

New generation of

- measuring instruments
- calibration systems
- test labs

Compliant with

IEC 61850-9-2



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MARSENERGO
INSTRUMENTS FOR POWER INDUSTRY



Digital solutions for power industry

REFERENCE STANDARD FOR DIGITAL SUBSTATIONS

Energomonitor-61850

Accuracy class 0.02, 0.05

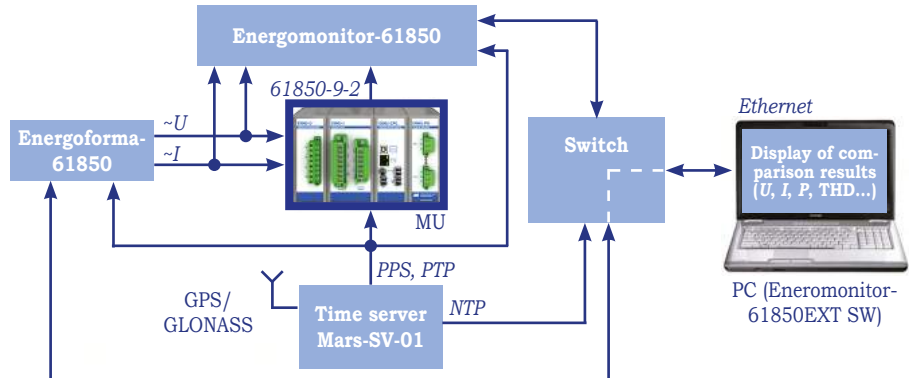
Functions

- ✓ Reference merging unit
- ✓ Comparator

Application

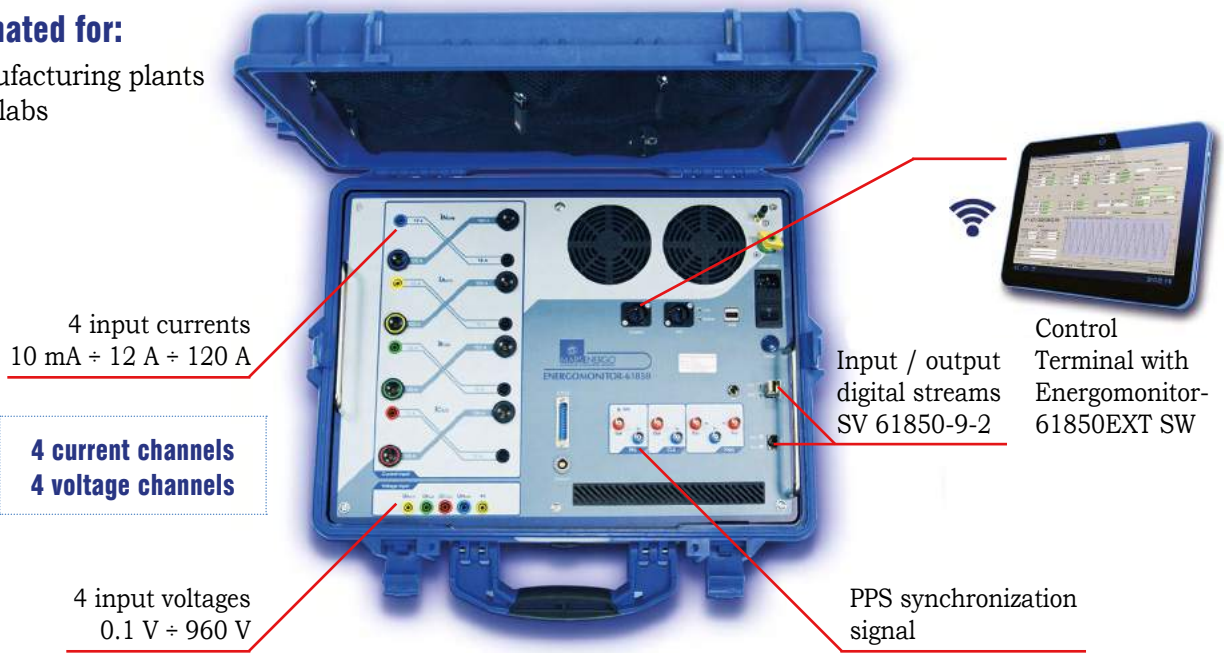
Accuracy testing of analog and digital instrument transformers (CTs and VTs), Merging Units (SAMU), and Phasor Measurement Units (PMU).

Diagram for testing merging unit



Designed for:

- ✓ Manufacturing plants
- ✓ Test labs



4 input currents
10 mA ÷ 12 A ÷ 120 A

4 current channels
4 voltage channels

4 input voltages
0.1 V ÷ 960 V

Input / output
digital streams
SV 61850-9-2

Control
Terminal with
Energomonitor-
61850EXT SW

PPS synchronization
signal

Accuracy specifications for basic parameters

Measured parameter	Measurement range	Intrinsic measurement error	
		Accuracy class 0.02	Accuracy class 0.05
AC voltage	0.1 to 960 V ($U_{NOM} = 1, 2, 5, 10, 30, 60, 120, 240, 480, 800$ V)	±0.01 %	±0.02 %
AC current	10 mA to 120 A ($I_{NOM} = 0.1; 0.25; 0.5; 1; 2.5; 5; 10; 25; 50; 100$ A)	±0.01 %	±0.02 %
Phase angle between the 1st voltage harmonics or between the first harmonics of voltage and current in the same phase	0° to 360°	Absolute: ±0.003° ±0.01°	
Apparent power	0.1 U_{NOM} to 1.2 U_{NOM} , V 0.1 I_{NOM} to 1.2 I_{NOM} , A	Relative: 0.02 % 0.04 %	
Active power		Relative: ±0.01 % ±0.05 %	
Reactive power		Relative: ±0.03 % ±0.1 %	
AC frequency		40 to 70 Hz	Absolute: ±0.0002 Hz ±0.001 Hz

