EV ComboCS4M - CCS simulation

Accelerate and make CCS developments more reliable

Trialog is working on EV charge since more than 10 years and had several opportunities to develop a strong expertise on EV charge protocols like IEC 61851, DIN 70121, ISO 15118 and OCPP1.6/2.0.
In this context, *TRIALOG* has developed several testing and validation tools.

ComboCS4M, the EV CCS simulator is one of these tools. It could be used in any setup in needs of a CCS EV implementation. For example to simplify CCS end of line validation and maintenance by providing quick test means for DIN 70121 and ISO 15118 protocols without any power transfer.

Technical Details

- Size: 160 x 125 x 52 mm
- Connectors:
    - Power supply: barrel jack
    - Control Pilot and Protective Earth: BNC
- Interface
    - WiFi hotspot
    - Ethernet
- Wires provided with the Simulator
    - AC/DC 230V/12V
    - Type 2 plug with BNC connector
    - Ethernet wire

Supported Features

ComboCS4M could be used in any setup in needs of a CCS EV implementation.
For example, to validate the correct behaviour of a CCS EVSE or of an SECC for AC or DC, ISO 15118-3 / ISO 15118-2 or DIN 70121 communications, including the HPGP PLC and IEC 61851-1 communications.
The goal of ComboCS4M is not to entirely check the EVSE CCS implementation[1], but to verify that the building process, installation operation or maintenance operation leads to a properly working device.

ISO 15118 and DIN 70121 standards define several use cases and functions. ComboCS4M supports all functions and more specifically:

- ISO 15118-3 / DIN 70121 for PLC communication
  - SLAC
  - SLAC Validation with BCB-Toggle
- ISO 15118-2 / DIN 70121
  - SDP
  - Supported state machines: AC and DC
  - Supported payment options: EIM and PnC
  - Supported optional use cases:
    - Service Details
    - PnC Certificate installation
    - Smart Charging
    - Renegociation
    - Metering Receipt
    - Welding Detection (DC charge only)
    - Pause / Resume

> **Implementation in progress**
> "Amplitude Map exchange" of ISO 15118-3 is still under validation and provided as developer preview into the ComboCS4M.

Auto Mode - Verify expected behaviour

In auto mode, once plugged to an EVSE or an SECC, the ComboCS4M is starting a DIN 70121 and an ISO 15118-2 test suite.

The test suite can be quickly described as below:

- Do the SLAC mechanism
- Select the DIN 70121 version: the EV ComboCS4M will be configure to support only DIN 70121, and DIN 70121 is expected to start
- Once charging loop is reached, wait 15s before to request to stop

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[1] Do you know ComboCS? It is done for that purpose! If you are interested, please contact us at emobilitysales@trialog.com.

- At the end of the charge, simulate an unplugged wire and wait 7s
- Simulate a plugged wire and do the SLAC mechanism
- Select DIN 70121 or ISO 15118: the EV ComboCS4M will be configured to support both ISO 15118-2 and DIN 70121, ISO 15118-2 is expected to start, but DIN 70121 is also accepted
- Once charging loop is reached, wait 15s before to request to stop
- At the end of the charge, simulate an unplugged wire

Manual Mode – Simulate an EV

In manual mode, once plugged to an EVSE or an SECC, the ComboCS4M is simply starting a DIN 70121 or ISO 15118-2 communication session as an EV will do.

Simple Configuration

The ComboCS4M is provided with a Wifi hotspot and an Ethernet plug allowing to access a configuration UI. Select the functioning mode of the ComboCS4M (AC, DC, EIM or PnC) and its SmartCharging behaviour: Departure time, Energy request and Battery State of Charge (DC only).

Figure 1: ComboCS4M configuration UI

Quick access to test result

On the ComboCS4M box, LEDs are indicating the progress of the charging session and the test suite result. It allows to visualize where it fails in case of failure.

Figure 2: ComboCS4M showing session progress with LEDs

Quick access to test results history

The ComboCS4M is provided with a Web interface, compatible with Windows, Linux and Mac, accessible over Ethernet or Wifi.

An historic of all charging session is kept available on the ComboCS and can be downloaded in CSV format for Excel. It allows to quickly identify a session by a number, to know its status and the failure reason.

