



Calmet TS33

Three-phase Fully Automatic
Test System

with Reference Standard and
Integrated Current and Voltage Source



Calmet Sp. z o.o.

- ❑ Calmet = **CAL**ibrators + **MET**rology
- ❑ founded in **1989**, roots come from LUMEL, big factory of measurement equipment in Poland, Zielona Gora
- ❑ designing, production, selling and servicing new kind of calibrators and electric equipment testers
- ❑ employs over 25 engineers, including 3 with Ph.D.
- ❑ cooperates with University of Zielona Gora; common projects and lectures
- ❑ since **1996** – electricity meters testing and power network parameters analysing
- ❑ since **2002** – generating and measuring network quality parameters
- ❑ since **2006** – automation of electro-utility automatic protective equipment testing
- ❑ since **2011** – automatic Test Benches for energy meter testing
- ❑ since **2019** – new group of Automatic Test Systems

Mesurement Equipment since 1989

**Customer Support
in problems solving**

**Energy meter testers, Current
Transformers testers, Power
quality analysers**



**1 phase,
0,2%**

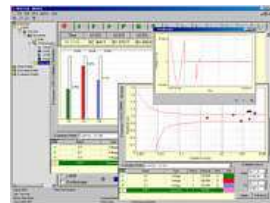
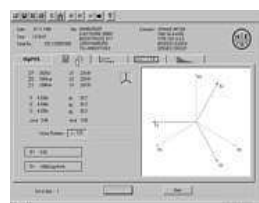


**3 phase,
0.05%**



**3 phase,
120A, 0.02%**

**Control Software for
measurement equipment**



**AC/DC Voltage, Current & Power
Calibrators, Test Benches**



3 phase U,I,φ,P,Q,S,E



1 phase U,I,φ,P,Q,S,E



3 phase Test Bench



Multifunctions DC/AC

**Current and Voltage Source with
Integrated Reference Standard**



Testing the entire energy measurement system!

Accuracy of all kinds of meters ϵ [%]

Electromechanical (Ferraris)



Electronic (static)



4 – Quadrants
Smart Meters



Max. demand



CT/PT burden, ratio, phase shift error



Wiring errors



TS33

Reference Meter & 3-phase U&I Source in one case! Modes of testing

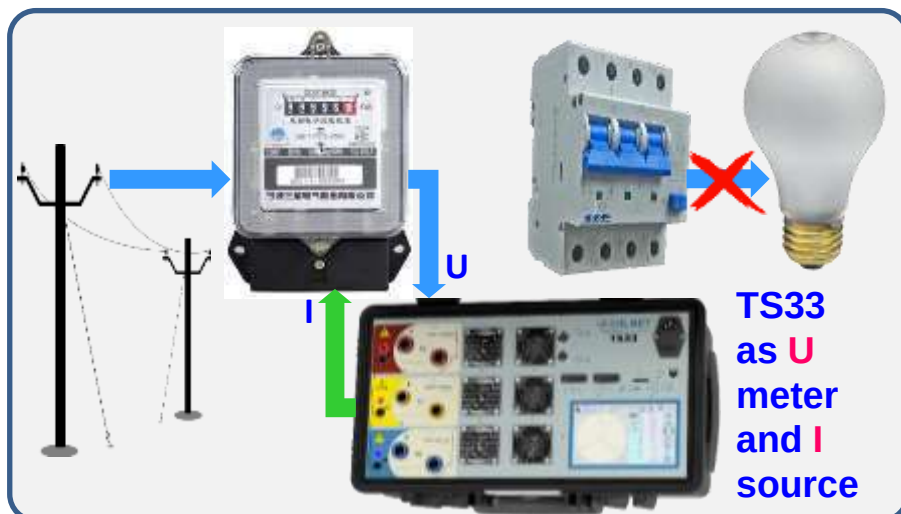


Testing **ON LINE** – meter and load are connected to the network; the value of metering point depends on current load; TS33 works as portable reference meter

Testing **OFF LINE** – meter & load are not connected to the network; metering point can be set in whole range of load; TS33 works as source of U&I and reference meter

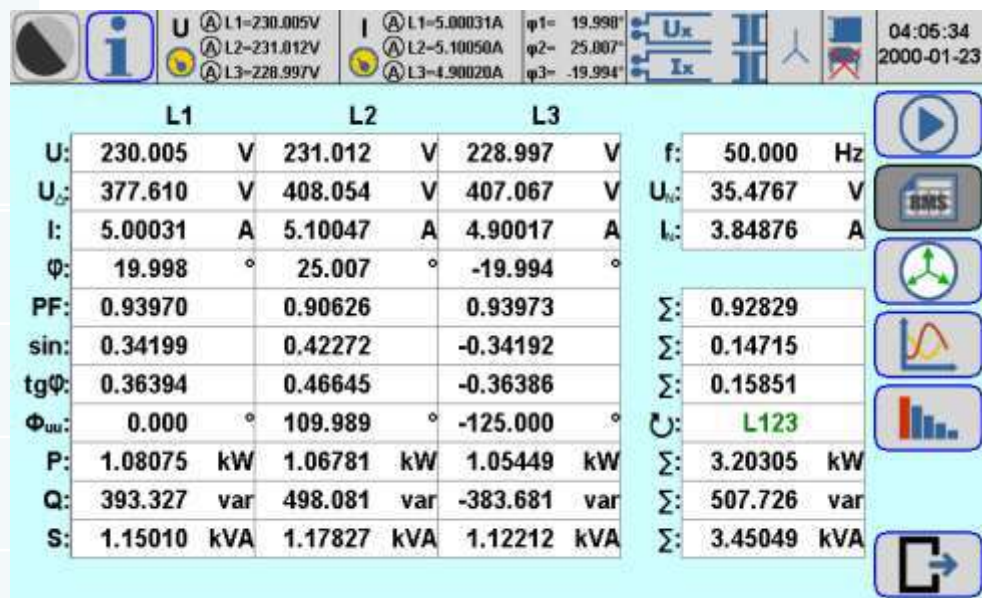


Testing **U-ON/ I-OFF LINE** – meter is connected to the network but load is disconnected; metering point can be set in whole range of current; TS33 works as U meter and I source with built in reference meter

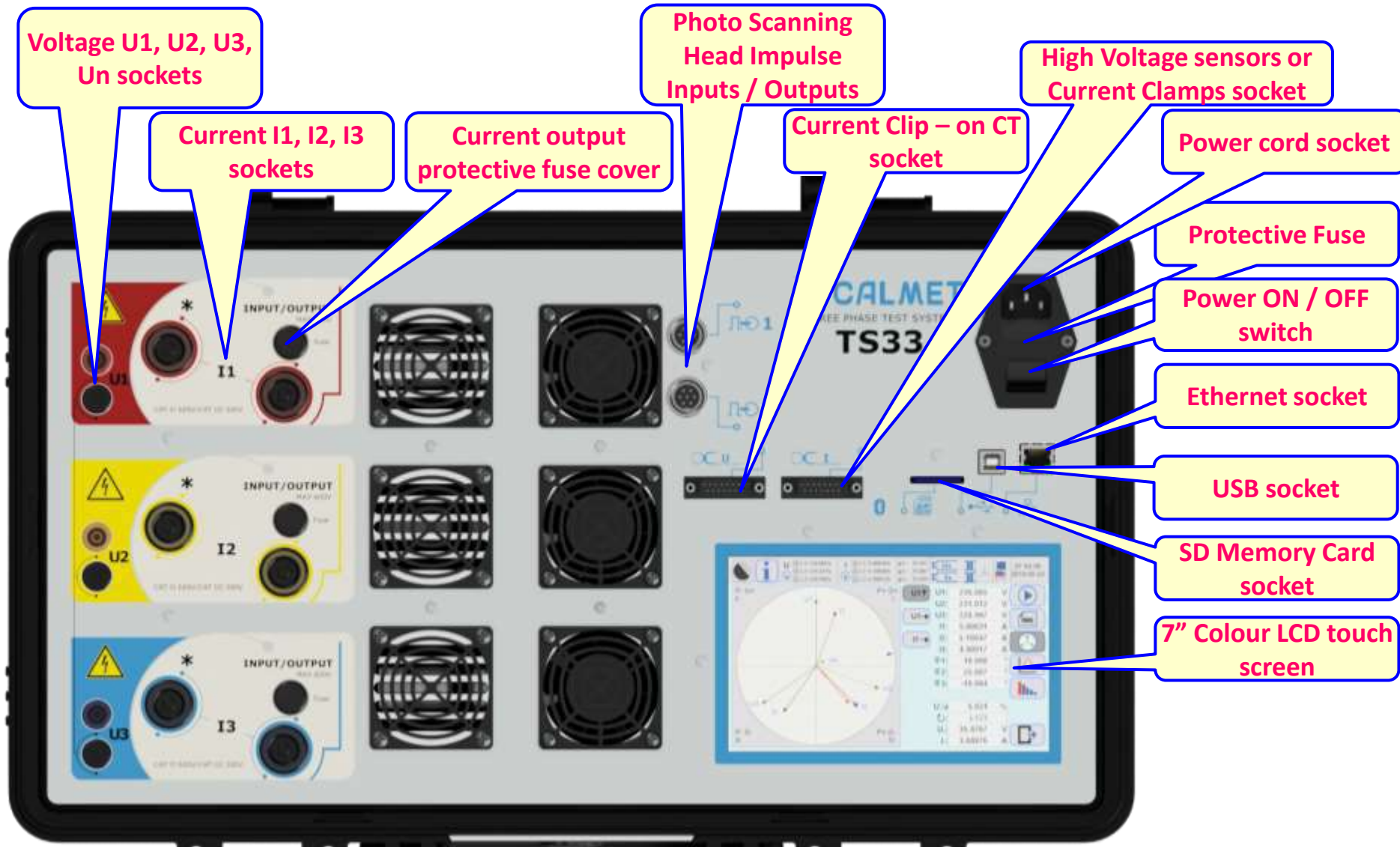


Testing without meter disconnecting!

- ▶ Easy verification of meters under precise load conditions, using integrated current and voltage source in class **0.02, 0.04** or **0.1**
- ▶ Voltage range **0.05...600V**
- ▶ Current range **0.001...120A(10)(100)(1000)(30/300/3000)A**
- ▶ Testing of energy meters, potential and current transformers (**CT / PT**)
- ▶ **Automatic operation** with predefined load points without the need of an external PC
- ▶ **Vector, oscilloscope**, bar and trend charts of three phase network
- ▶ Automatic Meter Constant recognition
- ▶ Automatic setting of measurement conditions
- ▶ **Big 7-inch full colour touch screen** and computer software Calmet TS PC Soft
- ▶ Reading data and remote controlled via **USB, Ethernet, Bluetooth**
- ▶ Recording data on flash memory SD card up to **32GB**
- ▶ Calibration Certificate



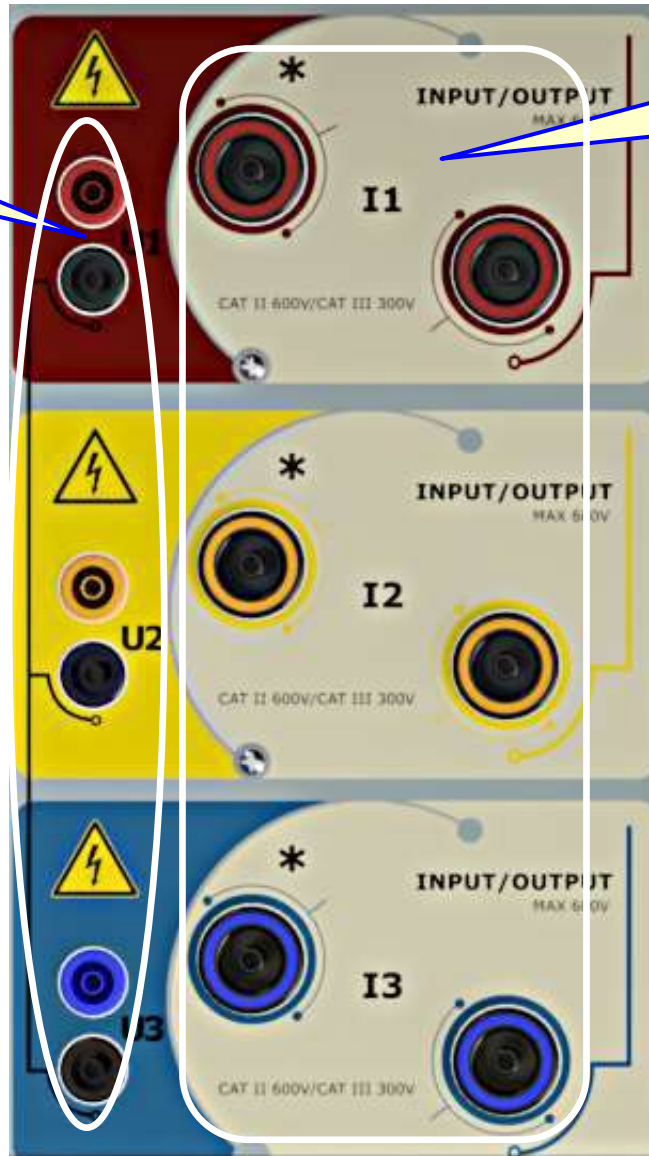
TS33 Inputs, Outputs and Connectors:



TS33 Voltage and Current Inputs:

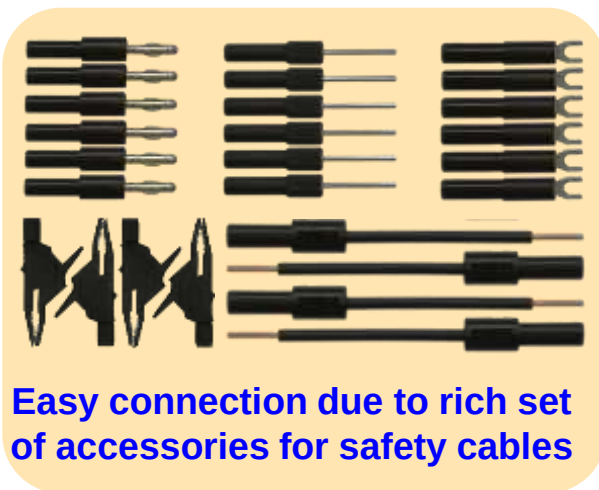
Voltage U1, U2, U3, Un Input /
Output sockets
0.05...600V

Current I1, I2, I3, Un Input / Output
sockets
0.001...120A

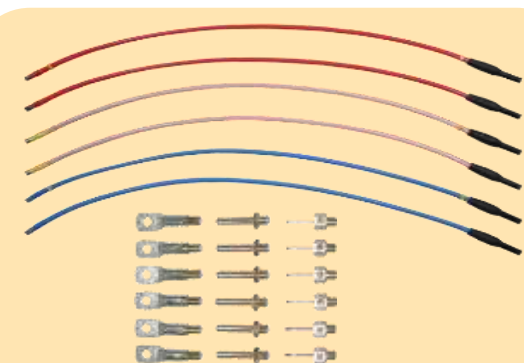


4mm Voltage Safety Cables
Length=2m

4mm Current Safety Cables
Length=2m, $I \leq 30A$



Easy connection due to rich set
of accessories for safety cables



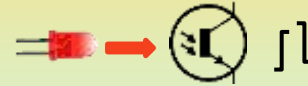
25mm² High Current Cables
Length=1m, $I \leq 120A$

TS33 Pulse Input / Output;

can test all kinds of Electricity Meters

Electronic energy meter

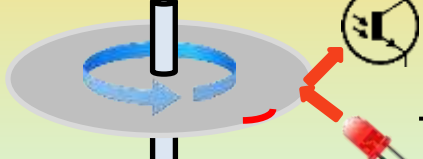
- red, green or infrared LED blinking or LCD segment flashing
- photo head with photo sensor



0.0001Hz...200kHz

Inductive energy meter

- disk with red or black mark
- photo head with LED lamp and photo sensor



1. Pulse Input / Output socket

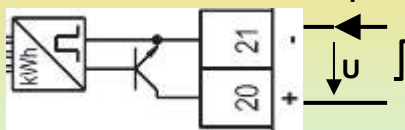
Electronic and Inductive energy meter

manual push – button and pulse generation



Electronic and Inductive energy meter

50 standard electric pulse



In case, that we need higher than offered by TS33 accuracy 0.04 or 0.1, we can use external reference easy way

Additional, external very, high accuracy Reference Meter

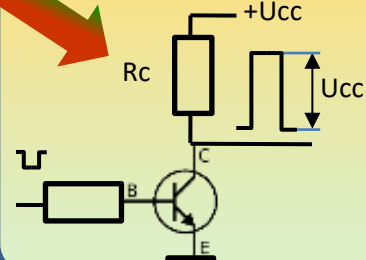


2. Pulse Input for external Reference Meter socket

Open collector pulse output + external Rc

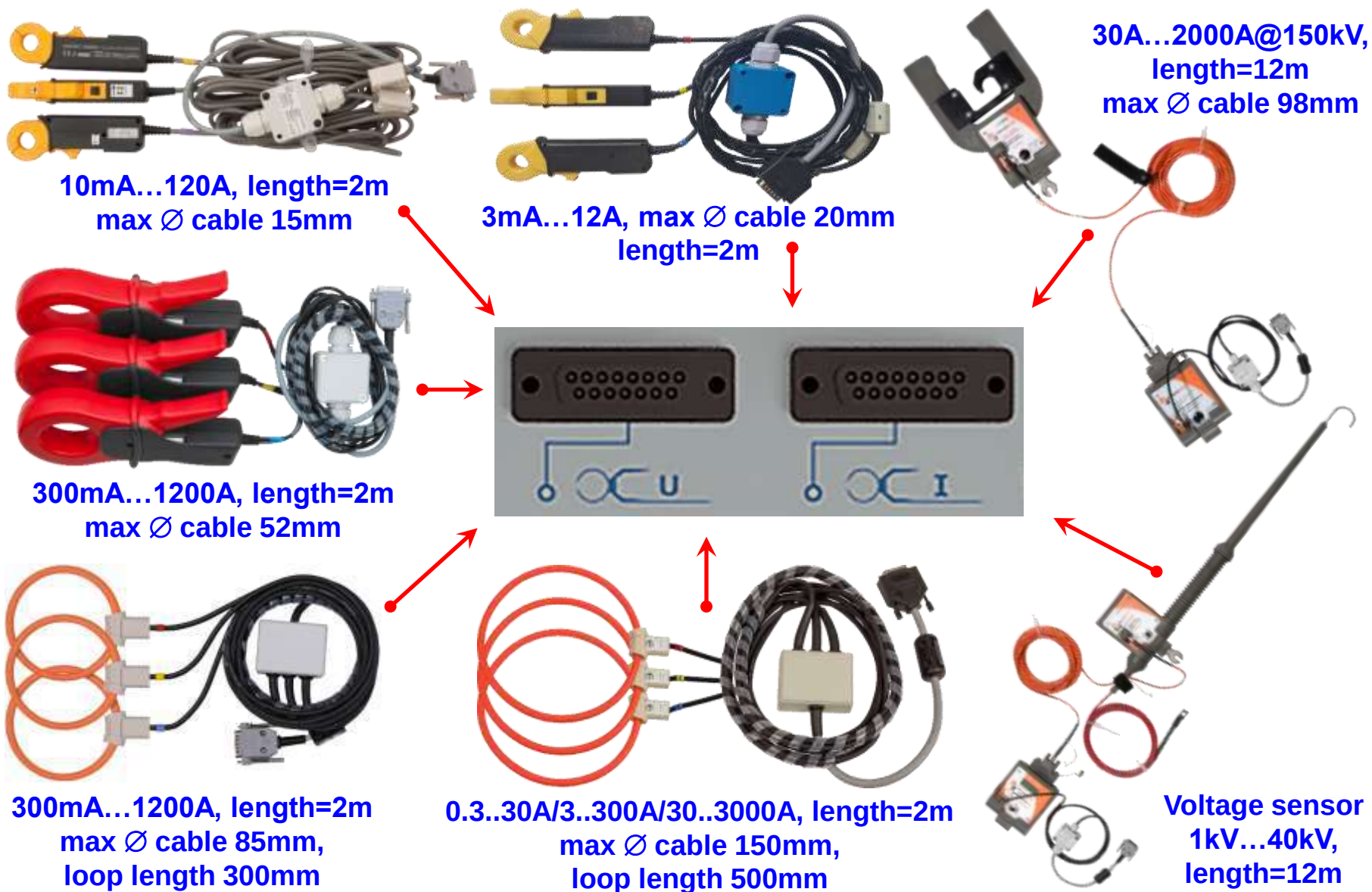
$U_{cc} \max \leq 27V$
 $I_c \max \leq 100mA$