REFERENCE STANDARD FOR DIGITAL SUBSTATIONS

Energomonitor-61850-M-2

Accuracy class 0.02, 0.05

Options

- 1 current phase
- 1 voltage phase

Benefits

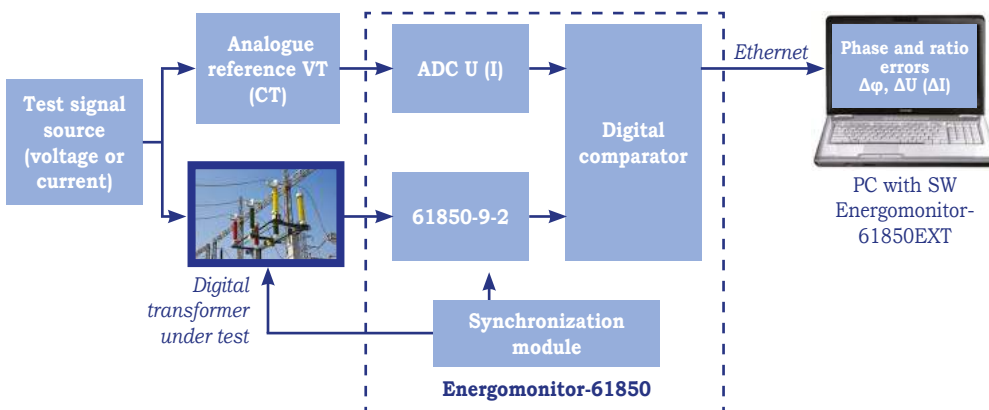
- ✓ Basically intended for accuracy testing of analogue and digital current and voltage transformers
- ✓ Ideal for use due to the compact design, light weight and minimal cost of ownership



Accuracy specifications as applied to testing of transformers

Error (absolute)	Analogue CTs and VTs	Digital CTs and VTs (IEC 61580)
Ratio	±0.002 %	±0.015 %
Phase	±0.1 min	±1 min

Test scheme for digital CTs and VTs (61850-9-2LE)



Status: In development

Energoforma-61850-100

Functions

1. Real-time mode

The instrument converts digital streams SV61850-9-2 into analogue current / voltage waveforms.

2. Stand-alone mode

The instrument digitally synthesizes output analogue signals from customer-specified parameters (with the possibility to download and add modulating signals to the generated waveforms)

Basic specifications

Parameter	Value
Number of channels	8 channels (4 currents and 4 voltages)
DAC resolution	18 bit
Number of points per period	4096
Data exchange rate	35 Mbit/s
Harmonics	1 to 100
Interharmonics	0.1 to 100.5 in increments 0.1

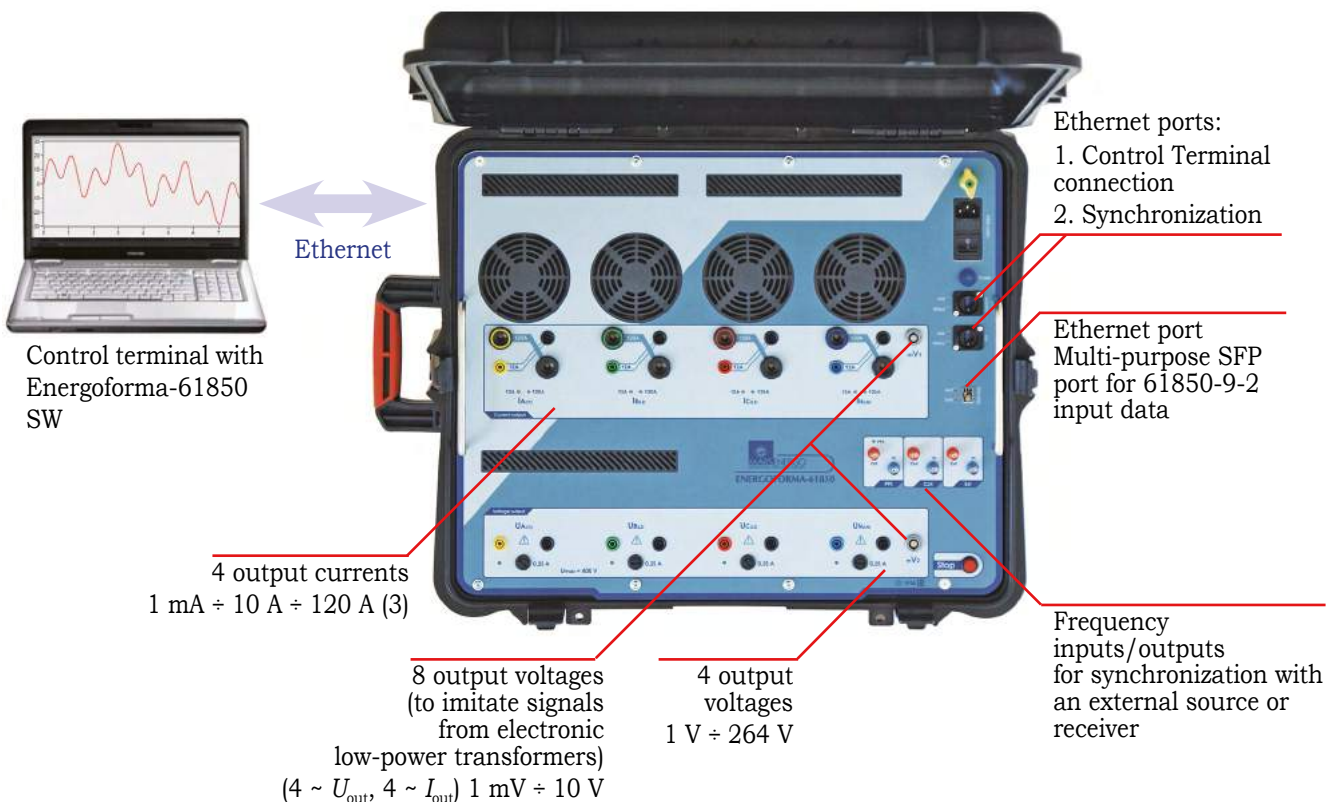
Benefits

Generation of synchronized current and voltage test signals for accuracy testing / calibration of:

- ✓ Merging Units (SAMU)
- ✓ Power quality analyzers
- ✓ Phasor Measurement Units (PMU)

Options

100 A × 3; 12 A × 4; 260 V × 4



Control terminal with Energoforma-61850 SW

4 output currents
1 mA ÷ 10 A ÷ 120 A (3)

8 output voltages
(to imitate signals
from electronic
low-power transformers)
(4 ~ U_{out} , 4 ~ I_{out}) 1 mV ÷ 10 V

4 output
voltages
1 V ÷ 264 V

Ethernet ports:
1. Control Terminal
connection
2. Synchronization

Ethernet port
Multi-purpose SFP
port for 61850-9-2
input data

Frequency
inputs/outputs
for synchronization
with an external source or
receiver

TEST SIGNAL / PHANTOM POWER SOURCE Energoforma-61850-12

Functions

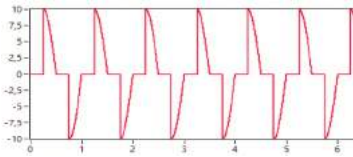
The EF-61850-12 generates current (4 phases) and voltage (4 phases) waveforms used to perform time-synchronized tests for measuring instruments in digital substations.

Options

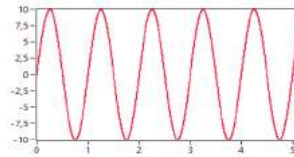
12 A × 4; 260 V × 4

Waveshapes

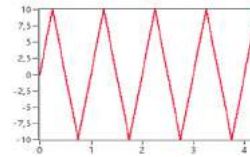
Phase control



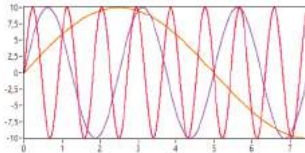
Sine



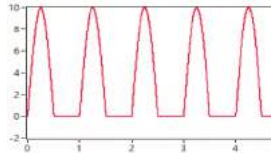
Triangle



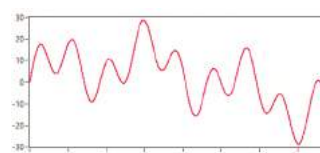
Oscillogram of harmonics



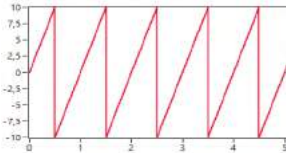
Rectified half-wave



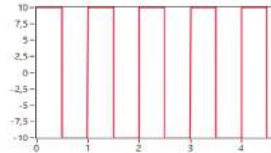
Combined waveform oscillogram



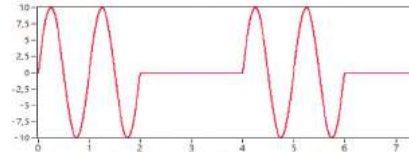
Ramp



Rectangular

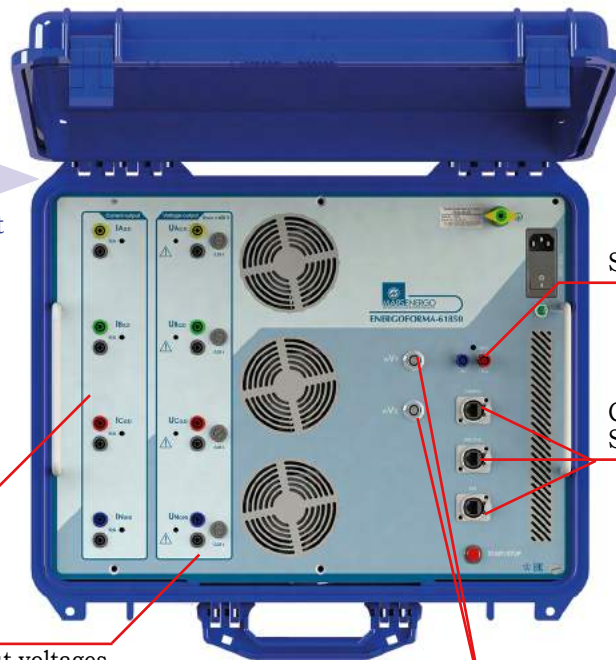


Subharmonics



Control Terminal with Energoforma-61850 SW

Ethernet



Synchronization (PPS)

Control Terminal (PC) SV 61850-9-2 input

4 output currents
1 mA ÷ 12A

4 output voltages
1 V ÷ 264 V

8 output voltages
for imitation of signals from
electronic low-power transformers
(4 ~ U_{out} , 4 ~ I_{out}) 1 mV ÷ 10 V

Status: In development

MULTIFUNCTIONAL PORTABLE
LOW-VOLTAGE REFERENCE SETUP

MarsTest-61850-P

Function

This is a new generation of portable reference setups which perform electrical power measurements and generate reference electrical signals.

Unlike typical reference setups, the MarsTest-61850-P supports calibration of both conventional and 61850-9-2LE-compliant measurement equipment.

Sphere of application

Accuracy testing and calibration of measurement channels in either conventional or digital substations.

