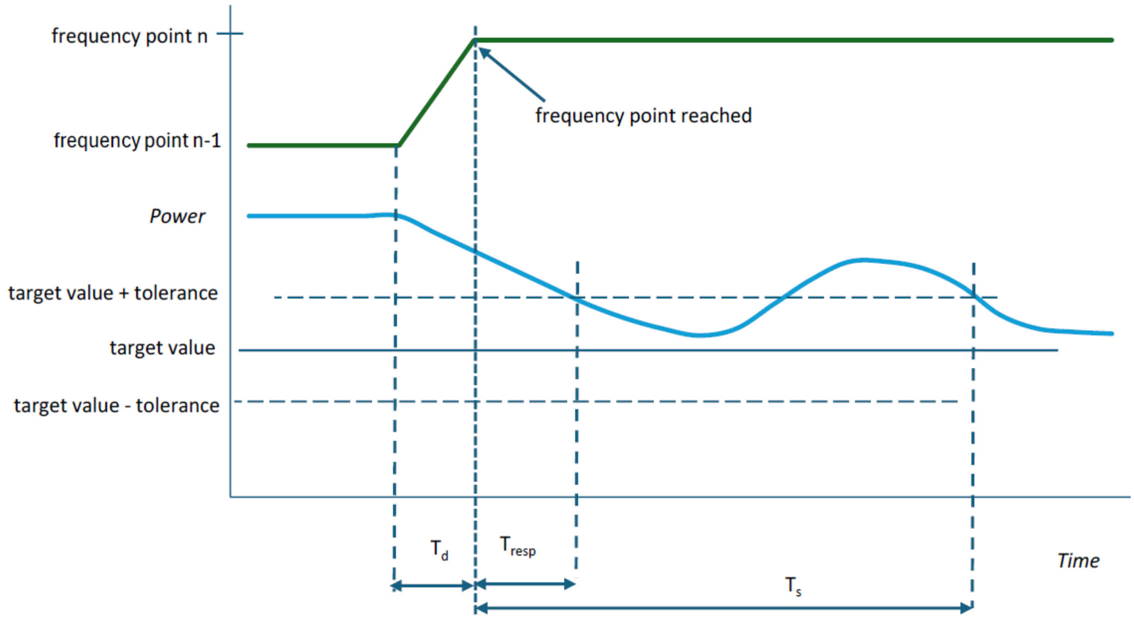
### 6.4. Verification of applying P(f) curve by an AC V2G EV and AC V2G EVSE

Compliance for LFSM-O and LFSM-U shall be verified against the requirements set out in Article 19.

The response time, $T_{resp}$ in Figure A1, shall be less or equal to 0.5 seconds for an active power setpoint change of 30% of $P_{ref}$, less or equal to 1.2 seconds for an active power setpoint change of 90%, and with an accuracy of 5% of $P_{max}$.

**Figure A1**

**Definition of response parameters**




$T_d$: Dead time
$T_{resp}$: Step response time
$T_s$: Settling time

All parameters for LFSM-O and LFSM-U shall be provided by the AC V2G EVSE to the AC V2G EV via digital communication.

*Compliance for the AC V2G EVSE shall be checked by setting the applicable parameters at the input terminals of the AC V2G EVSE and comparing with the received LFSM-O and LFSM-U curves within the AC V2G EV reference test device.*

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.4 adding an AC V2G EVSE reference test device that can provide the LFSM-O and LFSM-U curves. The AC V2G EV shall show compliance at both 49.8Hz (for CE) and 49.5Hz (for Ireland-Northern Ireland and Nordic) frequency thresholds for LFSM-U and at both 50.2Hz (for CE) and 50.5Hz (for Ireland-Northern Ireland and Nordic) for LFSM-O and starting active power levels of 50% of Pmax, 50% of MCC, 100% of MCC (LFSM-U only) and 100% of Pmax (LFSM-O only).*

*The AC V2G EV tests shall be repeated, to show compliance with the speed of response, for frequency steps of both 0.75Hz and 2.25Hz, decreasing frequency starting from below the 49.8Hz frequency threshold and increasing frequency starting from above the 50.2Hz frequency threshold.*

### 6.5. Verification of applying P(U) curve by an AC V2G EV and AC V2G EVSE

The AC V2G EV shall reduce the active power output depending on the grid voltage (P(U)). The P(U) curve shall be provided by the AC V2G EVSE to the AC V2G EV via digital communication.

