A STEP-BY-STEP GUIDE FOR CHECKING CAR CHARGERS FOR ELECTRIC VEHICLES

Megger

IMPORTANT

This guide is intended to assist engineers and technicians who are carrying out checks on car chargers for electric vehicles. The examples included relate specifically to checks performed with the Megger EVCC300 Electric Vehicle Charger Checker. Other versions of this guide cover testing with other types of test equipment. These can be found at [link].

1. It is essential that EV charger testing be carried out only by competent and suitably qualified persons who have experience in electrical testing. The information and guidance presented here are not substitutes for proper training in electrical safety and the correct use of electrical test equipment.
2. All testing of EV chargers must be carried out in accordance with locally applicable standards and regulations. The standards and regulations always take precedence if conflicts occur between them and statements made in this guide.
3. The Megger EVCC300 Electric Vehicle Charger Checker is intended to provide a quick and convenient method of carrying out routine checks on chargers to confirm that they are configured correctly and operating accordingly. It is also a useful aid in identifying certain types of faults. It is ideal for initial and routine assessments but not intended for comprehensive testing of the installation of the charger to the electric network or certification testing.

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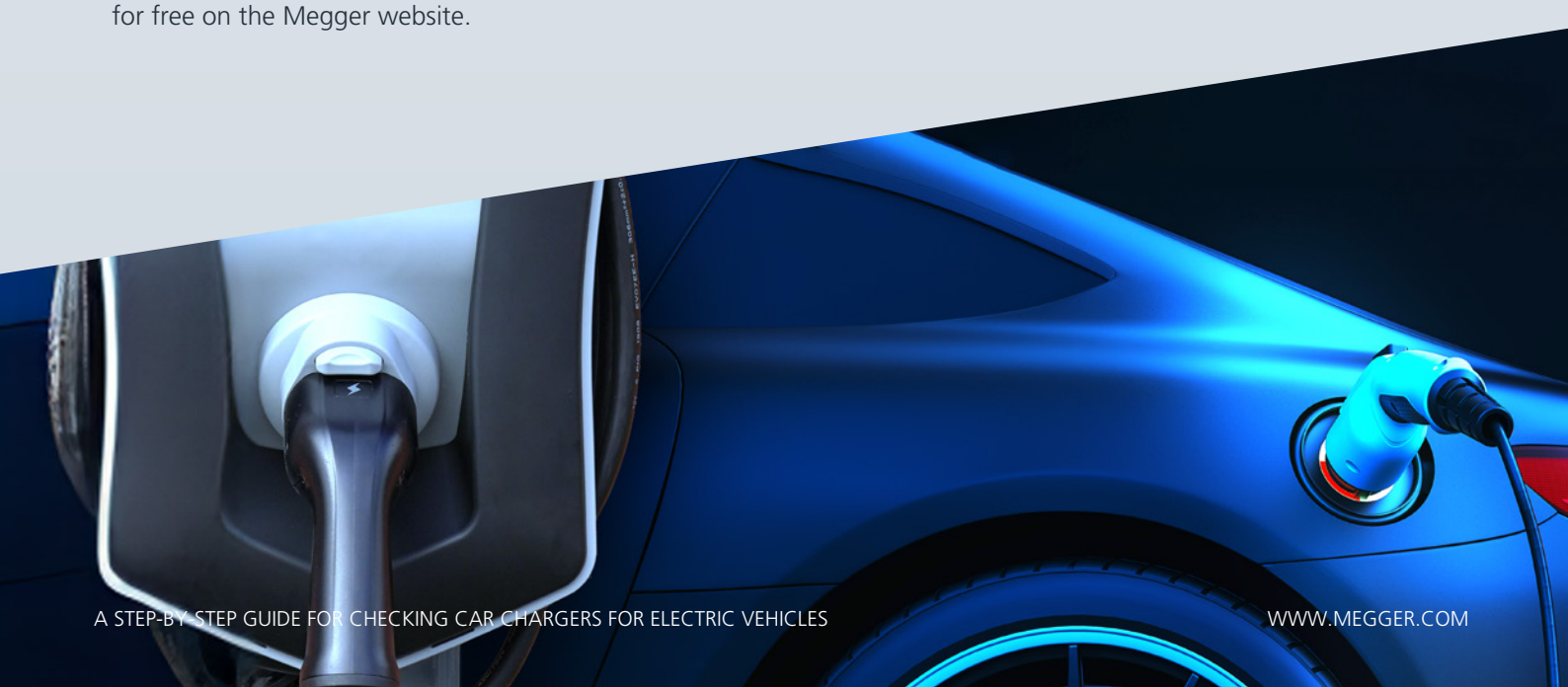
Introduction

The number of electric vehicles (EVs) in use is increasing rapidly in almost every country, resulting in a corresponding increase in the need for safe facilities to recharge their batteries. Checking and maintaining these facilities are excellent and growing business opportunities for electrical contractors. Much of the work involved is very similar to that needed when dealing with other types of electrical installation. This guide is intended to 'fill the gaps', particularly in relation to checking in-service chargers.