Calibrator
of digital
data streams
MarsGen-61850

Software for control of the system:
Energomonitor-61850ext
and **Energoforma-61850**



Reference
meter
**Energomonitor-
61850**



Phantom
power and test
signal source
**Energoforma-
61850**



Time Server
Mars-SV-01

MULTIFUNCTIONAL LABORATORY REFERENCE SETUP

MarsTest-61850-S

Accuracy classes 0.02, 0.05

Function

Accuracy testing of electronic digital meters, conventional analogue meters, Merging Units (SAMU), Phasor Measurement Units (PMU) and power quality analyzers.

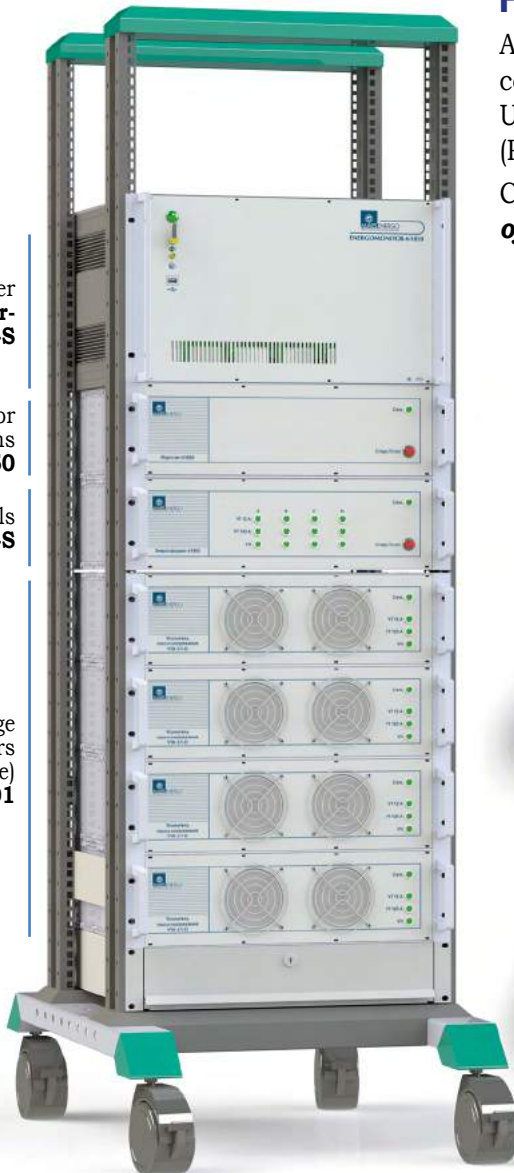
Can be applied as a **working standard of the first category.**

Reference meter
Energomonitor-61850-S

Calibrator of digital data streams
MarsGen-61850

Source of test signals
Energoforma-61850-S

Current and voltage amplifiers (single-phase)
CVA-01

**Basic specifications for Generator**

AC voltage	3 × 0.1 ... 528 V / 200 VA
AC current	3 × 1 mA ... 120 A / 200 VA
Angles	3 × 0 ... 360°
Frequency of the 1st harmonic	42 ... 70 Hz
Harmonic (interharmonic) numbers	1...100 (0.1...100.5)
Voltage dips and swells, flicker	IEC
DC voltage*	0 ... 300 V / 600 W
DC current*	0 ... 100 A / 600 W

* In the presence of DC amplifier unit.

Basic specifications for Reference standard

		0.02	0.05
Voltage	0.1÷960 V	±0.01 %	±0.02 %
Current (AC/DC)	1 mA÷120 A	±0.01 %	±0.02 %
Angles U-I, U-U	0÷360°	±0.01°	±0.03°
Active power		±0.015%	±0.05 %

CALIBRATOR OF DIGITAL DATA STREAMS MarsGen-61850

Accuracy class 0.05

Function

The instrument is intended for synthesis of IEC 61850-9-2 data streams which are directly applied to accuracy testing and calibration of the following measuring instruments with digital outputs:

- ✓ energy meters
- ✓ power quality meters.



Ethernet

Control Terminal with Energofirma-61850 software

Output connector for SV streams

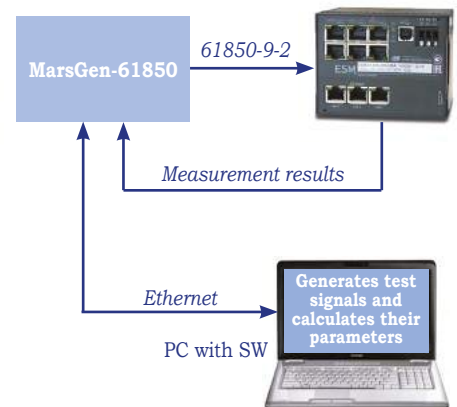
Ethernet port for PC control (generation of internal streams and control of external devices)

PTP synchronization

Frequency connectors for connection of external synchronization sources



Block diagram for testing digital energy meters



Setting accuracy of digital signals

Parameter	Range	Increments	Intrinsic error
Fundamental harmonic			
Fundamental frequency	40 ... 500 Hz	0.00001	±0.0003 %
Voltage	10 mV ... 15 MV	10 μV	±0.03 %
Current	1 mA ... 1.5 MA	1.0 μA	±0.03 %
Phase shift angle	-180° ... +180°	0.0001	0.03°
Active power	0,01 W ... 15 TW	—	±0.05 %
Power quality parameters			
Harmonic (interharmonic) order	0.1 ... 50	0.1	—
RMS of voltage or current (% of fundamental)	0 ... 50 %	0.0001	±0.01 %
Flicker	0.2 ... 10	—	±1.5 %
Duration of events	0.02 ... 600 s	—	0.005 s
Frequency	1 Hz	—	±2 · 10 ⁻⁶ Hz