Current Charging Session 85%

#	EVCCID	SessionId	Type	Result	Last message	Current stage	Error code	Actions
39	00018705366e		Not Selected	Pending	None	Waiting PLC	No error	Stop Plugged

Charging Sessions History

1

#	Start	Duration	EV MAC	EVCCID	RunId	SessionId	Type	Result	Last message	Last stage	Error code
31	1645201929	17 s	00018705366d	00018705366e	72089631	9db48b9eaad9bf50	DIN DC EIM	Success	SessionStopRes	Finished PCAP	No error
30	1645201223	292 s	00018705366d	00018705366e	1664540707	4f006905f72cb49f	DIN DC EIM	Success	SessionStopRes	Finished PCAP	No error
29	1645201011	170 s	00018705366d	00018705366e	72089631			Failure	None	Ready to charge PCAP	Remote host closed the communication - TCP error: The remote host closed the connection
28	1645200992	9 s	00018705366d	00018705366e	1664540707			Failure	None	Waiting Handshake PCAP	Comm Incompatibility
27	1645199573	1274 s	00018705366d	00018705366e	72089631	f3dc4f1f3702661b	ISO-2 DC EIM	Success	SessionStopRes	Finished PCAP	No error

Figure 3: Session history view

Quick access to communication data

The supervision view provides access to real-time evolution of the ongoing CCS communication on the ComboCS4M.
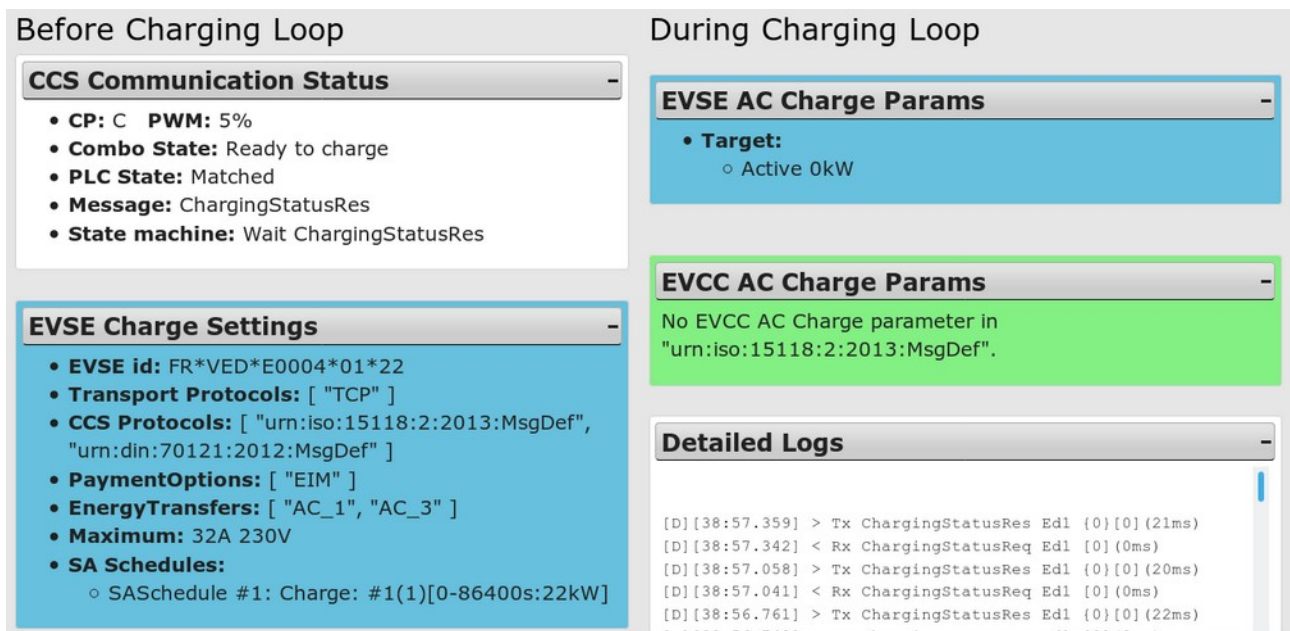
Figure 4: ComboCS interface - Example of ISO 15118 communication

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.

ComboCS LEDs and GPIOs

Figure 5: Face 2 of the ComboCS

The ComboCS4M is provided with 6 LEDs indicating the progress of the charging session. At plugin LEDs are blinking and lighting one by one. If an error happen, LEDs are kept in their existing state to visualize quickly where it failed.

