Universal Calibrator for Electrical Quantities for Power Utilities, Industry and R&D

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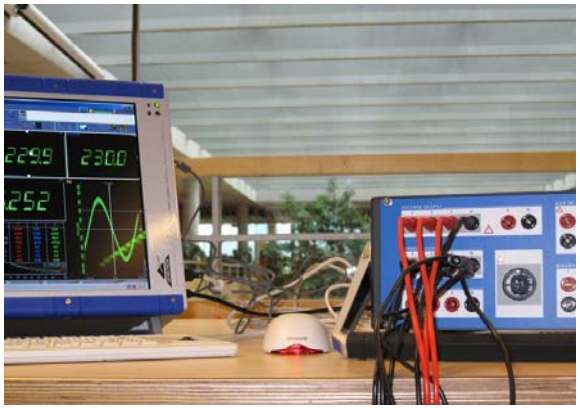
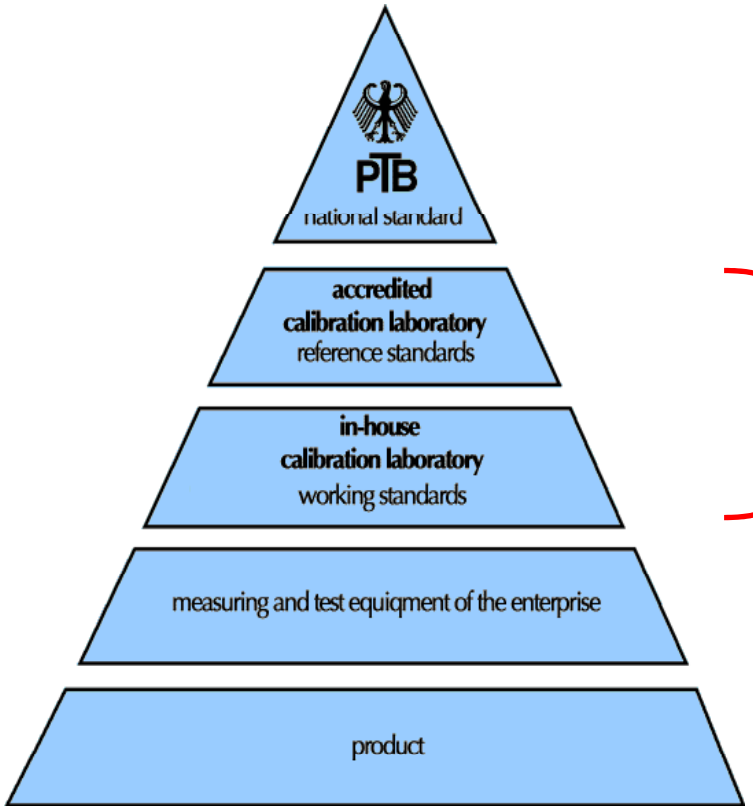
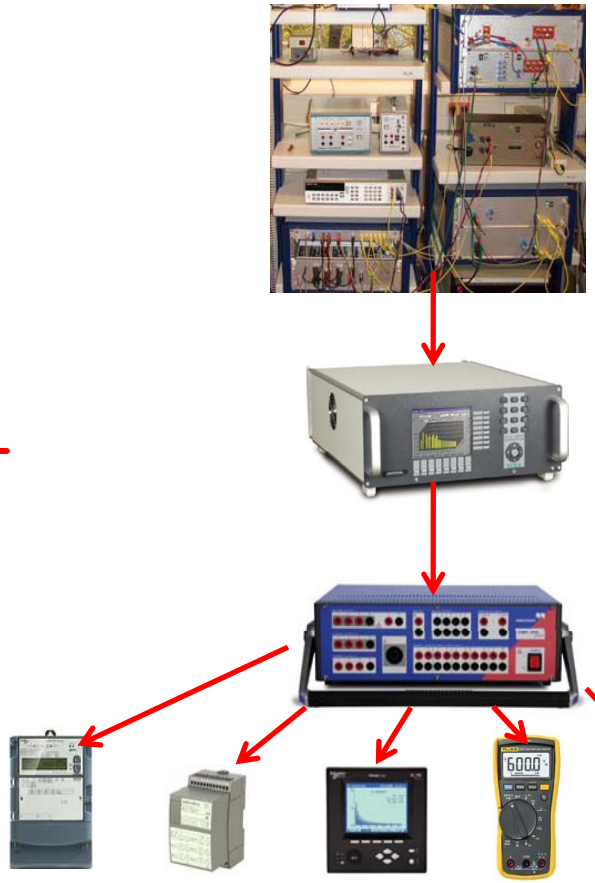


Encuentro Nacional de Metrología Eléctrica 2009
18-20 de noviembre
Electromagnetismo
Temperatura y Propiedades Termofísicas
Tiempo y Frecuencia

Calibration Hierarchy





0,005 %

0,01 %

0,05 %

0,2 %

Calibration of Measurement Devices

METERs

TRANSDUCERs

PQ METERs

PMUs (Phasor Measurement Units)

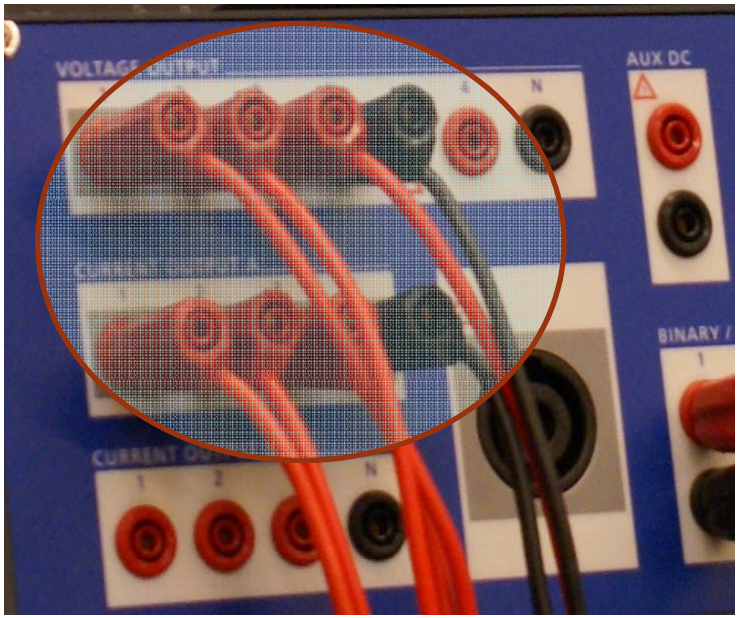
MERGING UNITs

All kind of other measurement equipment like

- current clamps
- multi meters
- Watt meters

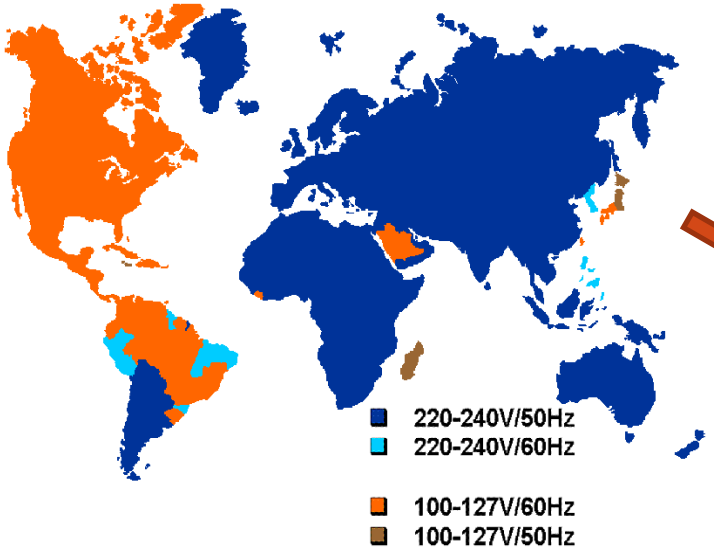
... any kind of measuring instruments for electrical quantities