Before proceeding, there are a few points that need to be explained:

- This guide refers only to chargers for electrically propelled vehicles – that is, electric vehicles (EVs) and hybrids driven by an electric motor powered by a high voltage battery. It does not cover the charging of low voltage batteries in vehicles that use other types of motive power, such as petrol or diesel engines.
- The equipment used for charging electric vehicles is usually called a 'car charger', an 'EV charger' or an 'EV charge point'. Strictly speaking, none of these descriptions are correct, as the charger itself is frequently within the vehicle. A more accurate description is 'electric vehicle supply equipment' or EVSE. However, this description is rarely used other than in standards and regulations, so to make this document easier to read and understand, the description 'car charger' is used throughout.
- Car chargers are usually classified as belonging to one of four 'Modes'. Mode 1, 2 and 3 car chargers supply AC to the vehicle and the AC is converted to DC in the vehicle. Mode 4 car chargers, which are used for high-power fast charging, supply DC to the vehicle. Mode 4 is the only type of car charger where the charger itself is not in the vehicle. The modes are explained in more detail in the application note 'An introduction to electric vehicle charging', available for free on the Megger website.
- Mode 1 charging is achieved by connecting a domestic power outlet to the car with a simple lead, essentially an extension lead. Mode 1 charging does not incorporate the safety features of Mode 2 or 3. The safety of this charging mode relies entirely on the safety of the electrical installation, as there is no additional functionality. This mode is becoming unusual and is illegal in many countries. Where it is used, however, the charging circuit should be tested in the same way as any other circuit in an electrical installation – no additional tests are possible.
- Mode 2 car chargers are simply in-line modules that incorporate basic control and protection capabilities. Car manufacturers commonly provide them for charging vehicles from a standard domestic electrical outlet.
- Mode 3 car chargers are currently the most common type. They are fixed items of equipment, often attached to a wall or a free standing post, and they provide a single- or three-phase AC supply to the vehicle. This guide is mainly concerned with testing Mode 3 car chargers.



A STEP-BY-STEP GUIDE FOR CHECKING CAR CHARGERS FOR ELECTRIC VEHICLES

- Mode 4 car chargers are DC chargers. Because they convert AC to DC internally, they incorporate more complex circuit protection than other types of chargers and use power line control (PLC) to manage the charging process. Specialised equipment is needed to test Mode 4 car chargers, and as a result, they are outside the scope of this document.
- Because, for all types of car charger except Mode 4, the charging system is actually in the vehicle, the equipment referred to as a car charger is, in reality, just a special-purpose electrical supply point. It differs from other supply points only because it includes control facilities and, in many cases, additional earth fault protection.
- Like other high power devices, such as electric showers and cookers, car chargers must be fed from a separate circuit that is not shared with any other load.
- Up to the point where the car charger itself is connected, the circuit feeding the charger is the same as any other circuit in an electrical installation. Therefore, this circuit should be installed and tested in accordance with the international standard IEC 60364 or local regulations in force for electrical installations in buildings – for example, BS 7671 in the UK – before the car charger is connected.
- This guide assumes that a Megger EVCC300 Electric Vehicle Charger Checker is being used to confirm the correct functioning and current output configuration of a charge point. If other types of test equipment are being used, see the alternative step-by-step guides, which can be found at [link].
- The design and functionality of car chargers are similar in almost all countries, but there are differences in terminology. This guide is intended to be international in scope, and where these differences occur, they are mentioned and explained in the text.

A STEP-BY-STEP GUIDE FOR CHECKING CAR CHARGERS FOR ELECTRIC VEHICLES

Equipment for testing car chargers

This guide covers only the use of the Megger EVCC300, which is a self-contained and simplified instrument that can be used to quickly and conveniently verify the functionality, configuration and basic safety of car chargers. For comprehensive testing of the installation of the charger to the electric network of car chargers and for certification testing, a multifunction installation tester (MFT) and a suitable car charger adaptor are needed. Other guides are available from Megger to cover the use of this type of equipment.