Meaning and behaviour of each LED is described below:

- **LED 1 : Control Pilot**
  - LED is off when unplugged (state A/E/F).
  - LED is blinking when plugged but not ready to charge (state B).
  - LED is on when plugged and ready to charge (state C/D). Therefore, for DC charge, it should become one at the beginning of the CableCheck process.

- **LED 2 : PLC Matched**
  - LED is blinking when the first SLAC message is received, until the end of the Matching process described in ISO 1511863 and DIN 70121.
  - LED is on when the SLAC process ifs finished with the succesful Matched state.

- **LED 3 : Cable Checked**
  - LED is blinking when the first SDP request is sent, just after the SLAC Matching process, until the end of the CableCheck process described in ISO 15118-2 and DIN 70121. A lot of steps are done in this stage (SDP, TCP/TLS connexion, Hadnshake, SessionSetup, Authorization, ChargeParameterDiscovery and also CableCheck for DC charge).
  - When CableCheck process is started, the LED 1 "Control Pilot" shall be on, since the EV is required to go to state C before CableCheck.
  - LED is on when the end of the CableCheck mechanism is reached.

- **LED 4 : Charging**
  - LED is on when the Charging Loop is reached (PowerDeliveryReq Start in AC, end of PreCharge loop in DC, when TargetVoltage-MeasuredVoltage <20V)

- ○ This LED is always either on or off, it does not blink, in order to let the user use this GPIO as a a logical state to switch a charge relay.
- **LED 5 : End of charge**
  - ○ LED is blinking when the end of the charge is requested by the EV or the EVSE
  - ○ LED is on when the charging session is ended
- **LED 6 (red) : Test result**
  - ○ LED is blinking when the session result is "Failure"
  - ○ LED is on when the session result is "Success"

As a sumary:

- A LED is off when the related state is not yet reached.
- A LED is blinking when the related state is in progress. With an exception for PreCharge: LED 4 is kept off until Charging Loop is reached in order to let the user use this GPIO as a a logical state to switch a relay.
- A LED is on when the related state is finished.

Therefore, all LEDs are going off when unplugged.

The GPIO connector of the ComboCS4M is a mirror of the LEDs. It alows the GPIO to be used to read the digital status of the LEDs, and therefore to know the status of the charging session.
The LED 4 "Charging" is always either on or off, it does not blink, in order to let the user use this GPIO as a a logical state to switch a charge relay.

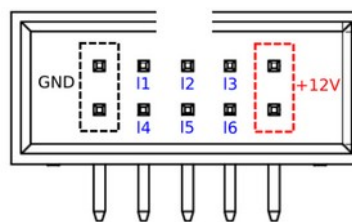The illustration below describes the pinouts of the GPIO connector:
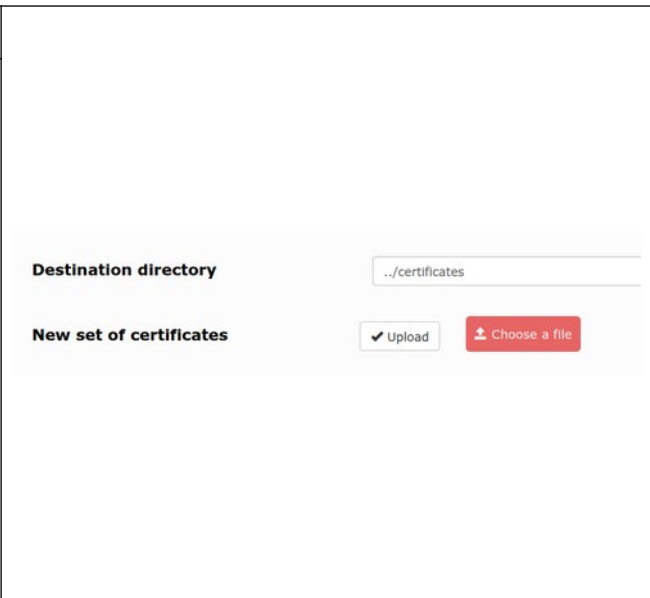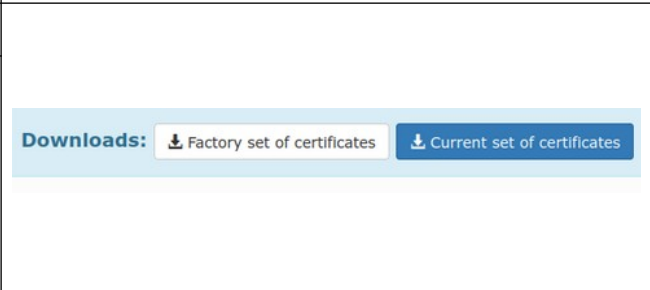

Figure 6: GPIO pinout

GPIO Voltage: 3,3V, Max current: 10mA.
Female connector is not provided with the tool. Search for HCSD-05-D-11.40-01-N-G-R reference (10 pins, 2 entries, 2.54mm space between pins).

