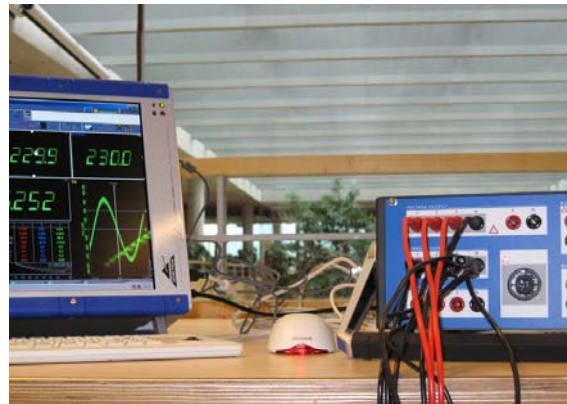


Universal Calibrator for Electrical Quantities for Power Utilities, Industry and R&D

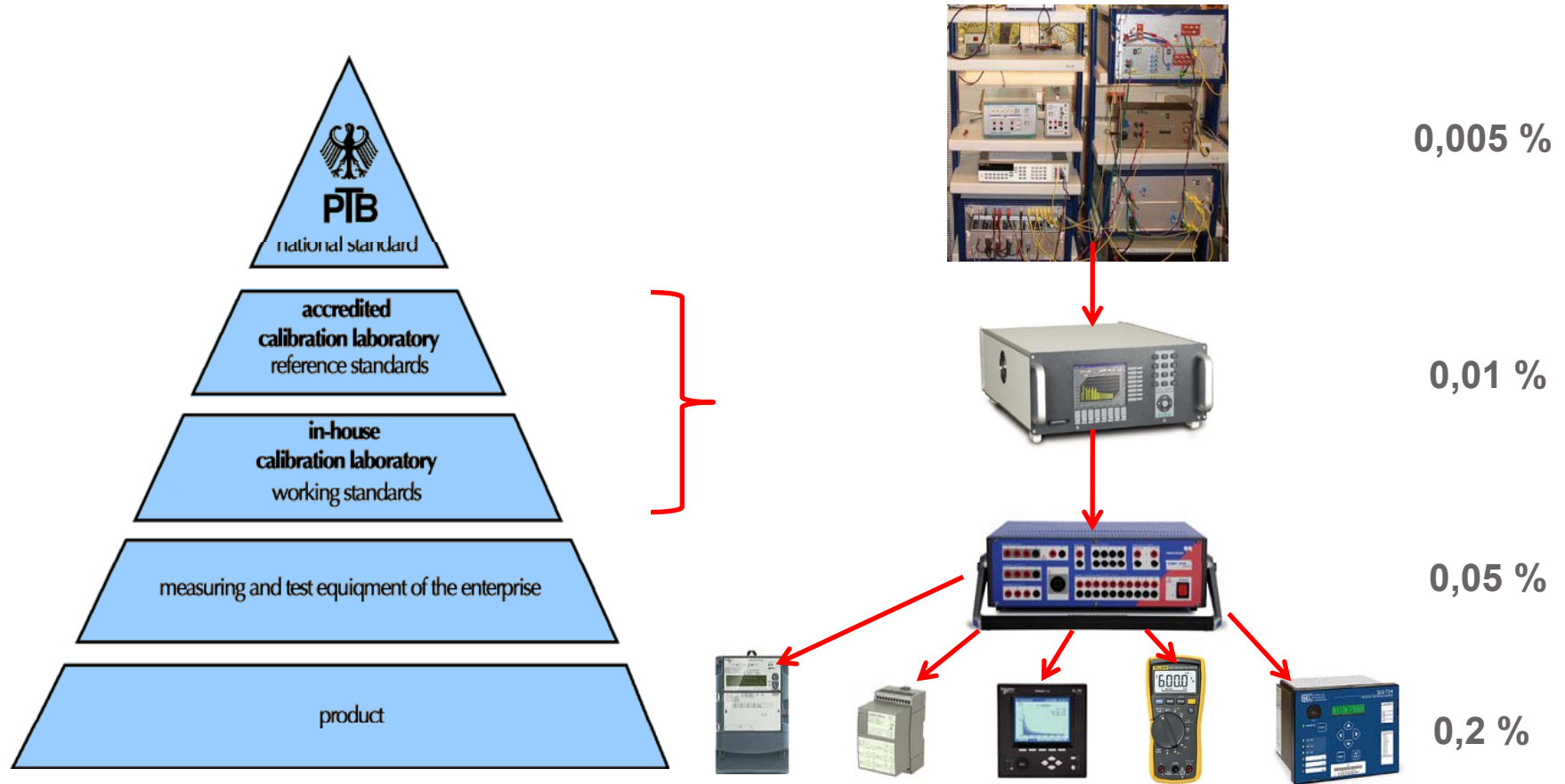
Reinhard Kuntner,
OMICRON electronics Austria
reinhard.kuntner@omicron.at



NOTE TO BE INCLUDED IN PRESENTATIONS FROM OTHER COMPANIES

NOTE . CENAM is not responsible for the content of this document. For any question or comment, please contact the author.