Control signals

Two control signals – proximity pilot (PP) and control pilot (CP) - are used to communicate between the vehicle and the car charger.

The PP signal indicates to the car charger that a vehicle is connected. One of its primary functions is to ensure that the EV does not drive off while charging is in progress. The PP signal can also be used to indicate the maximum charging rate applicable to a particular combination of car charger and EV. Car charger checkers need to be able to simulate PP signals.

The CP signal provides information about the status of the charging process, and for the purposes of testing a car charger, the test equipment needs to simulate these CP states::

- Displays the maximum current available to be drawn by the vehicle from the charging point
- State A – no vehicle connected
- State B – vehicle connected but not ready to charge
- State C – vehicle connected and ready to charge; ventilation not required
- State D – vehicle connected and ready to charge; ventilation required

A STEP-BY-STEP GUIDE FOR CHECKING CAR CHARGERS FOR ELECTRIC VEHICLES

Testing step-by-step

An important note about resetting chargers

Some of the tests described will make the charger trip because of simulated fault conditions, while others will necessarily cause protective devices to trip as part of the test. Before proceeding, check carefully that it will be possible to reset the charger or protective device after tripping. Chargers used in non-domestic applications are frequently networked, and supervisor-level access to the network may be needed to reset them. In some cases, however, the charger may offer a maintenance mode to permit local resetting during testing. If this mode is available, it should be used. A further issue relates to protective devices. These are often external to the charger and may even be in another building. It is, therefore, important to know the location of the devices and to be sure that access is available to reset them.

Before you start…

Always read the safety warnings in the printed quick start guide supplied with the EVCC300 or the full user guide, which is available from megger.com.

- Ensure that the EVCC300 has the correct mains/line supply setting
  - Use left/right keys to show ‘Settings’ and press the middle key to select.
  - Use left/right keys to show ‘Next’ and press middle key to select.
  - Highlight the line voltage of the supply that is powering the charger and press the middle key to select.
  - This setting will only need to be changed if you test a charger operating from a different supply voltage.
  - The touch voltage limit and language settings can be changed in a similar way.

- For some tests, EVCC300 will need to enable charging mode on the charger. For chargers with mobile app control, it is recommended that you contact the charger manufacturer to find out how to put the charger into maintenance mode.

Select the method of connecting to the charger

You can connect the EVCC300 to the charger directly or via a cable. Before you start testing, you must select which connection method you are using. Otherwise, the charger may not operate as required during testing.

- Use left and right arrow keys to show ‘Connection’, then press middle key to select this option.
- Use the left/right arrow keys to choose whether the EVCC300 will be connected direct to a charger or via a charging cable. Confirm your selection by pressing the middle key.

A STEP-BY-STEP GUIDE FOR CHECKING CAR CHARGERS FOR ELECTRIC VEHICLES

Protective Earth touch pad (contact test)

This important test uses a touch pad to detect any unwanted voltage on the charger connector ground pin. The instrument also measures voltages between any phase, neutral and ground connections. This test will show if the ground is not connected and will also reveal various wiring faults, including a live ground.

- Plug the EVCC300 into the charger or connect it via a cable.
- Use the left/right keys to select the 'PE contact' option, then press the middle key to confirm your selection.
- **While keeping your finger or thumb on the touch pad**, press TEST, hold for 2 seconds and then release.
- During the test, the EVCC300 will put the charger into a charging mode. This ensures that any disconnect in the ground connection will be detected.
- If the EVCC300 shows 'FAULT', there is a wiring problem. Do not continue testing. Investigate to locate and correct the fault.
- If the EVCC300 shows 'PROCEED', no faults were found and you can continue testing.

Resistance Protective Earth (RPE) test

This test is only needed if the charger has grounded external metalwork (Class I construction).

It performs a continuity check between the earth pin on the charging connector and the external metal work. The charger is not powered up during this test. If the charger has no grounded external metalwork, proceed to the RCD/GFCI test.

- EVCC300 into the charger.
- Connect the black test lead to the connector in the base of the EVCC300 handle.
- Use the left/right keys to select the 'RPE' option and confirm your selection by pressing the middle key. The instrument will show the main test screen.
- Connect the crocodile clip or probe on the black test lead to the metalwork on the charger.
- Press TEST, hold for 2 seconds and then release.
- The screen will show the resistance of the protective earth circuit. If this is below 0.5 Ω, the test result is satisfactory and will be shown with a green tick. If it is greater than 0.5 Ω, the charger has failed the test, and the result will be shown with a red X.
- To repeat the test, press the TEST button again.