The accuracy of the voltage measurement within the AC V2G EV shall be at least 1% of the nominal voltage and the accuracy of the power adjustment shall be better than 10% of Pmax.

The AC V2G EV shall evaluate all phase-neutral-voltages of all connected phases individually.

For voltage-controlled active power reduction, the AC V2G EV shall limit the active power output based on the highest voltage value either of each phase individually or symmetrically. The relevant system operator may choose between two methods:

1. Limitation of the maximum permissible active power output in accordance with Figure A2. If the voltage $U_{Start}$ is exceeded, the AC V2G EV shall linearly reduce the active power output from $P_{max}$ at $U_{Start}$ down to 0 at $U_{Stop}$.
2. Limitation of the maximum permissible active power output in accordance with Figure A3. If the voltage $U_{Start}$ is exceeded, the AC V2G EV shall linearly reduce the active power output from $P_M$ at $U_{Start}$ down to $\Delta P$ (with $\Delta P = P_{max} - P_M$) at $U_{Stop}$

$U_{Start}$ and $U_{Stop}$ shall be adjustable from 1pu – 1,25pu.

**Figure A2**

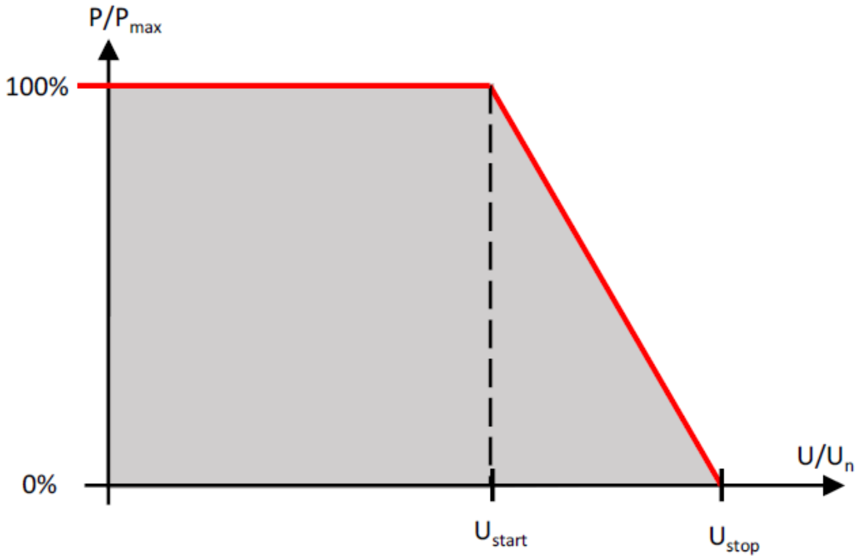
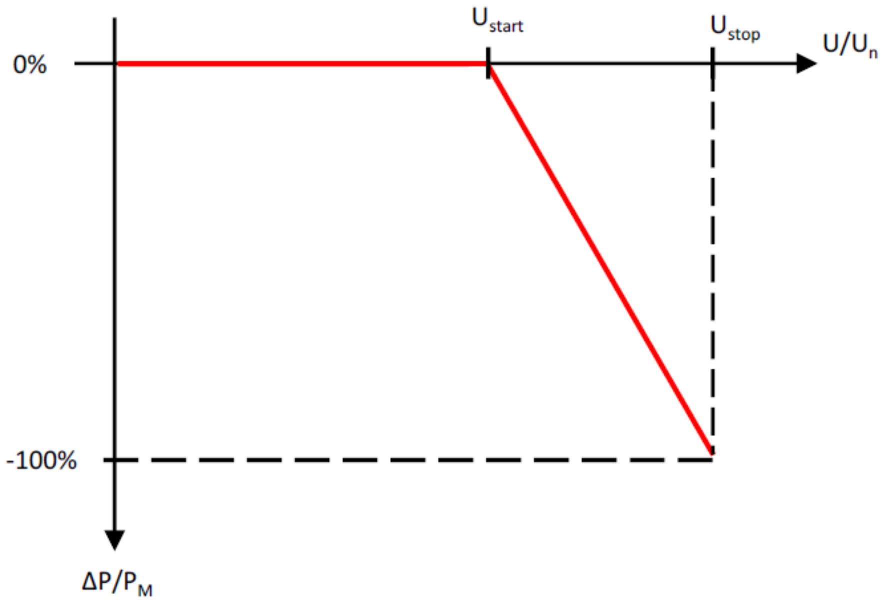