0.0001Hz...200kHz



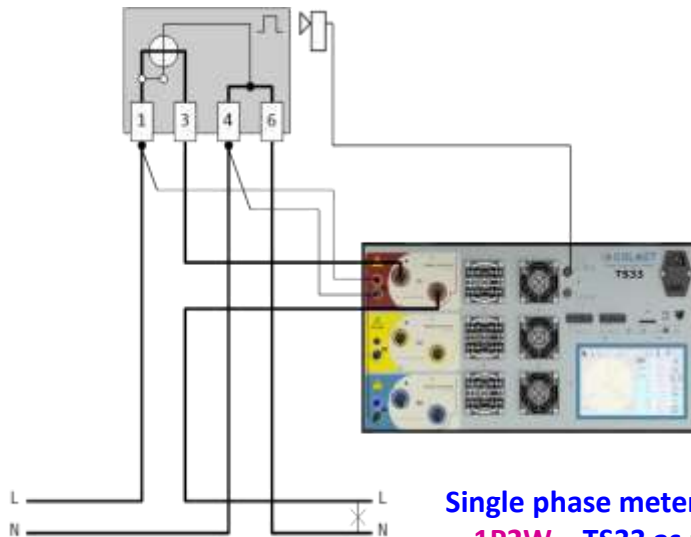
TS33 has pulse output with frequency proportional to the power, with freely programmable constant imp/kWh

TS33 Current Clamps and Voltage Sensors; wide range of measured signals

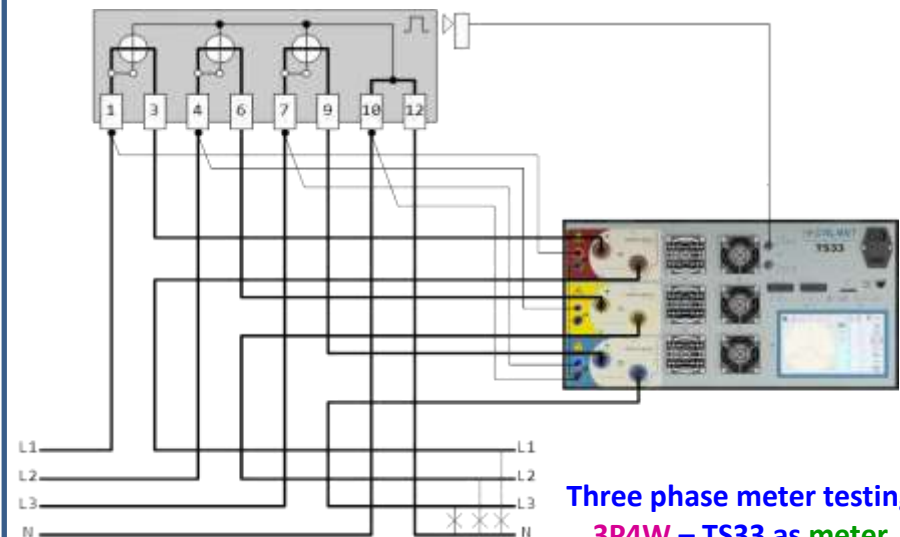


Bluetooth, wireless printer & laptop

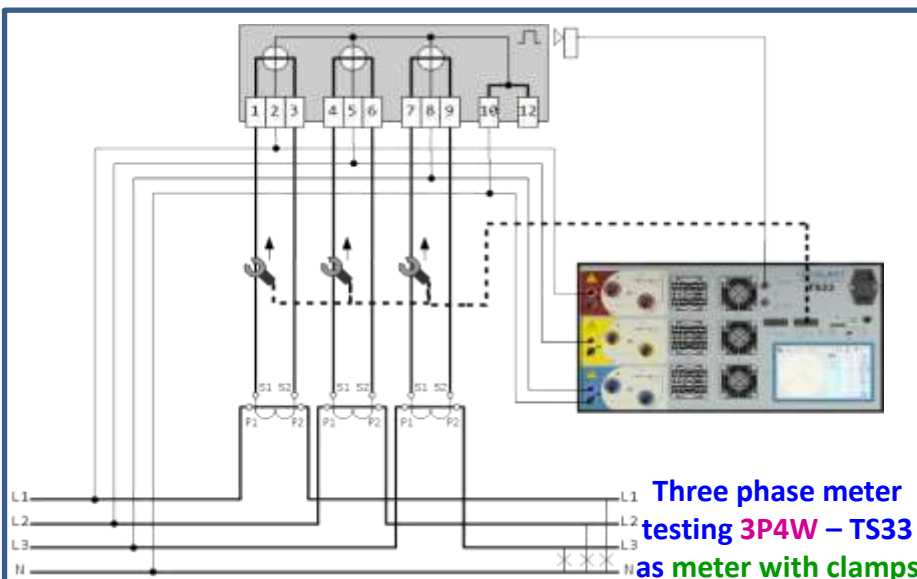
All possible types of connection: **1P2W**, **3P4W**, **3P3W**, ... , direct or with clamps



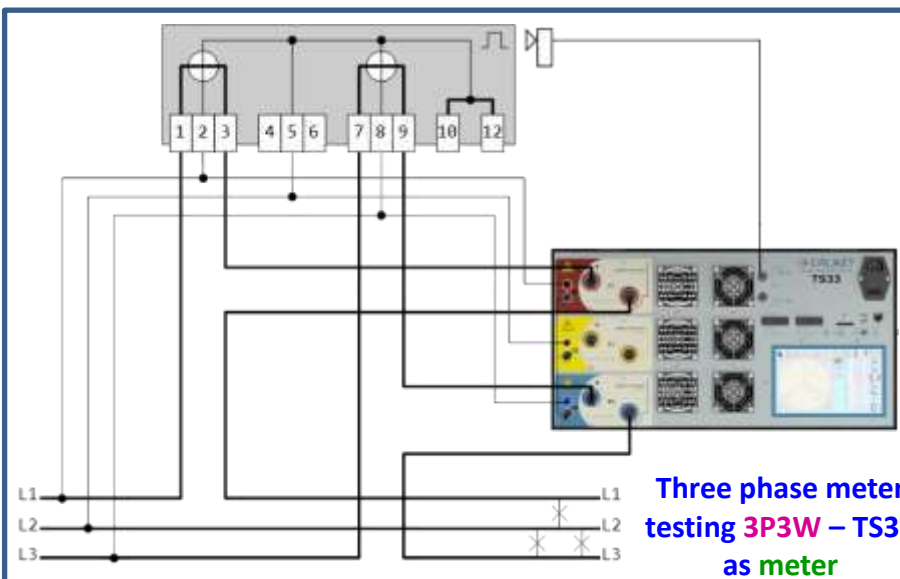
Single phase meter testing
1P2W – TS33 as meter



Three phase meter testing
3P4W – TS33 as meter



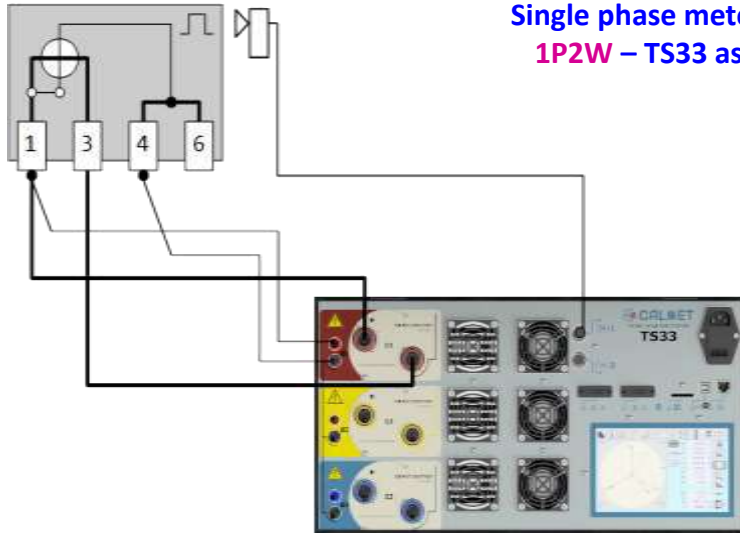
Three phase meter
testing **3P4W** – TS33
as meter with clamps



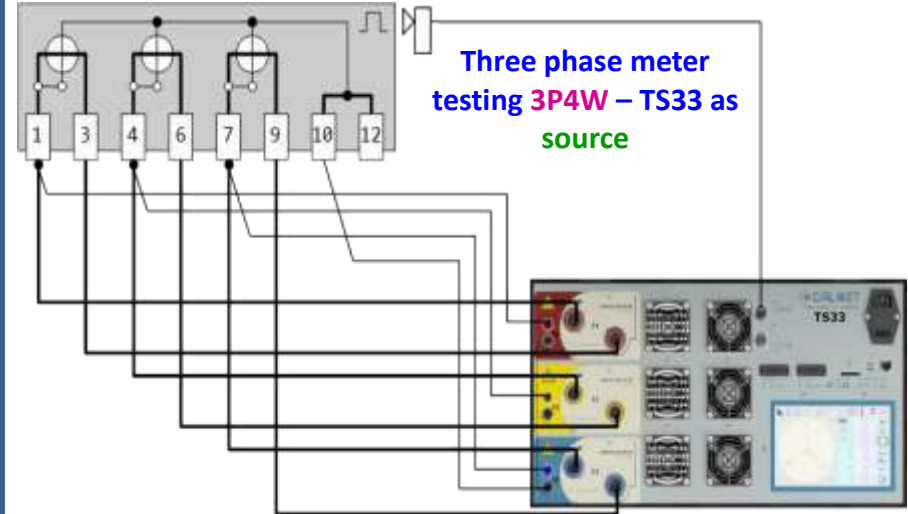
Three phase meter
testing **3P3W** – TS33
as meter

All possible types of meters: **1P2W**, **3P4W**, **3P3W**. TS33 as source and reference

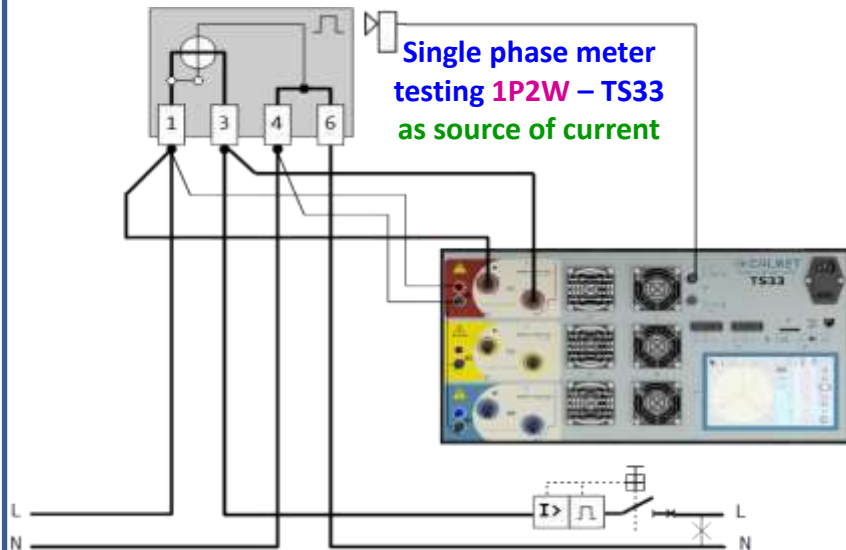
Single phase meter testing
1P2W – TS33 as **source**



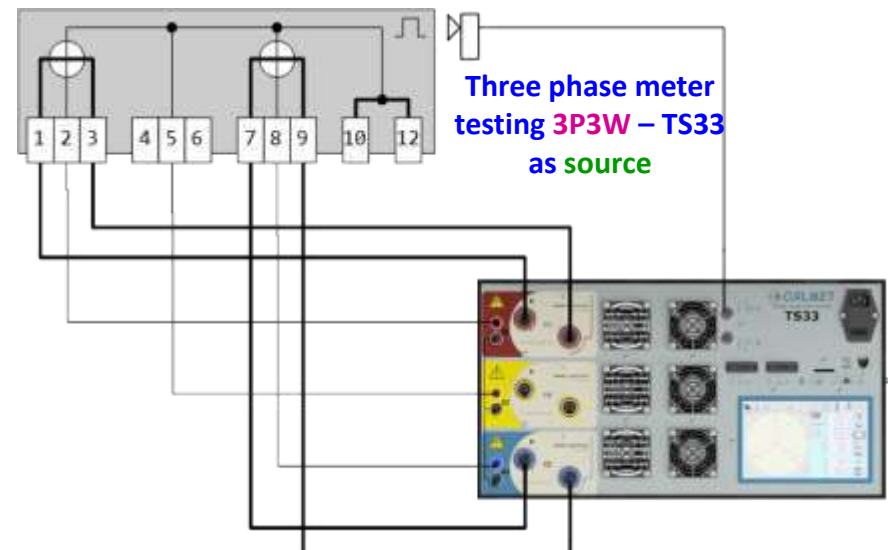
Three phase meter testing
3P4W – TS33 as **source**



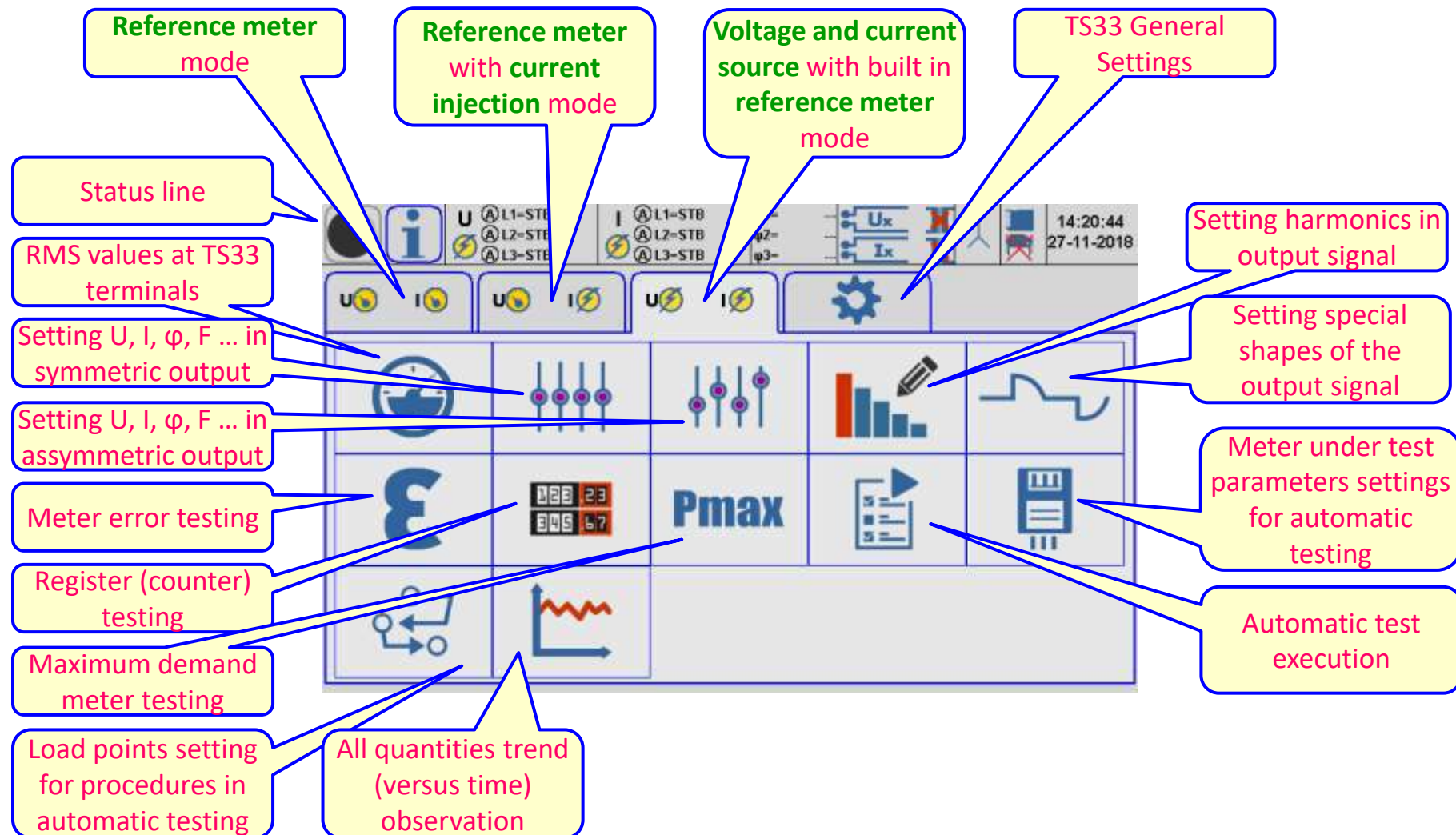
Single phase meter testing
1P2W – TS33 as **source of current**



Three phase meter testing
3P3W – TS33 as **source**



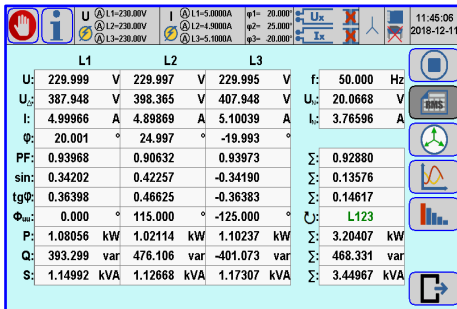
Functionality of TS33: as reference meter, as source of U&I, as U meter & I source



