

ComboCS - The CCS EVSE Simulator

Accelerate and make CCS developments more reliable

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Trialog is working on EV charge since more than 10 years and had several opportunities to develop a strong expertise on Electro-Mobility charge protocols like IEC 61851-1, DIN 70121, ISO 15118 and OCPP 1.6/2.0.

In this context, Trialog has developed several testing and validation tools.



ComboCS, the EVSE CCS Simulator is one of these tools. It aims to enable and simplify CCS developments by providing simulation and test means of DIN 70121 and ISO 15118 protocols without any power transfer. This tool allows to:

- Simulate the EVSE part of a CCS implementation in order to perform or simulation charging session following IEC 61851-1, DIN 70121 and/or ISO 15118;
- Follow in real-time the communication through the embedded UI;
- Change in real-time the EVSE behaviour;
- Launch different test case scenario to trigger nominal and non-nominal test cases.

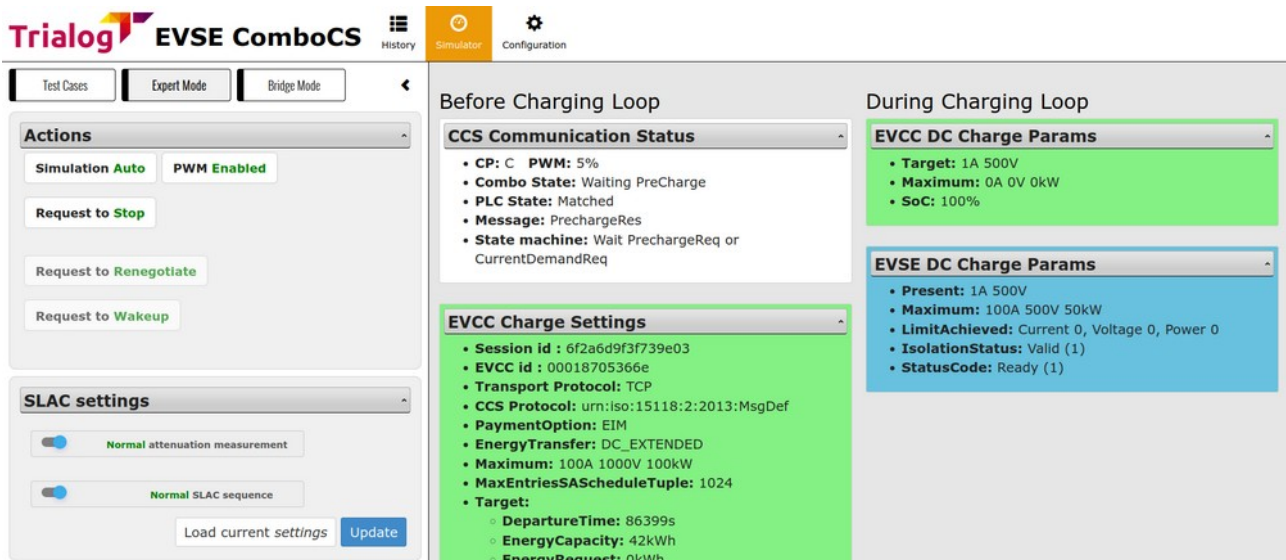


Figure 1: ComboCS User Interface

Technical Details

ComboCS is a box allowing to perform AC or DC, ISO 15118 or DIN 70121 communications, including the HPGP PLC and IEC 61851-1 communications.



Figure 2: ComboCS connectors - Face 1



Figure 3: ComboCS connectors - Face 2

- Size: 23x15x6 cm
- Power: +12V
- Connectors:
 - Control Pilot and Protective Earth: BNC

- Ethernet: RJ45
- CAN: DB9 (reserved for future usage or specific development)
- Wires provided with the Simulator
 - AC/DC 230V/12V
 - Type 2 plug with BNC connector
 - Ethernet wire

Supported Features

ISO 15118 and DIN 70121 standards define several use cases and functions. ComboCS supports almost all functions and more specifically:

- ISO 15118-3 / DIN 70121
 - SLAC
 - Validation
- ISO 15118-2 / DIN 70121
 - SDP
 - Supported state machines: AC and DC
 - Supported payment options: EIM and PnC
 - Supported optional functions:
 - Service Details
 - PnC Certificate installation
 - Smart Charging
 - Renegotiation
 - Metering Receipt
 - Welding Detection (DC charge only)

For test purpose, the Simulator could also be used to perform ISO 15118-2 communication over Ethernet without the PLC ISO 15118-3 link.