**Figure A3**




The dynamics of the P(U) control shall correspond to a step response or a first-order filter with a configurable time constant between 3 seconds and 60 seconds, with a default value of 5 seconds. The P(U) control shall be activated by the AC V2G EV after a jump in setpoint after the shortest possible initial time delay (maximum 3 seconds).

*Compliance for the AC V2G EVSE shall be checked by setting the applicable parameters at the input terminals of the AC V2G EVSE and comparing with the received P(U)-curve and time constant within the AC V2G EV reference test device.*

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.6 adding an AC V2G EVSE reference test device that can provide the P(U) curve.*

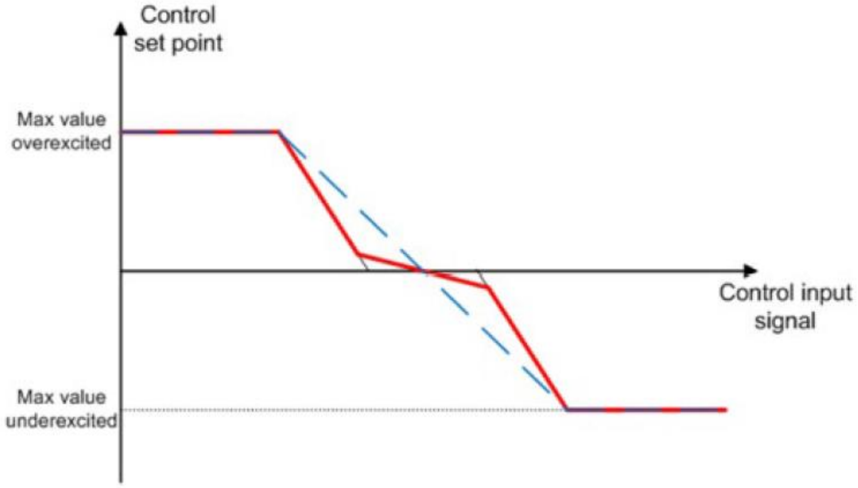
## 6.6. Verification of applying Q(U) curve by an AC V2G EV and AC V2G EVSE

The AC V2G EV and AC V2G EVSE shall exchange reactive power with the grid dependent on the voltage measured by the AC V2G EV (Q = f(U)).

A Q(U) function with a characteristic with a minimum and maximum value of Q and three connected lines in accordance with Figure A4 shall be configurable within the AC V2G EVSE and shall be transmitted to the AC V2G EV by digital communication.

**Figure A4**

**Example characteristics for Q control mode**




$Q/P_{max}$

Figures A4 and A6 show a generic representation of how the setpoint for reactive power varies with the relevant control input. In Figure A4 the control input signal is the EV terminal voltage. In Figure A6 the control input is active power, whilst the control setpoint is cos φ.

In addition, the AC V2G EVSE shall allow to set and transmit the following configurations:

1. The response to a voltage change as a time constant of a first order filter with a configurable range of 3 seconds to 60 seconds;

2. Two methods to limit the reactive power at low active power by:

   (a) A minimum cos φ configurable in the range of 0 - 0.95;

   (b) Two active power levels both with at least the range of 0% to 100% of $P_{max}$. The lock-in value turns the Q(U) mode on, the lock-out value turns Q(U) off. If lock-in is larger than lock-out, a hysteresis is given.

The arithmetic mean of the RMS values of the measured phase-neutral-voltages is the target for the reactive power that the AC V2G EV shall feed-in on all external conductors.