Requirements: three-phase system

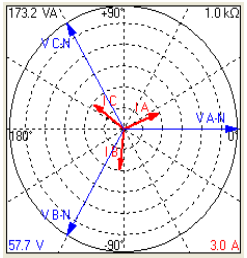


Devices in Three Phase Systems **require** **Three Phase Calibrators**

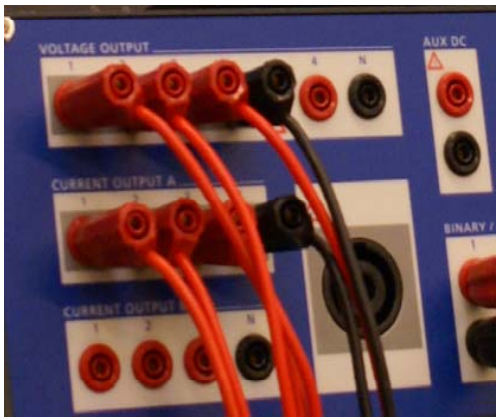
Requirements: quantities



0 ... 360°
10 ... 400 Hz



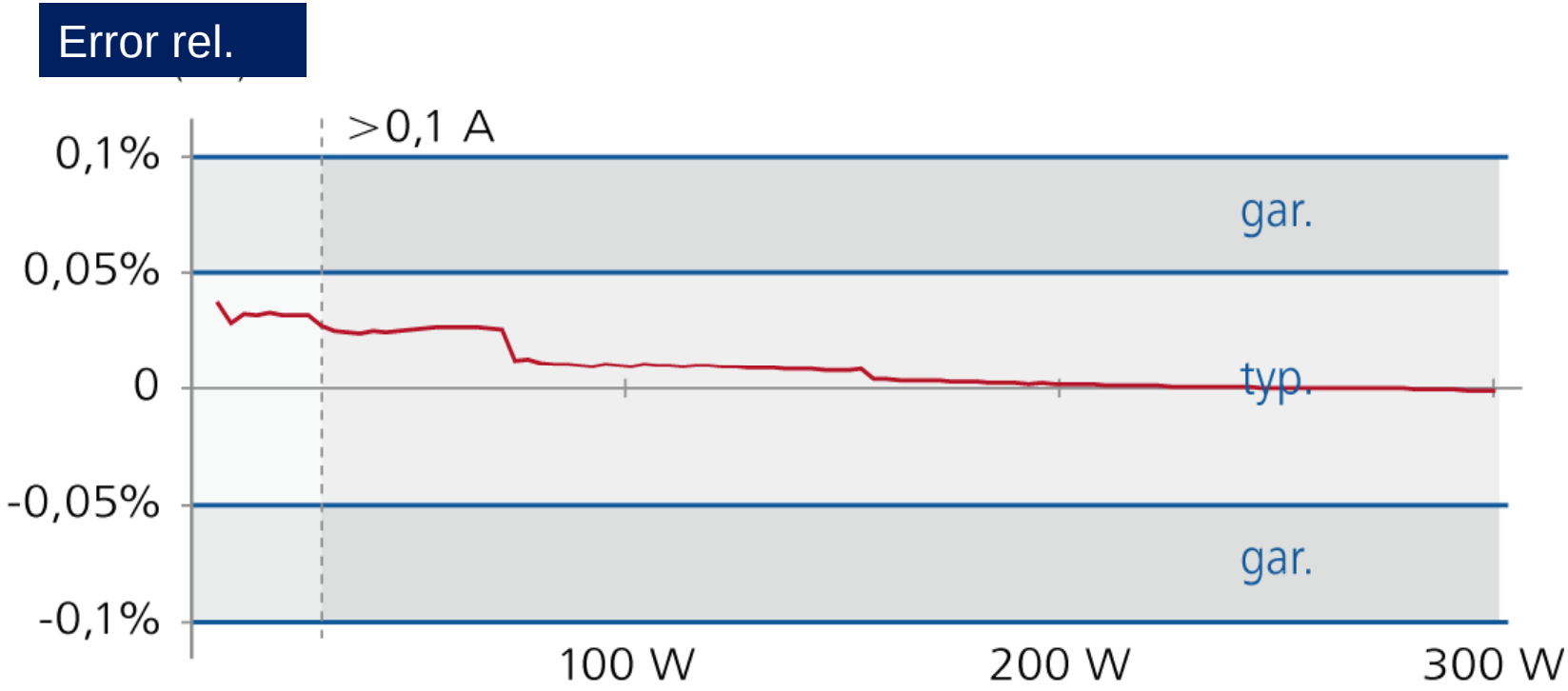
0 ... 300 V



0 ... 5 A (5*In)

0 ... 25 A
for directly connected devices

Requirements: high accuracy

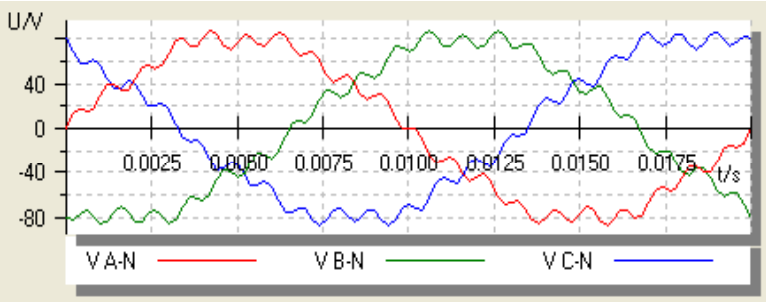


Accuracy (relative) of the output power

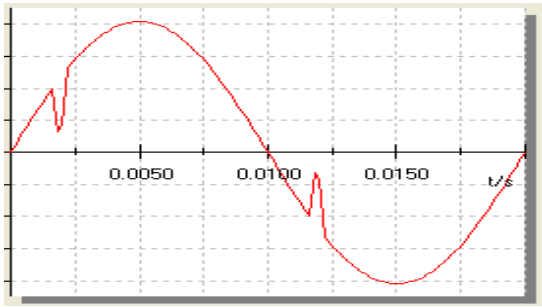
Requirements: high accuracy

Volt. & Curr. Accuracy	Error < 0,015 % rd. + 0,005 % rg. typ. Error < 0,04 % rd. + 0,01 % rg. guar.
Power Accuracy	Error (rel.) < 0,05 % typ. < 0,1 % guar. 10 – 63 Hz, 50 ... 127,5 / 300 V 0,1 ... 12,5 A
THD	I: 0,025 % typ. V: 0,015 % typ.
Frequency (volt./curr.)	DC ... 1000 Hz, error/drift < 0,5 ppm / ± 1 ppm