Calibration Hierarchy



Calibration of Measurement Devices

METERs

TRANSDUCERs

PQ METERs

PMUs (Phasor Measurement Units)

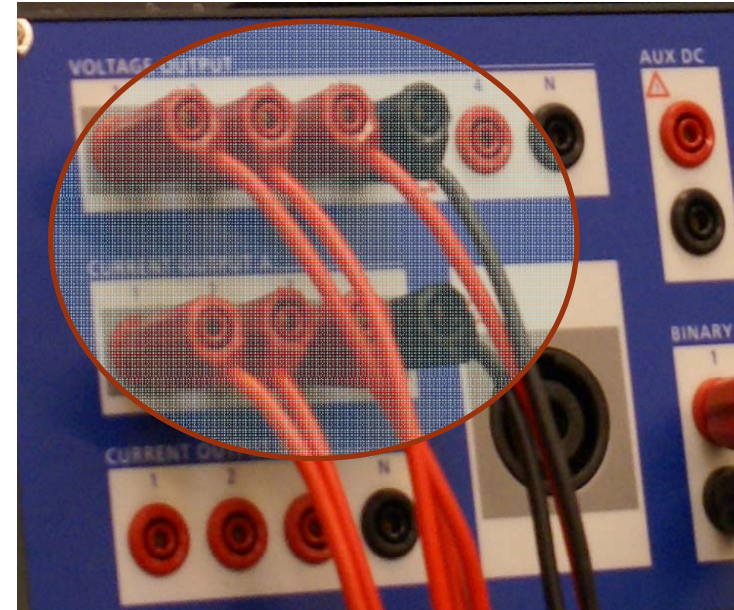
MERGING UNITs

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

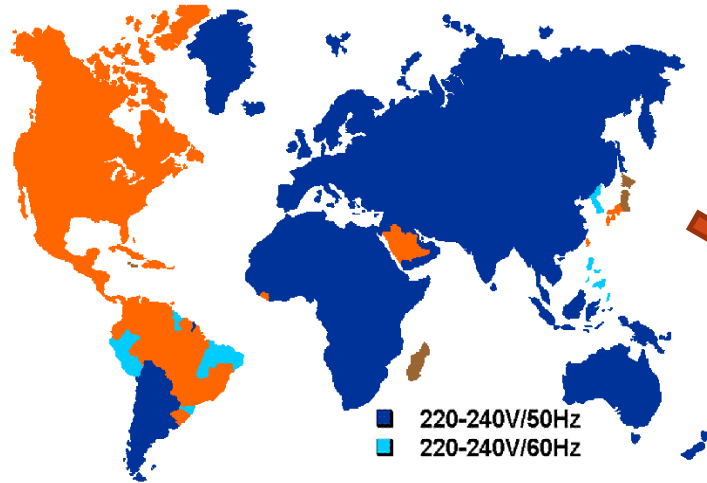


**Devices in Three
Phase Systems**

require

**Three Phase
Calibrators**

Requirements: quantities

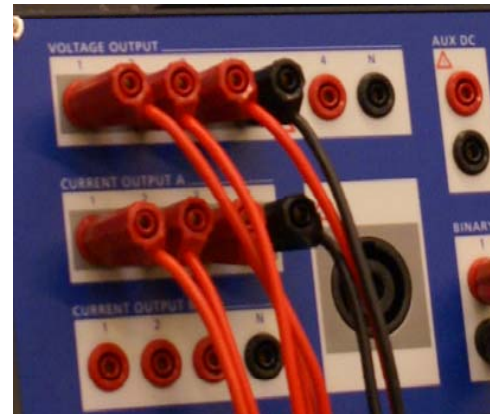
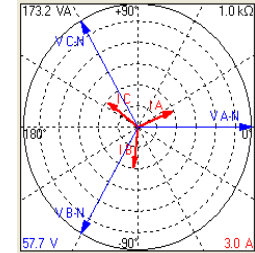