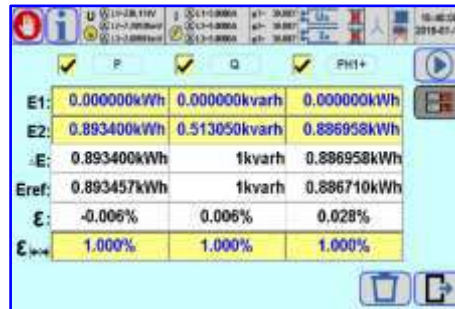
Easy, icon driven, operation on big 7" touch screen

TS33 reference meter mode: whole installation measurement „as it is”

RMS values of U,I,φ,F,P,Q,S



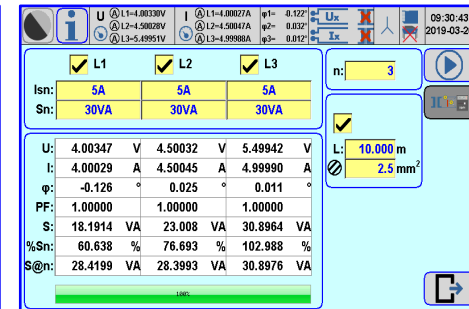
Counter (register) test



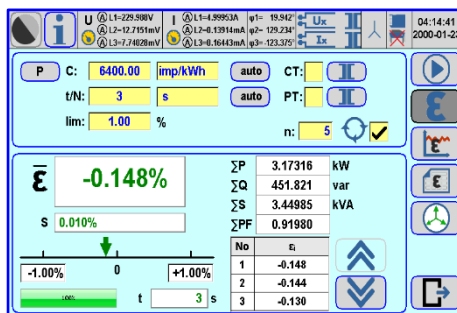
Maximum demand meter test



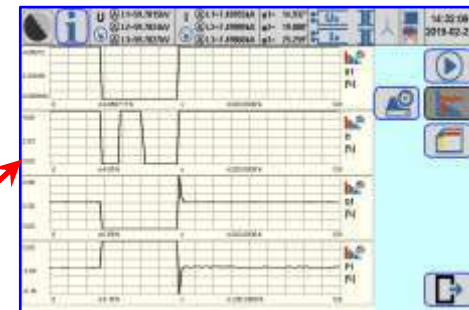
CT burden test



Meter error test in [%]



Harmonics trend test



PT burden test



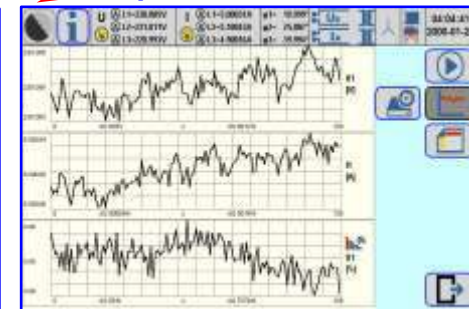
CT ratio test



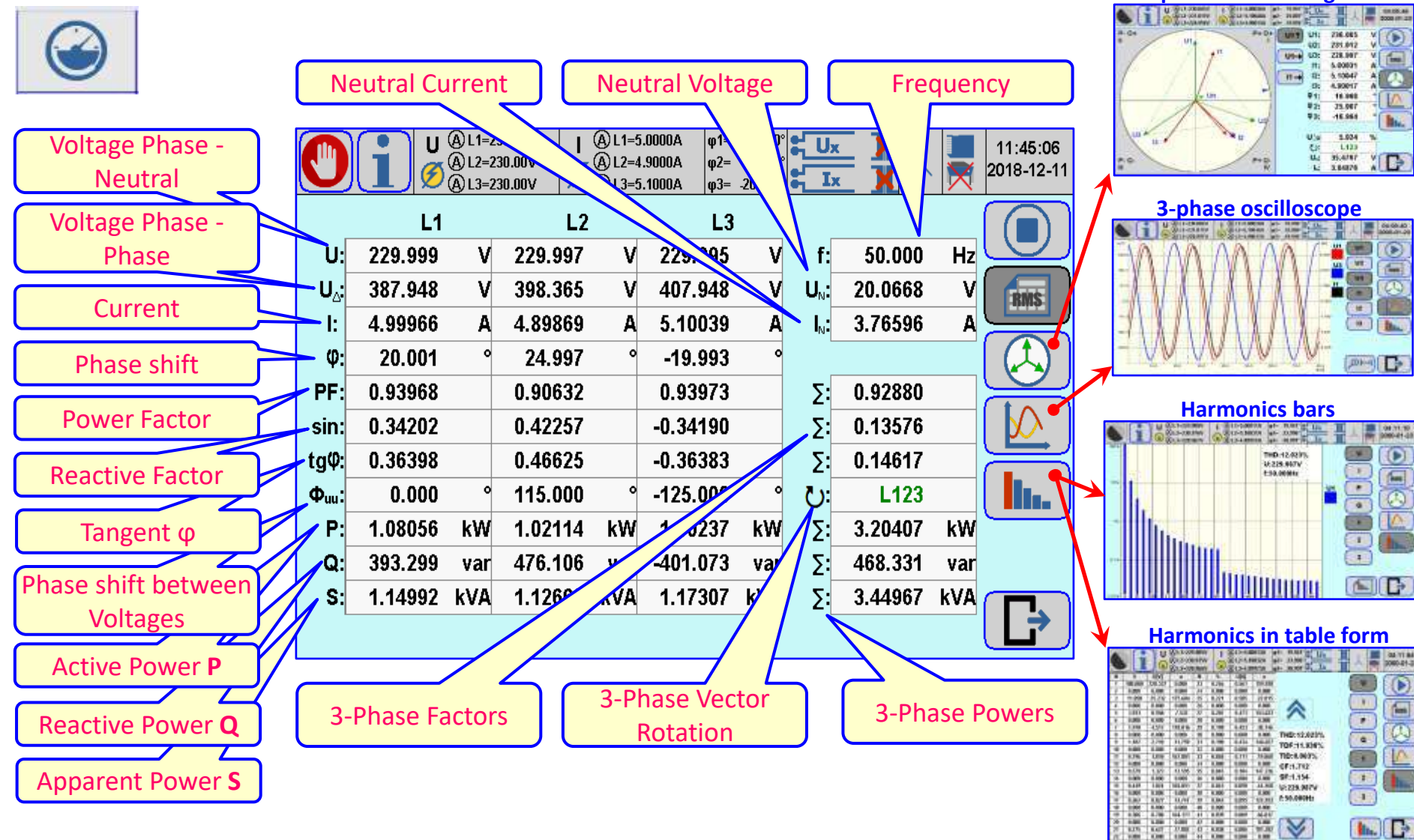
PT ratio test



U,I,φ,F,P,Q,S trend test



TS33 functionality: RMS values of U,I, ϕ ,F,P,Q,S measurement results

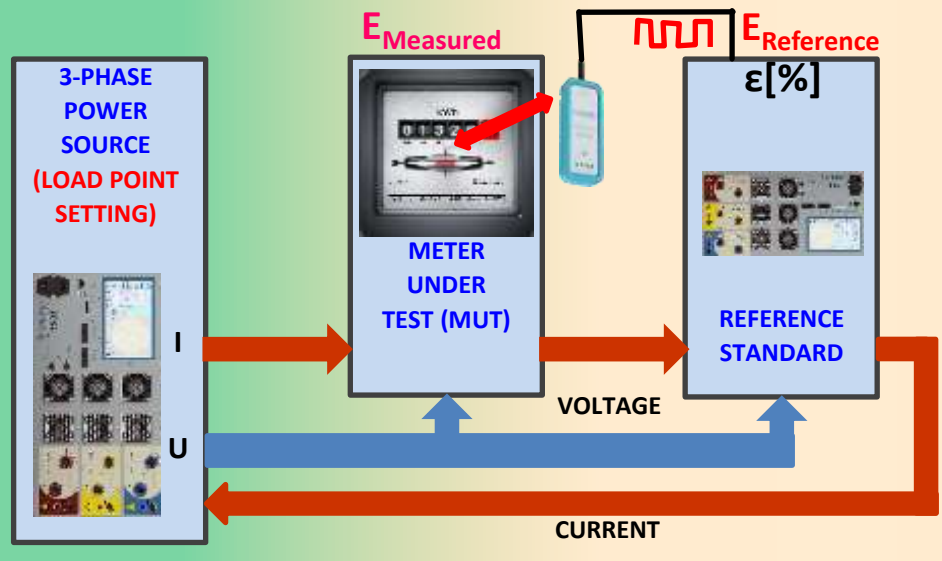




TS33 functionality: energy meter error testing idea

Principle of electricity meter testing

$$\varepsilon[\%] = \frac{E_{\text{Measured}} - E_{\text{Reference}}}{E_{\text{Reference}}} \cdot 100\%$$



TS33 works both:

- as programmable 3- phase source of voltage and current;
- as high accuracy reference meter.



Definition: energy meter testing (MUT) by energy comparison method consists in counting pulses from MUT and calculation of measured energy as:

$$E_{\text{Measured}}[\text{kWh}] = \frac{N[\text{pulses or turns number}]}{C[\text{imp/kWh}](\text{meter constant})}$$

and then compare it with, reference value measured by special, at least 5 times more accurate standard meter ($E_{\text{reference}}$).

Example: counted were 500 pulses by meter with constant 375 turns/kWh. The measured energy is:

$$E_{\text{Measured}} = \frac{500}{375} \text{ kWh} = 1.333 \text{ kWh}$$

TS33 functionality: automatic energy meter error testing in [%]



Type of Power/Energy selection
Fundamental only!

Meter constant units
Meter under test constant

AUTOmatic selection of meter constant and time of measurements

CT/PT usage
Number of measurements for averaging

Time of test or number of pulses

Limits of meter under test error

Average value of error

Standard deviation

3-Phase Powers

Partial error results

Summary Data:

- V: 230.00V
- I: 4.00A
- P: 89.98W
- Q: 7.151mVar
- S: 740.28mVA
- PF: 0.999

Test Parameters:

- C: 6400.00 imp/kWh
- t/N: 3 s
- lim: 1.00 %
- n: 5

Results:

- Average error: **-0.148%**
- Standard deviation: **0.010%**

Partial Error Table:

No	ϵ_i
1	-0.148
2	-0.144
3	-0.130

Summary Table:

	ΣP	ΣQ	ΣS	ΣPF
	3.17316 kW	451.821 var	3.44985 kVA	0.91980

Error diagram $\epsilon=f(t)$



Error table

No	PPM	Q/VAR	Line	ϵ_i [%]	ϵ [%]	OK
27	10.5518	3333.00	091.587	1.000	-0.148	OK
28	10.5518	3333.00	091.576	1.000	-0.148	OK
29	10.5434	3333.00	091.588	1.000	-0.148	OK
30	10.5418	3333.00	091.588	1.000	-0.148	OK
31	10.5518	3333.00	1259.48	1.000	-0.148	OK
32	10.5404	3333.00	1259.48	1.000	-0.148	OK
33	10.5418	3333.00	1259.48	1.000	-0.148	OK
34	10.5404	3333.00	1259.48	1.000	-0.148	OK
35	10.5418	3333.00	1259.47	1.000	-0.148	OK
36	10.5518	3333.00	1160.6	1.000	-0.148	OK
37	10.5518	3333.00	1160.6	1.000	-0.148	OK
38	10.5418	3333.00	1160.6	1.000	-0.148	OK
39	10.5418	3333.00	1160.6	1.000	-0.148	OK

Vector diagram

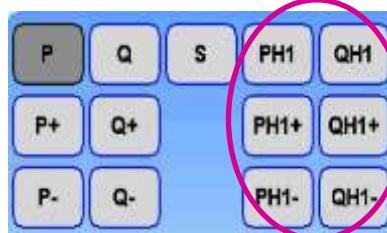


- ▶ function of computing meter error (partial errors, average error, standard deviation) directly in percentages [%] with method of setting time of measurement or number of impulses,
- ▶ function of automatic identification energy meter constant,
- ▶ function of automatic determining measurement time or number of pulses.

TS33 functionality: register (counter) test

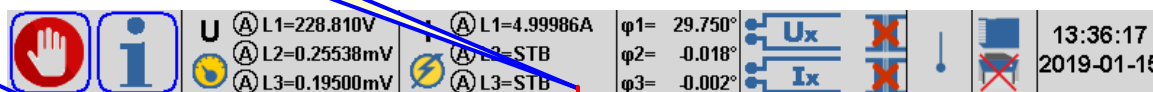


The type of power setting for selected register



Fundamental only !

Up to 3 registers testing at time



Test START / STOP

Register value before starting test

Register value after stopping test

Difference between E2-E1

Reference value of Energy flow

Value of error

Limits of error

	☒	P	☒	Q	☒	PH1+	
E1:		0.000000kWh	0.000000kvarh	0.000000kWh			
E2:		1.019123kWh	0.588698kvarh	1.019680kWh			
ΔE:		1.019123kWh	0.588698kvarh	1.019680kWh			
Eref:		1.019277kWh	0.588480kvarh	1.018611kWh			
ε:		-0.015%	0.037%	0.105%			
ε ↔		1.000%	1.000%	1.000%			

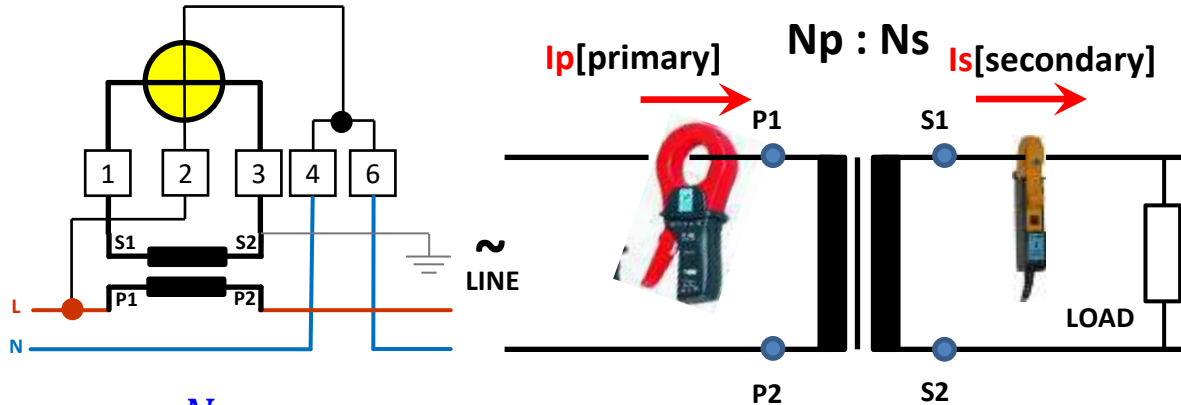
Value of active energy with all harmonics

Value of first harmonic only in active energy

- ▶ function of simultaneous testing up to three registers,
- ▶ function of every kind of power selection enables to test multi-quadrant meters,
- ▶ testing all harmonic energy or only fundamental (1-st harmonic) Energy, required for all new metres of reactive energy and active energy in near future



TS33 functionality: CT/PT ratio test idea;
small ratio and phase shift error are essential for reliable measurement



The test method is based on **primary current** measurement by means of current clamps from 0.1A to 3000A and **secondary current** measurement directly or also by means of clamps in 10mA to 10A range.

$$\delta I = \frac{\frac{N_P}{N_S} \cdot I_S - I_P}{I_P} \cdot 100\%$$

The ratio error is given by equation, where:

δI – current transformer error [%]

N_P - number of primary turns

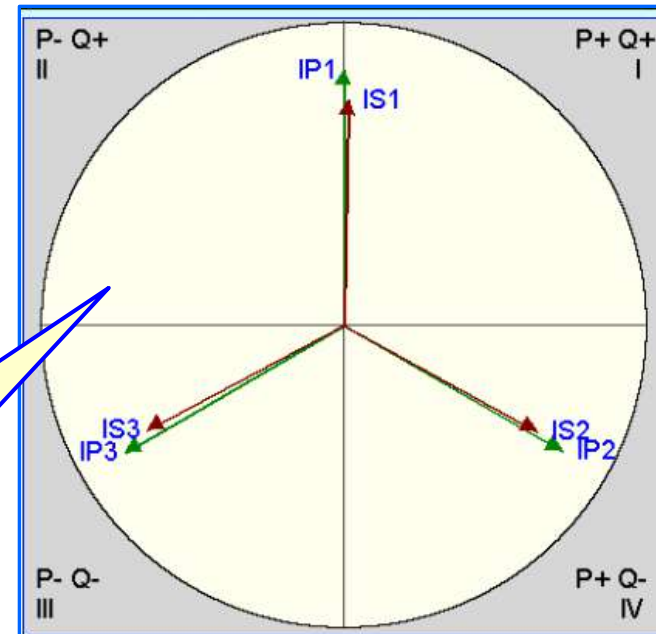
N_S - number of secondary turns

N_P / N_S – nominal CT ratio

I_P - primary current

I_S - secondary current

Three phase vector diagram of primary I_P and secondary I_S currents



Expected value of ratio error is $\delta I=0\%$ and phase shift error $\varphi=0^\circ$

TS33 functionality: CT/PT ratio test; vector diagram with primary and secondary side

Individual phase

CT limit of error (accuracy class)

Nominal primary current

Nominal secondary current

Primary current flow

Secondary current flow

Phase shift primary / secondary current

Calculated ratio

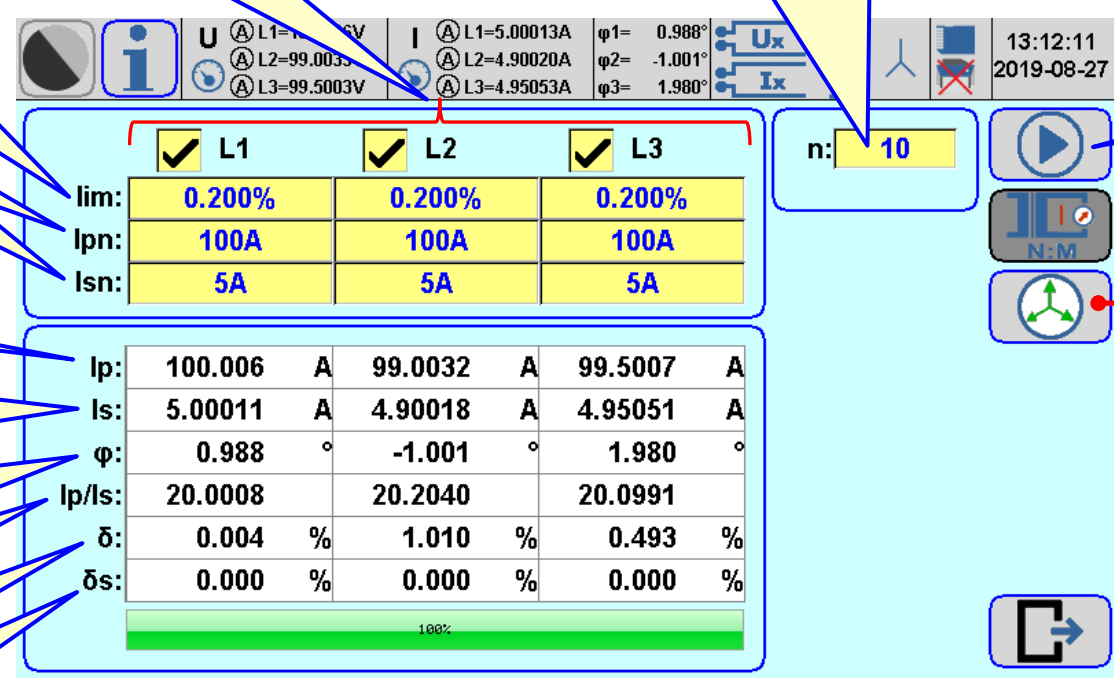
Ratio error in [%]

