MTE

Meter Test Equipment

E-Mobility Testing

Calibration of Electricity Meters applied in Electric Vehicle Supply Equipment (EVSE)

General

While climate change rose to the top of many governments' agendas and consumers attitudes have evolved, adoption of electric vehicles (EVs) is becoming a worldwide trend.

The combined annual sales of battery electric vehicles and plug-in hybrid electric vehicles tipped over the two-million-vehicle mark for the first time in 2019, while EVs staked their claim on a 2.5% share of all new car sales. US car manufacturer "Ford" announced that from 2030 they intend to sell only EVs in Europe while OEM "GM" goes even further supplying solely EVs by 2035.

The further development and implementation speed may vary between different regional markets while the long-term outlook for EVs remains strong triggered by factors such as consumer sentiment, policy and regulation, car manufacturers' strategy and the role of corporate companies.

It's expected that the global EV market grows by a CAGR of 29% over the next ten years: Total EV sales growing from 2.5 million in 2020 to 11.2 million in 2025, then reaching 31.1 million by 2030. By then EVs would secure approximately 32% of the total market share for new car sales.[1)]

The income from taxes on gasoline and diesel for road maintenance will decrease in future as the proportion of EVs increases. It is therefore likely that taxes will also be raised per kWh of electrical energy loaded to the EV. This will require the use of certified AC and DC electricity meters in Electric Vehicle Supply Equipment (EVSE), widely known as "charging stations", as this is for example already the case in Germany.

Therefore, the correct registration and billing of the charged electrical energy to the customer is becoming even more important while also a regular calibration of the EVSE on-site will be mandatory as this is the common case at fuel pumps.

[1)] Source: Deloitte Insights: Electric vehicles. Setting a course for 2030 (2020).

At typical fuel stations, the fuel volume displayed in gallons or liters undergoes regular calibration.

Likewise EVSE will require periodic calibration to ensure accurate measurement of the electrical energy in kWh charged into an EV battery.

Laws and regulations mandating such periodic calibrations or post-repair inspections to safeguard consumers and verify the accuracy of measurements.

Having a dense network of EVSE is one of the most important factors enabling the successful spread of EVs. While the availability of EVSEs is growing steadily, the reliability, efficiency and accuracy is often not yet addressed. Since the conformity with calibration law is also valid for EVSE, this must be checked periodically.

To maximize the opportunities presented by the growing demand for EVs and EVSEs infra-structure, utilities, meter manufacturers and meter service providers allover the world should examine the priorities they have and ask themselves key questions such as:

- How can we plan and build up an efficient and reliable EVSE infrastructure?
- What are the electricity meters being used in EVSE and how can we test its accuracy and correct registration?
- How can we make sure to provide a secure and reliable charging infrastructure while the consumer is being charged for the accurate amount of consumption?

Addressing such questions and challenges, MTE came up with different solutions along e-mobility testing for customers such as utilities, meter manufacturers, meter service providers or operators of EVSE.

(1) Calibration of built-in AC electricity meters or kWh energy measurement units on-site

For customers such as utilities, meter service providers or operators of EVSE, MTE developed different eMOB AC test adapters which enable single- or three-phase precision AC current and voltage measurement up to 32 A or 80 A and up to 300 V or 600 V (phase-neutral).

The eMOB AC test adapter is positioned between the EVSE AC and the EV. The reference meter measures voltage and current at the customer's transfer point, accounting for losses due to voltage drop between the internal measurement system and this point (either the plug of the tethered charging cable or the EVSE outlet).

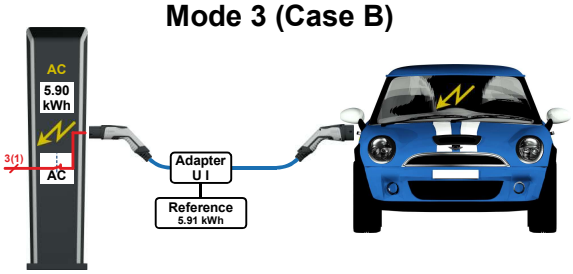
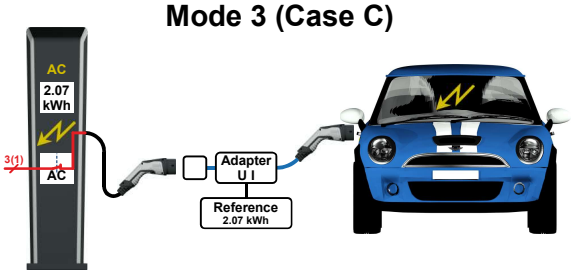
Such an eMOB AC test adapter for current and voltage in combination with one of our Portable Working Standards such as the PWS 2.3 genX, the PWS 3.3 genX or the CheckMeter 2.3 genX, is the right tool to perform a calibration of any 1- or 3-phase EVSE for slow charging with Alternating Current (AC) in accuracy class 0.1.