- 220-240V/50Hz
- 220-240V/60Hz
- 100-127V/60Hz
- 100-127V/50Hz



0 ... 360°
10 ... 400 Hz

0 ... 300 V

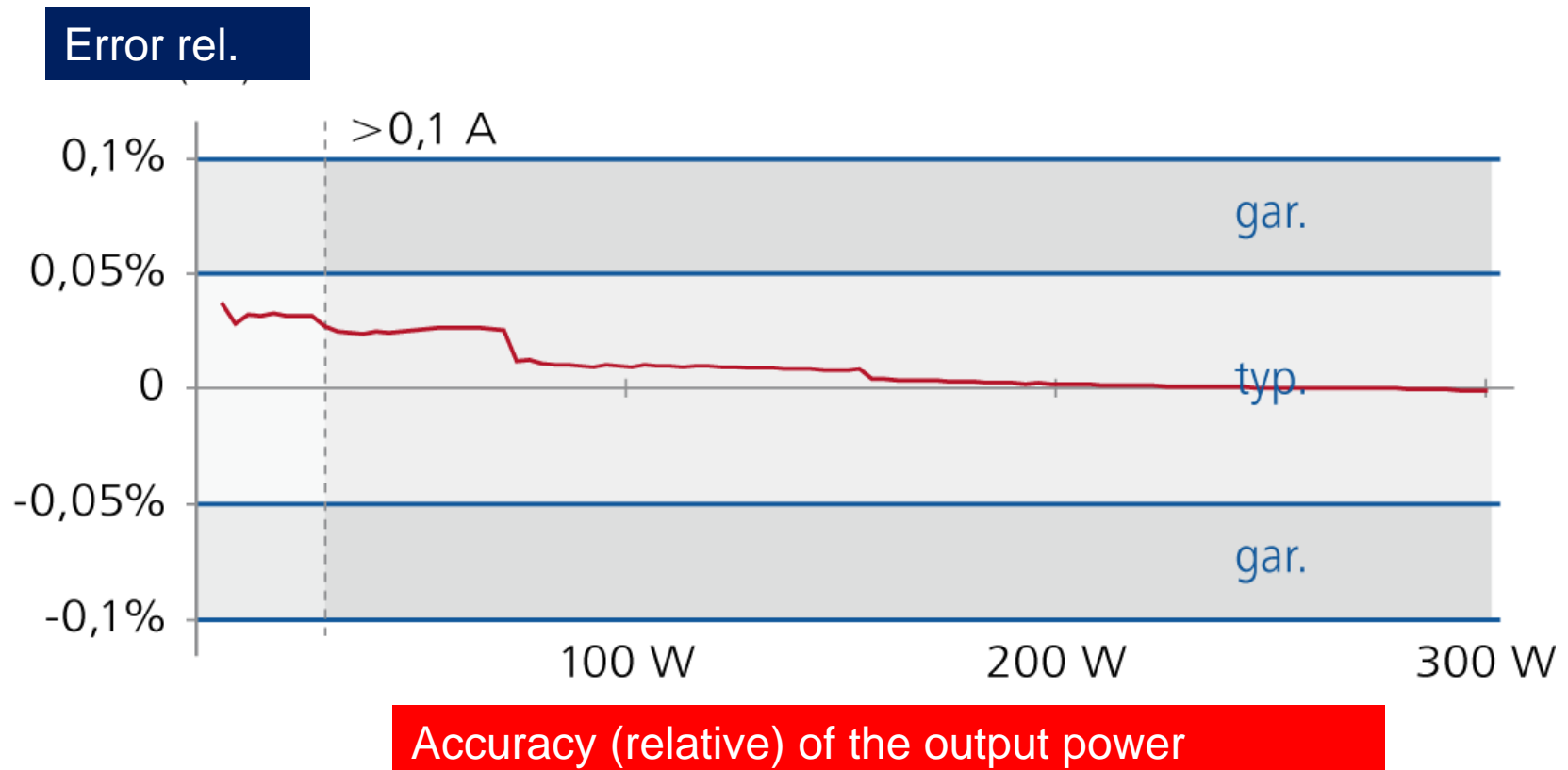


0 ... 5 A (5 * I_n)