Requirements: signal generation



Harmonics
Interharmonics
IEC 61000-4-30 / IEEE1159:
50th harmonic
Frequency portions → 3 kHz



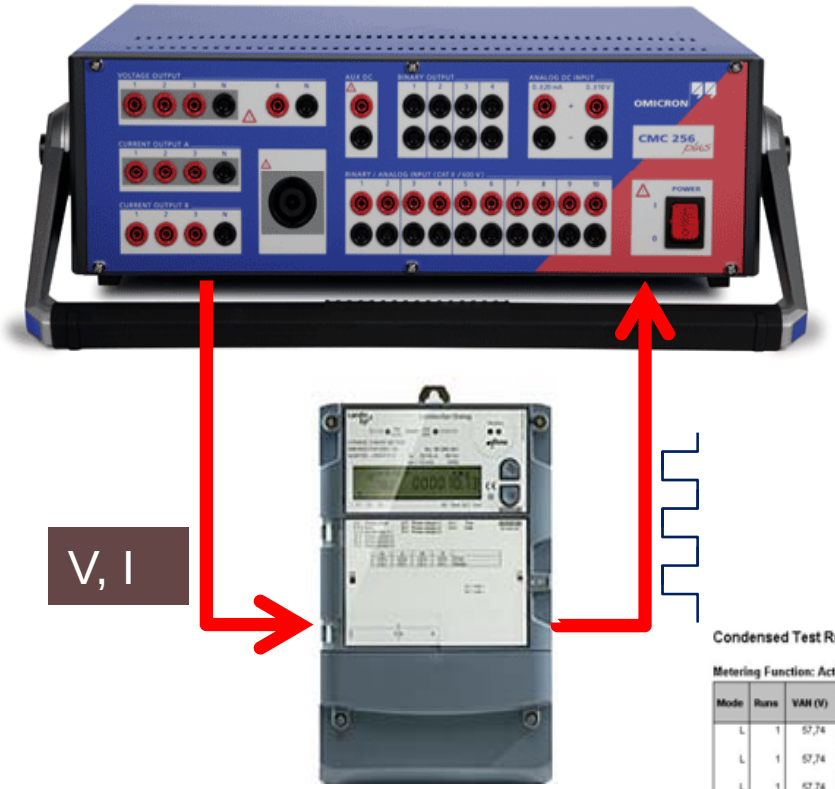
Transients
IEC 61000-4-30 / IEEE1159:
Notches (fast dips)
or other irregular waveform

Requirements: Test Automation

Ethernet port

USB port

Application: Calibration of a meter



Condensed Test Report

Metering Function: Active Power - Exporting

Mode	Runs	VAH (V)	VBH (V)	VCH (V)	IA (A)	IB (A)	IC (A)	cos φ	Nominal			Actual			Result	Correc.	Eval.
									Pul	Quant.	Time	Pul	Quant.	Time			
L	1	57,74	57,74	57,74	1,000	1,000	1,000	1,0000	50	500,000 mWh	10,392 s	50	499,389 mWh	10,380 s	0,1224 %	n/a	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,8660 ind	50	500,000 mWh	12,000 s	50	499,367 mWh	11,985 s	0,1268 %	n/a	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,8660 cap	50	500,000 mWh	12,000 s	50	499,413 mWh	11,986 s	0,1176 %	n/a	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,5000 ind	25	250,000 mWh	10,392 s	25	249,670 mWh	10,379 s	0,1321 %	n/a	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,5000 cap	25	250,000 mWh	10,392 s	25	249,742 mWh	10,382 s	0,1031 %	n/a	Passed

Application: Meter Testing with Active Sources

Basically on-site testing (portable test set)

Single position test system (1 meter at a time)

Basically for testing CT/VT connected meters

For commissioning, routine testing, testing on request, ...

Power/Time test method

Standard test-setup without reference meter

Testing with real or „virtual“ reference meter also possible

All type of meters to be tested

3 phase/4-wire

3 phase/3 wire

1 phase

Wh importing/exporting

varh importing/exporting

V^2h (iron losses of power transformers)

I^2h (copper losses of power transformers)

Qh (Quantity hour)

Various test modes required

$$\text{Error in [\%]} = \frac{E_{\text{Test Object}} - E_{\text{CMC}}}{E_{\text{CMC}}} \times 100\ [\%]$$

Load test

- **result: meter error (measurement unit !)**
- **if more than 1 run: average error and standard deviation**

Mechanism test (Dial test)