Implementation in progress

“Amplitude Map exchange” of ISO 15118-3 and “Pause / Resume” of ISO 15118-2 are still under development and will be soon added to ComboCS.

ComboCS Modes

SIMULATOR MODE

By default, the EVSE ComboCS can be plugged to a vehicle and perform a standalone and nominal CCS charging session without any other inputs.

The default configuration is:

- ISO 15118 or DIN 70121
- DC or AC Charge
- EIM or PnC payment option
- Charge Maximum Limits: 32A, 400V, 22kW
- Charge Minimum Limits: 6A, 0V
- CurrentRegTolerance: 1A, PeakCurrentRipple: 15A

This default behavior can be modified using the Configuration view, and adapted in live using the expert and test case modes defined below.

SUPERVISION MODE

ComboCS is provided with a Web interface, compatible with Windows, Linux and Mac, accessible over Ethernet or Wifi. It provides access to real-time evolution of the ongoing CCS communication.

The screenshot displays the ComboCS web interface, divided into two main sections: "Before Charging Loop" and "During Charging Loop".

Before Charging Loop:

- CCS Communication Status:**
 - CP: C PWM: 5%
 - Combo State: Ready to charge
 - PLC State: Matched
 - Message: ChargingStatusRes
 - State machine: Wait ChargingStatusRes
- EVSE Charge Settings:**
 - EVSE id: FR*VED*E0004*01*22
 - Transport Protocols: ["TCP"]
 - CCS Protocols: ["urn:iso:15118:2:2013:MsgDef", "urn:din:70121:2012:MsgDef"]
 - PaymentOptions: ["EIM"]
 - EnergyTransfers: ["AC_1", "AC_3"]
 - Maximum: 32A 230V
 - SA Schedules:
 - SASchedule #1: Charge: #1(1)[0-86400s:22kW]

During Charging Loop:

- EVSE AC Charge Params:**
 - Target:
 - Active 0kW
- EVCC AC Charge Params:**

No EVCC AC Charge parameter in "urn:iso:15118:2:2013:MsgDef".
- Detailed Logs:**

```
[D][38:57.359] > Tx ChargingStatusRes Ed1 [0][0] (21ms)
[D][38:57.342] < Rx ChargingStatusReq Ed1 [0][0] (0ms)
[D][38:57.058] > Tx ChargingStatusRes Ed1 [0][0] (20ms)
[D][38:57.041] < Rx ChargingStatusReq Ed1 [0][0] (0ms)
[D][38:56.761] > Tx ChargingStatusRes Ed1 [0][0] (22ms)
```

Figure 4: ComboCS interface - Example of ISO 15118 communication

All data exchanged between the EVSE of the EV is available through the user interface. The history of the whole decoded communication can be downloaded as a log file.

TEST CASE MODE

The Test Case Mode of ComboCS triggers CCS communication session for a list of nominal and non-nominal predefined cases.

The Test Case Mode proposes two types of test cases:

- **Limit testing:** Because of existing ambiguities in the norms and the multiplicity of the implementations, ComboCS is providing several test cases with limit and non-nominal behaviour of the EVSE, and even invalid behaviour of the EVSE observed « in the street ». Thanks to the experience of *TRIALOG* in the field, this list is increasing regularly.
- **Conformance testing:** ISO 1518-4 and ISO 15118-5 documents define test cases to validate conformance of the implementation to the normative documents. ComboCS is providing a subset of these test cases. The coverage is not yet complete, but increasing regularly.
- **EVSE simulation** (not released yet): Additionally to the limit test cases, ComboCS also provides test cases to mimic the behaviour of existing EVSE in the market.