eMOB AC adapter types

(A) eMOB I-32.3 AC-Type 2

Advantages

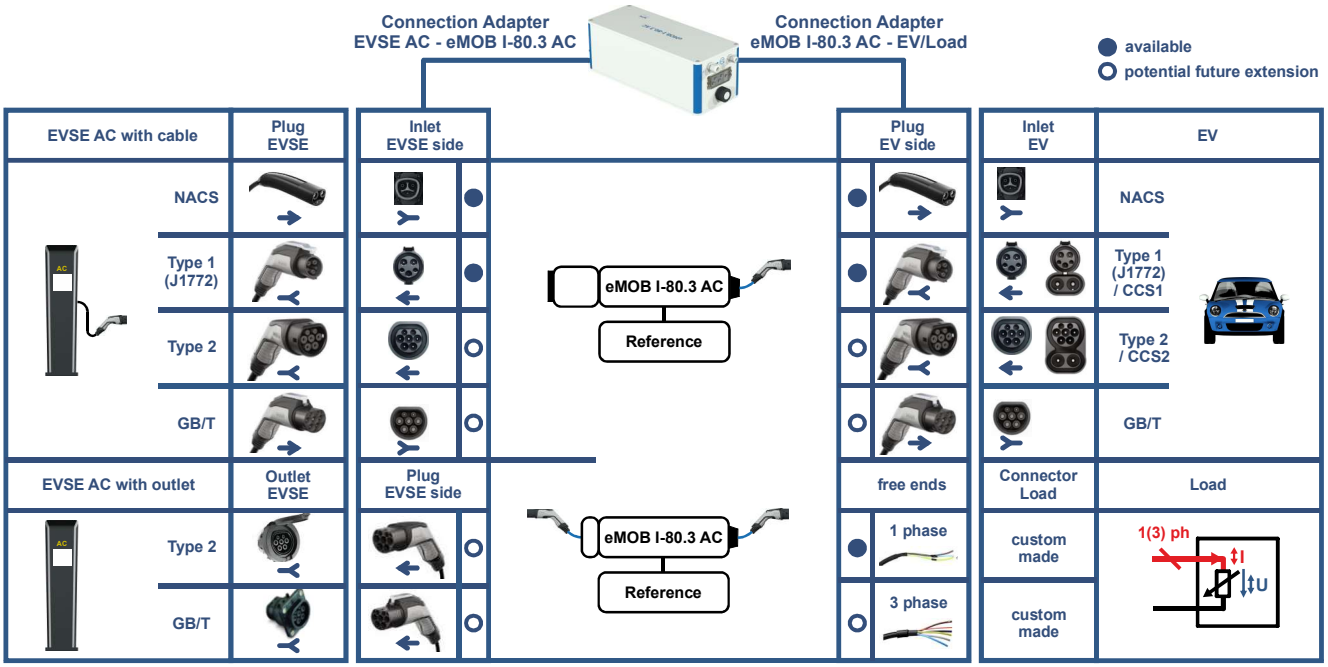
- Portable working standard accuracy class 0.1.
- Easy and fast connection between EVSE and EV.
- Operation with rechargeable battery (option) connected to 12 VDC input, if auxiliary supply connection is missing.
- Charging current three-phase up to 32 A (up to 22 kW power).

eMOB I-32.3 AC-Outlet Type 2	EVSE AC with Outlet
	Mode 3 (Case B) 
eMOB I-32.3 AC-Cable Type 2	**EVSE AC with Cable**
	Mode 3 (Case C) 

(B) eMOB I-80.3 AC-Modular

Advantages

- Complete modular EVSE AC Test System class 0.1 in combination with different kind of MTE's Portable Working Standards.
- Charging current 1(3) phase up to 80 A (power up to 19.2 kW (57.6 kW) at 240 V).
- User-friendly operation through a color touch-screen display with an intuitive graphical interface.
- Easy and fast connection between EVSE AC and EV with locking of the charging cable.
- Parallel recording of charging profile (trend graph of voltage, current and power).
- Interchangeable connection adapters enable global use and seamless switching between connectors (e.g. EVSE with Type 1(J1772) can be tested with EV with NACS and vice versa).
- Connection adapter with cable with free ends in combination with built-in EV simulation allows the connection of a fix or adjustable 1(3) phase AC test load instead of an EV.



Application example – PWS 2.3 genX + eMOB I-32.3 AC – Outlet Type 2

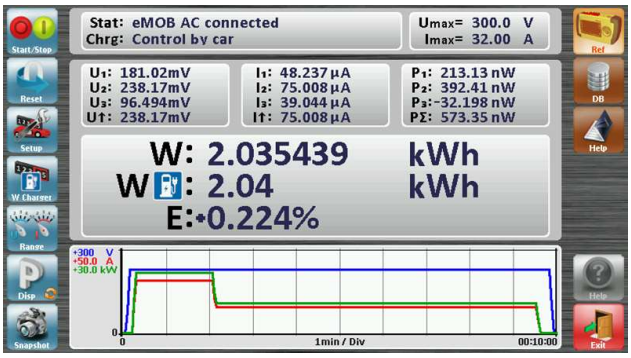
The adapter is used to test the energy measurement accuracy of the EVSE by comparison of the energy measured by the built-in AC electricity meter with the energy measured by the Portable Working Standard PWS 2.3 genX with an eMOB I-32.3 AC test adapter at the output of the charging station.

The eMOB I-32.3 AC test adapter is first connected to the PWS 2.3 genX and then connected to the EVSE and the EV or disipative load (e.g. fan heaters).

This can be done by a so-called register test or error measurement as shown in the example below.