- **result: meter error (incl. counting mechanism and meas. unit)**

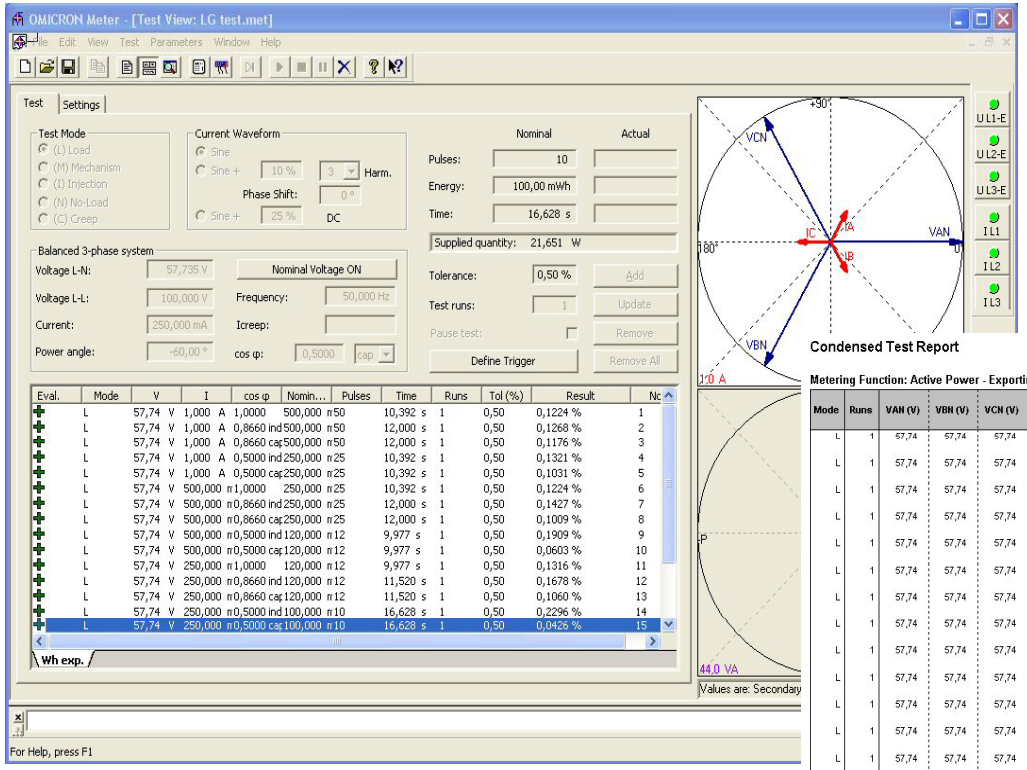
No-load test

- **result: started or not started**

Creep test

- **result: started or not started**

Test Software

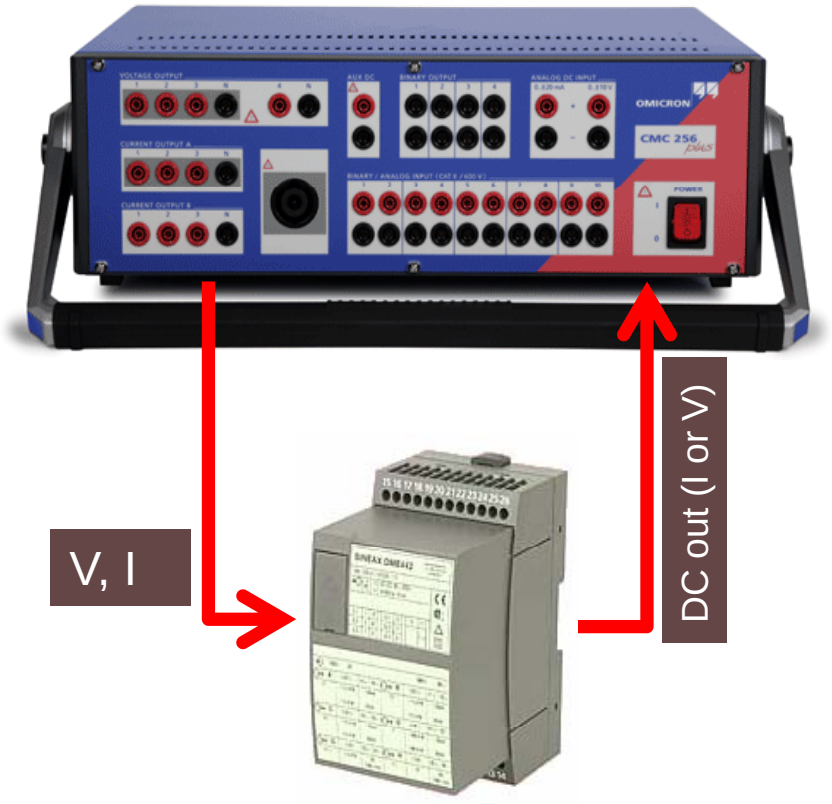


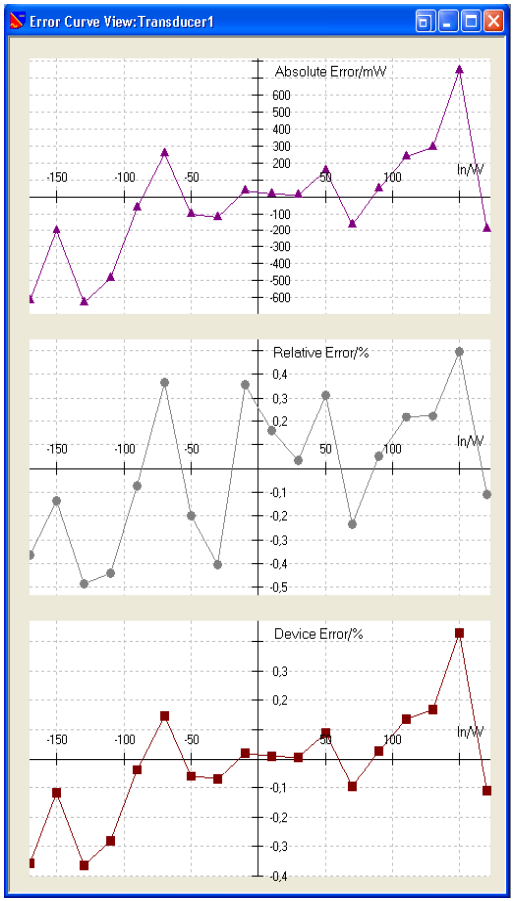
Condensed Test Report

Metering Function: Active Power - Exporting

Mode	Runs	VAN (V)	VBN (V)	VCN (V)	IA (A)	IB (A)	IC (A)	cos φ	Nominal			Actual			Result	Correc.	Eval.
									Pul	Quant.	Time	Pul	Quant.	Time			
L	1	57,74	57,74	57,74	1,000	1,000	1,000	1,0000	50	500,000 mWh	10,392 s	50	499,389 mWh	10,380 s	0,1224 %	n/a	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,8660 ind	50	500,000 mWh	12,000 s	50	499,367 mWh	11,985 s	0,1268 %	n/a	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,8660 cap	50	500,000 mWh	12,000 s	50	499,413 mWh	11,986 s	0,1176 %	n/a	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,5000 ind	25	250,000 mWh	10,392 s	25	249,670 mWh	10,379 s	0,1321 %	n/a	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,5000 cap	25	250,000 mWh	10,392 s	25	249,742 mWh	10,382 s	0,1031 %	n/a	Passed
L	1	57,74	57,74	57,74	500,000 m	500,000 m	500,000 m	1,0000	25	250,000 mWh	10,392 s	25	249,694 mWh	10,380 s	0,1224 %	n/a	Passed
L	1	57,74	57,74	57,74	500,000 m	500,000 m	500,000 m	0,8660 ind	25	250,000 mWh	12,000 s	25	249,644 mWh	11,983 s	0,1427 %	n/a	Passed
L	1	57,74	57,74	57,74	500,000 m	500,000 m	500,000 m	0,8660 cap	25	250,000 mWh	12,000 s	25	249,748 mWh	11,988 s	0,1009 %	n/a	Passed
L	1	57,74	57,74	57,74	500,000 m	500,000 m	500,000 m	0,5000 ind	12	120,000 mWh	9,977 s	12	119,771 mWh	9,958 s	0,1909 %	n/a	Passed
L	1	57,74	57,74	57,74	500,000 m	500,000 m	500,000 m	0,5000 cap	12	120,000 mWh	9,977 s	12	119,928 mWh	9,971 s	0,0603 %	n/a	Passed
L	1	57,74	57,74	57,74	250,000 m	250,000 m	250,000 m	1,0000	12	120,000 mWh	9,977 s	12	119,842 mWh	9,963 s	0,1316 %	n/a	Passed
L	1	57,74	57,74	57,74	250,000 m	250,000 m	250,000 m	0,8660 ind	12	120,000 mWh	11,520 s	12	119,799 mWh	11,501 s	0,1678 %	n/a	Passed
L	1	57,74	57,74	57,74	250,000 m	250,000 m	250,000 m	0,8660 cap	12	120,000 mWh	11,520 s	12	119,873 mWh	11,508 s	0,1060 %	n/a	Passed
L	1	57,74	57,74	57,74	250,000 m	250,000 m	250,000 m	0,5000 ind	10	100,000 mWh	16,628 s	10	99,771 mWh	16,590 s	0,2296 %	n/a	Passed
L	1	57,74	57,74	57,74	250,000 m	250,000 m	250,000 m	0,5000 cap	10	100,000 mWh	16,628 s	10	99,957 mWh	16,621 s	0,0426 %	n/a	Passed
L	1	57,74	57,74	57,74	100,000 m	100,000 m	100,000 m	1,0000	6	60,000 mWh	12,471 s	6	59,919 mWh	12,454 s	0,1346 %	n/a	Passed
L	1	57,74	57,74	57,74	100,000 m	100,000 m	100,000 m	0,8660 ind	6	60,000 mWh	14,400 s	6	59,893 mWh	14,374 s	0,1795 %	n/a	Passed
L	1	57,74	57,74	57,74	100,000 m	100,000 m	100,000 m	0,8660 cap	6	60,000 mWh	14,400 s	6	59,943 mWh	14,386 s	0,0959 %	n/a	Passed
L	1	57,74	57,74	57,74	100,000 m	100,000 m	100,000 m	0,5000 ind	6	60,000 mWh	24,942 s	6	59,849 mWh	24,879 s	0,2518 %	n/a	Passed
L	1	57,74	57,74	57,74	100,000 m	100,000 m	100,000 m	0,5000 cap	6	60,000 mWh	24,942 s	6	59,991 mWh	24,938 s	0,0145 %	n/a	Passed