Standard deviation of ratio error measurement

Number of measurements for averaging

Test START / STOP

Vector diagram of primary and secondary side allows for easy connection testing

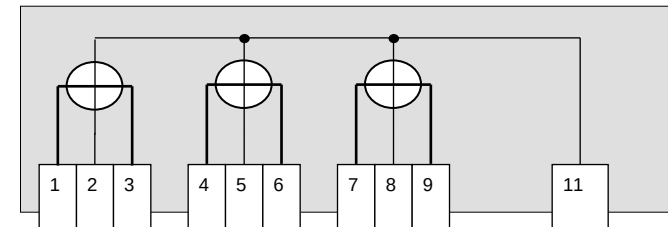
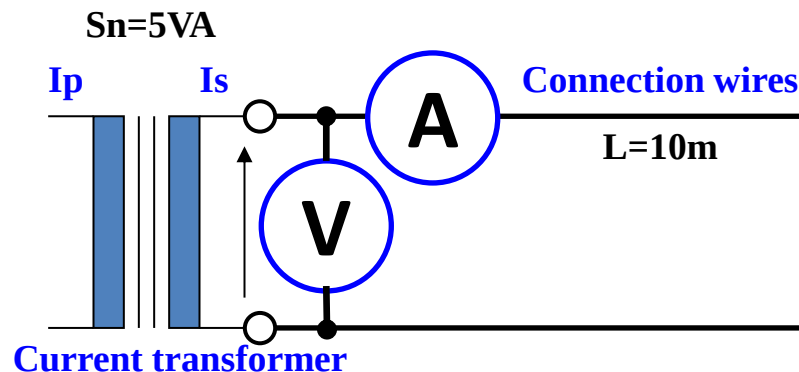
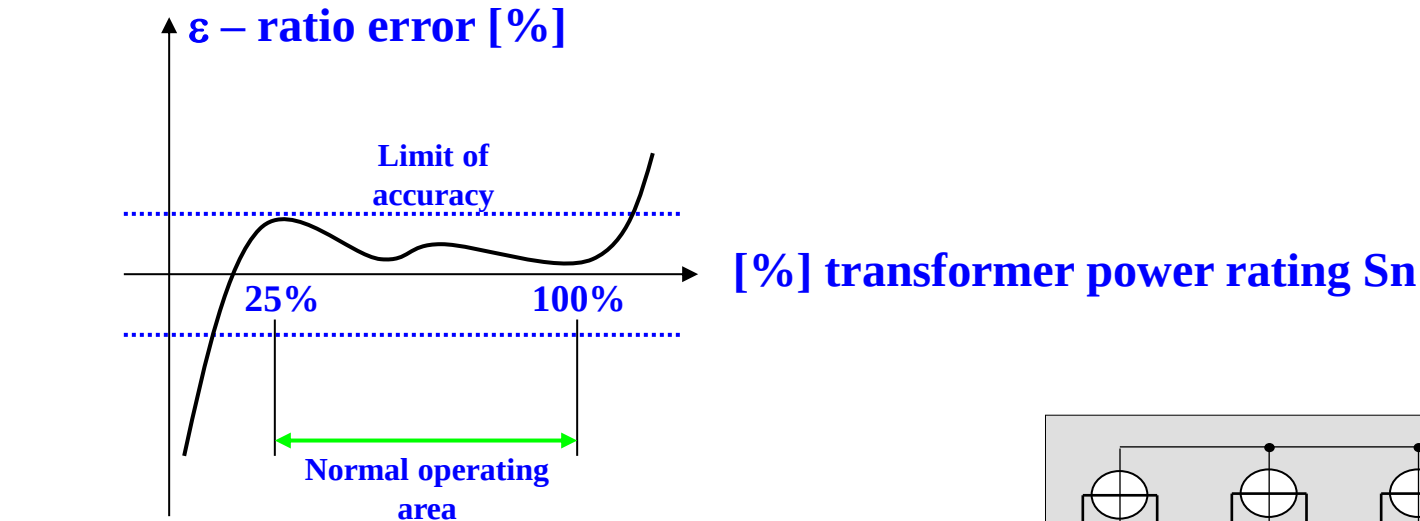
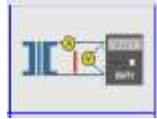


	L1	L2	L3
lim:	0.200%	0.200%	0.200%
l _{pn} :	100A	100A	100A
l _{sn} :	5A	5A	5A
l _p :	100.006 A	99.0032 A	99.5007 A
l _s :	5.00011 A	4.90018 A	4.95051 A
φ:	0.988 °	-1.001 °	1.980 °
l _p /l _s :	20.0008	20.2040	20.0991
δ:	0.004 %	1.010 %	0.493 %
δ _s :	0.000 %	0.000 %	0.000 %

- ▶ testing CT / PT ratio and phase shift error simultaneously in three phases,
- ▶ ratio error measured directly in [%],
- ▶ vector diagram allows easy check of proper installation connections and error removing

TS33 functionality: CT/PT burden test idea

CT/PT – current / voltage transformer can operate with stated accuracy only between 25% - 100% of burden (load). In case of **too long** length, or **too thin** wire dimension or **too small load**, the result, secondary current / voltage can be **out of accuracy** limits



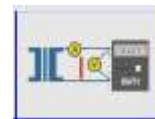
Example:

$$R_p = \frac{\rho_{CU} \cdot l}{S} = \frac{0,0175\Omega \frac{mm^2}{m} \cdot 2 \cdot 10m}{1mm^2} = 0,35\Omega$$

$$P_p = I_2^2 \cdot R_p = 5^2 A \cdot 0,35\Omega = 8,75VA$$

Conclusion: transformer load (wires, connectors, fuses, meter) can influence on accuracy

TS33 functionality: CT/PT burden test



Nominal secondary current

Nominal power of transformer

Voltage at secondary side

Secondary current

Phase shift between voltage and current

Secondary side power factor

Value of Apparent power

Usage of nominal power in [%]

Power what would be at nominal current

Individual phase

	L1	L2	L3
U:	4.00347 V	4.50032 V	5.49942 V
I:	4.00029 A	4.50045 A	4.99990 A
φ:	-0.126 °	0.025 °	0.011 °
PF:	1.00000	1.00000	1.00000
S:	18.1914 VA	23.008 VA	30.8964 VA
%Sn:	60.638 %	76.693 %	102.988 %
S@n:	28.4199 VA	28.3993 VA	30.8976 VA

100%

Number of measurements for averaging

Test START / STOP

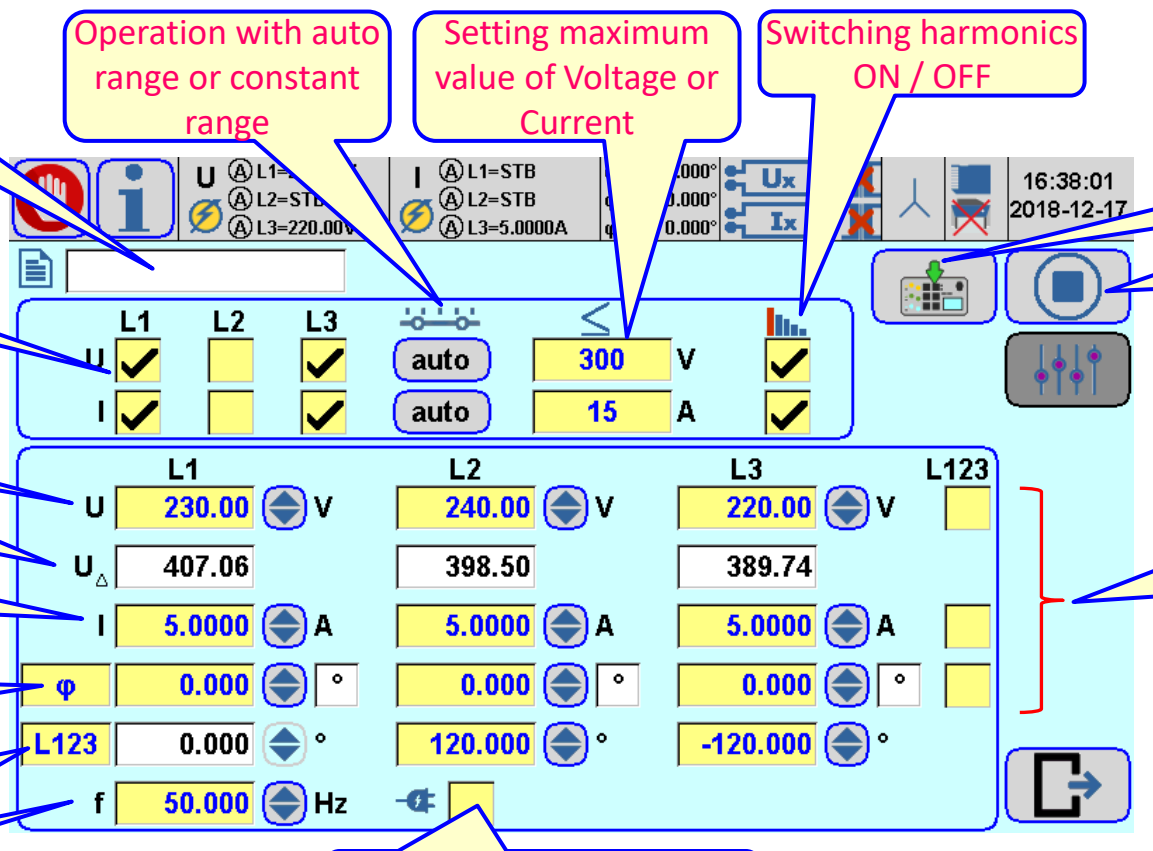
Distance between CT/PT and meter [m]

Cross section of connection wires

Nominal power will be overloaded when nominal current will flow

- ▶ function of simultaneous testing up to three burdens,
- ▶ function of proper work prediction at nominal current and load,
- ▶ analysis of secondary side power factor

TS33 functionality: Voltage and current source with built in reference meter mode



The screenshot shows the TS33 software interface with the following callouts and features:

- File name of stored settings**: Points to the file name field at the top left.
- Operation with auto range or constant range**: Points to the 'auto' range selection buttons for voltage and current.
- Setting maximum value of Voltage or Current**: Points to the numerical input fields for maximum voltage (300 V) and current (15 A).
- Switching harmonics ON / OFF**: Points to the harmonic switching icons.
- Set data acceptance**: Points to the data acceptance icon.
- START / STOP generation**: Points to the start/stop generation icon.
- Switching ON / OFF of individual U & I channels**: Points to the checkboxes for individual voltage and current channels.
- Voltage in phase L1 L2 L3**: Points to the voltage phase selection checkboxes.
- Voltage between phases**: Points to the voltage phase selection checkboxes.
- Current in phase L1 L2 L3**: Points to the current phase selection checkboxes.
- Phase shift U&I**: Points to the phase shift selection checkboxes.
- Phase shift between Voltages**: Points to the phase shift selection checkboxes.
- Frequency setting**: Points to the frequency input field (50.000 Hz).
- Frequency synchronised with power frequency**: Points to the frequency synchronization checkbox.
- Setting the same value for all three phases**: Points to the 'L123' selection checkboxes.

The main display area shows the following data:

	L1	L2	L3	L123
U (V)	230.00	240.00	220.00	
U _Δ (V)	407.06	398.50	389.74	
I (A)	5.0000	5.0000	5.0000	
φ (°)	0.000	0.000	0.000	
L123 (°)	0.000	120.000	-120.000	
f (Hz)	50.000			

- ▶ Individual setting in each phase value of voltage, current, power factor and phase shift between voltages,
- ▶ Independent switching ON / OFF of each current and voltage in phase L1, L2, L3,
- ▶ Automatic or manual range selection,
- ▶ Protection against overvoltage or overcurrent
- ▶ Pure sinusoidal or harmonic distorted signal generation

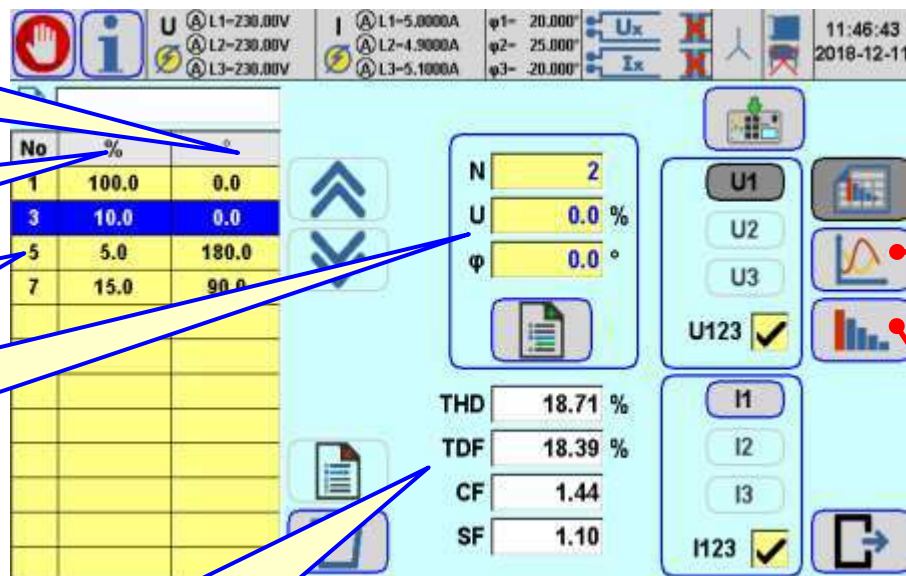
TS33 functionality: Voltage and current source – harmonic generation

Phase shift with reference to fundamental

Amplitude in % of fundamental

Number of harmonic

Setting number of harmonic, its amplitude and phase shift



Signal parameters:

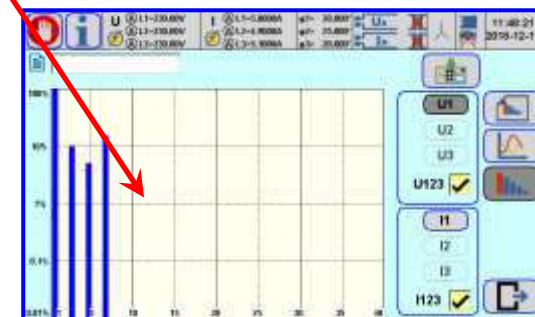
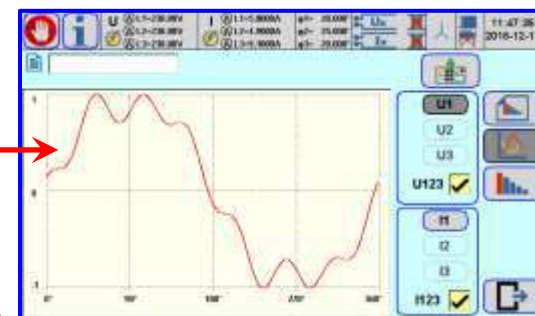
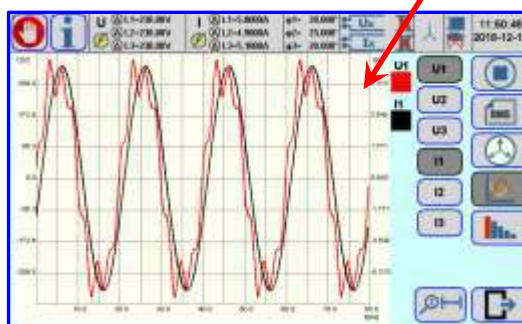
THD – total harmonic distortion (all harmonics to fundamental)

TDF – total distortion factor (all harmonics to RMS value)

CF – crest factor (peak value to RMS value)

SF – shape factor (average rectified value to RMS value)

Real signal measured at TS33 output



TS33 functionality: Automatic energy meter test in whole range of loads idea

METER TYPE



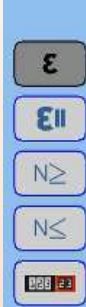
U:230V
I:10(60)A
f:50Hz
C:375imp/kWh
Cl: 2

U:230V
I:0.25-5(60)A
f:50Hz
C:6400imp/kWh
Cl: A



**Data
base**

TEST PROCEDURE



Type of test:

- error
- repeatability
- start up current
- no load test
- dial (register) test

Load points:

- value of current
- value of voltage
- power factor
- frequency
- harmonics



**Data
base**

TEST EXECUTION

- load points for test selection
- serial number of meter under test
- test execution
- results table

No		P[W]	Q[VAR]	lim[%]	ε[%]	sc[%]	OK
1	11:43:27	172.502	-0.008651	1.000	0.660	0.022	✓
2	11:44:50	344.987	-0.013448	1.000	0.638	0.010	✓
3	11:45:35	689.912	-0.049329	1.000	0.505	0.107	✓
4	11:46:57	1725.03	-1.00910	1.000	0.628	0.003	✓
5	11:48:16	2760.15	-0.290766	1.000	0.616	0.006	✓
6	11:49:37	3450.06	-0.479501	1.000	0.600	0.004	✓
7	11:50:56	4139.97	-0.750822	1.000	0.589	0.001	✓



**Data
base**

TS33 functionality: Automatic energy meter test – Meter Type

Fundamental only !