ComboCS4M for TLS and Plug&Charge

The ComboCS4M supports TLS and both Authorization and Certificate Installation use cases of Plug&Charge using ISO 15118-2.

Since Plug&Charge requires a PKI and since interoperability between PKIs is an important stage of testing, the ComboCS also allows to adapt to several environments:

You are already using a PKI	
The ComboCS4M can be configured with your own PKI. Upload your PKI into the ComboCS4M and configure the credentials to be used. In case you are using the Hubject's or CharIN's PKI, the ComboCS4M is already embedding these 2 V2G root certificates. This will allow to setup the TLS communication. However, to perform Authorization or Contract installation, you will require to deploy a certificate chain signed by these roots.	**Destination directory** ../certificates **New set of certificates** ✔ Upload ⬆ Choose a file
You do not have any PKI	
The ComboCS4M is provided with its own PKI. Download the test purpose PKI (certificates + private keys) on the ComboCS interface and install it on your EVSE.	**Downloads:** ⬇ Factory set of certificates ⬇ Current set of certificates

The ComboCS4M Plug&Charge features has been tested in dozen of Testing Symposiums and CharIN Testivals, and tested with other test systems (Verisco, Vector, Comemso, Keysight). It is used since 2018 in all Plug&Charge international interoperability demonstrations made with ElaadNL, Vedecom, GIREVE, Hubject, E-clearing.net, Trialog, Renault, Stellantis and others.

It is one of the few implementations used during the 2022 CharIN Testival in Poland to introduce the CharIN Plug&Charge logo.

ComboCS4M Options

SW UPGRADE TO ISO 15118-20 EXTENSION

> This feature is an option, not provided by default in ComboCS. It is available as a software update.

> ***Development in progress***
> A release is already available today and working. Interoprability has been tested during the first ISO 15118-20 vTestival hosted by Vector in 2022 July.
> Complete implementation is still in progress. New releases with enhancements are expected every 2 months until 2022 June.

By default, the ComboCS4M only supports the original versions of the standard: DIN 70121 and ISO 15118-2. This SW upgrade enables the brand new ISO 15118-20 support on ComboCS.

This option provides the same feature basis as the default one but for ISO 15118-20. However, it does not provide any test case mode for ISO 15118-20 since conformance tests are not defined yet by the normative comitee.

In order to simplify validation of ISO 15118-20, the tool allows to disable TLS or to use the TLS 1.2 mechanism defined in Iso 15118-2.

The following table is listing the current status of the implementation:

Use Case	Status
SDP	Available
V2GTP	Available
Protocol selection with SupportedAppProtocol	Available
AC unidirectional and bidirectional state machines Dynamic mode	Available
DC unidirectional and bidirectional state machines Dynamic mode	Available
AC unidirectional and bidirectional state machines Schedule mode	To be scheduled
DC unidirectional and bidirectional state machines Schedule mode	To be scheduled
TLS 1.3 with Mutual Authentication	Implementation in

	progress
Service Renegotiation	Implementation in progress
User Mobility Needs exchange	First version already available Implementation in progress
Plug&Charge Authorization	To be scheduled
Plug&Charge Contract Installation	To be scheduled
Pause & Resume	To be scheduled

SW UPGRADE TO COMBOCS VERSION EXTENSION

> This feature is an option, not provided by default in ComboCS4M. It is available as a software update.

Not sure the full-featured ComboCS version is the right one for your needs? Start with the ComboCS4M version and switch later on to the ComboCS one.

NON-INTRUSIVE SNIFFER OPTION

> This feature is an option, not provided by default in ComboCS4M. It requires to add some measurement hardware.