Register test

First a charging process at the EVSE is initialized but not started yet. Then the eMOB AC energy register test is prepared and the energy measurement is started at the PWS 2.3 genX. Now the charging of the EV at the EVSE is started and the amount of charged energy is observed and should reach at least 200 units of the last indicated digit before the charging is stopped at the EVSE. The energy measurement is then stopped at the PWS 2.3 genX and the charged energy is entered and the error of the EVSE kWh energy measurement unit compared to the PWS 2.3 genX + eMOB I-32.3 AC adapter is calculated and indicated.



Parallel to the register test a trend graph of voltage, current and power is recorded showing the charging profile during the test.

Error measurement

If the EVSE has a built-in AC electricity meter equipped with a test output, which generates LED pulses or electrical pulses proportional to the power, an error measurement can be performed as shown in the example. The charging of the EV must be started at the EVSE and running during the whole test.

One pulse represents a defined energy quantity, e.g. 1 Wh. In the example shown this test LED of the AC electricity meter is visible through a window in the charging station.

A scanning head connected to the PWS 2.3 genX is mounted over this window and adjusted to detect the LED pulses, which then are counted by the PWS 2.3 genX.

The energy registered by the AC electricity meter, based on the counted LED pulses, is later compared with the reference energy measured by the PWS 2.3 genX + eMOB I-32.3 AC test adapter and the error of the energy measurement of the EVSE is calculated and indicated.

With our universal test software CALegration, running on a tablet or portable PC, EVSE test results saved on the SD card of the Portable Working Standard can be readout and a test report can be generated. An EVSE AC or EVSE DC register test can also be performed directly in CALegration with remote control of the Portable Working Standard + eMOB adapter.

(2) Calibration of built-in DC electricity meters or kWh energy measurement units on-site

In general, the principle and application are the same as applied at AC electricity meters. For this set-up, MTE developed different **eMOB DC** test adapters.

(A) eMOB I-200.1 DC-CCS2

This eMOB DC test adapter with CCS2 inlet (IEC 62196-3) and DC charging cable with CCS2 plug can in combination with a reference standard, such as the new PWS 3.3 genX, measure single-phase DC voltage up to 1000 V, DC current up to 200 A and resulting DC power/energy.

Advantages

- Portable working standard accuracy class 0.05
- Easy and fast connection between EVSE and EV
- Battery operation (option), if auxiliary supply connection is missing
- Field testing of EVSE up to 1000 VDC | 200 ADC (up to 200 kW power)
- User-friendly functions such as integrated operation manual
- Large 9" touch screen color display and web server for remote display of graphical user interface and remote control of the unit.

(B) eMOB I-500.1 AC/DC (under development)

Combi test adapter to calibrate EVSE DC up to 500 A and 1-phase EVSE AC – NACS/Type 1 (J1772) up to 80 A.

eMOB I-500.1 AC/DC-NACS/CCS1
NACS or CCS1 selectable with slider

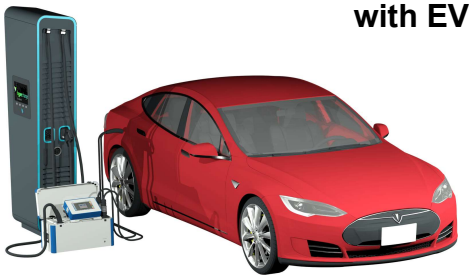
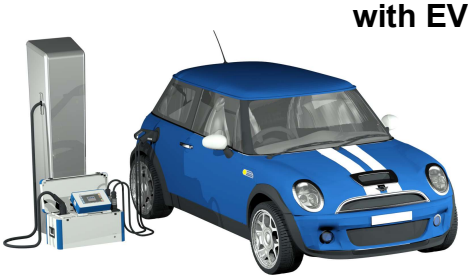
Advantages

- Universal EVSE Test System class 0.1 in combination with the Portable Working Standard PWS 3.3 genX.
- DC charging current up to 500 A (power up to 500 kW at 1000 V).
- AC charging current up to 80 A (19.2 kW at 240 V), with NACS or CCS1/Type 1(J1772) version only.
- User-friendly operation through a color touch-screen display with an intuitive graphical interface.
- Parallel recording of charging profile (trend graph of voltage, current and power).

eMOB I-500.1 DC-CCS2

- Verification of the charged energy error against the energy measured by the reference (register test) and/or error measurement using a scanning head, if the EVSE AC features an optical or electrical pulse output proportional to power.
- Interchangeable charging cables at the output enable the change between connectors (e.g. EVSE with CCS1 can be tested with EV with NACS and vice versa) and the connection of a load.

Test of EVSE DC and EVSE AC with EV or dissipative load with the same test adapter

Test of EVSE DC-NACS		Test of EVSE AC-Type 1
with EV	with Load	with EV
		

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(3) Calibration of kWh accuracy of entire EVSE DC on-site with simulated load

Portable Test System for EVSE DC kWh accuracy test at defined load points with Phantom Load up to 600 kW (1000 V, 600 A).