Additionally to the available test cases, an HTTP/REST and WebSocket API is provided with ComboCS, allowing to define its own test cases and integrate ComboCS to its own validation process (end of line test, non regression tests, ...).

These test cases provides a great overview of the implementation state of the Vehicle in several use cases.

Current Test Case

#12 PowerDeliveryRes
FAILED_PowerDeliveryNotApplied

Description:
Just before the Charging Loop (AC or DC), the EVSE is sending a PowerDeliveryRes ResponseCode 'FAILED_PowerDeliveryNotApplied' to notify that it cannot delivery energy (as defined in [V2G2-480] and [V2G-DC-401]).

Expected Result:
The EVCC shall:

- Stop the TCP communication abruptly
- Notify errors to higher layers

State: Pending

RestartStop

Logs:
Start preamble: reset settings & simulate unplug
Waiting 7s...
Preamble finished
Start HLC-C: simulate plug
Waiting V2G communication session startup...
State: Pending

Download more logs

Figure 5: ComboCS Test Case Mode

Each test case is provided with a description of the test, explanation of the successive steps, and the expected results with links to the normative requirements.
An indicative result is provided at the end of the scenario.

Possibility of custom developments

On demand, it is possible to update ComboCS in order to create test cases specific to your needs and projects.

EXPERT MODE

Using the expert mode, it is possible to modify at any time the nominal behavior of the EVSE ComboCS before or during the Charging Loop.

Expert mode allows to define precisely each values sent by the EVSE in a CCS communication. Some cases require synchronisation and timing that cannot be done manually. Therefore, such cases can be passed using the Test Case mode.

Simulation **Auto**

PWM **Enabled**

Actions

Request to **Stop**

☐ Wait external authorization

Request to **Renegotiate**

Tx EVSE Charge Settings

Maximum ?

32

^

v

A

230

^

v

V

22.08

^

v

kW

Minimum:

6

^

v

A

0

^

v

V

CurrentRegTolerance ?

Sent ▾

1

^

v

A

PeakCurrentRipple:

15

^

v

A

Load current settings

Update

Figure 6: Expert mode interface

INSPECTION MODE

When ComboCS Inspection mode is enabled, all PLC traffic is redirected to a Wireshark opened on the operator machine, providing access to the raw Ethernet traffic from SLAC to ISO 15118-2 or DIN 70121 for further analysis.

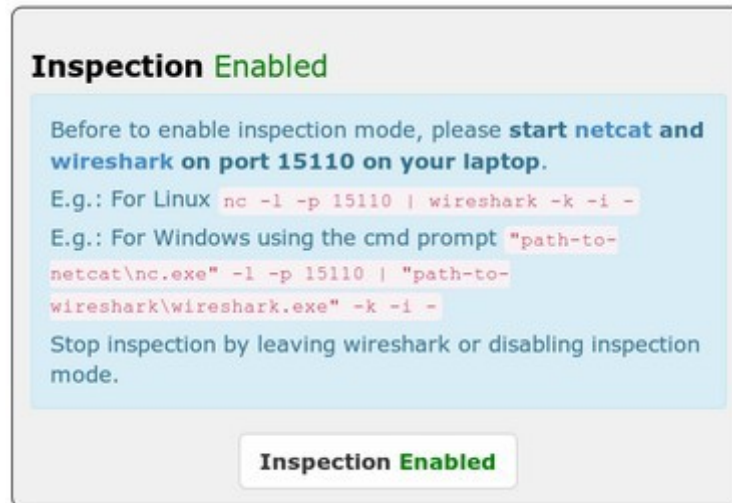


Figure 7: Bridge mode interface

Thanks to a Wireshark plugin developed by Trialog, provided with the tool, the Ethernet traffic is directly decoded in Wireshark and ready for analysis.