RCD/GFCI test – Part 1: personal protection

Residual current device (RCD) and ground fault current interrupter (GFCI) are electrical safety devices that quickly breaks an electrical circuit if there is leakage current to earth. If current flows through the human body for anything other than a very short time, injury or even death may result, so rapid disconnection is essential.

In this test, the EVCC300 measures how long it takes, in milliseconds, for the RCD/GFCI protecting the EV charger circuit to trip if there is an earth fault. This time must be short enough to ensure adequate protection for anyone in contact with the circuit.

- Make sure the RCD/GFCI is reset.
- Plug the EVCC300 into the charger.
- Select the RCD/GFCI option. Use the left/right keys to select the 'RCD/GFCI' option, then press the middle key to confirm your selection.
- The test screen will appear.
- The left/right keys will now toggle between the RCD (GFCI) type (current rating) and the test angle (0° and 180°).
- The test angle determines where in the mains/line supply voltage waveform the test current starts to flow. The test should be done with both settings, as RCD/GFCI characteristics may be different depending on the test angle.
- Press 'Select' to confirm the selection of the option highlighted.
- Use up and down keys to highlight desired test settings and press select.
- For this test, select a 'Pers. Prot.' test current. This should be the same as the rating of the RCD/GFCI fitted to the EV charger supply circuit.
- When the required test settings are displayed, press TEST, hold for 2 seconds and release.
- The charger will be powered up for this test and the protective device will trip. Make sure you have access to the device so that you can reset it.
- Three results will be displayed: the charger output voltage, the touch voltage (the voltage that will appear on the ground during fault conditions) and the device trip time.
- The EVCC300 will indicate whether the charger has passed (green tick) or failed (red cross) the tests.

If the EV charger does not go into charging mode, this may be because it is a mobile enabled charger. Contact the charger manufacturer for advice on how to put the charger into maintenance mode.

A STEP-BY-STEP GUIDE FOR CHECKING CAR CHARGERS FOR ELECTRIC VEHICLES

RCD/GFCI test – Part 2: nuisance tripping (optional test)

This test checks that the RCD/GFCI trips at the correct current, which should be the same as the device rating – for example, 6 mA. The EVCC300 will increase the test current until the device trips, then display the current it tripped at. If the trip current is too low, it is possible that the device will trip when it shouldn't, creating a nuisance for the charger user.

- Plug the EVCC300 into the charger.
- Select the RCD/GFCI option using the left/right keys, then press the middle key to confirm your selection.
- The test screen will appear.
- The left/right keys will now toggle between the RCD/GFCI current rating and the test angle (0° and 180°).
- Press 'Select' to choose the option highlighted.
- The RCD type screen shows the tests relevant to the supply voltage that has been set. (For more on setting the supply voltage, see the Before you start… section earlier in this document).
- For this test, select a 'Nuisance' test option and a test current appropriate for the protection device fitted to the charger supply circuit.
- When the required test settings are displayed, press TEST, hold for 2 seconds and release.
- The charger will be powered up for this test and the protective device will trip. Make sure you have access to the devices so that you can reset it.
- Three results will be displayed: the charger output voltage, the touch voltage (the voltage that will appear on the ground during fault conditions) and the device trip current.
- The EVCC300 will indicate whether the charger has passed (green tick) or failed (red cross) the tests.

This is an additional test that can help identify a low trip current caused by either an over-sensitive RCD/GFCI or by a high ground leakage current already present in the circuit.

EVSE interface tests

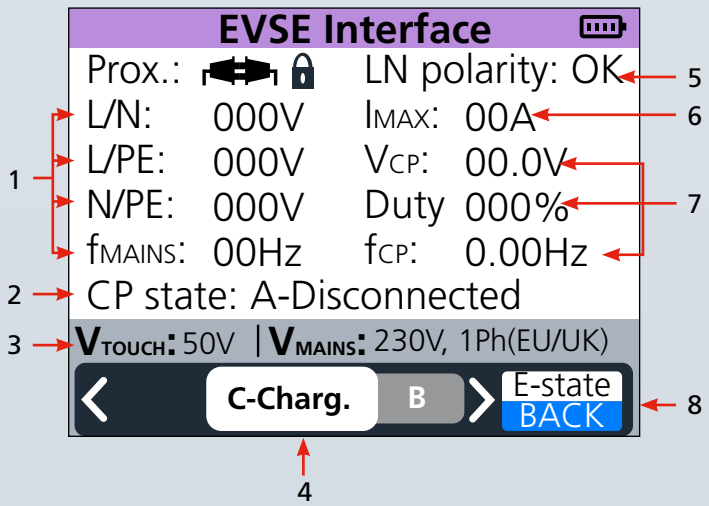
This is a series of tests to test key aspects of the charger's functionality:

- The proximity pilot (PP) test checks connection and latching. If the car doesn't know it's connected, it would be possible for the driver to drive off.
- The control pilot (CP) test simulates electric vehicle (EV) CP states A, B, C, D, E and F. These are the codes the EV uses to communicate with the charger (see earlier in this document). The EVCC300 acts as if it were a car, setting the codes and reading the EV response CP signal. It also displays the CP voltage, duty cycle and frequency.
- As part of the CP test, the EVCC300 displays the maximum charging current the charger is telling the EV it can take. You should check that this aligns with the supply rating and configuration of the charger.
- The charger output voltage is measured and displayed during the CP test, and the polarity is checked.

A STEP-BY-STEP GUIDE FOR CHECKING CAR CHARGERS FOR ELECTRIC VEHICLES

To carry out the EVSE interface tests:

- Plug the EVCC300 into the charger.
- Use the left/right keys to select the 'Interface' option, then press the middle key to confirm the selection.
- The test screen will appear.
- Use the two keys on the left to change the applied CP code.
- The CP code selection is live and operational all of the time.
    - A = Disconnected status
    - B = Connected status
    - C = Charging – with this code shown, the charger should engage charging
    - D = Charging with ventilation – in this condition, the car is asking for the charging to stop temporarily so the car can ventilate its batteries to cool them down
- You can press the TEST button for any CP code that has been selected. The EVCC300 will then make a series of measurements and display the results.
- You should test each CP code in turn following this sequence: A, then B, then C, then in the opposite direction on the code selector to get to code D).
- If the charger does not respond to code C, go through the sequence of codes again but more slowly. Some chargers need a short time at code B before they are ready to move to code C.
- Once the measurements are shown on the screen, they are not updated. After a few seconds, warning triangles will appear to remind you of this. These triangles do not indicate that the test has failed.
- A short press of the right hand button will produce a charger Error state (E-state). This shorts the CP to ground to simulate a fault to test the charger's reaction. The charger should indicate that a fault is present.
- A long press of the right hand button takes the EVCC300 back to the main test selection screen.
- At the end of each test, the EVSE Interface test screen will show these results:



Item	Description
1	Charge output / mains voltage measurements
2	Control pilot code read from charger
3	Touch voltage limit and mains supply setting
4	Softkey 1 and 2 Set code (simulating the vehicle)
5	Polarity of charger output L to N status
6	Maximum current available from charger
7	Control pilot measurements
8	Softkey 3 Short press = E-state Long press = Back

A STEP-BY-STEP GUIDE FOR CHECKING CAR CHARGERS FOR ELECTRIC VEHICLES

Auto test sequence

The EVCC300 has a great time saver function. The user can select which tests they would like to perform and then the EVCC300 will run through all of the tests one by one automatically.

On the Autotest screen use the up and down softkeys (1 and 3) to highlight the test you wish to switch on or off. Tests switched on (toggle in upper position) will be performed during the autotest sequence.

There are three tests you can switch on or off. These are:

A. Protective bonding (RPE) If the charger being tested is double insulated with no external metalwork this test would not be required

B. RCD / GFCI - If you are unable to access the RCD or GDCI and therefore unable to reset it, do not perform this test. When selecting the RCD / GFCI test the user will be asked to select which test they wish to perform during the auto sequence.

C. Reset Charger - Switch on if you wish to reset the charger at the end of the autotest sequence

As each autotest is performed the result will simply be indicated by either a green tick (test PASS), orange question mark (test with a QUESTIONABLE RESULT) or a red cross (test FAIL)

After completing tests

When you have finished your tests, disconnect the EVCC300, and make sure that the charger is reset and returned to normal operating mode. In particular, be sure to exit maintenance mode if this has been used and to properly refit any covers that have been removed to gain access to, for example, protective devices.

Calibration

Calibrated instruments are not essential for routine checking of car chargers, but they are highly recommended as, otherwise, it is impossible to be confident about the accuracy of the results obtained. Calibration intervals vary, but the instrument manufacturer will be able to provide dependable advice.certainly the charger or back-office system that is preventing it from resetting. Chargers and installations vary considerably in this respect, but if all other methods fail, it may be possible to force the charger to reset by turning off the power to it, waiting a short time, and turning it on again. This should, however, always be a last resort. Contact the car charger manufacturer for additional advice.

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