0 ... 25 A

for directly connected devices

Requirements: high accuracy

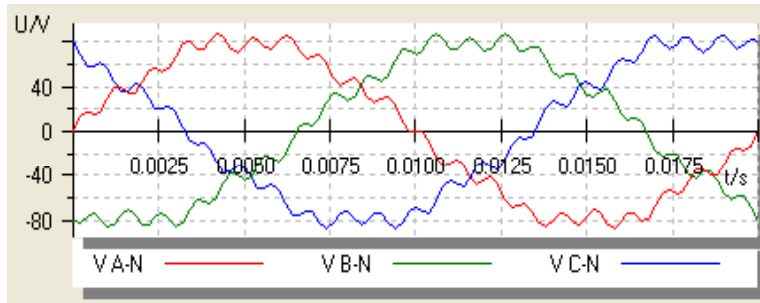


Requirements: high accuracy

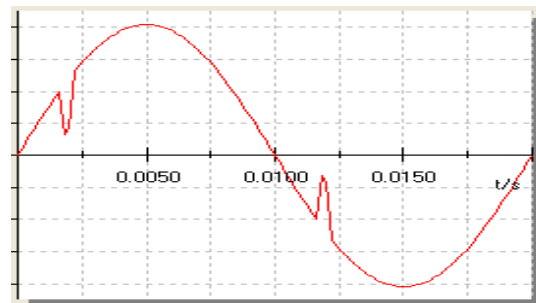


Volt. & Curr. Accuracy	Error < 0,015 % rd. + 0,005 % rg. typ. Error < 0,04 % rd. + 0,01 % rg. guar.
Power Accuracy	Error (rel.) < 0,05 % typ. < 0,1 % guar. 10 – 63 Hz, 50 ... 127,5 / 300 V 0,1 ... 12,5 A
THD	I: 0,025 % typ. V: 0,015 % typ.
Frequency (volt./curr.)	DC ... 1000 Hz, error/drift < 0,5 ppm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



V, I



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.
									Val	Quant.	Time	Val	Quant.	Time			
L	1	57,74	57,74	57,74	1,000	1,000	1,000		50	500,000	10,382 s	50	499,309	10,380 s	0,1224 %	nil	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,8660 ind	50	500,000	12,000 s	50	499,367	11,985 s	0,1288 %	nil	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,8660 cap	50	500,000	12,000 s	50	499,413	11,986 s	0,1176 %	nil	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,5000 ind	25	250,000	10,382 s	25	249,670	10,379 s	0,1321 %	nil	Passed
L	1	57,74	57,74	57,74	1,000	1,000	1,000	0,5000 cap	25	250,000	10,382 s	25	249,742	10,382 s	0,1031 %	nil	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

V²h (iron losses of power transformers)

I²h (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

The screenshot shows the OMCRON Meter software interface. On the left, the 'Test' and 'Settings' panels are visible. The 'Test Mode' is set to 'Load'. The 'Current Waveform' is 'Sine +'. The 'Balanced 3-phase system' settings show a voltage of 57,735 V and a frequency of 50,000 Hz. The 'Condensed Test Report' on the right displays a phasor diagram with vectors for voltage (VAN, VBN, VCN) and current (IA, IB, IC) in a three-phase system.

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	10,392 s	50	499,389	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	12,000 s	50	499,367	11,885 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	12,000 s	50	499,413	11,886 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	10,392 s	25	249,670	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	10,392 s	25	249,742	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	10,392 s	25	249,694	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	12,000 s	25	249,644	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	12,000 s	25	249,748	11,888 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	9,977 s	12	119,771	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	9,977 s	12	119,328	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	9,977 s	12	119,842	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	11,520 s	12	119,799	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	11,520 s	12	119,973	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	16,628 s	10	99,771	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	16,628 s	10	99,857	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	12,471 s	6	59,919	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	14,400 s	6	59,893	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	14,400 s	6	59,943	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	24,942 s	6	59,849	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	24,942 s	6	59,991	24,938 s	0,0145 %	n/a	Passed