Power type measured by meter

Type of meter in Data Base or new meter

Comment to the meter

Meter connection type: STAR / DELTA / SINGLE PHASE

Meter constant entered in:
[imp/kWh]
[imp/Wh] [Wh/imp]

Programmable in [s] delay between applying signals to the meter and test start (prepayment meters with relay)

Conclusion: parameters of different types of metres can be stored with individual names in data base and then recalled during automated tests

Base voltage of meter under test

Maximum voltage to protect meter

Base (nominal) current

Maximum current

Current transformer if used and its primary and secondary nominal current

Potential transformer if used and its primary and secondary nominal voltage

Parameters shown in the interface:

- Buttons: P, Q, S, PH1, QH1, PH1+, QH1+, PH1-, QH1-, P+, Q+, P-, Q-
- Buttons: U, I, L1=STB, L2=STB, L3=STB, φ1=, φ2=, φ3=, Ux, Ix, 15:21:02, 2019-01-02
- Buttons: PAFAL12E, PAFAL12EA5gw
- Buttons: STAR, DELTA, SINGLE PHASE
- Buttons: C, 6400, imp/kWh
- Buttons: 0, s
- Buttons: PT, CT
- Buttons: Upn, 30000, V, Ipn, 800, A
- Buttons: Usn, 57.7, V, Isn, 5, A
- Buttons: Ub, 230, V, Umax, 300, V
- Buttons: Ib, 5, A, Imax, 60, A

TS33 functionality: Automatic energy meter test – Procedure



- error test
- repeatability
- start up current
- no load, creep test
- register (dial) test

Type of test

Error limit

Time of test

Number of measurements for averaging

Name of load point

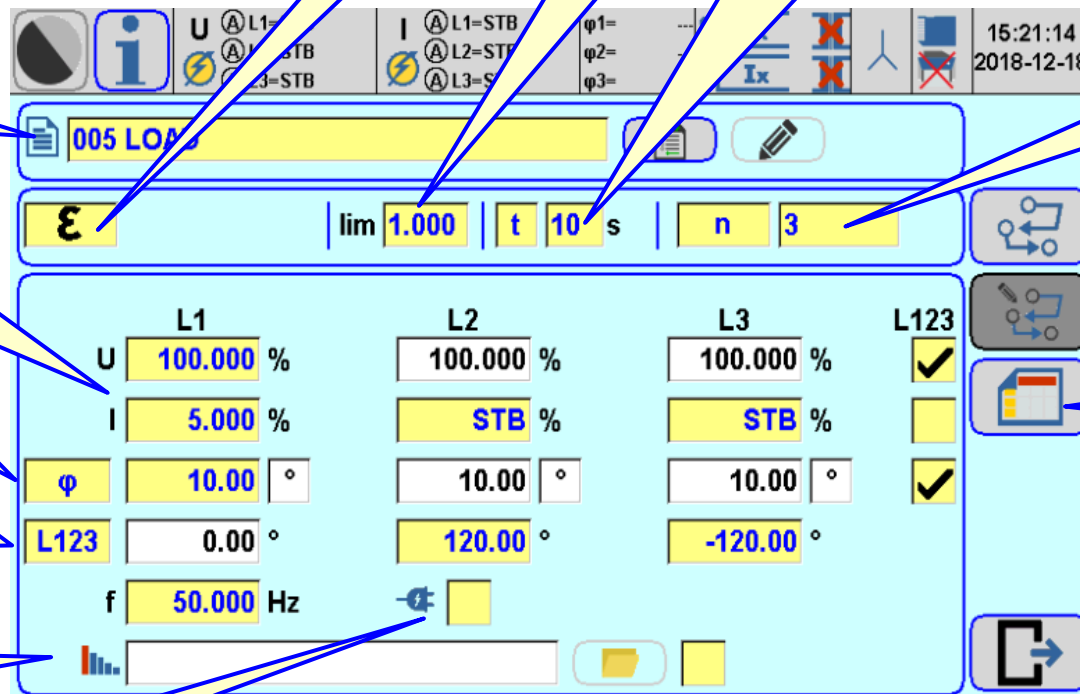
Load point parameters in [%] of base value defined in Meter Type

Phase shift or power factor

Symmetry of voltages and rotation direction

Harmonics in signal

Synchronization with network frequency



005 LOAD

lim 1.000 | t 10 s | n 3

	L1	L2	L3	L123
U	100.000 %	100.000 %	100.000 %	☒
I	5.000 %	STB %	STB %	☐
ϕ	10.00 °	10.00 °	10.00 °	☒
L123	0.00 °	120.00 °	-120.00 °	
f	50.000 Hz			

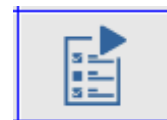
Table with load points



	005 LOAD
1	005 LOAD
2	005 LOAD
3	005 LOAD
4	005 LOAD
5	005 LOAD
6	005 LOAD
7	005 LOAD
8	005 LOAD
9	005 LOAD
10	005 LOAD

Conclusion: it is possible to define each load point and kind of test and then save the sequence of points in one procedure in data base, which can be recalled during automated tests

TS33 functionality: Automatic energy meter test – Execution



Test Procedure name

Type of Meter in data base

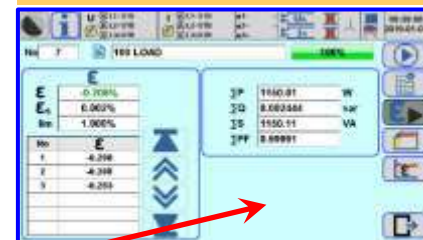
List of load points with one selected

Marked load point values

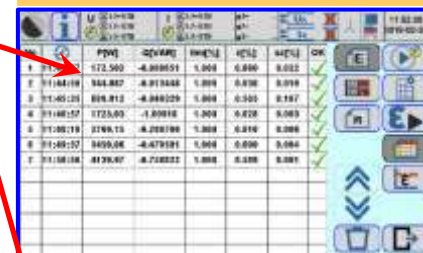
Ok	No	Load Point
	1	U: 500V 50Hz
	2	U: 230V 50Hz
	3	U: 110V 50Hz
	4	U: 57V 50Hz
	5	I: 120A 50Hz
	6	I: 12A 50Hz
	7	I: 1A 50Hz
	8	I: 0.12A 50Hz
	9	I: 0.02A 50Hz
	10	F: 230V 50Hz

	L1	L2	L3
U	230.000V	230.000V	230.000V
I	10.0000A	10.0000A	10.0000A
ϕ	0.00°	0.00°	0.00°
f	50.000Hz		
P	L123		
	6900.00W		
	0%		
	0%		
	0%		

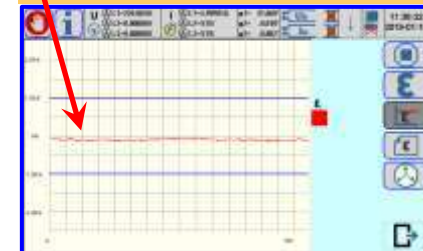
Load point execution and error results



Results in table format



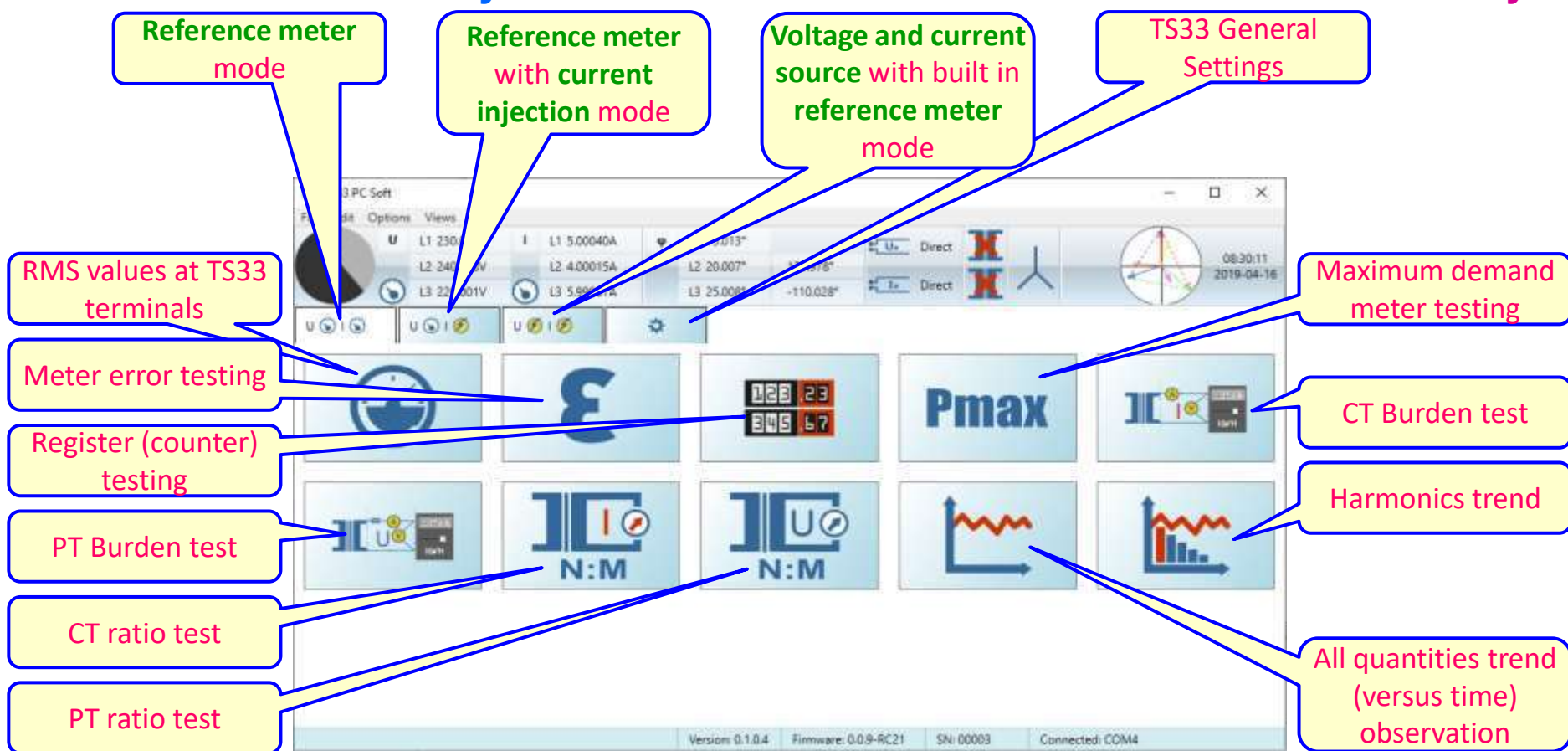
Results as diagram



Conclusion: Automatic testing allows to perform full test of Energy Meter on site due to **Meter Type** and **Procedures** stored in data base. As results are displayed:

- table, which can be stored in memory and transferred to PC
- diagram of error in [%] against load point in the procedure

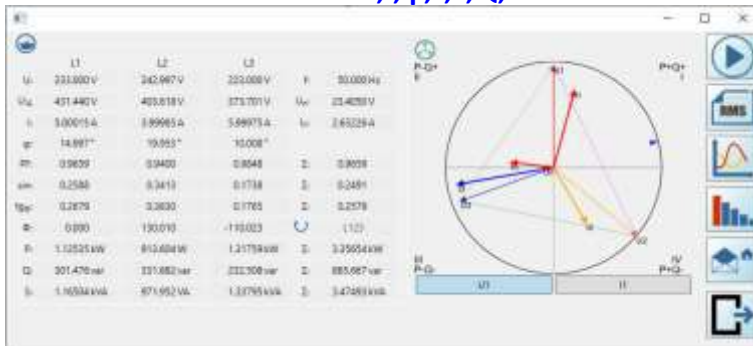
TS33 PC Soft functionality: all of TS33 functions can be accessed in remote way



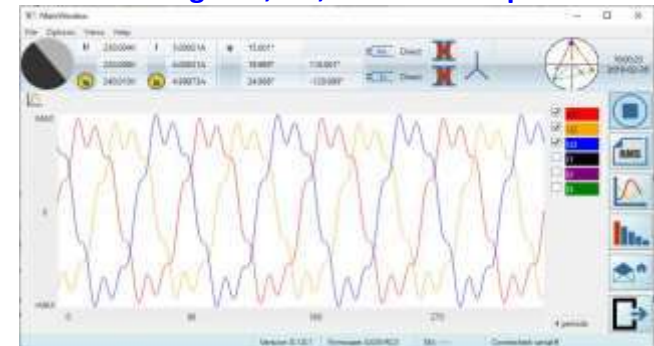
Conclusion: All functionality of the TS33 is available through **USB**, **Bluetooth** and **Ethernet** connection (including **Internet** remote control). TS33 PC Soft enables to download real time results of measurement made by TS33, download stored in memory results, readout the SD card memory and remote control of measurements. Results can be then saved in Data Base, printed or exported to eg. Excel sheet.

TS33 PC Soft functionality: example screenshots

RMS values of U,I, ϕ ,F,P,Q,S



Voltage U1, U2, U3 oscilloscope



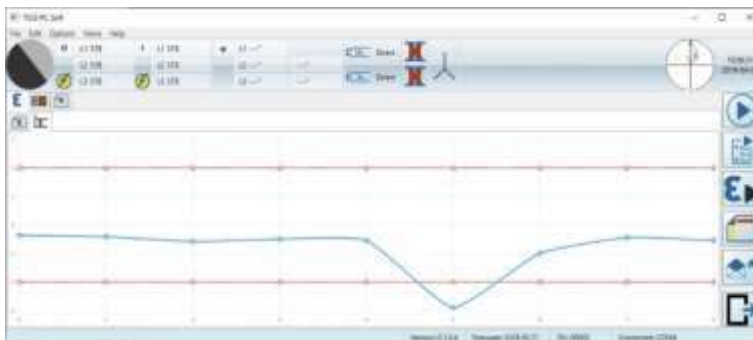
Voltage, current and THD trend



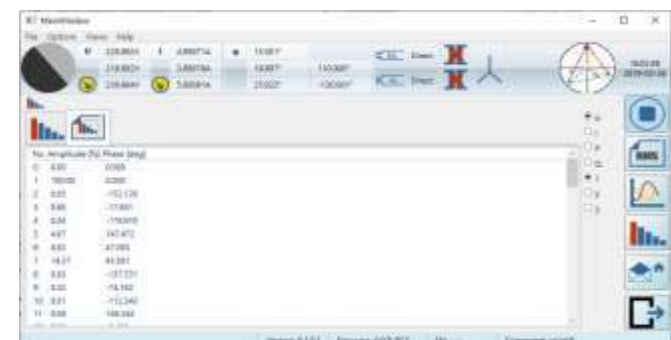
Harmonics in voltage U1



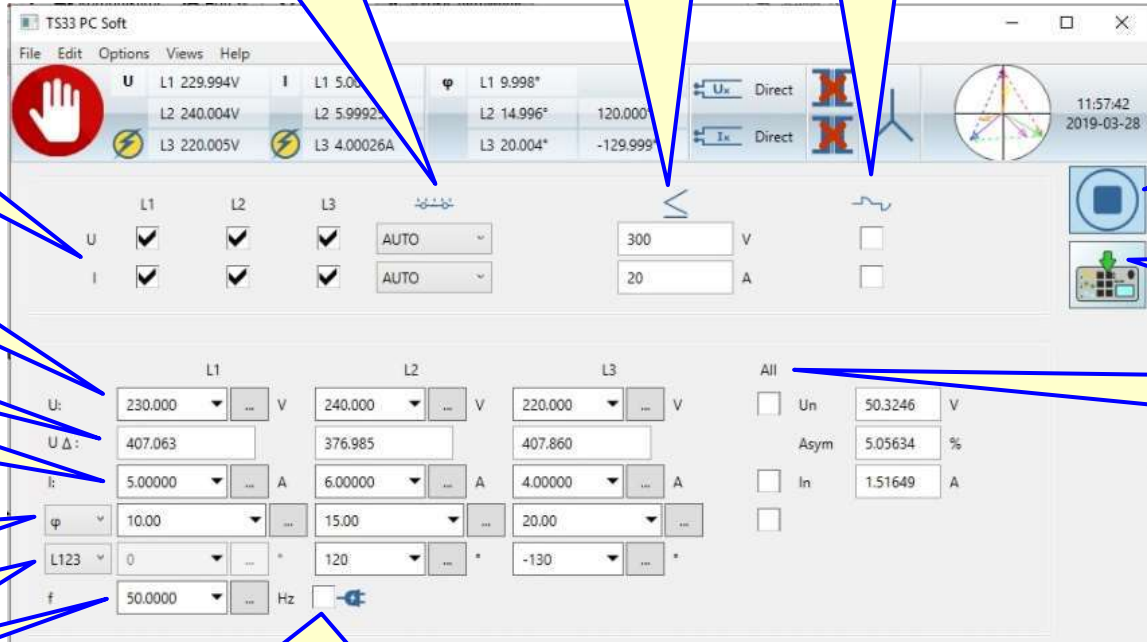
Meter error versus I load $\epsilon=f(I)$



Harmonics in table form



TS33 PC Soft functionality: remote control of TS33 source



The screenshot shows the TS33 PC Soft interface with various controls and readouts. Callouts point to specific features:

- Operation with auto range or constant range:** Points to the range selection dropdowns for voltage and current.
- Setting maximum value of Voltage or Current:** Points to the input fields for maximum voltage (300 V) and current (20 A).
- Switching harmonics ON / OFF:** Points to the harmonic control buttons.
- Switching ON / OFF of individual U & I channels:** Points to the channel selection checkboxes.
- Voltage in phase L1 L2 L3:** Points to the phase voltage readouts.
- Voltage between phases:** Points to the phase-to-phase voltage readouts.
- Current in phase L1 L2 L3:** Points to the phase current readouts.
- Phase shift U&I:** Points to the phase shift settings for voltage and current.
- Phase shift between Voltages:** Points to the phase shift settings between voltage phases.
- Frequency setting:** Points to the frequency input field (50.0000 Hz).
- Frequency synchronised with power frequency:** Points to the synchronization checkbox.
- START / STOP generation:** Points to the start/stop button.
- Set data acceptance:** Points to the data acceptance button.
- Setting the same value for all three phases:** Points to the 'All' checkbox for setting common values.

- ▶ Individual setting in each phase value of voltage, current, power factor and phase shift between voltages,
- ▶ Independent switching ON / OFF of each current and voltage in phase L1, L2, L3,
- ▶ Automatic or manual range selection,
- ▶ Protection against overvoltage or overcurrent,
- ▶ Pure sinusoidal or harmonic distorted signal generation.