In Sniffer mode, the ComboCS4M does not simulate anymore an EV or a Charging Station, but is plugged directly between an EV and a Charging Station communicating using CCS. ComboCS4M can then snif passively the communication without interacting in any way with the PLC trafic. In such a mode, all PLC trafic is available on a dedicated RJ45 port, providing access to the raw Ethernet trafic from SLAC to ISO 15118-2 or DIN 70121. This trafic can be displayed on a Wireshark opened on the operator machine, for further analysis.
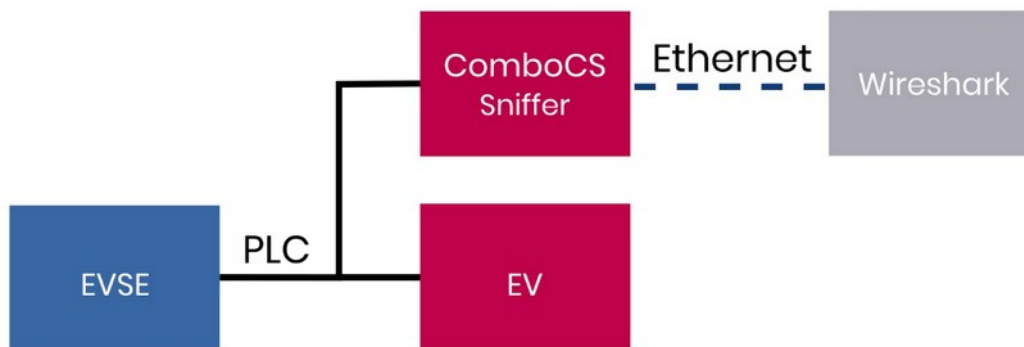
Figure 7: ComboCS + sniffer option

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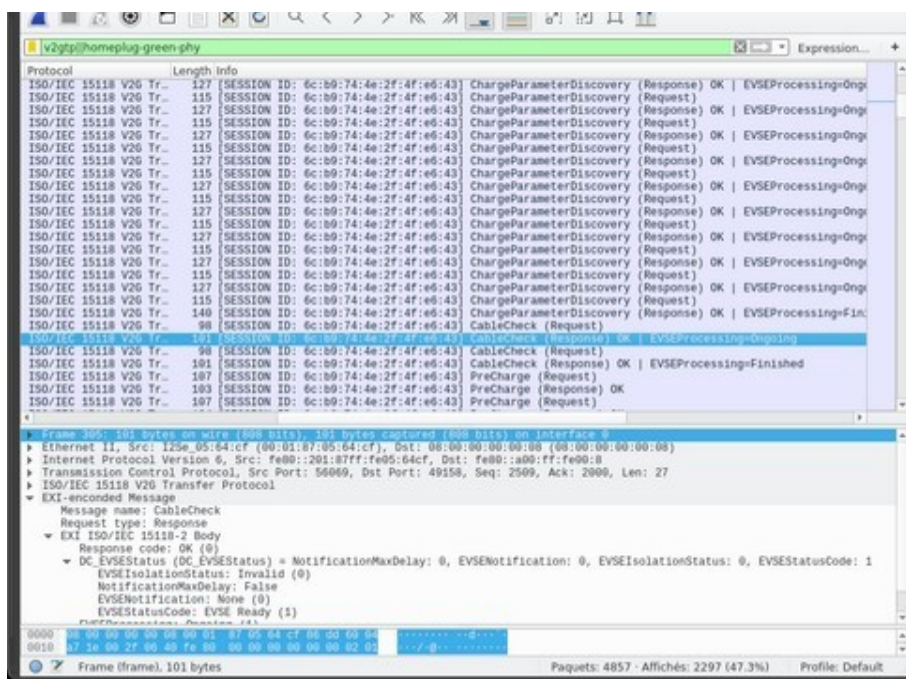

Figure 8: PLC traffic is available through Wireshark

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

PSD MEASUREMENT OPTION

This feature is an option, not provided by default in ComboCS4M. It is available as a software update and delivery of new hardware parts.