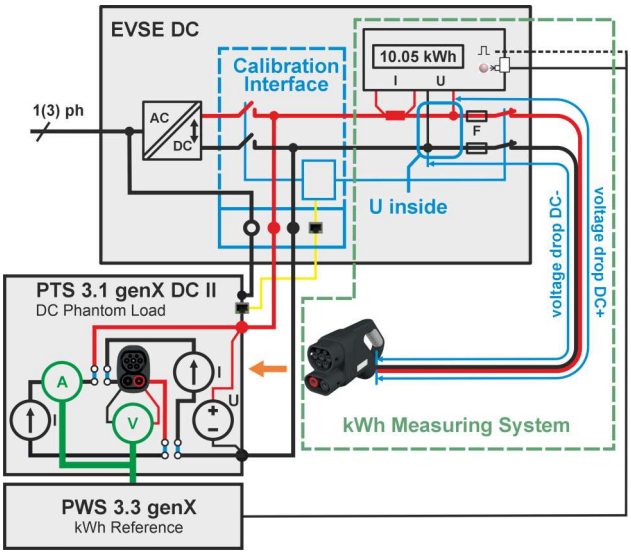
(A) PTS 3.1 genX DC I (under development)

Advantages

- Universal EVSE DC Test System class 0.04 in combination with the Portable Working Standard PWS 3.3 genX with DC Phantom Load Power Source for test of DC charging stations on-site at defined load points up to 600 kW (600 A, 1000 V).
- More compact, lighter, and more cost-effective than a dissipative or regenerative load of equivalent power.
- Allows test of bidirectional energy flow (EVSE to EV and EV to EVSE (V2G Vehicle to Grid)).
- Compatible with various connector types (example shown with CCS2 connector).
- Version available with two current sources for simulation of voltage drop on DC+ and DC- path between built-in measurement system and end of charging cable (PTS 3.1 genX DC II).

(B) PTS 3.1 genX DC II (under development)

DC Phantom Load with two current sources and one voltage source



The PTS 3.1 genX DC can simulate any positive or negative flowing DC power by injecting DC voltage between DC+ and DC- path (0 … 1000 V) and DC current in the path with the current measurement element (0 … 600 A) separately into the EVSE DC. In this way up to 600 kW can be simulated with a few kW.

To apply this so-called phantom load test principle, the EVSE DC must be equipped with a calibration interface allowing this.

The reference PWS 3.3 genX measures the DC current (A) in parallel. The charging cable of the EVSE DC is plugged into the EV inlet of the PTS 3.1 genX DC, where the DC voltage is measured (V) at the transfer point of the energy to the customer.

This allows to perform energy register tests or error measurements by comparing the simulated charged energy measured by the EVSE DC kWh measurement unit with the energy measured by the reference at defined load points in an automatic sequence.

If the voltage measurement of the kWh measurement unit is inside as shown here, the voltage drops between this point and the end of the charging cable on DC+ and DC- must be regarded.

Because the current is injected only on one path (DC+) with the phantom load principle, a second galvanically separated DC current source is needed to simulate the same voltage drop on the other path (DC-) to simulate the situation at real operation.

If the EVSE DC is equipped with 4 wire voltage measurement at the end of the charging cable, this voltage drop simulation is not necessary and a simpler version with one current source and one voltage source can be applied, the **PTS 3.1 genX DC I.**

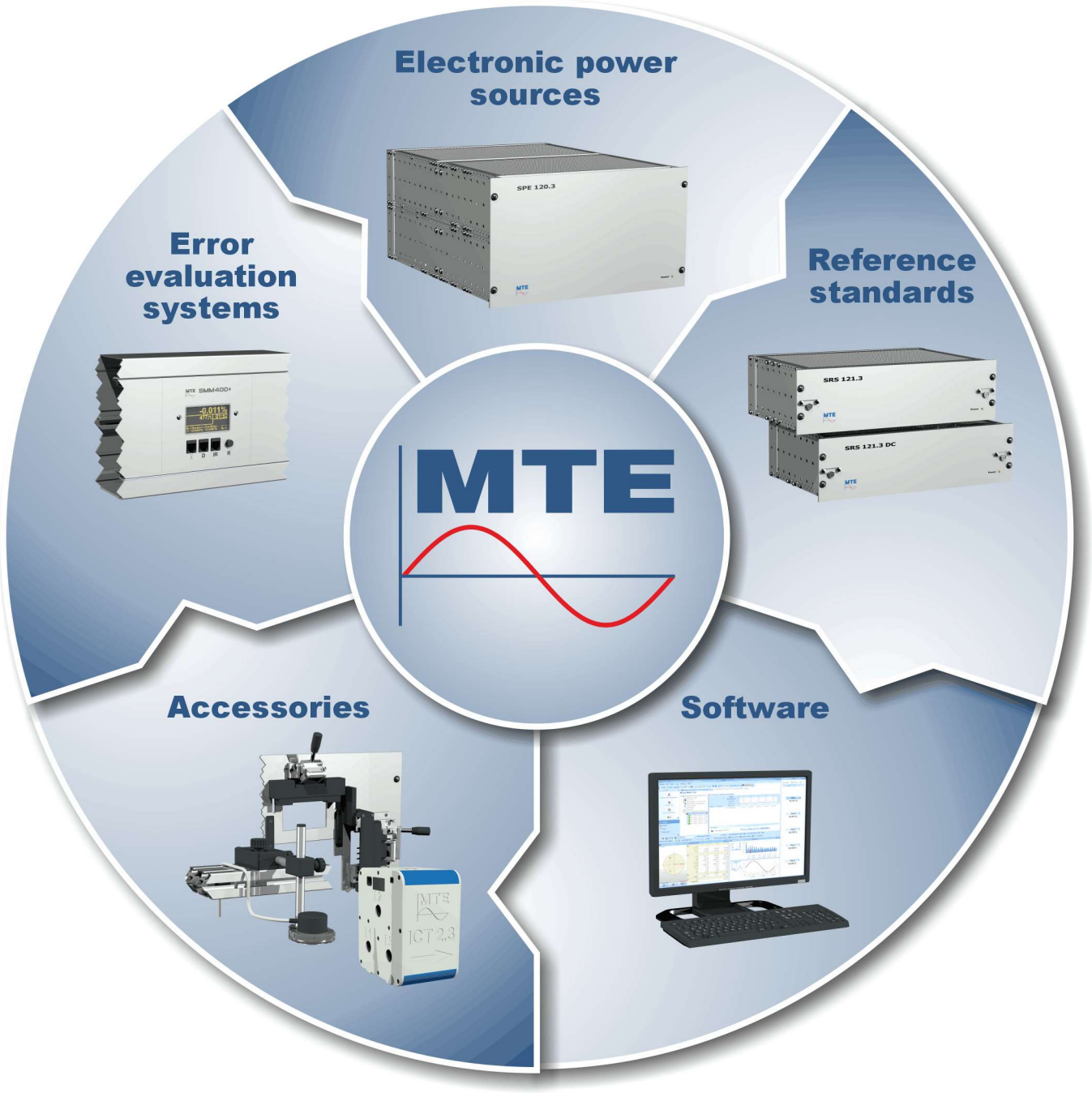
Calibration of AC and DC electricity meters in the laboratory