TS33: testing three phase electronic (static) Energy Meter example (1)

TS33 as **Voltage and Current Source** and Reference Meter and meter under test connected **directly**



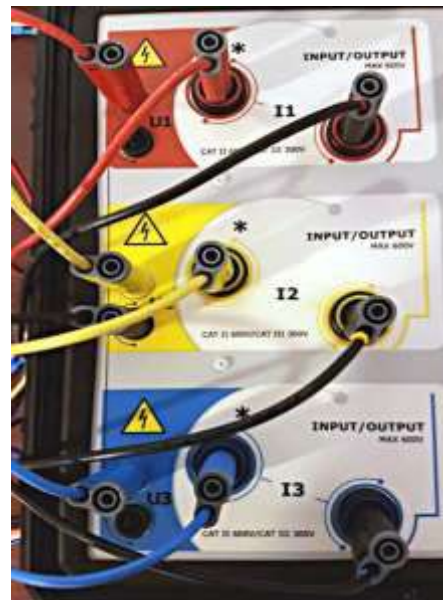
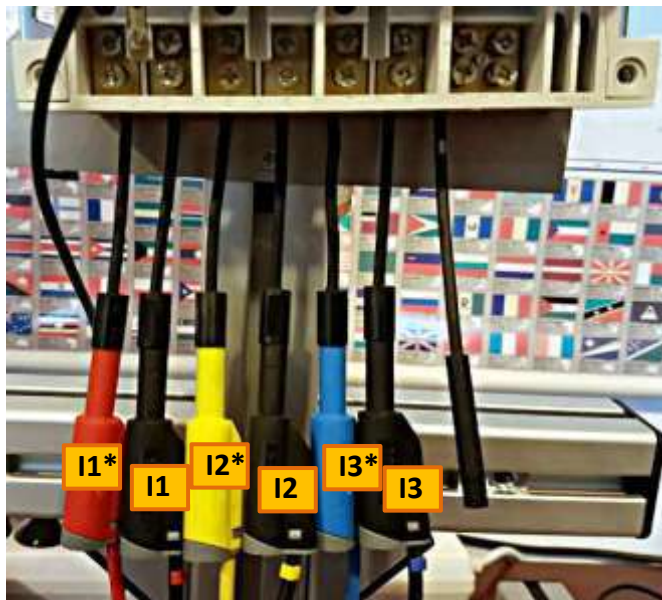
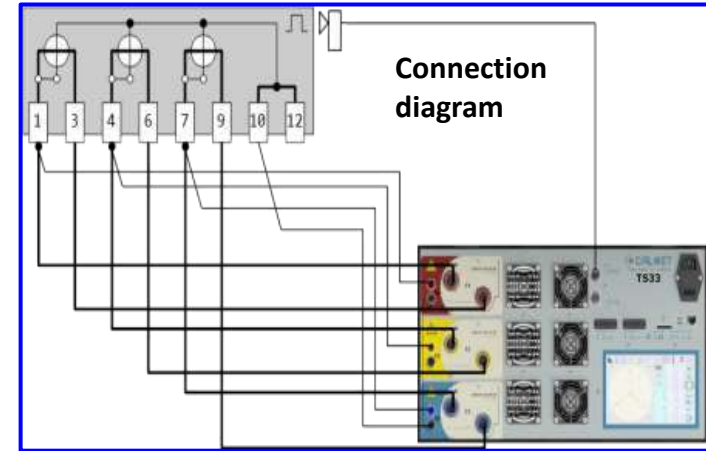
Meter parameters:

Base voltage: 230V
Base current: 5A
Max. current: 100A
Meter constant:
1000 imp/kWh

Typical three phase electronic meter with LED and its parameters

CAUTION!!!
Unconnect meter
from network before
connection to TS33
(voltage and current is
delivered by TS33)

Connect current I1, I2, I3, N by means of „Cu” pins and then voltage U1, U2, U3 by stacked, safety plugs to I1*, I2*, I3* respectively and then to TS33 inputs U and I.



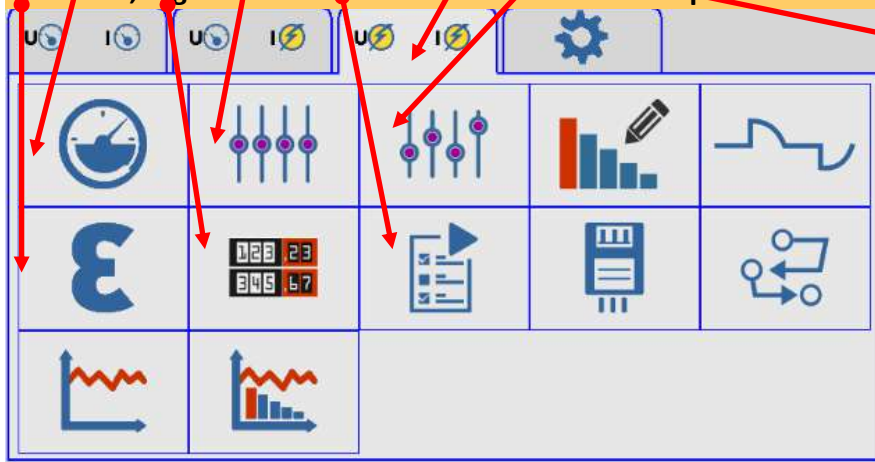
TS33: testing three phase electronic (static) Energy Meter example (2)

TS33 as **Voltage and Current Source** and Reference Meter and meter under test connected **directly**



Connected meter ready for testing

In the TS33 LCD select U&I generation mode and then RMS values at the output, setting symmetric U&I, setting asymmetric U&I, error test, register test or whole characteristics test procedure



Setting the output values (load point)

Three phase operation; individual outputs switch ON/OFF

Limit of maximum voltage & current

Send to the output

Generate signal

Set harmonics

Set value of Voltage

Set value of current

Set value of frequency

Set phase shift between U1&U2

Set phase shift between U2&U3

Set synchronization with network frequency

Set value of phase shift U&I

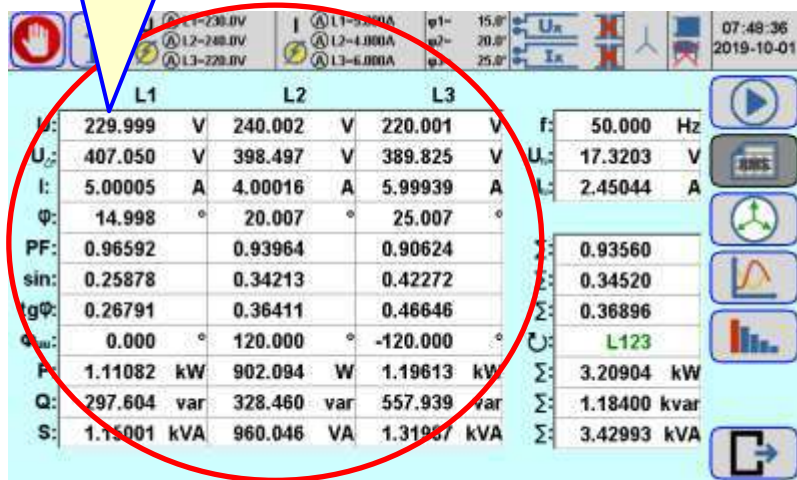
U		L1		L2		L3	
U	250 V	230.00 V	240.00 V	220.00 V			
I	30 A	5.0000 A	4.0000 A	6.0000 A			
φ		15.000 °	20.000 °	25.000 °			
U ₁₂₃		0.000 °	120.000 °	-120.000 °			
f		50.000 Hz					

TS33: testing three phase electronic (static) Energy Meter example (3)

TS33 as **Voltage and Current Source** and Reference Meter and meter under test connected **directly**

Load point parameters

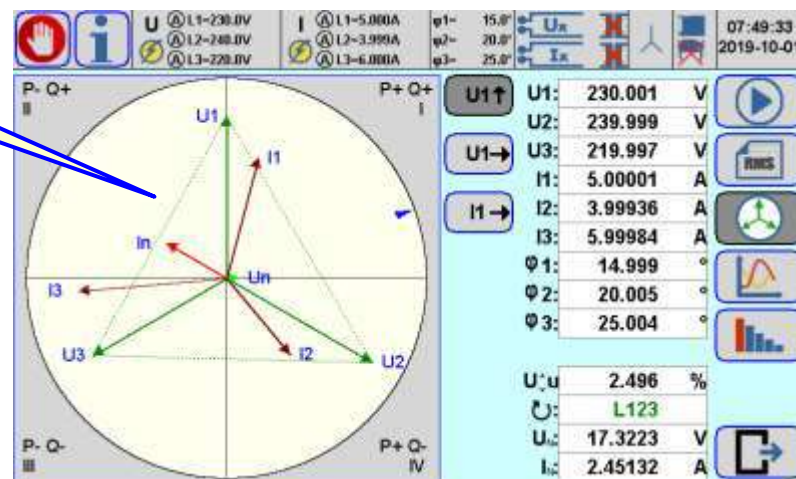
This mode requires meter disconnection!



Vector diagram

Testing schedule:

- connect voltage and current by clamps
- enter meter parameters and start error measurement

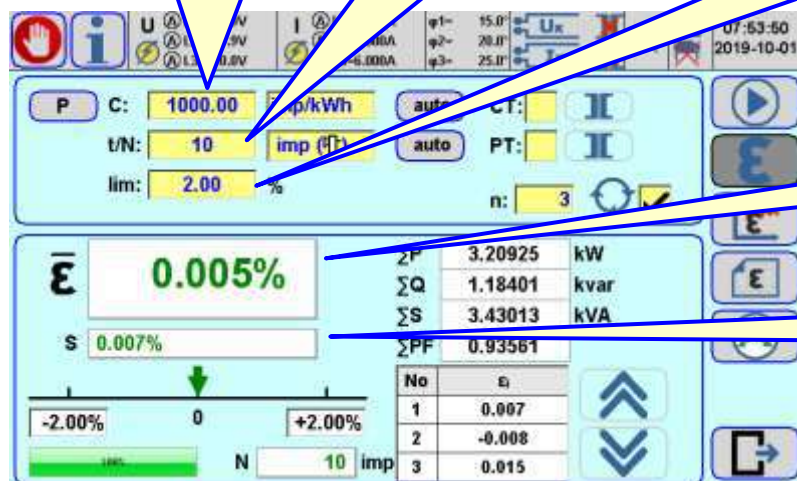


Meter constant

Time of test

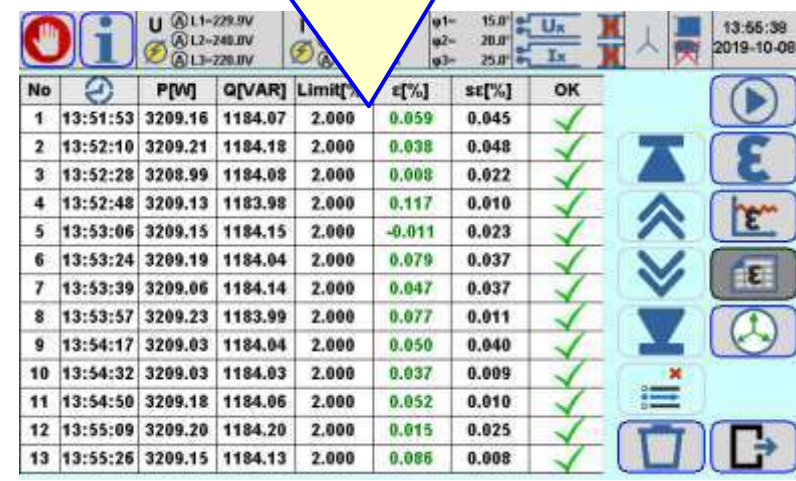
Class of Meter under test

Table with recorded results versus time



Averaged error result

Standard deviation



TS33: testing three phase electronic (static) Energy Meter example (4)

TS33 as **Voltage and Current Source** and Reference Meter and meter under test connected **directly**

Automatic Procedure for whole load characteristics

Meter Type Definition

Meter name: AP20EC3G
Connection type: Pafal Apaton
Power type: P+
Comment: 07:58:40 2019-10-01
Base voltage: Ub 230 V Umax 250 V
Max. voltage: 250 V
Max. current: Ib 5 A Imax 100 A
Base current: 5 A
Delay time: 5 s
Meter constant: 1000 imp/kWh
PT primary & secondary voltage: Upn 57.7 V lpn 57.7 A
CT primary & secondary current: Usn 2.5 V Isn 2.5 A

Test Point and Procedure Definition

Add load point to list
Time of measurement: 08:02:14 2019-10-01
Load point name: 100pr
Meter Class: E
Number of measurements per result: n 3
lim 2.000 t 20 s
L1 L2 L3 L123
U 100.000 % 100.000 % 100.000 %
I 100.000 % 100.000 % 100.000 %
φ 0.00 ° 0.00 ° 0.00 °
L123 0.00 ° 120.00 ° -120.00 °
f 50.000 Hz
Frequency
Harmonics
Phase shift U&U

List edition insert, move up/down remove

No	
1	Sprlmin
2	10pr
3	20pr
4	50pr
5	100pr
6	150pr
7	200pr
8	300pr
9	400pr

List of load points

Meter error test
Voltage in [%]
Current in [%]
Phase shift U&I
Vector rotation

To save Meter Type and Procedure use **i** button and then **button**

Meter or Procedure name field

00000008

TS33: testing three phase electronic (static) Energy Meter example (5)

TS33 as **Voltage and Current Source** and Reference Meter and meter under test connected **directly**

Automatic Procedure for whole load characteristics

Meter Test Execution

Meter type name: AP20EC3G

Test procedure name: 5TO400PR

Test starting: S0 test C test

Load point name: 400pr

Selected load points:

No	Load Point
1	5prlmin
2	10pr
3	20pr
4	50pr
5	100pr
6	150pr
7	200pr
8	300
9	400

Load point values:

	L1	L2	L3
U	230.000V	230.000V	230.000V
I	20.0000A	20.0000A	20.0000A
ϕ	0.00°	0.00°	0.00°
f	50.000Hz		
P	L123		
	13800.0W		

Table with results for each load point:

No	Time	P[W]	Q[VAR]	ϵ [%]	st[%]	lim[%]	OK
1	08:15:54	172.508	0.015868	0.227	0.073	2.000	✓
2	08:17:47	344.991	0.019772	0.061	0.020	2.000	✓
3	08:19:24	690.018	0.033439	0.053	0.006	2.000	✓
4	08:21:01	1724.93	0.176649	0.030	0.008	2.000	✓
5	08:22:32	3449.80	0.176346	0.020	0.002	2.000	✓
6	08:24:00	5175.01	0.370188	0.015	0.002	2.000	✓
7	08:25:28	6900.57	0.503801	0.015	0.001	2.000	✓
8	08:26:58	10349.8	1.27710	0.014	0.003	2.000	✓
9	08:28:25	13748.7	2.56355	0.016	0.006	2.000	✓

Individual load point test

Averaged error result: 0.016%

Standard deviation: 0.006%

Error limit: 2.000%

Individual errors:

No	ϵ
1	0.027
2	0.009
3	0.011

Summary Statistics:

	Value	Unit
ΣP	13748.7	W
ΣQ	2.56355	var
ΣS	13795.1	VA
ΣPF	0.99664	

Results transferred to the PC Soft as diagram



TS33: testing single phase electromechanical Energy Meter example (1)

TS33 as Reference Meter and meter under test directly connected



Meter parameters:

Base voltage: 230V

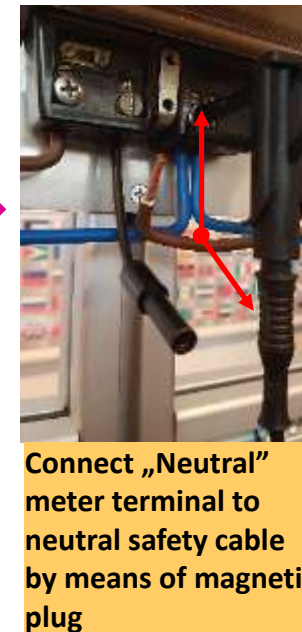
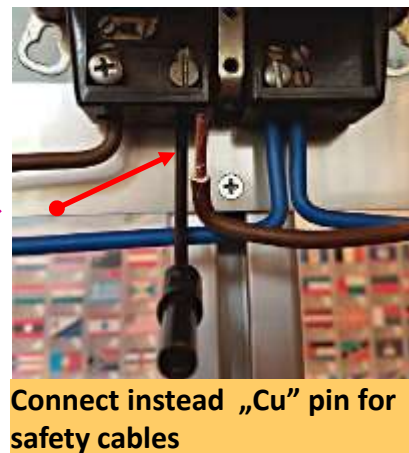
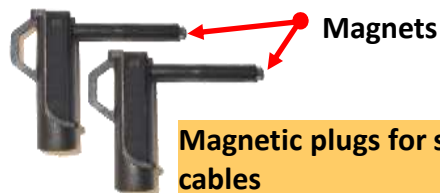
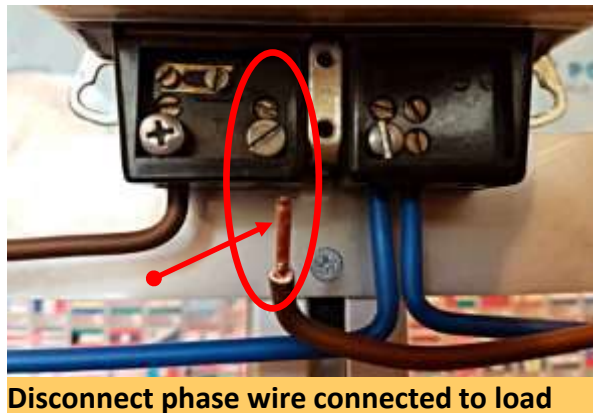
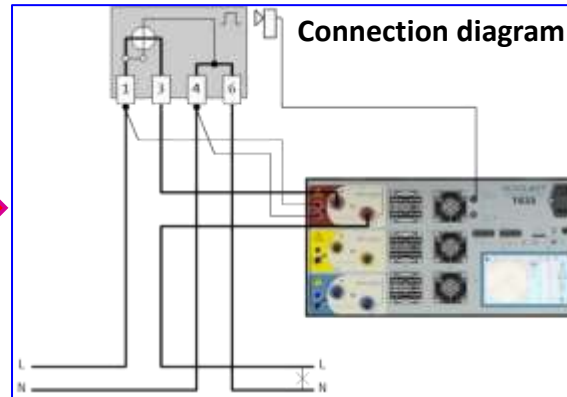
Base current: 5A

Max. current: 40A

Meter constant:

375 turns/kWh

Typical, „old fashioned”, electromechanical meter and its parameters



TS33 : testing single phase electromechanical Energy Meter example (2)

TS33 as Reference Meter and meter under test directly connected



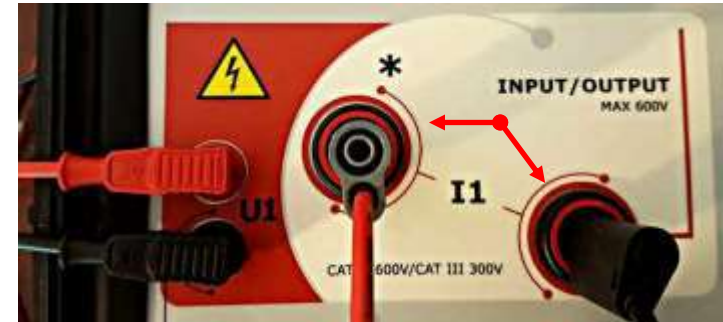
Connect cables from meter to voltage inputs of TS33



Connect phase current cable to „Cu” pin (red)



Connect return current cable by means of crocodile clip (black)



Connect current cables from meter to current inputs of TS33



Crocodile clip



Scanning head assembly:

- place mechanical fixing device in front of rotor
- „click” scanning head into hole
- connect cable to TS33 scanning head input no1