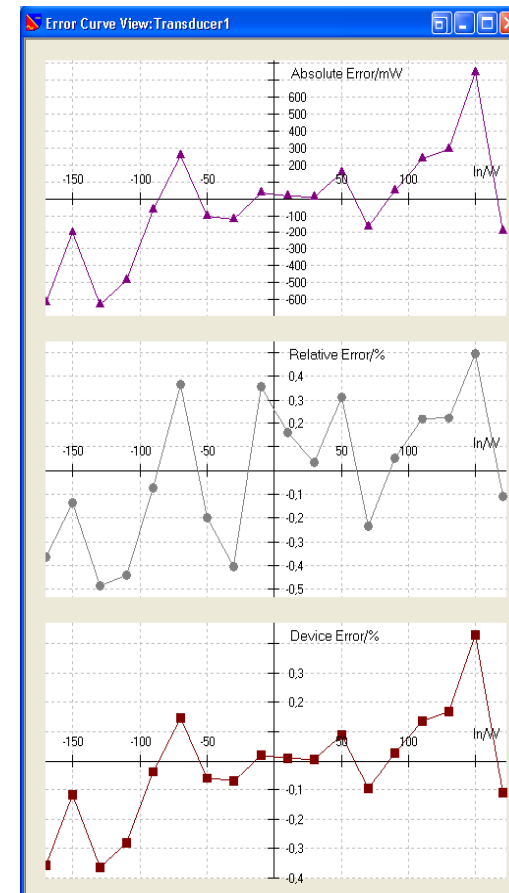
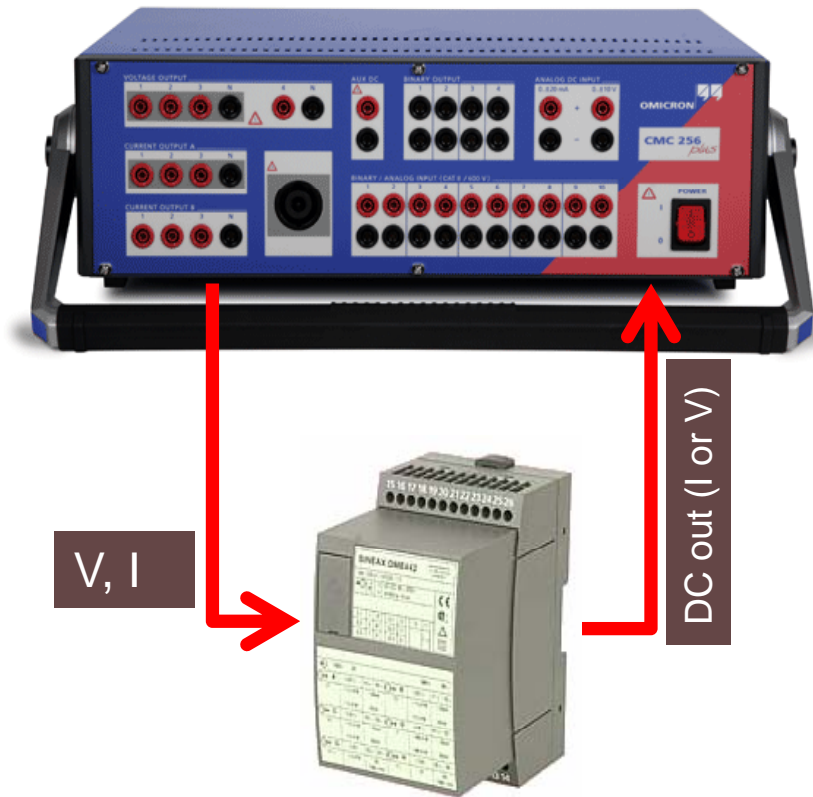


Encuentro Nacional de Metrología Eléctrica 2009
 26. März 2009
 18-20 de noviembre 2009

- Electromagnetismo
- Temperatura y Propiedades Termofísicas
- Tiempo y Frecuencia