MTE has a broad experience in the field of testing different electricity meters and hundreds of customized high precision meter test systems to its credit.

Based on its comprehensive product range and the modular system components MTE may cover all kind of standard requirements from the metering industry as well as upcoming adaptations in the course of EVSE and its components or specific AC and DC electricity meters.

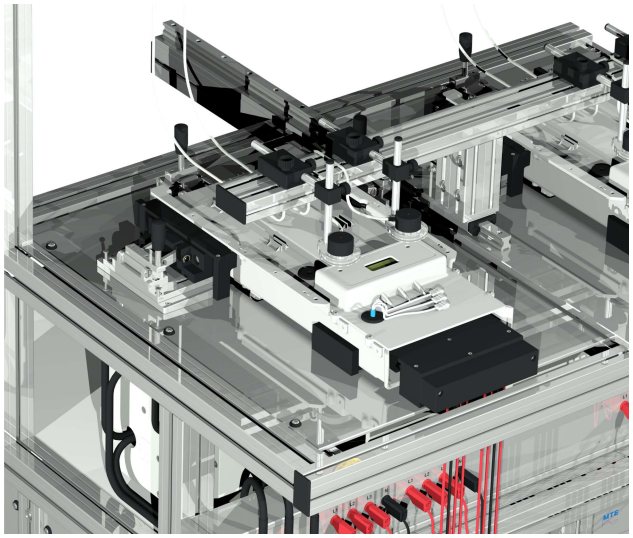
The modular approach provides flexibility and enables MTE to select the optimal customer orientated solution for each single- or three-phase meter test system the customer requires to meet the changing needs in the metering world. It's the customer who chooses the degree of automation, the integration of various test modules and steps or the number of measuring positions and throughput of meters.

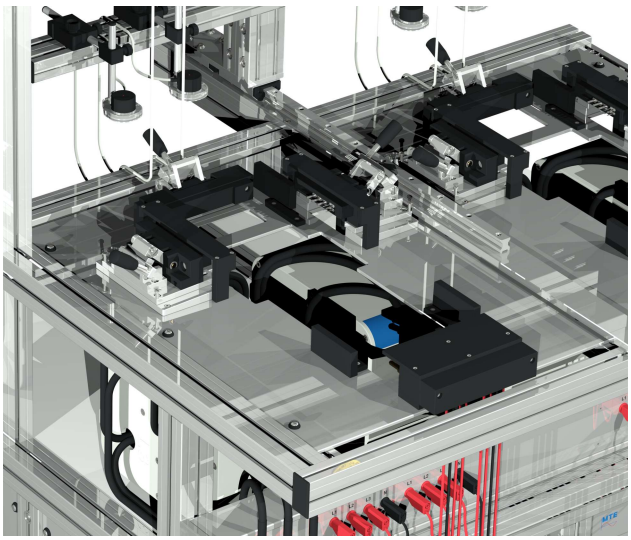
All key components of a test system are coming from the same and MTE's own single source.