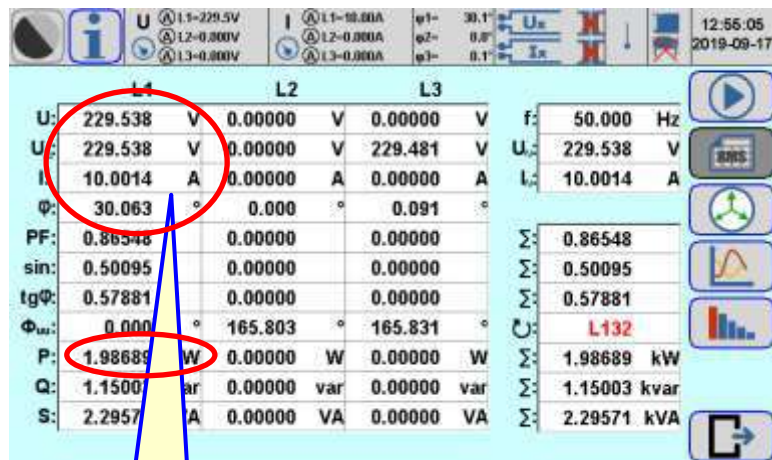
Now the measurement system is ready to test meter error and register test

In the TS33 LCD select U&I measurement mode and then RMS measurements, error test or register test



TS33 : testing single phase electromechanical Energy Meter example (3)

TS33 as Reference Meter and meter under test directly connected



Vector diagram

Testing schedule:

- connect meter
- check voltage current, PF and vector diagram
- enter meter parameters and start error measurement



Load point parameters

Meter constant

Class of Meter under test

TS33 enables fast and efficient way of testing

Type of power measured by meter

Time of test

Number of results for averaging

Table with recorded results versus time



Averaged error result

Standard deviation

Partial error results



TS33 : testing single phase electronic (static) Energy Meter example (1)

TS33 as Reference Meter and meter under test directly connected



Meter parameters:

Base voltage: 230V

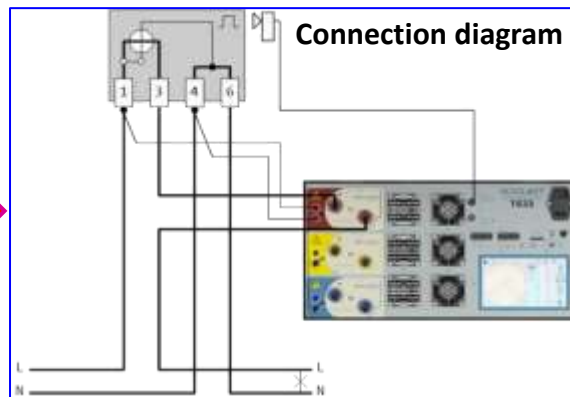
Base current: 5A

Max. current: 60A

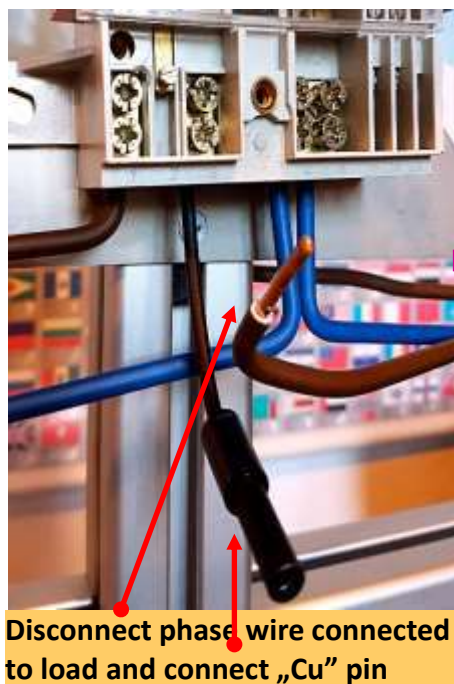
Meter constant:

6400 imp/kWh

Typical single phase electronic meter with LED and its parameters



Wiring to meter terminals



Disconnect phase wire connected to load and connect „Cu” pin



Connect safety plug and crocodile clip to phase and load current accordingly



Connect voltage by safety magnetic plugs



Connect voltage and current to TS33 inputs

TS33 : testing single phase electronic (static) Energy Meter example (2)

TS33 as Reference Meter and meter under test directly connected



Assembly scanning head fix to see LED in hole



„Click” scanning head and set LED sensing option

Meter constant

Time of test

Class of Meter under test

Averaged error result

Load point parameters

START test button

Interface showing test parameters and results:

- Parameters: C: 6400.00 imp/Wh, t/N: 10 s, lim: 1.00 %, CT: I, PT: I, n: 3
- Averaged error result: $\bar{\epsilon} = 0.299\%$
- Load point parameters: $\Sigma P = 994.597$ W, $\Sigma Q = 575.201$ var, $\Sigma S = 1.14895$ kVA, $\Sigma PF = 0.86566$
- Results table:

No	ϵ_i
1	0.303
2	0.295

Interface showing real-time measurements:

	L1	L2	L3		
U:	229.719 V	0.00000 V	0.00000 V	f:	50.000 Hz
U ₀ :	229.719 V	0.00000 V	229.662 V	U ₀ :	229.719 V
I:	5.00058 A	0.00000 A	0.00000 A	I ₀ :	5.00058 A
ϕ :	30.052 °	0.000 °	0.091 °	Σ :	0.86557
PF:	0.86557	0.00000	0.00000	Σ :	0.50079
sin:	0.50079	0.00000	0.00000	Σ :	0.57856
tg ϕ :	0.57856	0.00000	0.00000	Σ :	0.57856
Φ_{uu} :	0.000 °	51.809 °	51.837 °	Σ :	994.304 W
P:	994.304 W	0.00000 W	0.00000 W	Σ :	575.268 var
Q:	575.268 var	0.00000 var	0.00000 var	Σ :	1.14873 kVA
S:	1.14873 kVA	0.00000 VA	0.00000 VA	Σ :	1.14873 kVA

Table with recorded results versus time

Table with recorded results versus time:

No		P[W]	Q[VAR]	Limit[%]	ϵ [%]	SE[%]	OK
1	11:01:04	994.499	575.310	1.000	0.258	0.008	✓
2	11:01:45	994.507	575.301	1.000	0.258	0.004	✓
3	11:02:25	994.500	575.293	1.000	0.265	0.007	✓
4	11:03:05	994.527	575.309	1.000	0.271	0.006	✓
5	11:03:43	994.525	575.293	1.000	0.301	0.008	✓
6	11:04:25	994.538	575.295	1.000	0.298	0.004	✓
7	11:05:05	994.539	575.291	1.000	0.296	0.004	✓
8	11:05:46	994.548	575.288	1.000	0.281	0.005	✓
9	11:06:24	994.550	575.286	1.000	0.283	0.002	✓
10	11:07:04	994.539	575.270	1.000	0.295	0.001	✓
11	11:07:44	994.558	575.275	1.000	0.280	0.003	✓
12	11:08:22	994.556	575.270	1.000	0.273	0.006	✓
13	11:09:00	994.555	575.260	1.000	0.279	0.006	✓

TS33 : testing single phase electronic (static) Energy Meter example (1)

TS33 as Reference Meter and meter under test connected by **current clamps CT100AC**



Meter parameters:

Base voltage: 230V

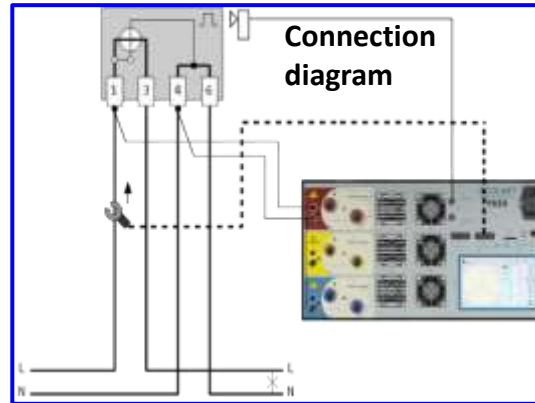
Base current: 5A

Max. current: 60A

Meter constant:

6400 imp/kWh

Typical single phase electronic meter with LED and its parameters



Wiring to meter terminals



Current clamp closed on phase to load cable. Note **direction** ➔!



Connect current clamp plug into the socket on TS33. Clamp symbol appears on display.



Connect voltage magnetic plugs and assembly the scanning head

TS33 : testing single phase electronic (static) Energy Meter example (2)

TS33 as Reference Meter and meter under test connected by current clamps CT100AC



Connect voltage cables to TS33

Current clamps connected

Load point parameters

START test button

	L1	L2	L3
U	229.736 V	0.00000 V	0.00000 V
I	4.99855 A	0.00000 A	0.00000 A
Φ	30.030 °	0.000 °	0.729 °
PF	0.86576	0.00000	0.00000
sin	0.50046	0.00000	0.00000
gΦ	0.57806	0.00000	0.00000
P	994.190 W	0.00000 W	0.00000 W
Q	574.702 var	0.00000 var	0.00000 var
S	1.14835 kVA	0.00000 VA	0.00000 VA

Current clamps do not require any break or modification of metering installation

Meter constant

Class of Meter under test

Time of test

Averaged error result

Table with recorded results versus time

Parameter	Value
P	6400.00
t/N	10
lim	1.00 %
CT	I
PT	I
n	3
ΣP	994.193 W
ΣQ	574.663 var
ΣS	1.14833 kVA
ΣPF	0.86577
ε	0.350%
s	0.004%
No	1
ε	0.345
No	2
ε	0.355

No	Time	P[W]	Q[VAR]	Limit[%]	ε[%]	sc[%]	OK
1	11:43:03	994.163	574.684	1.000	0.353	0.005	✓
2	11:43:43	994.177	574.689	1.000	0.350	0.001	✓
3	11:44:21	994.173	574.689	1.000	0.355	0.003	✓
4	11:45:01	994.164	574.686	1.000	0.356	0.003	✓
5	11:45:41	994.172	574.688	1.000	0.345	0.004	✓
6	11:46:22	994.173	574.686	1.000	0.356	0.004	✓
7	11:47:03	994.161	574.674	1.000	0.367	0.004	✓
8	11:47:44	994.165	574.675	1.000	0.374	0.006	✓
9	11:48:25	994.165	574.676	1.000	0.382	0.005	✓
10	11:49:04	994.167	574.677	1.000	0.378	0.006	✓
11	11:49:47	994.174	574.681	1.000	0.369	0.005	✓
12	11:50:27	994.161	574.669	1.000	0.381	0.006	✓
13	11:51:08	994.175	574.673	1.000	0.371	0.005	✓

TS33 : testing single phase electronic (static) Energy Meter example (1)

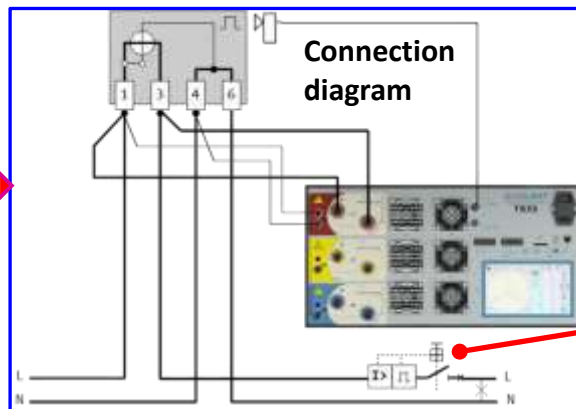
TS33 as **Current Source** and Reference Meter and meter under test connected **directly**



Meter parameters:

Base voltage: 230V
Base current: 5A
Max. current: 60A
Meter constant:
6400 imp/kWh

Typical single phase electronic meter with LED and its parameters



CAUTION!!!
Switch OFF the circuit breaker before TS33 connection (voltage is taken from network, current is injected by TS33)



connect current input and output of the meter (eg. magnetic plugs) by means of safety cables to TS33 current inputs;
connect neutral meter terminal to the neutral voltage input of TS33;
Shunt TS33 voltage input and current output (*).



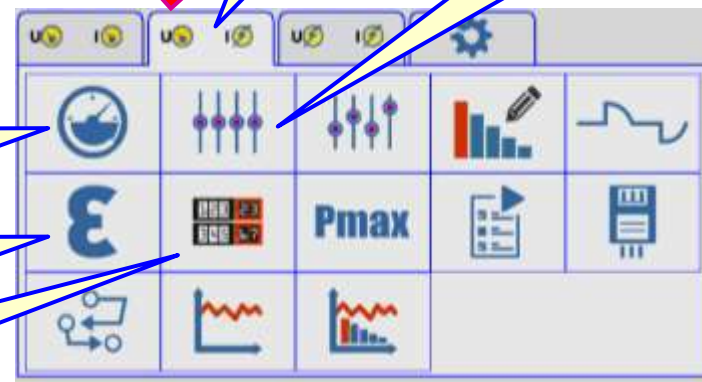
In the TS33 LCD select U measurement and I generation mode

Setting value of current and phase shift

RMS measured values

Meter error test

Meter register test



TS33 : testing single phase electronic (static) Energy Meter example (2)

TS33 as **Current Source** and Reference Meter and meter under test connected **directly**

Single phase operation

Limit of maximum current

Send to the output

RMS values at the output

Generate signal

Set value of current

Set value of phase shift

Testing schedule:

- connect meter
- set current and phase shift
- enter meter parameters and start error measurement

This mode doesn't require any meter disconnection!

Meter constant

Number of pulses

Class of Meter under test

Averaged error result

Standard deviation

Table with recorded results versus time

No	P[W]	Q[VAR]	Limit[%]	ε[%]	σε[%]	OK	
1	12:34:11	996.515	575.352	1.000	0.196	0.012	✓
2	12:34:29	996.579	575.376	1.000	0.191	0.012	✓
3	12:34:49	996.618	575.452	1.000	0.219	0.012	✓
4	12:35:05	996.573	575.460	1.000	0.197	0.010	✓
5	12:35:23	996.560	575.389	1.000	0.214	0.013	✓
6	12:35:41	996.636	575.260	1.000	0.206	0.008	✓
7	12:36:00	996.500	575.420	1.000	0.202	0.016	✓
8	12:36:18	996.673	575.412	1.000	0.206	0.010	✓
9	12:36:37	996.614	575.395	1.000	0.195	0.002	✓
10	12:36:54	996.406	575.311	1.000	0.196	0.009	✓
11	12:37:13	996.541	575.501	1.000	0.188	0.012	✓
12	12:37:31	996.504	575.479	1.000	0.198	0.004	✓
13	12:37:49	996.781	575.388	1.000	0.197	0.006	✓

TS33: testing three phase electronic (static) Energy Meter example (1)

TS33 as Reference Meter and meter under test connected by means of **current clamps**

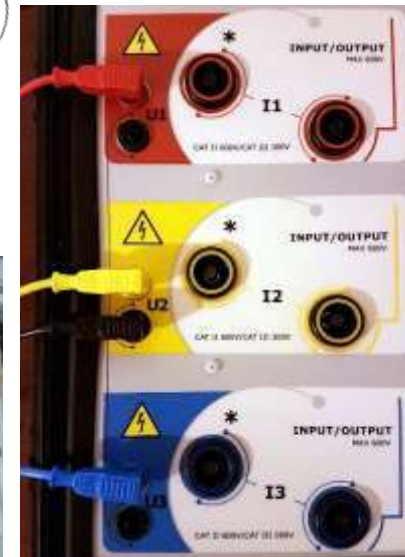
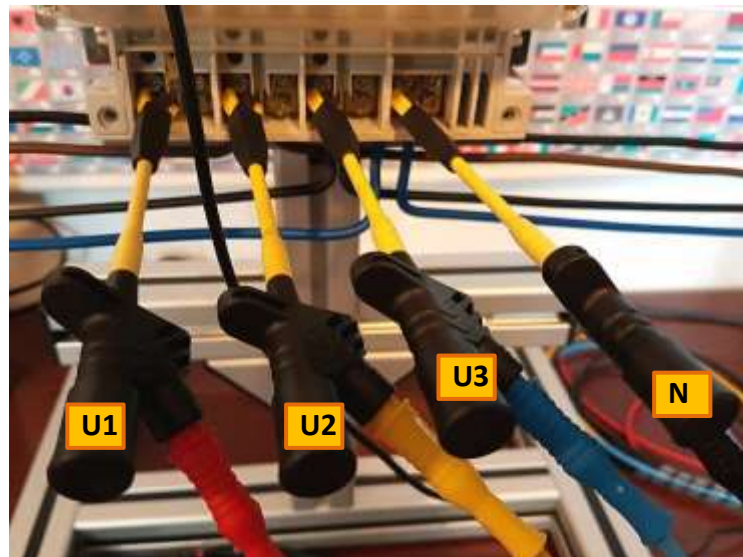
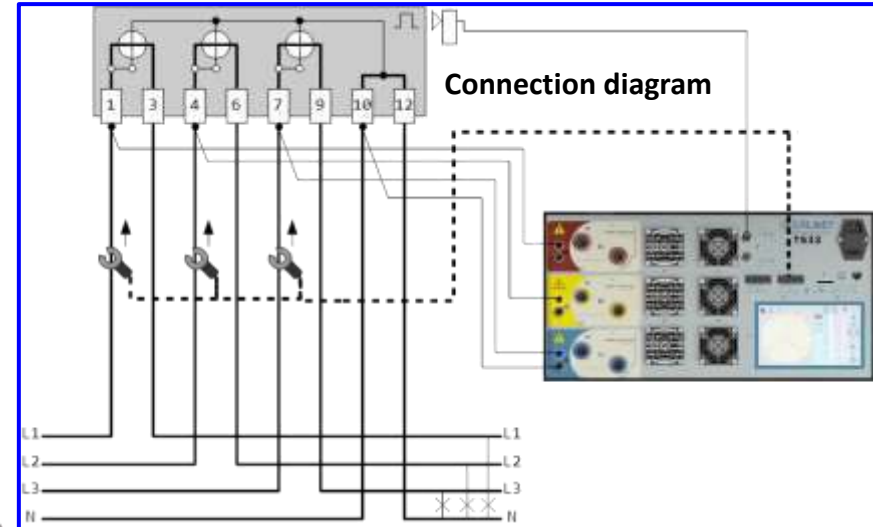


Meter parameters:

Base voltage: 230V
Base current: 5A
Max. current: 100A
Meter constant: 1000 imp/kWh

Typical three phase electronic meter with LED and its parameters

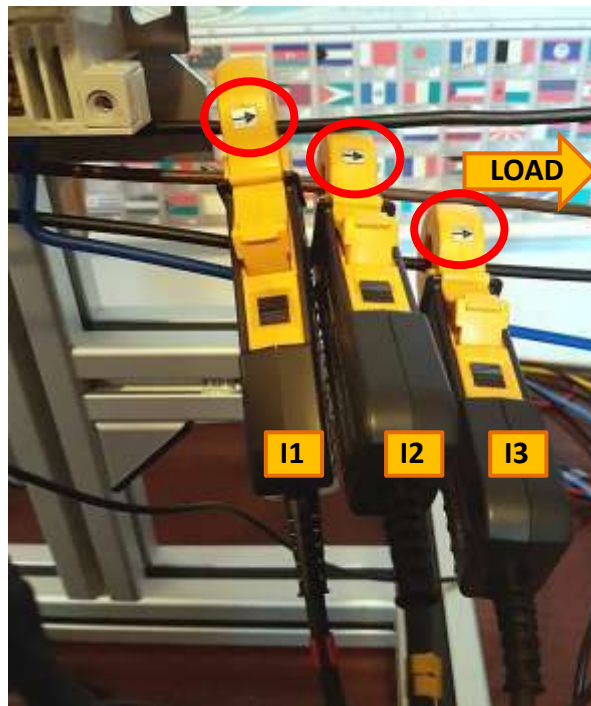
Connect voltage U1, U2, U3 and neutral N by means of crocodile clips



Connect voltage U1, U2, U3 and neutral N to voltage inputs of TS33.
Neutral inputs in the TS33 are internally connected between them.