TRAINING TEST BENCH FOR MAINTENANCE OF DIGITAL SUBSTATION EQUIPMENT

MarsDesk-DSS-M

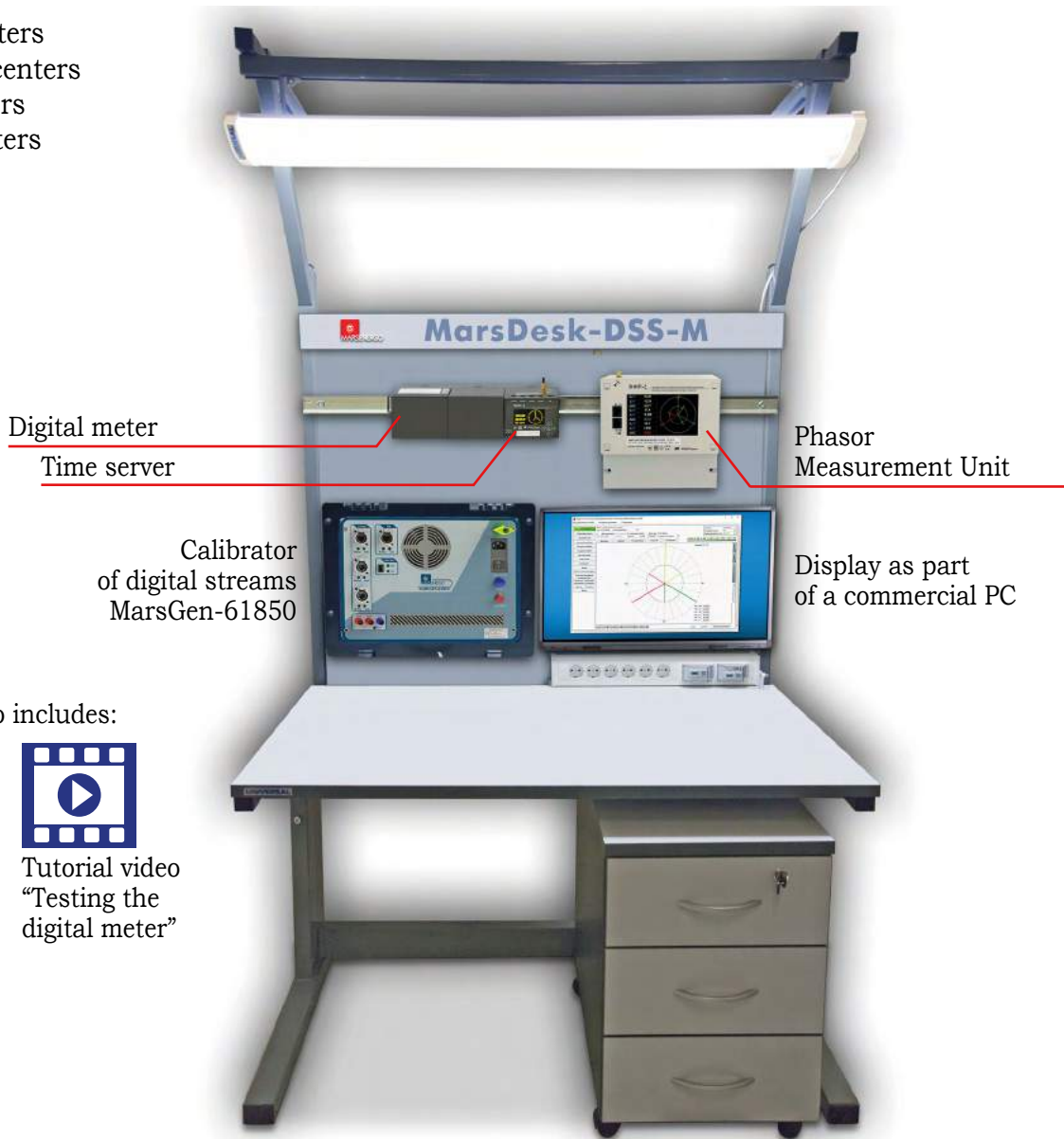
The MarsDesk-DSS-M is designed to train electricians to test/ calibrate measurement equipment in a digital substation: digital energy/PQP meters with IEC 61850-9-2 inputs, phasor measurement units etc.

The test bench provides a complete suite of means for testing measurement equipment in a digital substation with the calibrator MarsGen 61850.

It is used to train and skill up electricians so that they can meet the new digitalization requirements of energy sector.

Designated for:

- Training centers
- Science lab centers
- Manufacturers of digital meters



The package also includes:



MarsDesk SW



Tutorial video
"Testing the digital meter"

MULTI-PURPOSE TEST SYSTEM FOR CALIBRATION OF SMART METERS CONNECTED TO ELECTRONIC TRANSFORMERS WITH LOW-POWER ANALOGUE OUTPUTS

MTS-ME 3.1KM-E

Purpose and sphere of application

Accuracy testing and calibration of smart energy meters of accuracy class 0.2S (or less accurate) specified by IEC 60044-X standards.

Basic customers: manufacturers of smart meters, accredited metrological labs and certification bodies.

- 1 Error calculator
Calmar-S

- 2 SW **EnformMTS-E**



Software:

- Controls the waveform generator Energoforma 3.1KM-E and reference meter Energomonitor 3.1KM-E,
- Receives the results of measurement error calculation from the Calmar-S
- Creates test reports and maintains the database of meters.