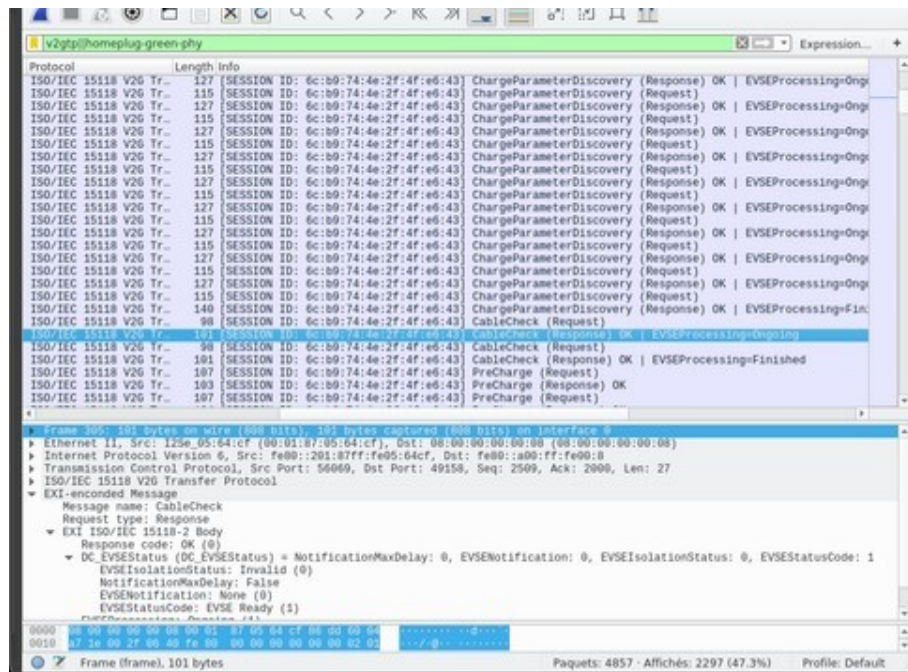


Figure 8: PLC traffic is available through Wireshark

Please notice:

The CCS communication between the EV and the EVSE can sometime be encrypted with TLS, for example when using the PnC feature.

In order to decrypt a secured communication, Wireshark shall be configured with either:

- The TLS private key of the charging station. Such a key will allow to decrypt all communications with this charging station.
- A premaster secret generated using the TLS credentials of the charging station or the vehicle. A premaster secret is unique for each charging session.

The TLS private key of the EVSE ComboCS can be downloaded from the ComboCS UI and configured into Wireshark.

This bridge mode also allows to inject PLC traffic in an existing AVNL.

ComboCS Options

NON-INTRUSIVE SNIFFER OPTION

This feature is an option, not provided by default in ComboCS. It requires to add some measurement hardware.

In Sniffer mode, the ComboCS does not simulate anymore an EV or a Charging Station, but is plugged directly between an EV and a Charging Station communicating using CCS. ComboCS can then sniff passively the communication without interacting in any way with the PLC traffic. In such a mode, all PLC traffic is available on a dedicated RJ45 port, providing access to the raw Ethernet traffic from SLAC to ISO 15118-2 or DIN 70121. This traffic can be displayed on a Wireshark opened on the operator machine, for further analysis.

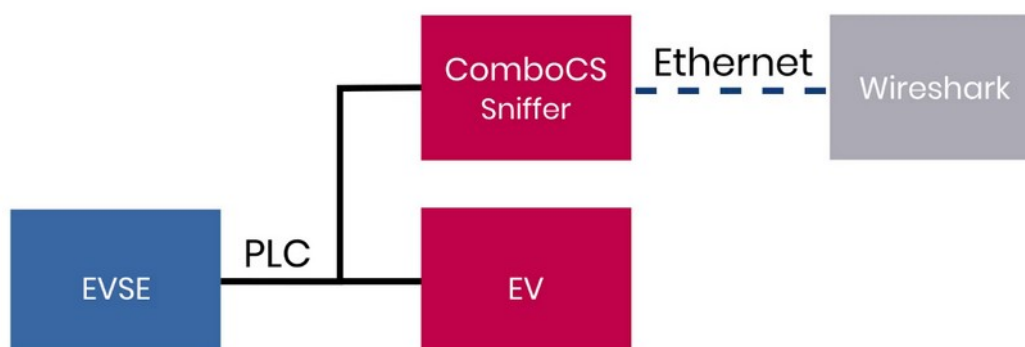


Figure 9: ComboCS + sniffer option

Thanks to a Wireshark plugin developed by Trialog, the same used in the Bridge mode described above, the Ethernet traffic is directly decoded in Wireshark and ready for analysis.