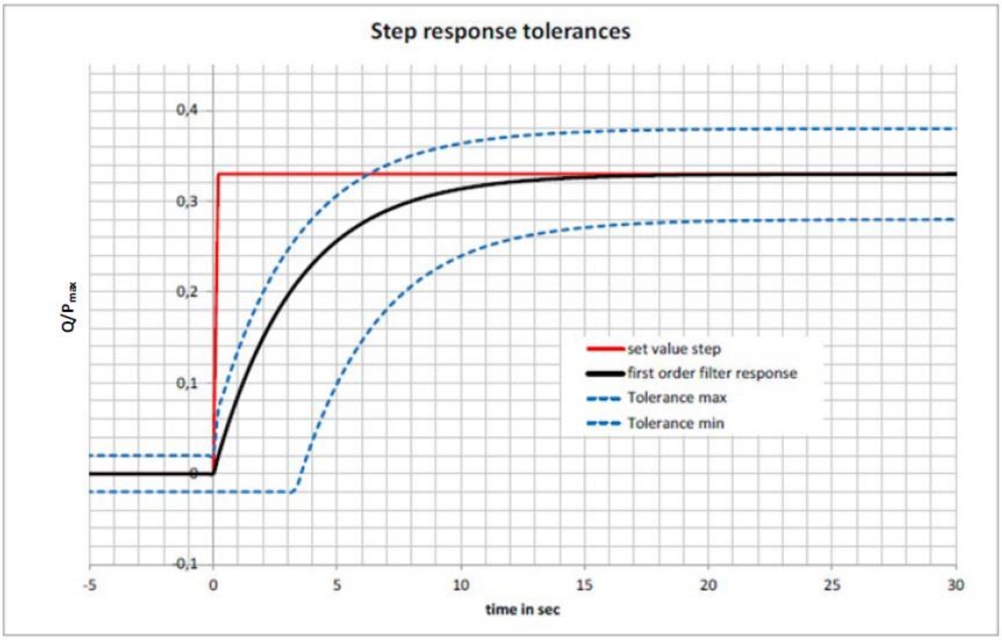
The voltage measurement of the AC V2G EV shall not exceed a maximum measurement error of ±1%.

When operating above or equal to 10% of $S_{max}$, the static reactive power capability of the AC V2G EV shall be provided with an accuracy of ± 2% $S_{max}$. Below 10% of $S_{max}$ a static accuracy of ± 10% of $S_{max}$ shall apply.

The dynamic accuracy of the AC V2G EV shall be in accordance with Figure A5 with a maximum tolerance of ± 5% of $P_{max}$, plus a time delay of 3 seconds deviating from the ideal first order filter response.

**Figure A5**

**Example of dynamic control response and tolerance band for a step from Q=0 to Q= 33%Pmax with τ=3.33 seconds**




The dynamic response of the EV/EVSE to voltage changes is not considered here.

*Compliance for the AC V2G EVSE shall be checked by setting the applicable parameters at the input terminals of the AC V2G EVSE and comparing with the received Q(U)-curve and additional configurations within the AC V2G EV reference test device.*

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.5.2.4 adding an AC V2G EVSE reference test device that can provide the Q(U) curve.*

## 6.7. Verification of applying cos φ (P) / Q(P) curve by an AC V2G EV and AC V2G EVSE

The AC V2G EV and AC V2G EVSE shall exchange reactive power with the grid depending on the current active power measured by the AC V2G EV (cos φ = f(P), or Q = f(P)).

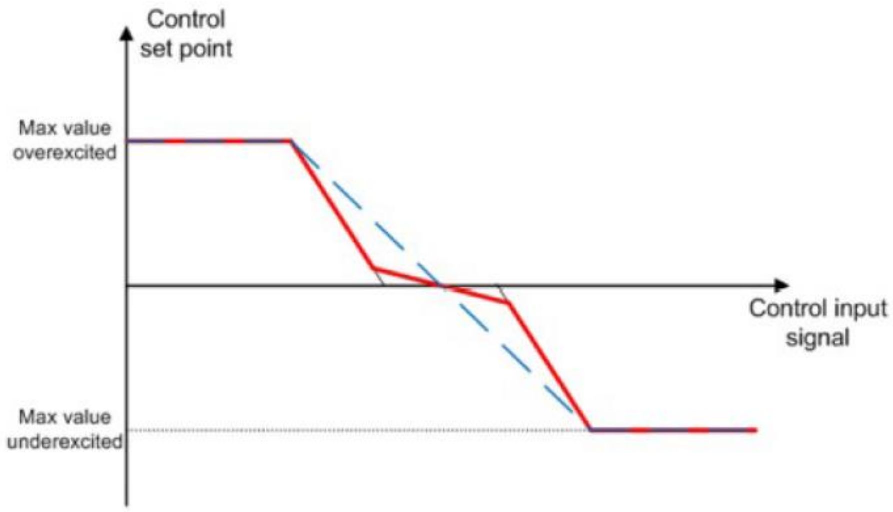
For three phase AC V2G EV the value for the reactive power is the derived from the arithmetic mean of the three RMS values of $P_M$ that the AC V2G EV shall feed-in on all external line conductors.