Specific development required

> To fully automate the process, the CCS implementation shall be adapted to use the ComboCS4M interface, or a custom development is required on the ComboCS4M 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 beween 1.8MHz and 30MHz. The measurement shall be done at the EVSE DC plug or AC inlet , a calibration shall be done according the internal wiring of the EVSE 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 EVSE that communicates permanently over PLC. A specific development is recommended on the EVSE to trigger such a communication[2]. The ComboCS4M 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 ComboCS4M in order to provide the delta to be applied on the EVSE PLC Modem calibration.
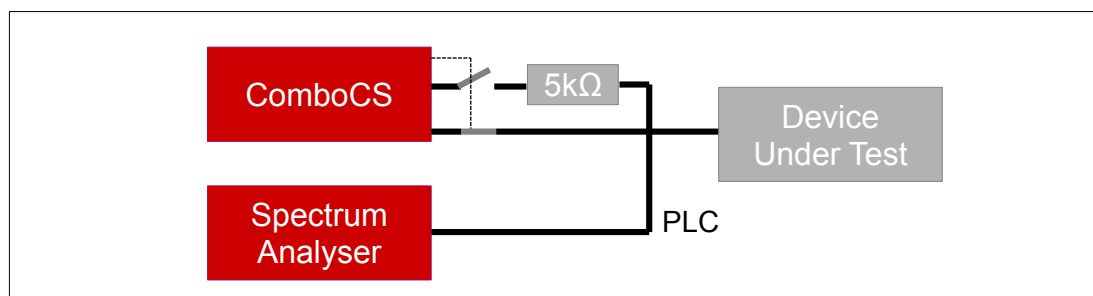
PSD measurement add-on basic setup

The ComboCS4M also provides a generic communication interface over HTTP to:

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

If the EVSE is adapted to integrate this communication interface, the PSD measurement setup could be completely automated. Otherwize, it requires several manuel steps.

A custom development can also be discussed with the Trialog team and added into the ComboCS4M in order to adapt the setup to your specific needs.

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

VDV261 OPTION

This feature is an option available as a software update.

With the VDV261 option, the EV will behaves like buses connecting to a VDV261 backend for preconditioning and monitoring. The backend is not provided with this option.
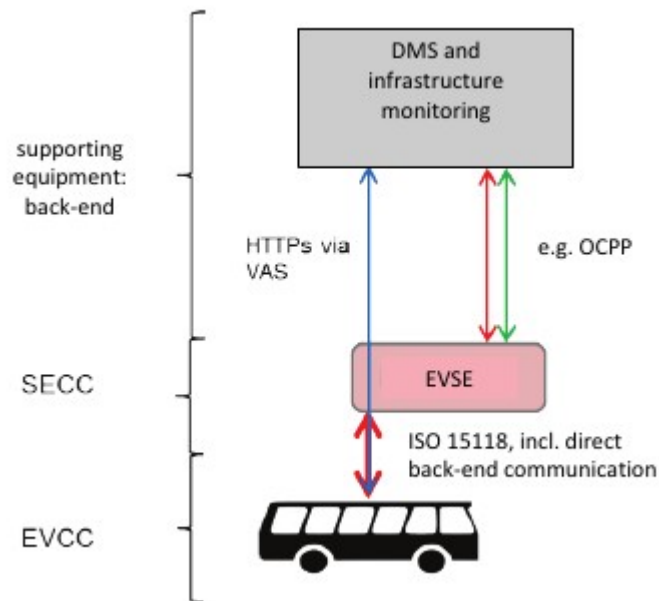

Figure 9: VDV261 typical flow

- The EV ComboCS4M can be configured to select VDV261 Value-Added-Service when proposed by the EVSE
- Once selected, the EV ComboCS4M will connect to the provided VDV261 back-end
- VDV261 data are displayed in the Supervision view of the EV ComboCS4M

Additional accessories

Additional accessories are available.

	Additional Type 2 / BNC plug One is already provided with the tool.

	External 12V battery An external battery allows to use the ComboCS4M tool even when no AC high power source is available.

Additional support

TRAINING AND EXPERTISE

To accelerate your learning curve of the tool and get sure your team is quickly up and running, Trialo can propose:

ComboCS Training	Half a day or one day of training about the ComboCS usage for CCS testing and PSD measurement. Training can be done on site or using a remote conference tool.
CCS Training	2 days of training to master the CCS ecosystem Typical summary of the training: **Worshop 1:** • Scope of ISO 15118 / DIN70121 • Role of Normative Working Groups • Actors and roles of electric mobility: EV, CS, CSO, eMSP, Aggregator, etc. • ISO 15118 Reference Use Case (ISO 15118-1) **Worshop 2:** • ISO 15118-2 Application Messaging + Cyber Concept • ISO 15118-3 PLC Concept **Worshop 3:** • What's new and what's different in ISO 15118-20 • ISO 15118-20 (V2G) Application Messaging • ISO 15118-20 Cybersecurity Aspects **Workshop 4:** • Implementation of ISO 15118: tools available on the market • Brainstorming