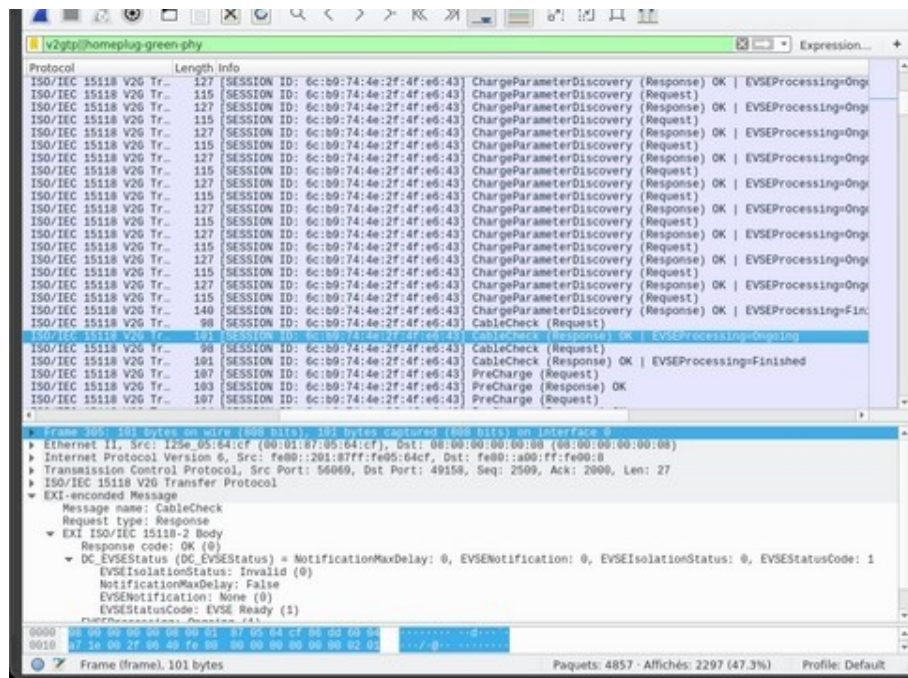


Figure 10: PLC traffic is available through Wireshark

Please notice:

The CCS communication between the EV and the EVSE can sometime be encrypted with TLS, for example when using the PnC feature.

In order to uncrypt a secured communication, Wireshark shall be configured with either:

- The TLS private key of the charging station. Such a key will allow to uncrypt all communications with this charging station.
- A premaster secret generated using the TLS credentials of the charging station or the vehicle. A premaster secret is unique for each charging session.

It is important to have access to one of this credential from at least the vehicle or the charging station side. Otherwise, the communication cannot be decoded by the Wireshark plugin.

Such a mode could have an impact on PLC power emission and shall not be used during PSD measurement.

PSD MEASUREMENT OPTION

Specific development required

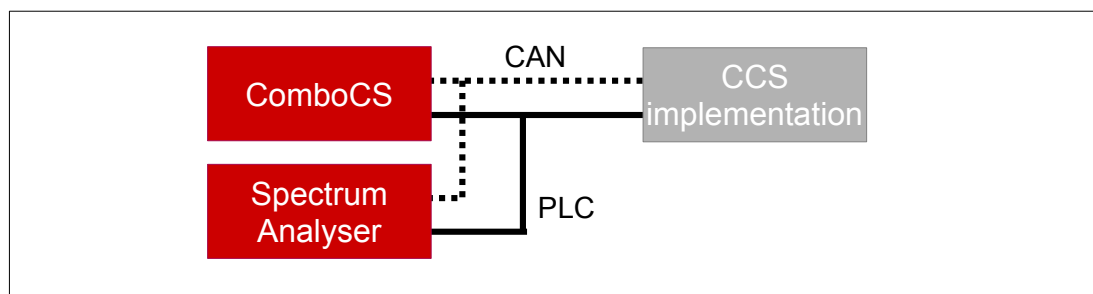
This feature is an option, not provided by default in ComboCS. It requires to add some measurement hardware.