Application: Calibration of a Transducer

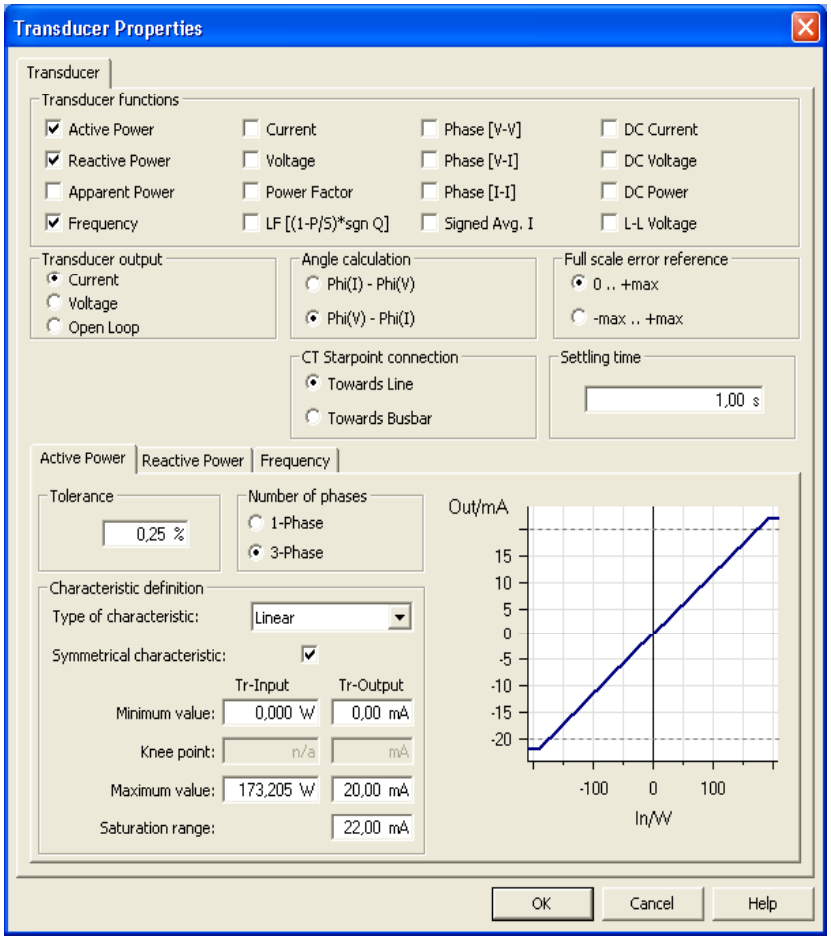




Application: Transducer Testing

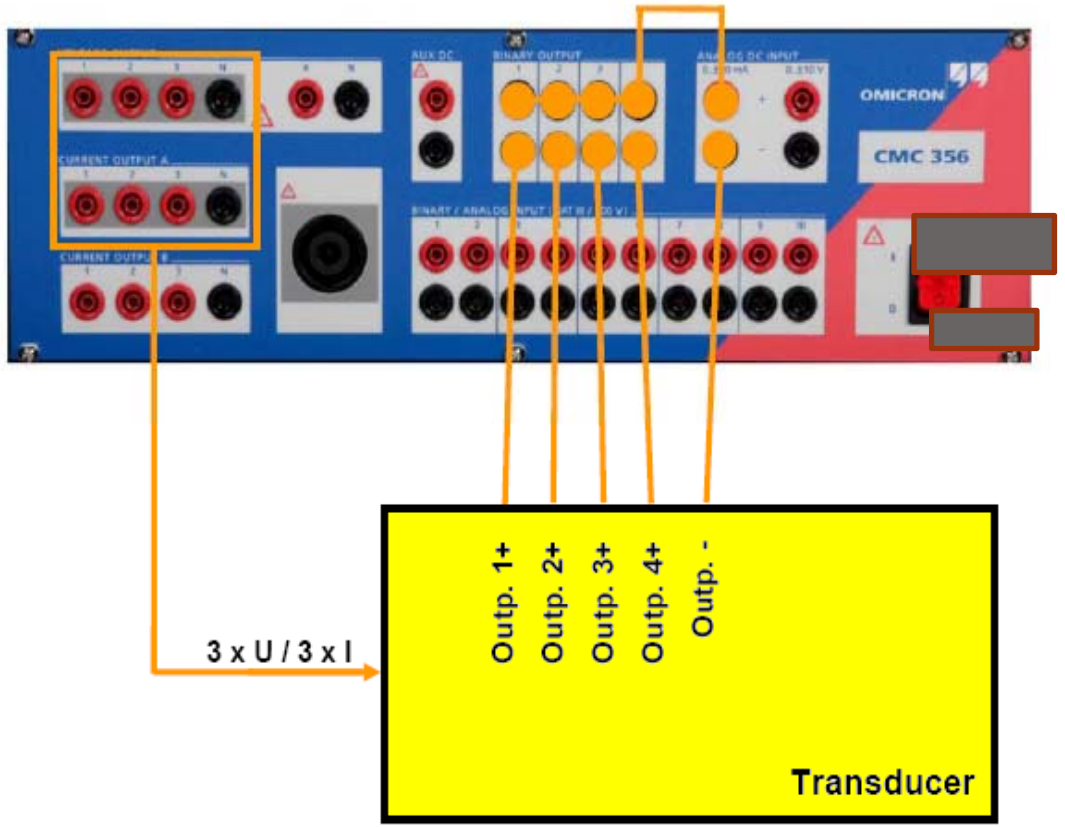
- Testing of multifunctional transducers (up to 4 functions without re-wiring)
- Testing of meter functions and threshold values as part of an integrated test
- For commissioning, routine testing, qualification testing as part of the manufacturing process
- Automatic testing
- Static output if tranducer needs to be adjusted
- Single step function to include remote displays
- Open loop mode for devices without analog output

Test Object Definition



- **all kinds of tranducer functions**
- **all kinds of characteristics**
  - **linear**
  - **compound**
  - **quadratic**
  - **directional or bi-directional**
- **CT starpoint connection setting avoids the need for re-wiring**

Test ing multifunctional transducers without re-wiring



All types of transducers to be tested

Active, Reactive & Apparant Power

Frequency

Current

Signed average current

Voltage (L-N, L-L)

Phase (I-V, I-I, V-V)