### *6.7.1. cos φ =f(P)*

A cos φ (P) function with a characteristic with a minimum and maximum value of cos φ and three connected lines in accordance with Figure A6 shall be configurable within the AC V2G EVSE and shall be transmitted to the AC V2G EV by digital communication.

**Figure A6**

**Example characteristics for Q control mode**




In Figure A6 for cos φ = f(P) the control input is active power, whilst the control setpoint is cos φ.

The AC V2G EV shall apply all received configurations and shall apply a new reactive power setpoint latest within 10 seconds after the corresponding active power value is reached.

The arithmetic mean of the RMS values of $P_M$ is the target for the reactive power that the AC V2G EV shall feed-in on all external line conductors.

For three phase AC V2G EV the target for the reactive power is the arithmetic mean of the three RMS values of PM that the AC V2G EV shall feed-in on all external line conductors.

When operating above or equal to 10% of $S_{max}$, the static reactive power capability of the AC V2G EV shall be provided with an accuracy of ± 4% $S_{max}$. Below 10% of $S_{max}$ a static accuracy of ± 10 % of $S_{max}$ shall apply.

The dynamic accuracy of the AC V2G EV shall be in accordance with Figure A5 (see point 6.6) with a maximum tolerance of ± 5% of $P_{max}$, plus a time delay of 3 seconds deviating from the ideal first order filter response.

*Compliance for the AC V2G EVSE shall be checked by setting the applicable parameters at the input terminals of the AC V2G EVSE and comparing with the received cos φ (P) curve within the AC V2G EV reference test device.*

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.5.2.5 adding an AC V2G EVSE reference test device that can provide the cos φ (P)-curve.*

### *6.7.2. Q = f(P)*

A Q = f(P) function with a characteristic with a minimum and maximum value of Q and three connected lines in accordance with Figure A6 shall be configurable within the AC V2G EVSE and shall be transmitted to the AC V2G EV by digital communication.

In Figure A6 for Q = f(P) the control input is active power, whilst the control setpoint is Q.

The AC V2G EV shall apply all received configurations and shall apply a new reactive power setpoint value latest within 10 seconds after the corresponding active power value is reached.

The arithmetic mean of the RMS values of $P_M$ is the target for the reactive power that the AC V2G EV shall feed-in on all external line conductors.

For three phase AC V2G EV the target for the reactive power is the arithmetic mean of the three RMS values of $P_M$ that the AC V2G EV shall feed-in on all external line conductors.

When operating above or equal to 10% of $S_{max}$, the static reactive power capability of the AC V2G EV shall be provided with an accuracy of ± 4% $S_{max}$. Below 10% of $S_{max}$ a static accuracy of ±10% of $S_{max}$ shall apply.

The dynamic accuracy of the AC V2G EV shall be in accordance with Figure A5 (see paragraph 6.6) with a maximum tolerance of ±5% of $P_{max}$, plus a time delay of 3 seconds deviating from the ideal first order filter response.

*Compliance for the AC V2G EVSE shall be checked by setting the applicable parameters at the input terminals of the AC V2G EVSE and comparing with the received Q(P) curve within the AC V2G EV reference test device.*

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.5.2.5 adding an AC V2G EVSE reference test device that can provide the Q(P) curve.*

## 6.8. Verification of applying reactive power setpoints by an AC V2G EV and AC V2G EVSE

The AC V2G EV shall apply reactive power setpoints received via digital communication from the AC V2G EVSE. Depending on the required setpoint control mode at the POC, the AC V2G EVSE shall communicate Q setpoint or cos φ setpoint values.

In the case of change of the setpoint, the total settling time for a new setpoint shall be adjustable between 10 seconds and 60 seconds. The total settling time starts with the reception of the setpoint value by the AC V2G EVSE and ends with the adaption of the value by the AC V2G EV.