To fully automate the process, the CCS implementation shall be adapted to use the ComboCS interface, or a custom development is required on the ComboCS to put the CCS implementation in a dedicated measurement mode and change the PLC calibration.

In order to comply with ISO 15118 and DIN 70121, a CSS implementation shall emit a PLC level of -35dBm (i.e. -75dBm/Hz) for each PLC carrier between 1.8MHz and 30MHz. The measurement shall be done at the Vehicle inlet, a calibration shall be done according the internal wiring of the Vehicle from the point of measurement to the PLC Modem.

The generic PSD Measurement option of the ComboCS facilitates the calibration of a CSS implementation. In this mode, the ComboCS shall be connected to a Vehicle that communicates permanently over PLC¹. A specific development shall be done on the Vehicle to trigger such a communication. The ComboCS will then measure the PLC power emission on each carrier thanks to the setup defined in ISO 15118-3 and DIN 70121 summarized below.

The result is analysed and computed by the ComboCS in order to provide the delta to be applied on the Vehicle PLC Modem calibration.



PSD measurement add-on basic setup

The ComboCS also provides a generic communication interface over HTTP to:

- trigger the permanent PLC communication on the Vehicle
- retrieve the current PLC Modem calibration of the Vehicle
- apply the new PLC Modem calibration of the Vehicle

If the Vehicle is adapted to integrate this communication interface, the PSD measurement setup could be completely automated. Otherwise, it requires several manual steps.

A custom development can also be discussed with the *TRIALOG* team and added into the ComboCS in order to adapt the setup to your specific needs.

¹Some other solution are available on the market, that do not required the implementation of this permanent communication over PLC on the Vehicle, but they are not compliant with ISO 15118-3 and DIN 70121.

POWER TRANSFER **OPTION**

Specific development required

This feature is an option, not provided by default in ComboCS. It requires to add some hardware and involve some developments to target your specific needs.

In order to perform power transfer using ISO 15118 communication, specific modules for AC and DC can be added to ComboCS. Depending of your needs, Trialog can adapt ComboCS to use your existing hardware, or provide you a specific solution.

Example of solution for AC charging: Add a module with an inlet to behave like a real AC charging station.

Development in progress

The plug and play AC modules described above are still under development and planned for 2022.

Annual Subscription

The ComboCS tool described in this document is ready to use. It has been tested and validated by the Trialog team, tested with several Vehicles in the field and during 3 Testing Symposiums and 2 CharIN Testivals and is currently used by more than 50 companies around the world.

The ComboCS is also still actively maintained by Trialog to fix eventual remaining bugs, test with new Vehicles, facilitate the usage of the tool, and ensure the correct behaviour of the Simulation mode regarding the current consensus of the normative groups and ISO 15118 user group.

In order to provide such corrective and evolutive updates of the ComboCS, Trialog is proposing an annual subscription including:

- Access to corrective releases of the ComboCS
- Access to evolutive releases of the ComboCS

Trialog will deliver at least one release per year to fix bugs that might have been detected and to deploy enhancement of existing features (same feature basis).

Trialog can share its internal previsional roadmap but does not garanty any delivery planning in the scope of this annual subscription. A dedicated contract can be defined to adapt this roadmap to your company requirements.

In addition to the access of these releases, the subscription also offers access to Trialog's hotline through an online ticketing system. It can be used to ask questions about ComboCS usage and report issues encounter with the ComboCS.

The subscription is done on a yearly basis. The first year of the ComboCS subscription is already included when buying the tool. Subscription for upcoming years is done on the conditions defined when buying the tool if done continuously. In case of interruption, paying for the not covered period is necessary to get the update.

Contact us

For more information about **ComboCS**, please contact us: emobilitysales@trialog.com.

Do you know ComboCS4M for End of Line testing?

Trialog has developped a simple version of ComboCS, the ComboCS4M, dedicated to Vehicle On-Board Charger End of Line testing: plug the ComboCS4M to your On-Board Charger and get a quick result about the status of PLC and ISO 15118 status to know if the system is ready or not to be used. The perfect tool for end of line testing or to managing curative maintenance.

Interested? Please contact us!