DC voltage, current, power

Various testing options required

Sweep test: variation of influencial quantities

- **frequency**
- **voltage (if not part of the quantity to be tested)**

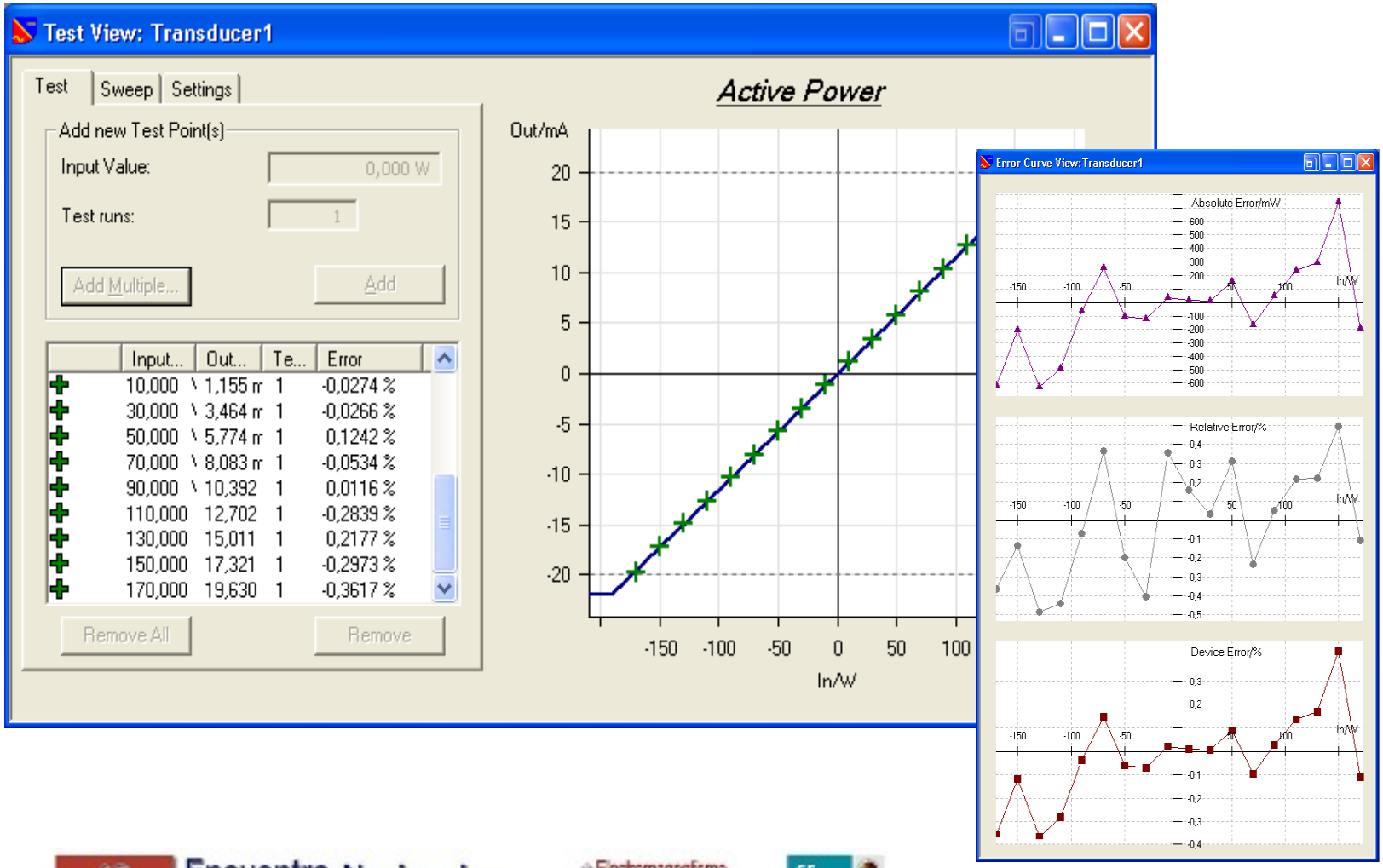
Test Modes

- **auto stepping (standard test mode)**
- **manual stepping (if remote displays shall be included in the test)**

Test Set-up

- **closed loop (standard test mode if I_{DC} or V_{DC} are available)**
- **open loop (in case I_{DC} or V_{DC} are not available). Open Loop testing is suitable for all kinds of device calibrations**

Test software



Application: Calibration of PQ analyzers

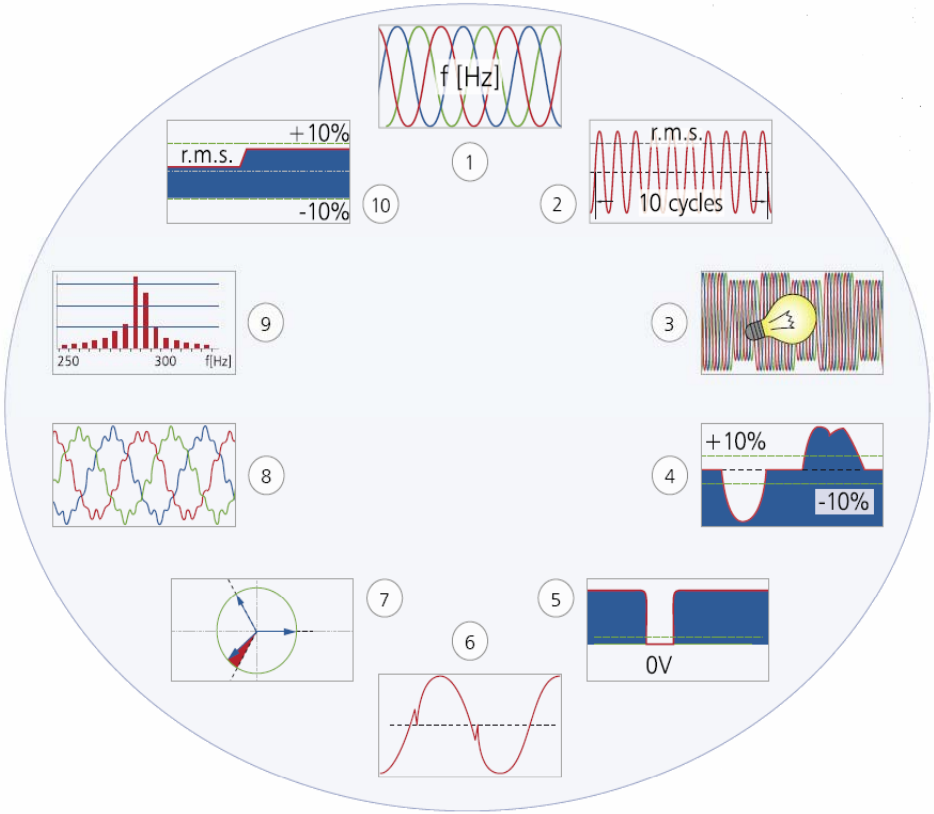
V, I

open loop: result reading (manual test)

closed loop: anlog, binary or protocol (automatic test)