Calibration of EVSA AC kWh energy measurement units in the laboratory

- Voltage range: 30 V … 300 V phase-neutral (optional: 480 V, 600 V)
- Current range: 1 mA … 120 A (optional: 200 A)



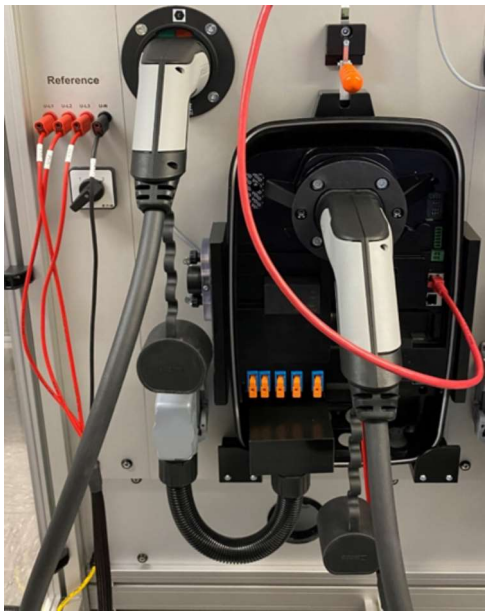


Calibration of entire EVSE AC in the laboratory

Final calibration of EVSE AC in fabrication at 1 up to N measurement positions. The EVSE AC of type wall box is mounted on a special connection adapter and the charging cable is plugged into an integrated EV inlet with EV simulation.

Test System for 1 to 5 entire AC wall boxes with cable Type 2

Test System for 1 to 10 entire AC wall boxes with outlet Type 2

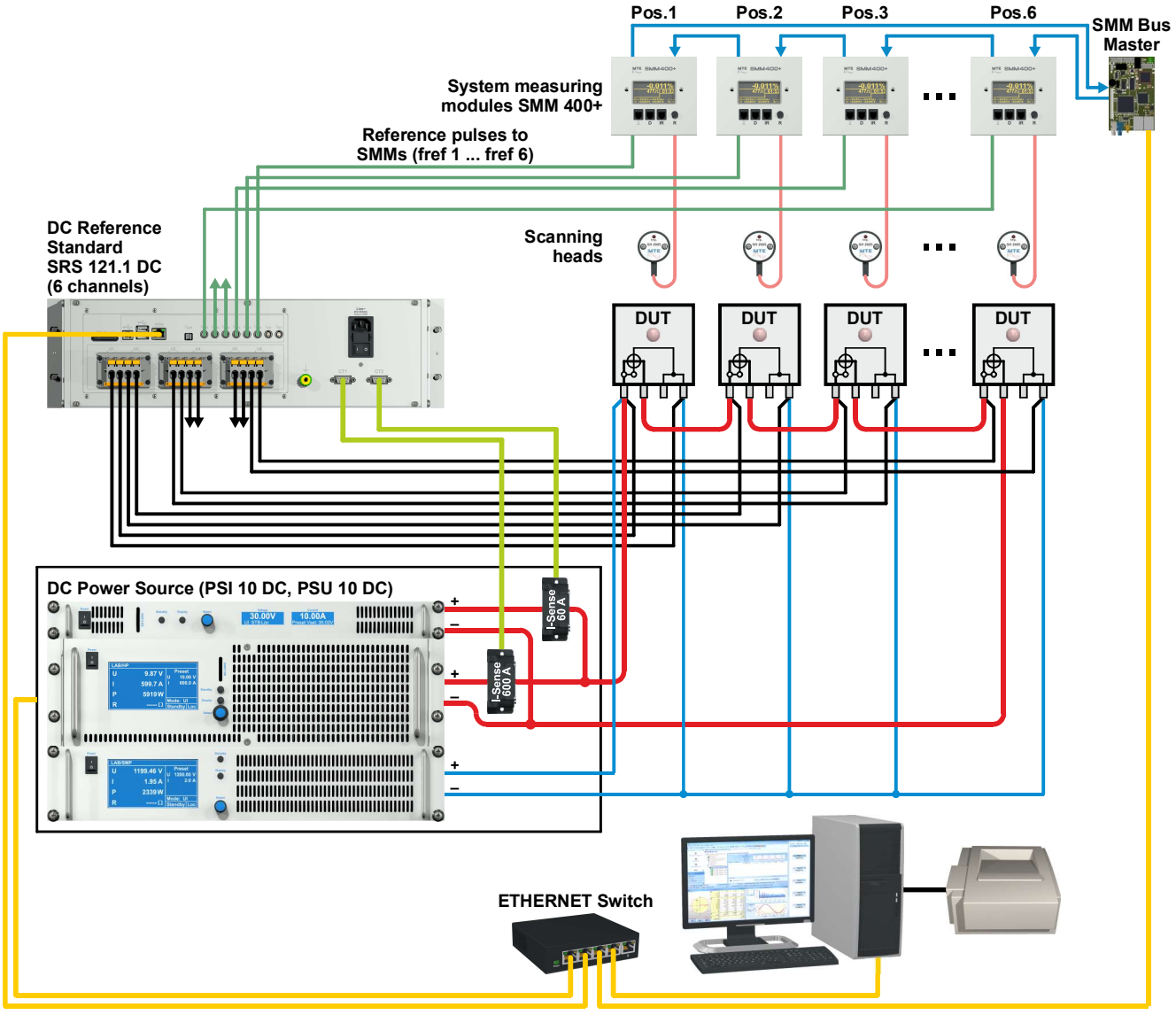


1 to 6 Position Test System for DC Electricity Meters or DC Energy Measuring Units of EVSEs with U and I path connected

- Voltage range: 100 V … 1000 V
- Current range: 5 A … 600 A
- DC reference standard class 0.04 (6 channels)

If 2 or more DC electricity meters with closed link (voltage and current path connected) are tested and the test voltage is connected to the current at position 1, the following positions will see a lower test voltage, reduced by the voltage drop on the current path between the meters, which varies with the current amplitude.