- 3 Source of test signals
Energoforma-3.1KM-E

- 4 Voltage amplifier **VA-6.1**

- 5 Reference meter
Energomonitor-3.1KM-E

Benefits

- ✓ Measuring range: 1 mV ... 1000 V
- ✓ Suitable for use in avionic and marine applications (with a fundamental frequency of 400 Hz)

6 Devices (smart meters) under test



Accuracy classes: 0.02; 0.05

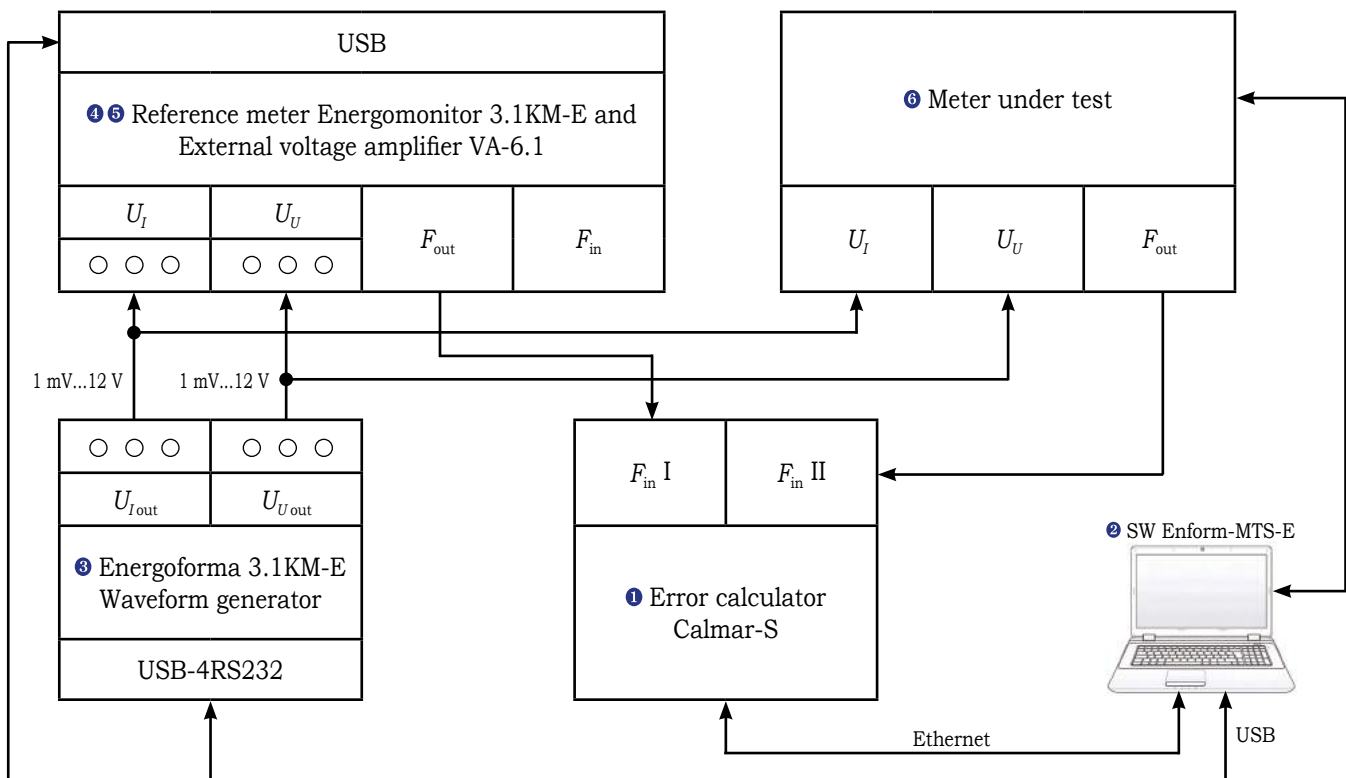
Range of signals from low-power electronic transformers: 6 channels (3 × I, 3 × U) from 1 mV to 10 V

Accuracy specifications of MTS-ME 3.1KM-E (with respect to testing of IEC 60044 devices)

Measured values	Measurement range	Measurement error	Notes
AC voltage (U_U)	1 mV ... 12 V	Relative, %, or less	$U_{U_{NOM}}$: 10 mV; 100 mV; 1 V; 10 V
		± 0.02	$U_{U_{NOM}} > 2 V$
		± 0.03	$U_{U_{NOM}} \leq 2 V$
AC current (I_I)	1 mV ... 12 V	Relative, %, or less	$U_{I_{NOM}}$: 1; 10; 100 mV; 1; 10 V
		± 0.02	$U_{I_{NOM}} > 2 V$
		± 0.03	$U_{I_{NOM}} \leq 2 V$
Active electrical power (P)	0.01 P_{NOM} to 1.44 P_{NOM}	Relative, %, or less	0.9 < cos ϕ < 1.0
		± 0.02	$U_{NOM} > 2 V$
		± 0.03	$U_{NOM} < 2 V$
Power factor ($PS=P/S$)	0.1 to 1.0	Absolute ± 0.001	
AC frequency (f_1)	40 to 70 Hz 400 Hz	Absolute, Hz ± 0.001	
Phase angle between the fundamental harmonics of input voltage and current in the same phase (φ_1), degrees	0 to 360	Absolute, degrees ± 0.01	

Output power of the generator Energoforma 3.1KM-E: at least VA per a channel.

Calibrating the smart meter (principle diagram)



REFERENCE COMPARATOR FOR ACCURACY TESTING / CALIBRATION OF ELECTRONIC LOW-POWER INSTRUMENT TRANSFORMERS OF VOLTAGE AND CURRENT (LPIT)

MarsComp K-1000

Benefits

- One and the same instrument performs two functions: accuracy testing/calibration of both voltage and current transformers.
- Conventional CTs (1 A, 5 A) and VTs (100 V, 100/ $\sqrt{3}$ V) can be used as reference transformers (together with the MarsComp).