To apply the specified behaviour the AC V2G EVSE shall forward the setpoint values over digital communication with and adjustable processing time of 4 seconds to 55 seconds.

The AC V2G EVSE processing time starts with receiving the setpoint by an external source and ends with sending the setpoint via digital communication.

The AC V2G EV shall apply the received setpoint within a maximum of 5 seconds.

Digital communication may take up to 1 second.

*Compliance for the AC V2G EVSE shall be checked by measurement of the processing time.*

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.5.2.3 adding an AC V2G EVSE reference test device that can provide the reactive power setpoint values.*

## 6.9. Verification of immunity to disturbances

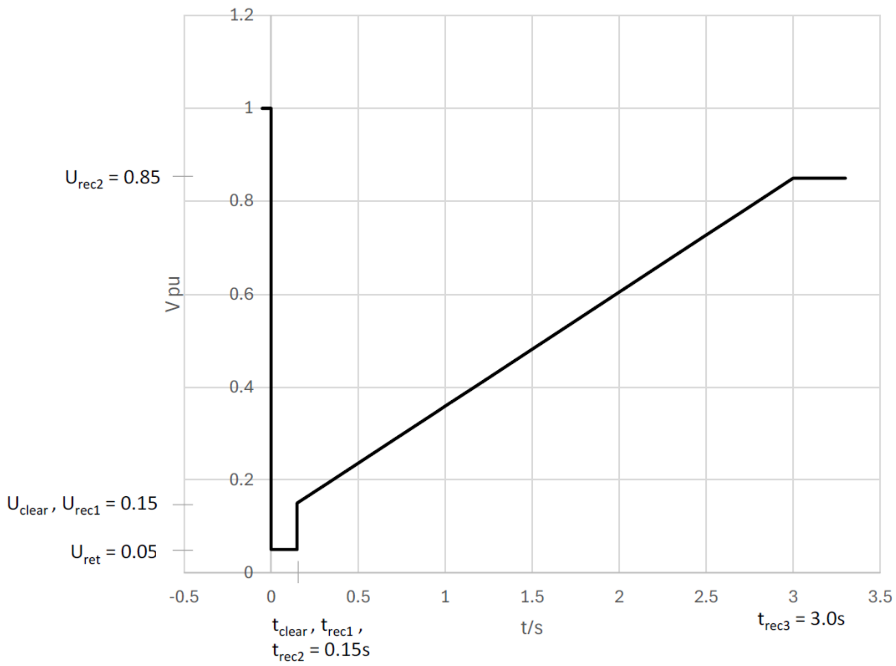
### *6.9.1. Verification of UVRT immunity of an AC V2G EV and AC V2G EVSE*

An AC V2G EV and AC V2G EVSE, when operating above the minimum stable operating level, shall be capable of remaining connected to the network and continuing to operate stably after the power system has been disturbed by faults in the transmission network as set out in

Article 19(8) and (9) and in accordance with a voltage-against-time-profile set out in Figure A7.

**Figure A7**

**Under-voltage fault-ride-through capability of AC V2G EV and AC V2G EVSE**




The voltage-against-time-profile expresses a lower limit of the profile of the lowest phase-to-phase voltage (or single phase to neutral voltages for single phase AC V2G EV) on the network voltage level during a symmetrical fault, as a function of time before, during and after a fault. $U_{ret}$ is the retained voltage at the connection point during a fault, $t_{clear}$ is the instant when the fault has been cleared. $U_{rec1}$, $U_{rec2}$, $t_{rec1}$, $t_{rec2}$ and $t_{rec3}$ specify certain points of lower limits of voltage recovery after fault clearance.

The lowest phase to neutral voltage or, if no neutral is present, the lowest phase to phase voltage shall be evaluated by the AC V2G EV and AC V2G EVSE.

To apply the specified behaviour the AC V2G EVSE shall keep all switching devices closed and maintain stable communication to the AC V2G EV as defined by the relevant system operator.