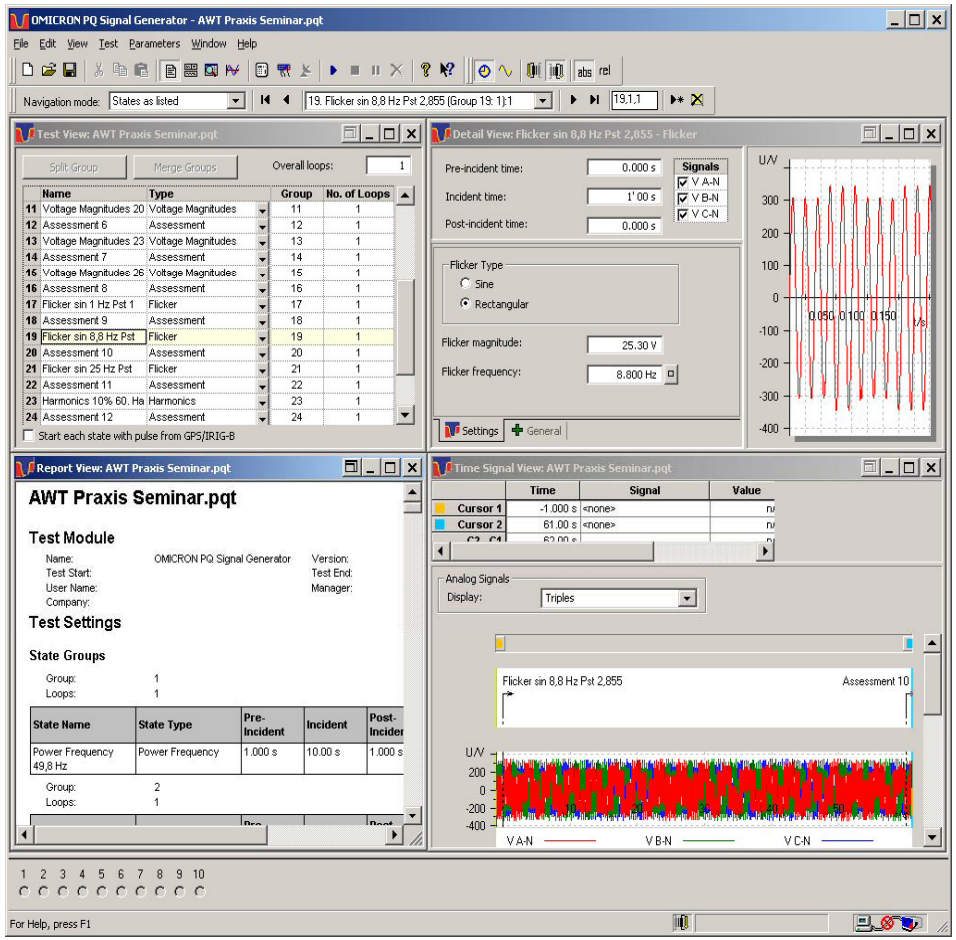
Numerous PQ meters, stationary and portable

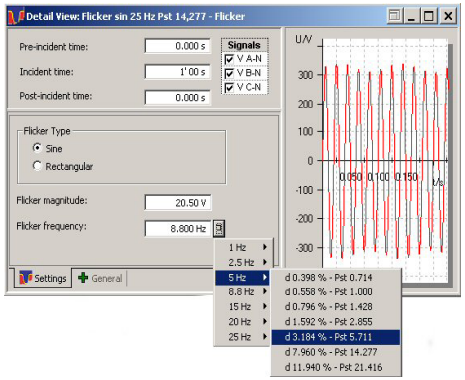
PQ phenomena according to IEC 61000-4-30

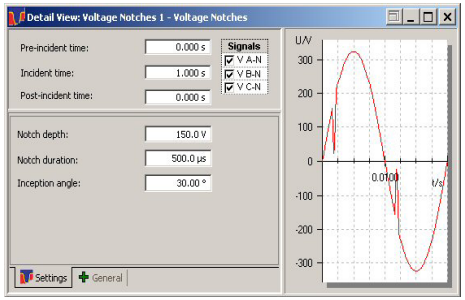


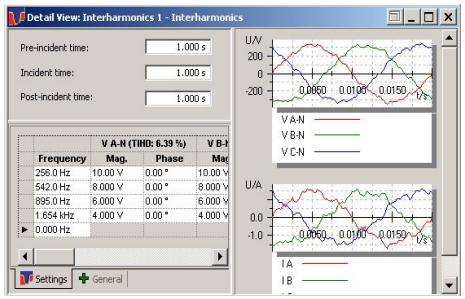
1... Power frequency
2... Magnitude of supply voltage
3... Flicker
4... Supply voltage dips and swells
5... Voltage interuptions
6... Transient voltages
7... Supply voltage unbalance
8... Voltage (current) harmonics
9... Voltage (current) interharmonics
10... Rapid voltage changes