Accuracy class 0.02



Accuracy specifications as applied to testing of electronic VTs or CTs

Error (absolute)	Limits of permissible error
Ratio (voltage, current), %	± 0.015
Phase, min	± 1.0
Composite, %	± 0.03

Accuracy specifications as applied to testing of conventional (analogue) VTs or CTs

Error (absolute)	Limits of permissible error
Ratio (voltage, current), %	± 0.002
Phase, min	± 0.1

Complex voltage / current LPITs under test

Primary currents
50 A ... 5 kA

Voltages
3 kV ... 35 kV

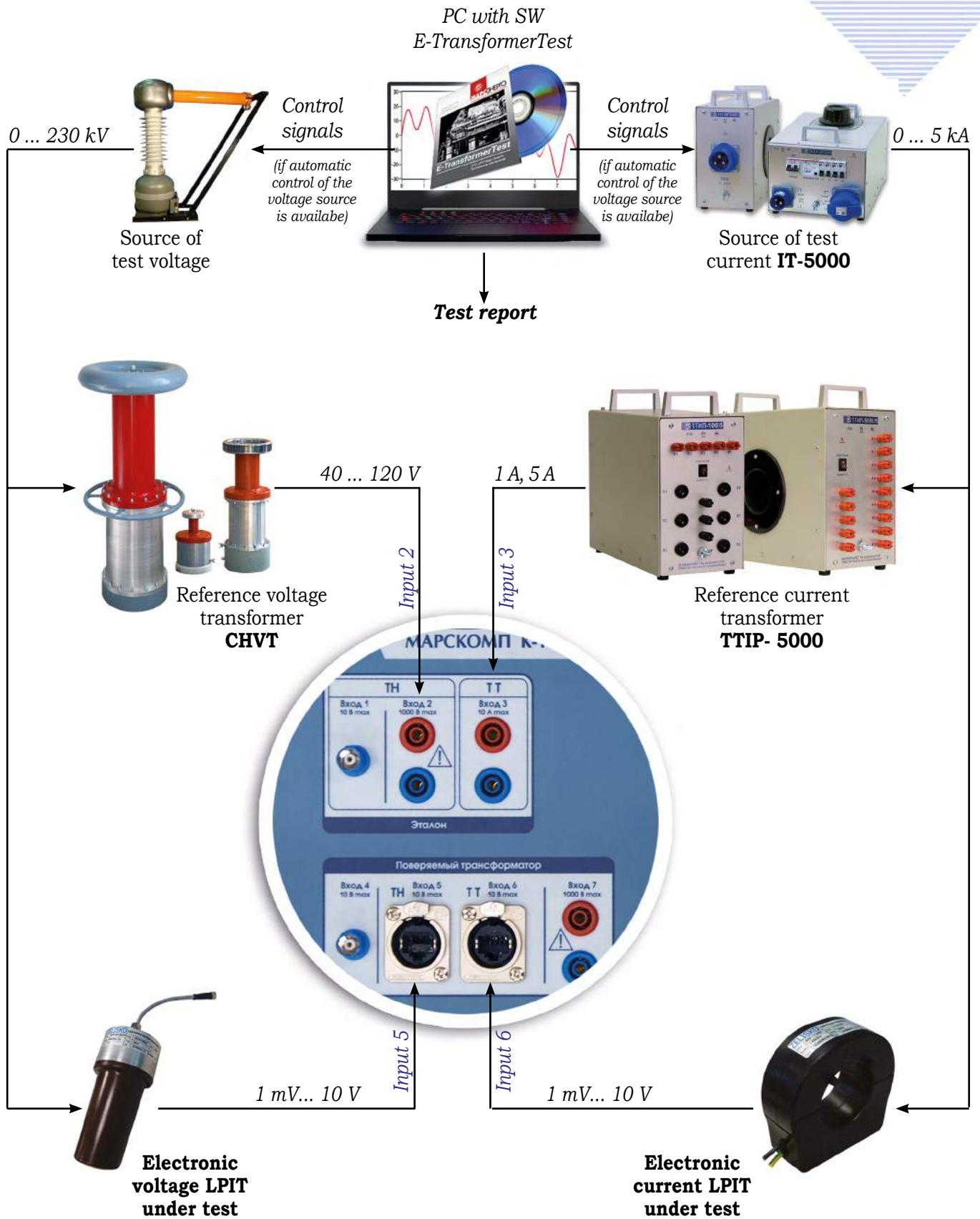
A →
B →
C →
N →



Secondary signals
1 mV ... 10 V

Testing electronic voltage LPIT

Testing electronic current LPIT



**AMPLITUDE / FREQUENCY RESPONSE MEASUREMENT SYSTEM FOR
CERTIFICATION OF INSTRUMENT VOLTAGE TRANSFORMERS**

MarsTest-VT-PQ

Purpose and sphere of application

The MarsTest-VT-PQ is a system that automates amplitude/frequency response certification tests of instrument voltage transformers (VTs) 6...220 kV. During these tests voltage harmonics of order from 0.3 to 50 (15 Hz to 2.5 kHz) are applied to the transformers, while the amplitude and phase angle (0 to 10°) measurements are performed upon them according to IEC/TR 61869-103.

The system covers the needs of VT manufacturers, certification labs, power distribution companies etc.

Purpose of the certification tests

To make a conclusion on the suitability of transformers under test for power quality measurements.