To overcome this problem with variable test voltages influencing the accuracy of the calibration, a DC reference standard with 6 U channels is used to measure the exact test voltage at 1 up to 6 test positions individually. Together with the common current sensors these leads to 6 DC power reference channels with 6 pulse outputs fref 1 … fref 6 connected to 1 up to 6 error evaluation modules SMM 400+. These are used for error measurements, if the DUTs are equipped with optical or electrical pulse outputs. Should no pulse outputs be available, register tests can be performed individual for each position.



DC Meter Calibration System

The DC Meter Calibration System is designed to test single-phase DC electricity meters with open and closed I-P links. It is fully electronic, using only solid state electronic components and is controlled by a PC via the integrated ethernet interfaces.

The system is equipped with following components:

- DC Power source with one DC voltage amplifer and two DC current amplifiers
- DC reference standard SRS 121.1 DC
- Control unit STE 10

DC Power Source

Fully static single-phase DC sources for the generation of voltage and current for the meters under test. The power sources works independently from the supply network.

DC Voltage amplifier

- Voltage range: 0 ... 1200 VDC | 2400 W
- Accuracy: ≤± 0.2 %
- Stability: ≤± 0.05 %

DC Current amplifiers

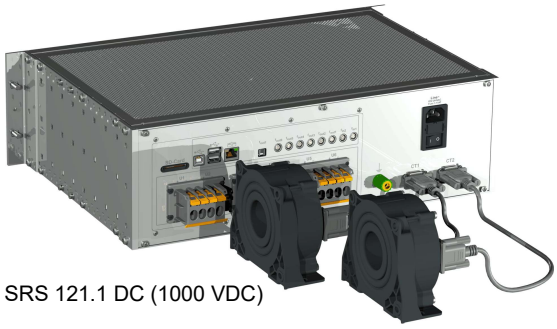
- Current range: 0 ... 80 ADC | 1200 W
  0 ... 600 ADC | 10000 W
- Accuracy: ≤± 0.2 %
- Stability: ≤± 0.05 %

DC Reference Standard

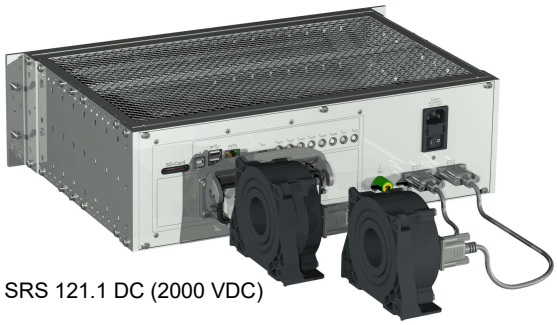
The SRS 121.1 DC is a 6-channel single-phase reference standard for DC power / energy class 0.04 for verification of 1 up to 6 DC Meters or DC Energy Measuring Units of EVSEs (Electric Vehicle Supply Equipment) at the same time.

- Voltage range: 0.5 ... 1000 VDC or
  0.5 ... 2000 VDC
- Current range: 0.1 ... 600 ADC
- Accuracy: ≤± 0.04 %

Extended ranges at DC power source and DC reference standard up to 1500 (2000) VDC and 1000 (1500) ADC can be realized on request.



SRS 121.1 DC (1000 VDC)



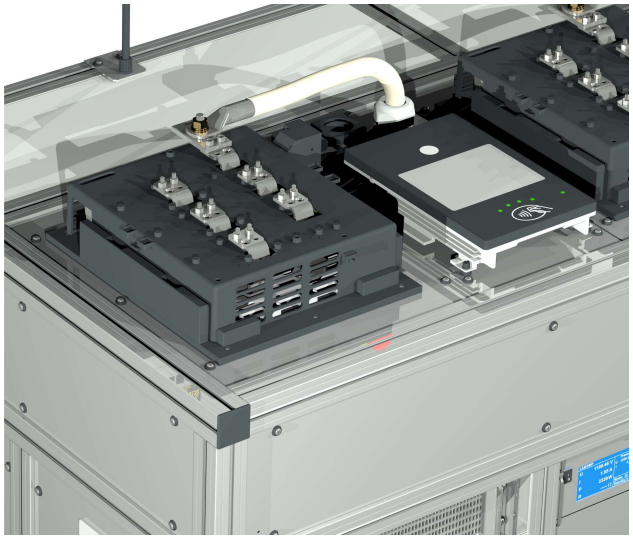
SRS 121.1 DC (2000 VDC)

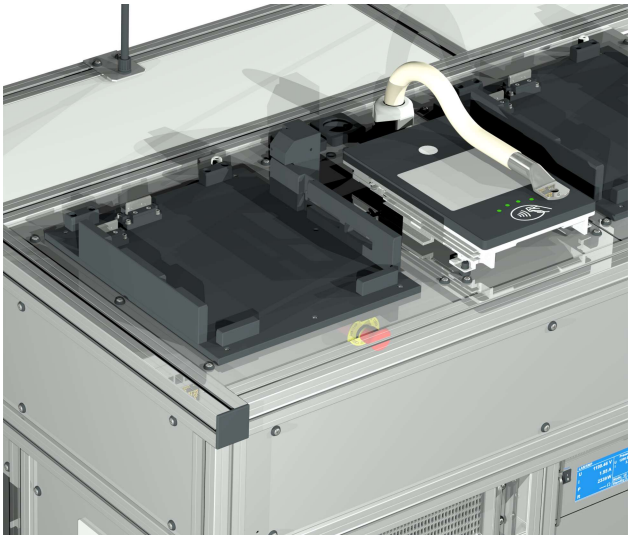
Calibration of DC electricity meters in the laboratory