PQ Test Software

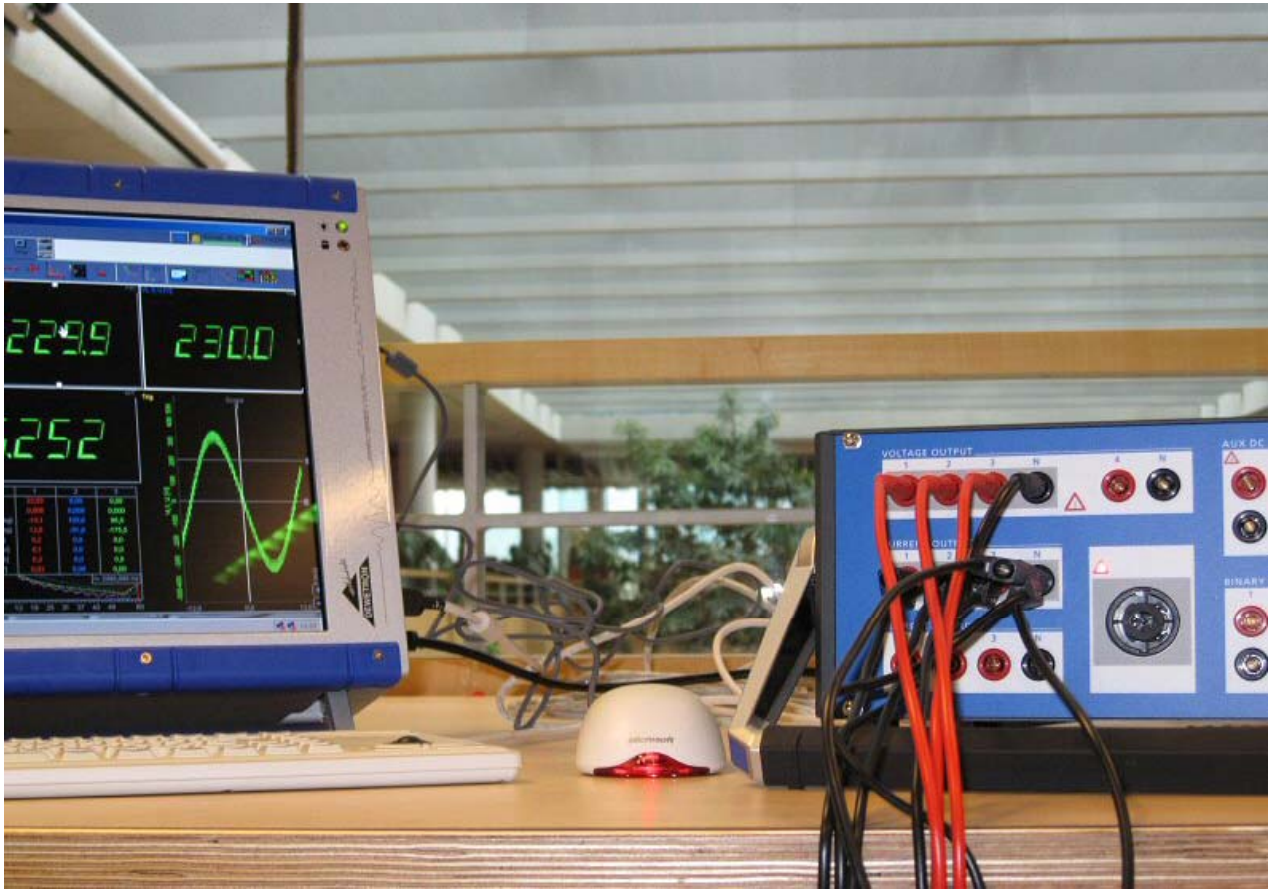








Special PQ Test: automatic calibration of a PQ analyzer

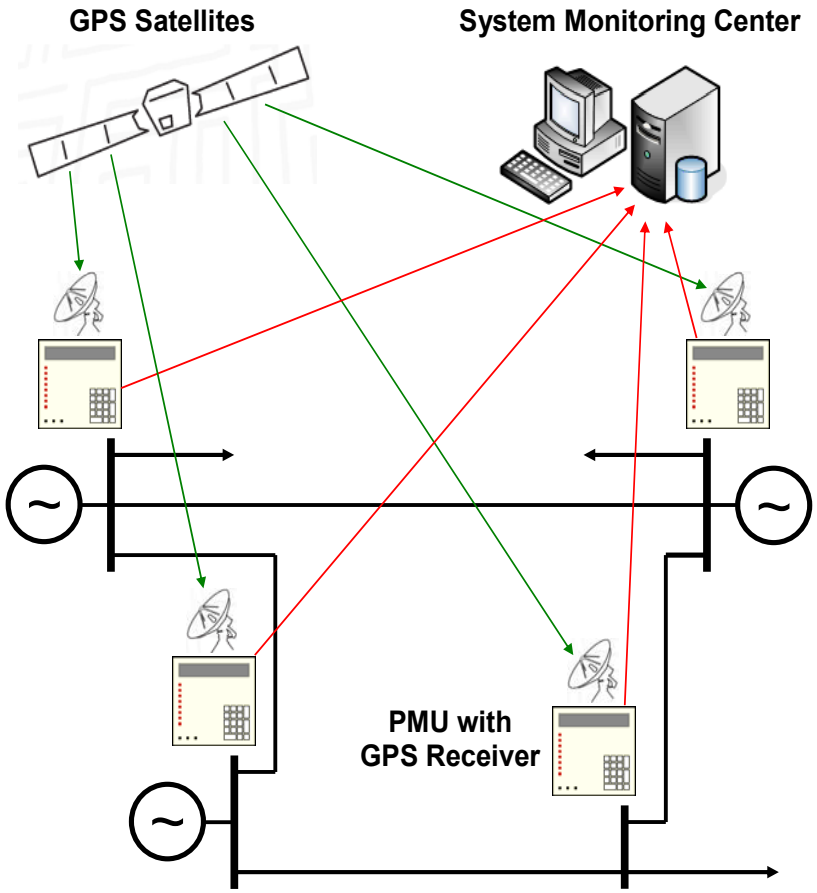


Automatic calibration routine with a customized software

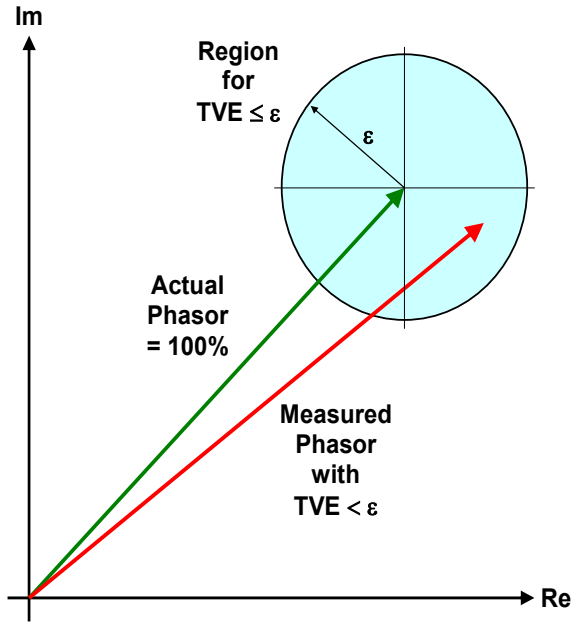
MEAORDER	NAME	LOWERLIMIT	UPPERLIMIT	ACTUALVA...	EVALUATION
10	Frequency	49.93315	50.06685	49.99985	passed
11	Frequency	54.92795	55.07205	55.00004	passed
15	Frequency	59.9277	60.0723	59.9999	passed
16	Frequency	16.62987	16.77014	16.69768	passed
20	U_rms_L1	107.6555	112.3445	109.9953	passed
21	U_rms_L2	107.6555	112.3445	109.9578	passed
22	U_rms_L3	107.6555	112.3445	109.9776	passed
30	U_L1_H3	22.85615	23.14385	22.99028	passed
31	U_L2_H3	22.85615	23.14385	22.98026	passed
32	U_L3_H3	22.85615	23.14385	22.98537	passed
33	U_L1_H10	2.270615	2.329385		
34	U_L2_H10	2.270615	2.329385		
35	U_L3_H10	2.270615	2.329385		
40	THD_U_L1	1.9851	2.0149		
41	THD_U_L2	1.9851	2.0149		
42	THD_U_L3	1.9851	2.0149		

Current 1s / Total 13s

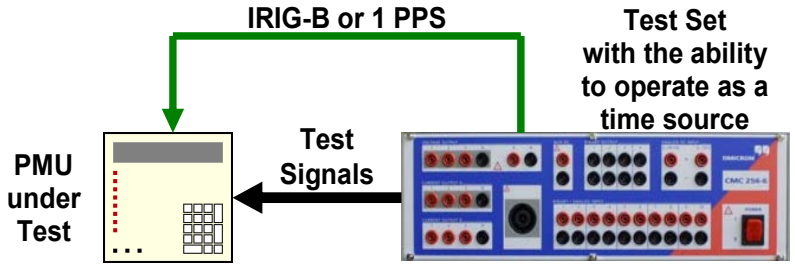
Calibration of Phasor Measurement Units



Calibration of Phasor Measurement Units: requirements



- ε = 0,25% (~0,1% / 0,1° error)
- 1 PPS or IRIG-B signal
- accuracy: 100 ns
- permanent synchronization



Summary: Benefits of an Universal Calibrator

- Reduction of payback period by a higher degree of economic utilization
- Facilitation and standardization of calibration procedures
- Reduction of downtimes by automated and standardized procedures
- Less error-prone procedures and thus more reliable results
- Increased satisfaction of the personnel