Components

1 Low-voltage measurement set

Components:

1.1 SW
MarsTest-VT-PQ

1.2 Reference instrument/comparator

1.3 Voltage amplifier

1.4 Waveform generator

PC



2 High-voltage source of special design

2.1 Step-up transformer

2.2 Broadband voltage transformer



2.3 Control unit

3 Reference VT

Capacitive voltage transducer

or

Voltage divider



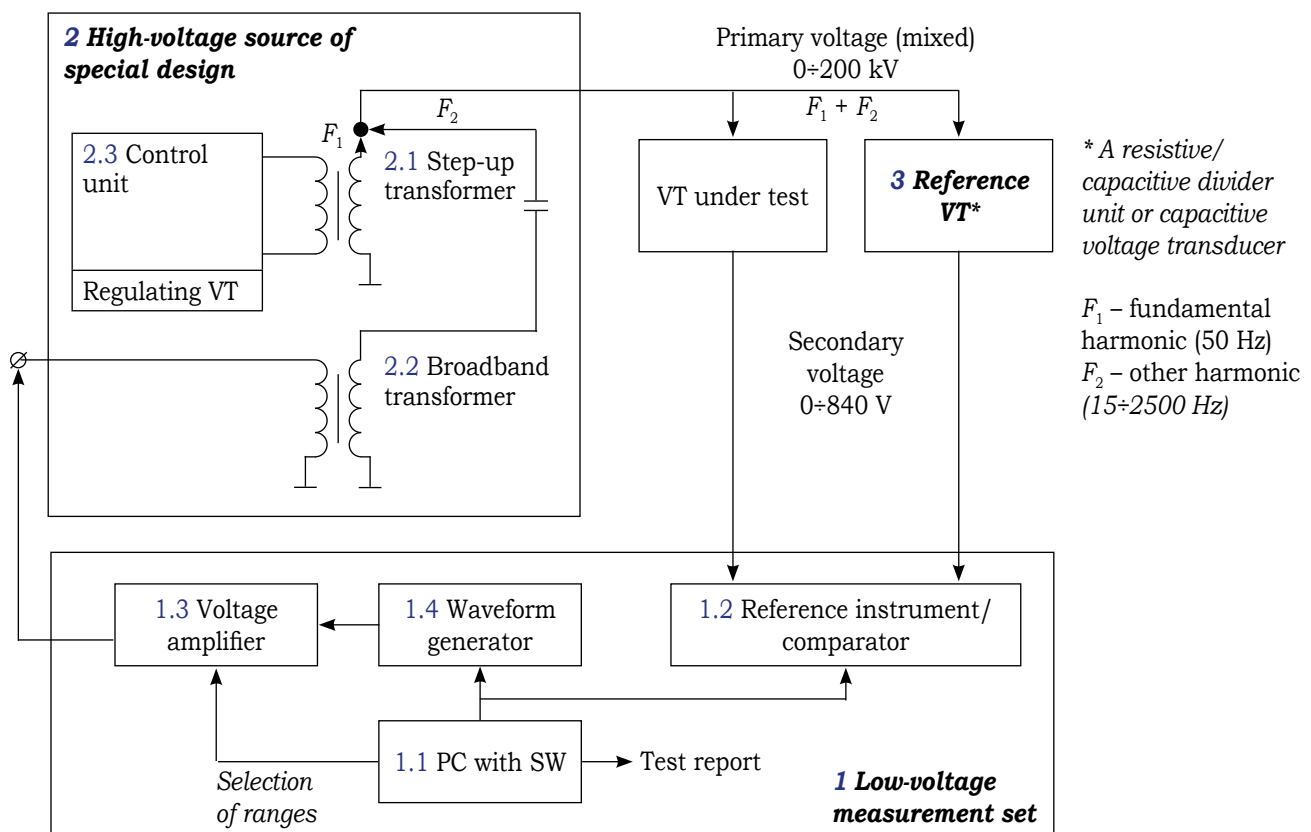
Accuracy specifications for the low-voltage measurement set

Measured parameter	Measurement range	Type and limits of permissible measurement error	Notes
1 RMS of voltage (at frequency f), V	$0.1U_{UL}$ to U_{UL}	Relative, % $\pm[0.05+0.02(U_{UL}/U-1)]$	Frequency of the 1st voltage harmonic $f=h \cdot 50$, where the harmonic order number h belongs to the intervals: - 0.2 to 0.9 in steps of 0.1 - 1 to 60 (inclusive) in steps of 1
2 Frequency of AC voltage f , Hz	15 to 2500 Hz	Relative, % ± 0.02	$0.1U_{UL} < U < U_{UL}$
3 RMS of the odd and even voltage harmonic components of order h , where $h = 0.3$ to 50 (15 Hz to 2.5 kHz), V	$0.1U_{UL}$ to U_{UL}	Relative, % $\pm[0.05+0.02(U_{UL}/U-1)]$	Frequency of the 1st voltage harmonic f : 45 to 55 Hz
4 Phase angle between the voltage waveforms of frequency f across two channels	0 to 10°	Absolute, 1 min Absolute, 10 min	0 to 60 min 1 to 90°
5 Phase angle between the voltage harmonic components across two channels (φ_h), min	0 to 60	Absolute, 10 мин	$h = 0.3 \dots 50$ at a rated fundamental voltage of 50 Hz

U_{UL} – the upper limit of voltage measurement range: 0.84; 1.68; 4.2; 8.4; 84; 168; 420; 840 V

U – the voltage reading

Test scheme



HIGH-VOLTAGE MOBILE TEST LAB ME-AUDIT-DSS

Designated for accuracy testing and calibration of IEC 61850-9-2 devices (merging units, digital meters and phasor measurement units) and electronic transformers with digital outputs of the following types:

- ✓ AC current transformers up to 5 kA (IEC 60044-8-2010)
- ✓ AC voltage transformers up to $330/\sqrt{3}$ kV (IEC 60044-7-2010).

Accuracy specifications

Accuracy class of reference current* or voltage** transformer	Limits of permissible measurement error		
	ratio, %	phase, min	composite, %
0.05	0.056	3.32	0.12

* Current range – 50 A ... 5 kA

** Voltage range – $6/\sqrt{3}$... $110/\sqrt{3}$... $330/\sqrt{3}$ kV

Basic components:

- ✓ Reference setup Mars-Test-61850 (1)
- ✓ Adjustable sources of voltage and current (2 and 3)
- ✓ Reference voltage and current transformers (4 and 5)



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