Test bench for calibration of 5 single-phase DC electricity meters

DC reference standard and power source, single-phase:

- Voltage range: 100 V … 1000 V
- Current range: 5 A … 600 A





EMH Energie-Messtechnik GmbH holds the DAkkS accreditation for DC Power / Energy measurements

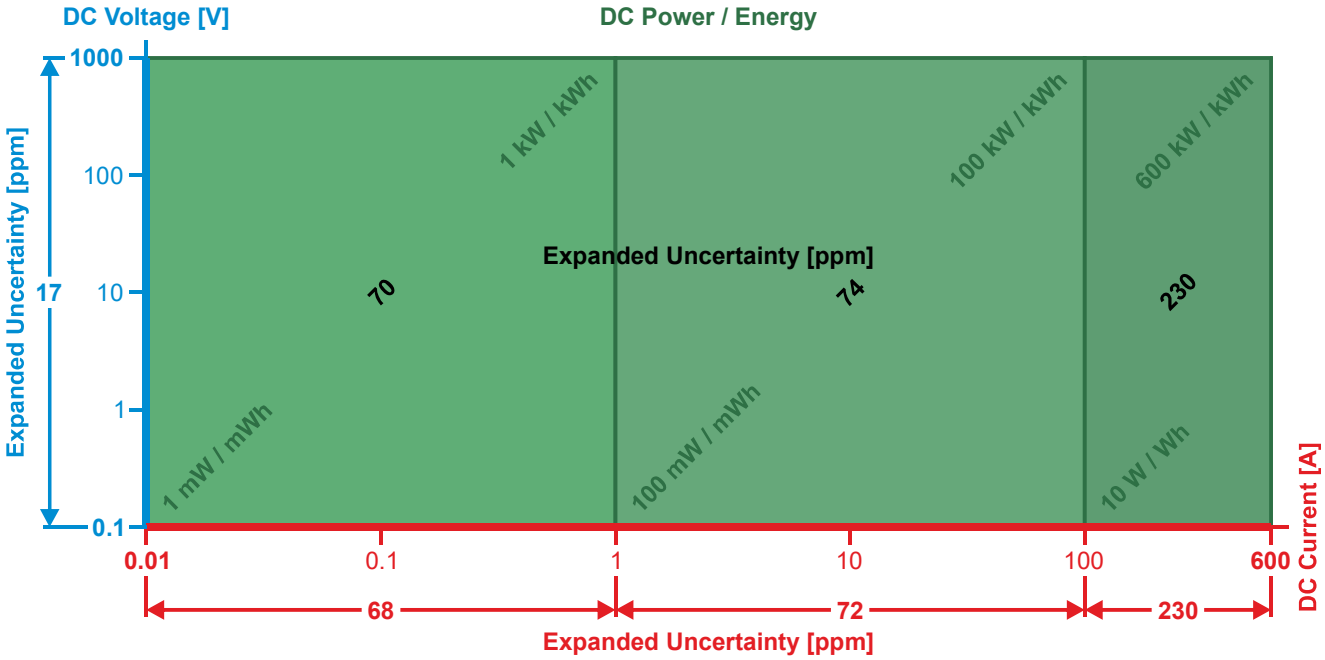
The EMH DAkkS Calibration Laboratory got as one of the first among the calibration laboratories in Germany the DAkkS Accreditation for DC Power / Energy measurements up to 600 kW / 600 kWh.

Scope of Accreditation

- DC Voltage: 100 mV ... 1000 V
- DC Current: 10 mA ... 600 A
- DC Power: 1 mW ... 600 kW
- DC Energy: 1 mWh ... 600 kWh

Thus, EMH's accreditation to ISO/IEC 17025 guarantees the consistent and high quality of calibration services for MTE Meter Test Equipment and its customers in the field of portable and stationary DC test systems.

EMH Energie-Messtechnik GmbH DAkkS ISO/IEC 17025 accreditation Calibration and Measurement Capabilities for DC Measurements [ppm]



Future extension of DC voltage range up to 1500 V and DC current range up to 800 A is planned.

The following MTE leaflets are available:

Overviews:	Company Portrait / Portable Test Equipment / Stationary Meter Test Systems Automatic Test Systems / Transformer Monitoring / E-Mobility Testing
Comparator:	K2008
Portable Reference Standards:	PRS 600.3
Portable Working Standards:	PWS 3.3 *genX* / PWS 2.3 *genX*
Portable Standards:	CheckMeter 2.3 *genX*
Portable Test Systems:	PTS 400.3 PLUS / PTS 3.3 *genX* / PTS 2.3 *genX* CheckSystem 2.3 / CheckSystem 2.1
Portable Power Sources:	PPS 400.3 / PPS 3.3 *genX* / CheckSource 2.3
Software:	CAL*egration*®

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Test it!