Expertise	Hours of support per email, phone or on-site regardings CSS standards, OCPP, charge systems, PLC calibration and support for test and validation. *Please notice Trialog is already providing a hotline with the ComboCS annual subscription for every questions your may have regarding the usage of the tool and potential issues. The purpose of this hotline is not to provide expertise.*

POWER TRANSFER SUPPORT

In order to perform power transfer using DIN ComboCS4M or ISO 15118 communication, you can connect your own power electronics to the ComboCS. The GPIO and HTTP API described in the User Manual of the ComboCS4M allow to connect most power setup to the ComboCS4M.

To accelerate and simplify the integration of the ComboCS4M into your power bench, depending of your needs, Trialog can:

- Provides hours of support
- Adapts the ComboCS4M software to fit your specifc solution
  - Ex 1: Connect the ComboCS4M to a specific power supply using LXI
  - Ex 2: Implement a dedicated CAN interface

Example of solutions for AC charging:

- Add several consumers to simulate different level of power transfer.
- Or use current loop on EVSE meter to simulate high power transfer with only a minimal real power transfer exchange.

Example of solutions for DC charging:

- Add several resistors to mimic different levels of power transfer.
- Control generative loads over CAN to test power transfer.

Annual Subscription

The ComboCS4M tool described in this document is ready to use. It has been tested and validated by the Trialog team, tested with several EVSEs in the field and during 3 Testing Symposiums and 3 CharIN Testivals and is currently used by more than 50 companies around the world.

The ComboCS4M is also still actively maintained by Trialog to fix eventual remaining bugs, test with new EVSEs, 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.

Access to releases

In order to provide such corrective and evolutive updates of the ComboCS4M, Trialog is proposing an annual subscription including:

- Access to corrective releases
- Access to evolutive releases

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

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.

Access to Trialog's hotline

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 ComboCS4M usage and report issues encounter with the ComboCS4M.

Please notice, a dedicated expertise budget is required in case you need training or support for OCPP, CCS and EV charge system expertise. Contact us for details.

Activation of the subscription on a yearly basis

The subscription is done on a yearly basis. The first year of the ComboCS4M 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.

This subscription is strongly recommended by Trialog but does not modify the licence rights that can be acquired from Trialog. Your company will be able to continue to fully use the ComboCS4M without this subscription. However, without subscription, your company will not get access to any release nor Trialog's ticketing system.

Contact us

*For more information about **ComboCS4M**, please contact us:* emobilitysales@trialog.com.

Do you know ComboCS?

Trialog has also developed a full-feature version of ComboCS4M dedicated to EVSE development and validation: the ComboCS version is embedding conformance and interoperability test cases, expert mode to reproduce exact EV behaviours and more advance features like the inspection mode.

Check below the differences between the 2 versions:

	ComboCS4M	ComboCS
Session History view List history of simulated charging sessions, logs and PCAP	✓	✓
Supervision view Real-time access to ISO 15118 and DIN 70121 communication data on the UI	✓	✓
Simulation mode Plug and start the ISO 15118 / DIN 70121 communication	✓	✓
Analogic output at charge startup Automaticaly connect your power bench	✓	✓
HTTP API Automate your own test cases Control the tool without any UI	✓	✓
PCAP per session Standard file format to access ISO 15118 and DIN 70121 communication data on Wireshark	✓	✓
Expert mode Complete control of the simulation Reproduce real car behaviors	Limited	✓
Test case mode ISO 15118-4 conformance + interoperability test cases		✓
Inspection mode Real-time access to ISO 15118 and DIN 70121 communication data on Wireshark		✓
SW upgrade to ComboCS option	Compatible	N/A
SW upgrade to ISO 15118-20 option	Compatible	Compatible
Sniffer option To be plugged between a car and a station Real-time access to ISO 15118 and DIN 70121 communication data on Wireshark	Compatible	Compatible
PSD measurement option	Compatible	Compatible

Custom development	Compatible	Compatible

ComboCS is the perfect tool for your technical team developing and validating an EVSE.

Interested? Please contact us!