*For the capability of remaining connected to the network and to continue to operate stable, country specific certification shall apply for the AC V2G EVSE.*

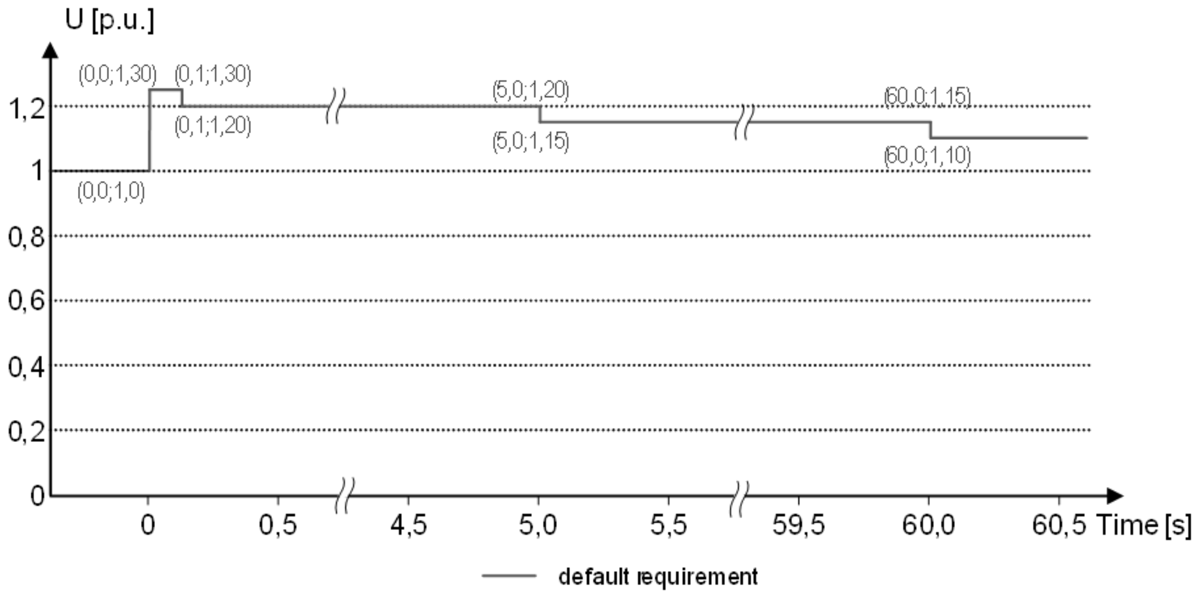
*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.3.3.*

*6.9.2. Verification of OVRT immunity of an AC V2G EV and AC V2G EVSE*

An AC V2G EV and AC V2G EVSE shall be capable of remaining connected to the network and continuing to operate stably as long as the voltage at the point of connection remains below the voltage-time curve of Figure A8.

**Figure A8**

**Over-voltage fault-ride-through capability of an AC V2G EV and AC V2G EVSE**




The highest phase to neutral voltage or, if no neutral is present, the highest phase to phase voltage shall be evaluated by the AC V2G EV and AC V2G EVSE.

To apply the specified behaviour the AC V2G EVSE shall keep all switching devices closed and maintain stable communication to the AC V2G EV as defined by the relevant system operator.

*For the capability of remaining connected to the network and to continue to operate stable, country specific certification shall apply for the AC V2G EVSE.*

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.3.3.*

### 6.10. Verification of harmonic emissions and flicker of an AC V2G EV and an AC V2G EVSE

Individually, the AC V2G EV and the AC V2G EVSE shall limit the harmonic emissions in accordance with the requirements in EN 61000-3-2:2019+A1:2021 and flicker in accordance with the requirements in EN 61000-3-3:2013+A1:2019+A2:2021+AC:2022 independent of the rated power of the AC V2G EV and AC V2G EVSE.

*Compliance for the AC V2G EV and AC V2G EVSE shall be individually checked by a test setup set out in EN 50549-10:2022 clause 5.7.2.2 for harmonic emissions and clause 5.7.2.3.2 for flicker.*

### 6.11. Verification of limitation of DC injection of an AC V2G EV

The AC V2G EV shall not inject DC currents into individual phases greater than 0.5 % of the nominal current ($I_n$) or 20 mA whatever is the higher value. $I_n$ is considered the minimum of $I_{n\_EV}$ and $I_{n\_EVSE}$.