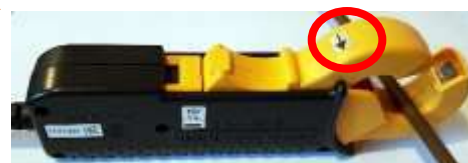
TS33: testing three phase electronic (static) Energy Meter example (2)

TS33 as Reference Meter and meter under test connected by means of current clamps



Close current clamps on load cables, respectively I1, I2, I3. Take care about clamps direction (⇒)

Assembly to the meter and connect to the TS33 photo scanning head



Open clamp jaws and place them on wire. Direction (⇒)!

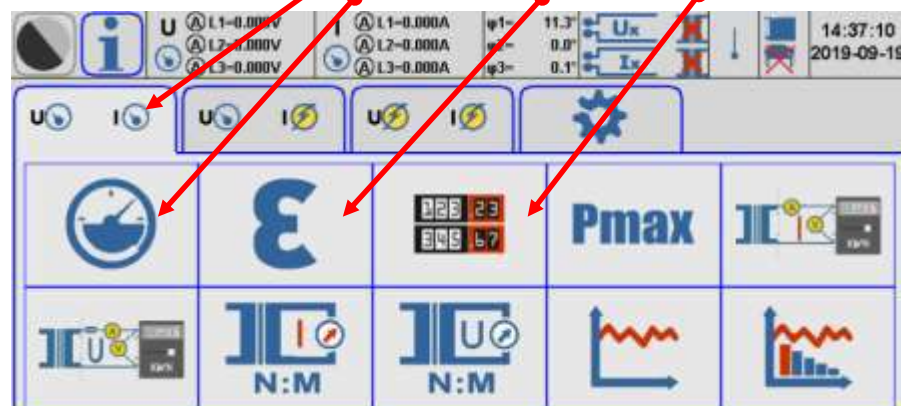


Close clamp jaws and lock them. Direction (⇒)!



Connect common current clamps output to the TS33 input

In the TS33 LCD select U&I measurement mode and then RMS measurements, error test or register test



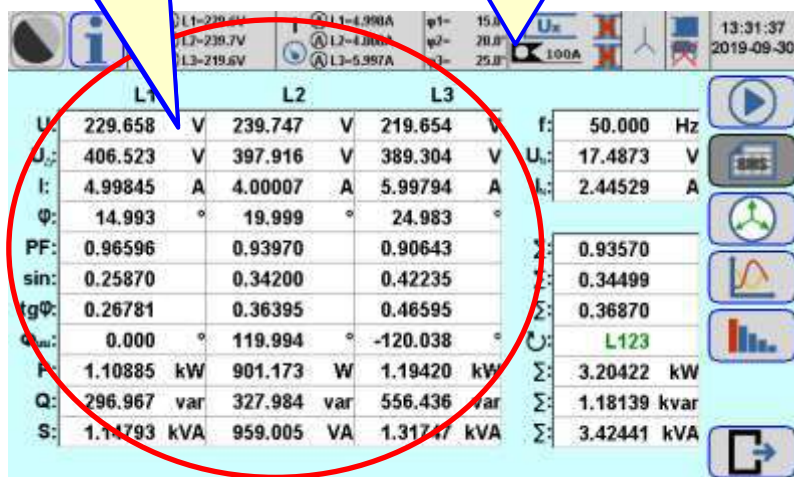
TS33: testing three phase electronic (static) Energy Meter example (3)

TS33 as Reference Meter and meter under test connected by means of current clamps

Load point parameters

CT100AC current clamp

This mode doesn't require any meter disconnection!



Vector diagram

Testing schedule:

- connect voltage and current by clamps
- enter meter parameters and start error measurement

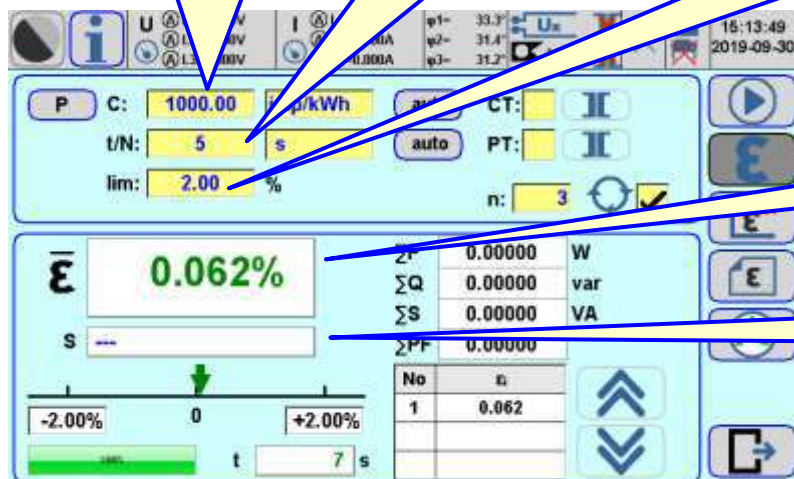


Meter constant

Time of test

Class of Meter under test

Table with recorded results versus time



Averaged error result

Standard deviation

No		P[W]	Q[VAR]	Limit[%]	ε[%]	se[%]	OK
1	13:35:13	3204.27	1181.38	2.000	0.032	0.013	✓
2	13:35:54	3204.27	1181.39	2.000	0.046	0.010	✓
3	13:36:36	3204.26	1181.38	2.000	0.026	0.004	✓
4	13:37:15	3204.29	1181.39	2.000	0.031	0.001	✓
5	13:38:00	3204.28	1181.39	2.000	0.042	0.007	✓
6	13:38:44	3204.26	1181.39	2.000	0.044	0.007	✓
7	13:39:26	3204.28	1181.39	2.000	0.045	0.009	✓
8	13:40:08	3204.28	1181.39	2.000	0.039	0.004	✓
9	13:40:50	3204.31	1181.41	2.000	0.032	0.006	✓
10	13:41:33	3204.28	1181.40	2.000	0.035	0.005	✓
11	13:42:15	3204.31	1181.40	2.000	0.044	0.006	✓
12	13:42:57	3204.30	1181.40	2.000	0.040	0.005	✓
13	13:43:39	3204.30	1181.39	2.000	0.035	0.010	✓

TS33: testing current transformers CT ratio and phase shift error example (1)

TS33 as Reference Meter and CT primary and secondary current measured by current clamps



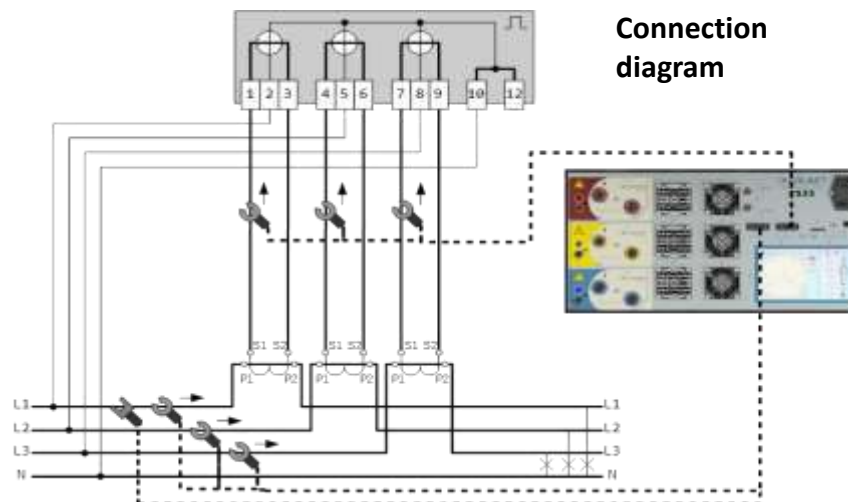
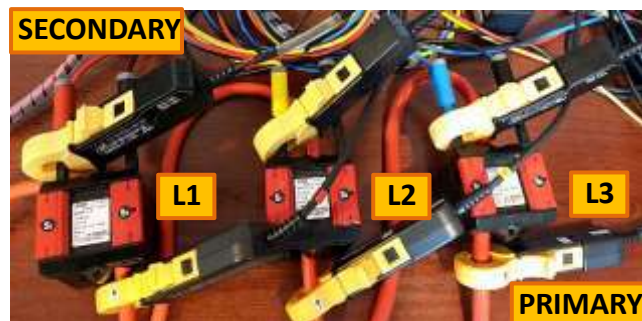
CT parameters:

Ratio: 100/5A

Power: 2.5VA

Class: 0.2

Typical current transformer CT in metering installation



Connection diagram

TS33 can test automatically up to 3 different CTs at time

Accuracy class of current transformer

Nominal primary current

Nominal secondary current

Primary current

Secondary current

Phase error

Actual ratio

Ratio error

Standard deviation

CT100AC current clamps on primary and secondary side

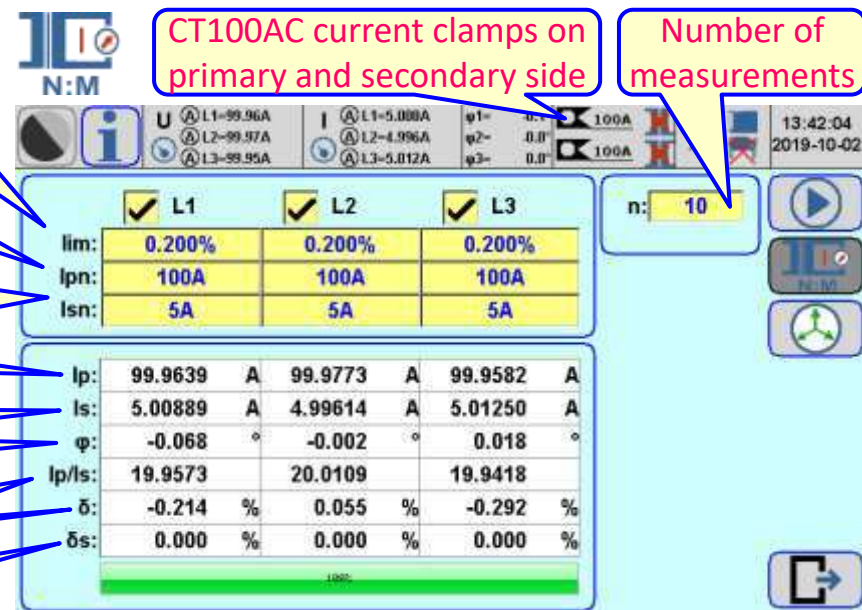
Number of measurements

TS33 side clamps connection



Primary clamps

Secondary clamps



TS33: testing current transformers CT burden example (1)

TS33 as Reference Meter and CT secondary current measured by current clamps and voltage directly



CT parameters:

Ratio: 100/5A

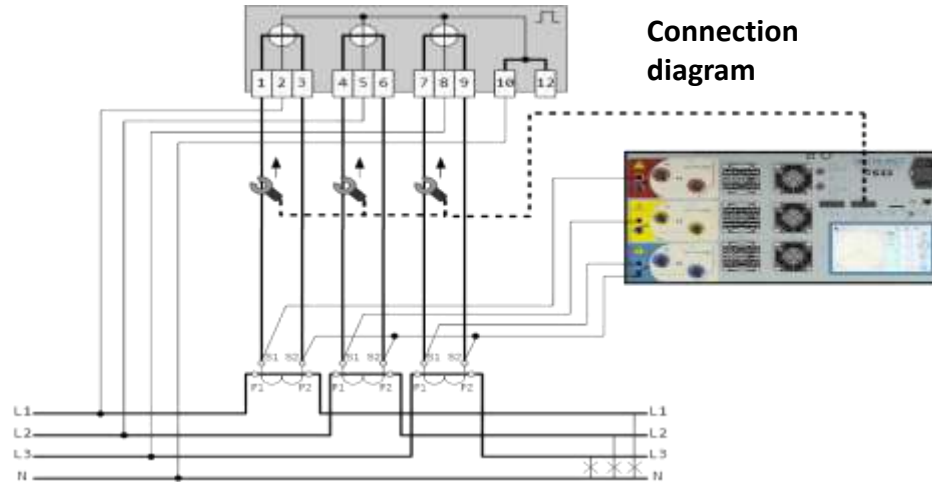
Power: 2.5VA

Class: 0.2

Typical current transformer CT in metering installation



TS33 side voltage connection



Connection diagram

TS33 can test automatically up to 3 different CTs at time

Voltage and clamps connection to the CT



Nominal secondary current

Nominal secondary power

Voltage at secondary CT side

Secondary current

Phase shift

Power factor

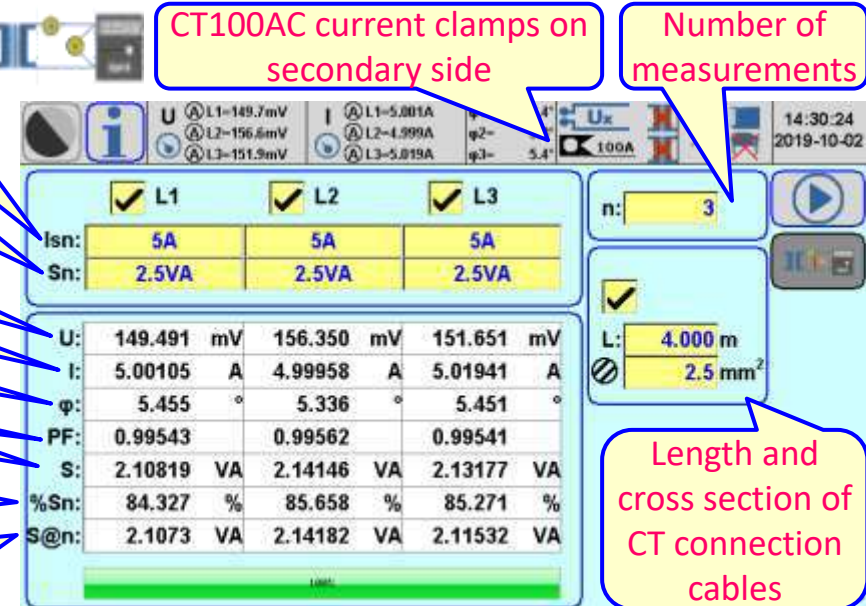
Apparent power

% of used power

S which would be at nominal current

CT100AC current clamps on secondary side

Number of measurements



Length and cross section of CT connection cables

TS33: how to order – versions, options, accessories

TS33 versions: accuracy class 0.02%, 0.04% or accuracy class 0.1%

Standard scope of delivery



TS33 Automatic Test System



Power cord



Fuses



C091 Amphenol connector

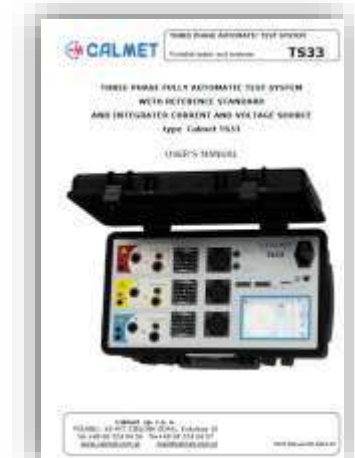


EA36

Voltage and current connection cables



**Manufacturer Calibration
Certificate**



Operation manual

TS33: how to order – versions, options, accessories

TS33 optional accessories:

Optional scope of delivery **1**



Laptop PC



TS33 PC Soft



CT10AC current clamps



CT100AC current clamps



CT1000AC current clamps



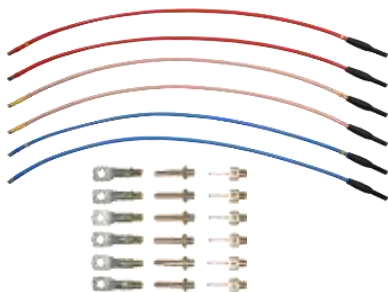
FCT3000AC.B flexible clamps



AmpLiteWire 2000AC
(@150kV)



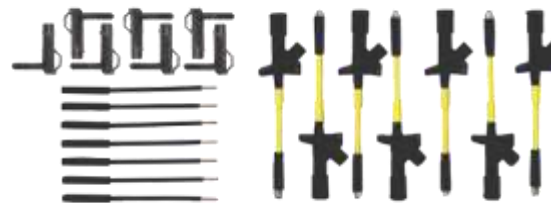
VoltLiteWire 40kVC



EA30 120A cable set



DR200D thermal printer



EA20 accessories for safety
cables



CF106H photo head for LED
& mechanical meters

TS33: how to order – versions, options, accessories

TS33 optional accessories:

Optional scope of delivery **2**



ER10 single position rack for hanging meter



EH10.3 Quick Connector for meters



ER10H.3 single position rack with quick connector



ET31 case for additional accessories



Calibration Certificate from ISO17025 accredited lab



Certificate of Origin from Customs and Chamber of Commerce

To see more devices and information visit our Web site: www.calmet.com.pl



Smart Calibration Devices

[HOME](#)
[PRODUCTS](#)
[LABORATORY](#)
[DOWNLOAD](#)
[ABOUT US](#)
[CONTACT](#)

TOP PRODUCTS

- TS33 - Three phase Fully Automatic Test System
- C300B - Power Calibrator
- TE30 - Working Standard

PRODUCTS BY CATEGORY

- Power calibrators and power quality calibrators
- Multifunction calibrators
- Resistance calibrators
- Electricity meters testers and reference standards
- Instrument transformers testers
- Protection relays testers
- Network quality analysers
- Meter test stations

Electricity meters testers and reference standards



TS33 - Three-phase Fully Automatic Test System with Reference Standard and Integrated Current and Voltage Source

The Calmet TS33 portable test system consists of a three-phase reference meter of accuracy class 0.04% (or 0.1%) and an integrated three-phase current and voltage source up to 3x120A/600V

[Data sheet](#)

[Read more ...](#)



TE30 - Portable Three-Phase Working Standard and Power Quality Analyzer

Electricity meters tester class 0.05 and 0.1. Three phase tester of current transformers and analyser of power network quality. It makes possible electricity meters testing on the site or in the laboratory

[Data sheet](#)

[Read more ...](#)



Caltest 10 - Electricity meters tester

Single phase portable electricity meters tester class 0.5 powered from tested circuit with load force possibility apart from tested object. There is no need to disconnect the users during measurement

[Data sheet](#)

or contact by e-mail: mail@calmet.com.pl