*Compliance for the AC V2G EVSE shall be checked by setting the applicable parameters at the input terminals of the AC V2G EVSE and comparing with the received limit within the AC V2G EV reference test device.*

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.7.2.4 adding an AC V2G EVSE reference test device that can provide the DC injection limit.*

## 6.12. Verification of RoCoF immunity of an AC V2G EV and AC V2G EVSE

The AC V2G EV and AC V2G EVSE shall be capable of remaining connected to the network and operate at rates-of-change-of-frequency as set out in Article 19.

If the power output of the generating unit has no influence on the capability of the generating unit to cope with the RoCoF variation, the generating unit may be tested at any power within the active power range declared by the manufacturer.

*For AC V2G EV and AC V2G EVSE compliance shall be checked by a test setup set out in EN 50549-10:2022 clause 5.3.1 with frequency ride through curves as set out in Figure 1 and 2 of this Regulation.*

## 6.13. Verification of phase jump immunity of an AC V2G EV and AC V2G EVSE

The AC V2G EV shall have phase jump immunity equal to or exceeding 20° in the case of a symmetrical phase jump.

After the phase jump, 90% of pre-fault power or available power, whichever is the smallest, shall be resumed within 1 second at the latest.

*Compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.3.2.*

The AC V2G EVSE shall keep all switching devices closed and maintain stable communication to the AC V2G EV as defined by the relevant system operator.

*For the AC V2G EVSE, country specific certification shall apply and compliance shall be checked by the test setup defined in EN 50549-10:2022 clause 5.3.2.*

## 6.14. Verification of frequency and voltage operating range of an AC V2G EV and an AC V2G EVSE

### *6.14.1. Frequency operating range*

The AC V2G EV and AC V2G EVSE shall be capable of remaining connected to the network and operating within the frequency range as set out in Table 4 of this Regulation.

*Compliance for the AC V2G EV and EVSE shall be checked by the test setup set out in EN 50549-10:2022 clause 5.2.1.*

### *6.14.2. Voltage operating range*

6.14.2.1. Continuous operating range

For continuous operating range, the AC V2G EV and AC V2G EVSE shall be capable of remaining connected to the network and operate continuously within the range of 0.85 pu – 1.1 pu at the connection point.

*For continuous operating range, compliance for the AC V2G EV shall be checked by the test setup set out in EN 50549-10:2022 clause 5.2.2. For the AC V2G EVSE, country specific certification shall apply.*

6.14.2.2. Voltage support during faults and voltage steps / UVRT and OVRT operating range

For UVRT and OVRT operating range, the AC V2G EV shall reduce its current output as fast as technically feasible, and in no more than 100 milliseconds, down to or below 10% of the rated current of $P_{max}$ as appropriate when the voltage is outside of a static voltage range communicated by the AC V2G EVSE via digital communication. The static voltage range shall be adjustable from 0.05 pu – 1 pu for the undervoltage boundary and from 1 pu – 1.25 pu for the overvoltage boundary. The default setting shall be 0.85 pu for the undervoltage boundary and 1.1 pu for the overvoltage boundary. Each phase to neutral voltage or, if no neutral is present, each phase-to-phase voltage shall be evaluated by the AC V2G EV.

At voltage re-entry into the static voltage operating range, the AC V2G EV shall resume with a linear or first order filter response behaviour to 90% of pre-fault active power or available power, whichever is the smallest. For active power, the re-entry time shall not exceed 1 second.

For reactive power the first order filter shall be adjustable between 1 second and 60 seconds, as communicated by the AC V2G EVSE via digital communication. The re-entry voltage value shall be adjustable from 0.05 pu – 1 pu for the undervoltage re-entry and from 1 pu – 1.25 pu for the overvoltage re-entry. Both are communicated by the AC V2G EVSE via digital communication.

*For compliance with the UVRT and OVRT, operating ranges the AC V2G EV shall be checked by the test setup in EN 50549-10:2022, clause 5.3.3 adding an AC V2G EVSE reference test device that provides all settings set out in this clause 5.3.3.*

The AC V2G EVSE shall keep all switching devices closed and maintain stable digital communication to the AC V2G EV as defined by the relevant system operator.

*For the AC V2G EVSE, country specific certification shall apply. For the transmission of all settings set out in the clause 5.3.3 of EN 50549-10:2022, compliance for the AC V2G EVSE shall be checked by setting the applicable parameters at the input terminals of the AC V2G EVSE and comparing with the received settings within the AC V2G EV reference test device.*