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

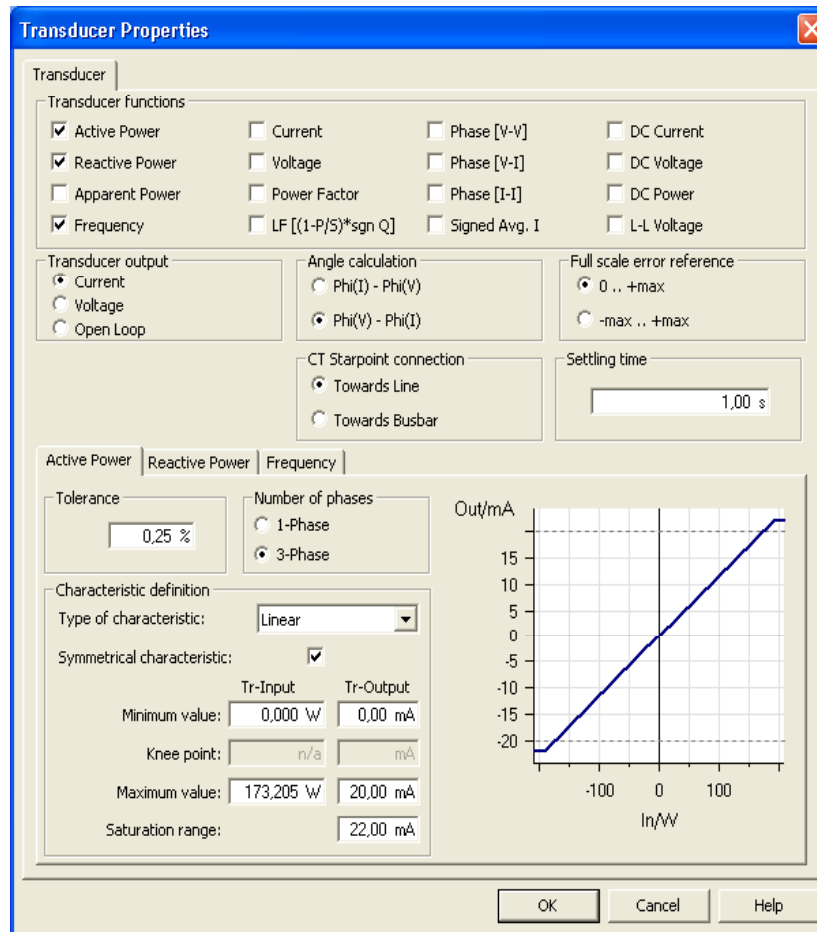
Automatic testing

Static output if transducer needs to be adjusted

Single step function to include remote displays

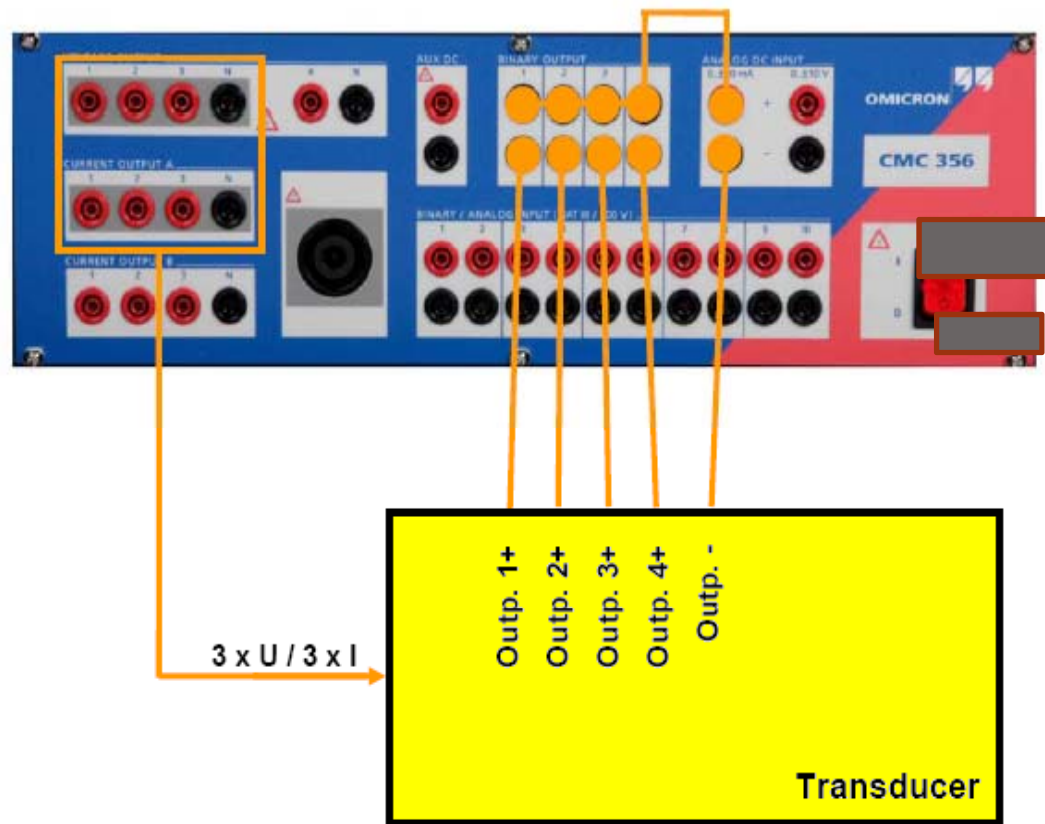
Open loop mode for devices without analog output

Test Object Definition



- all kinds of transducer 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 influential quantities

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

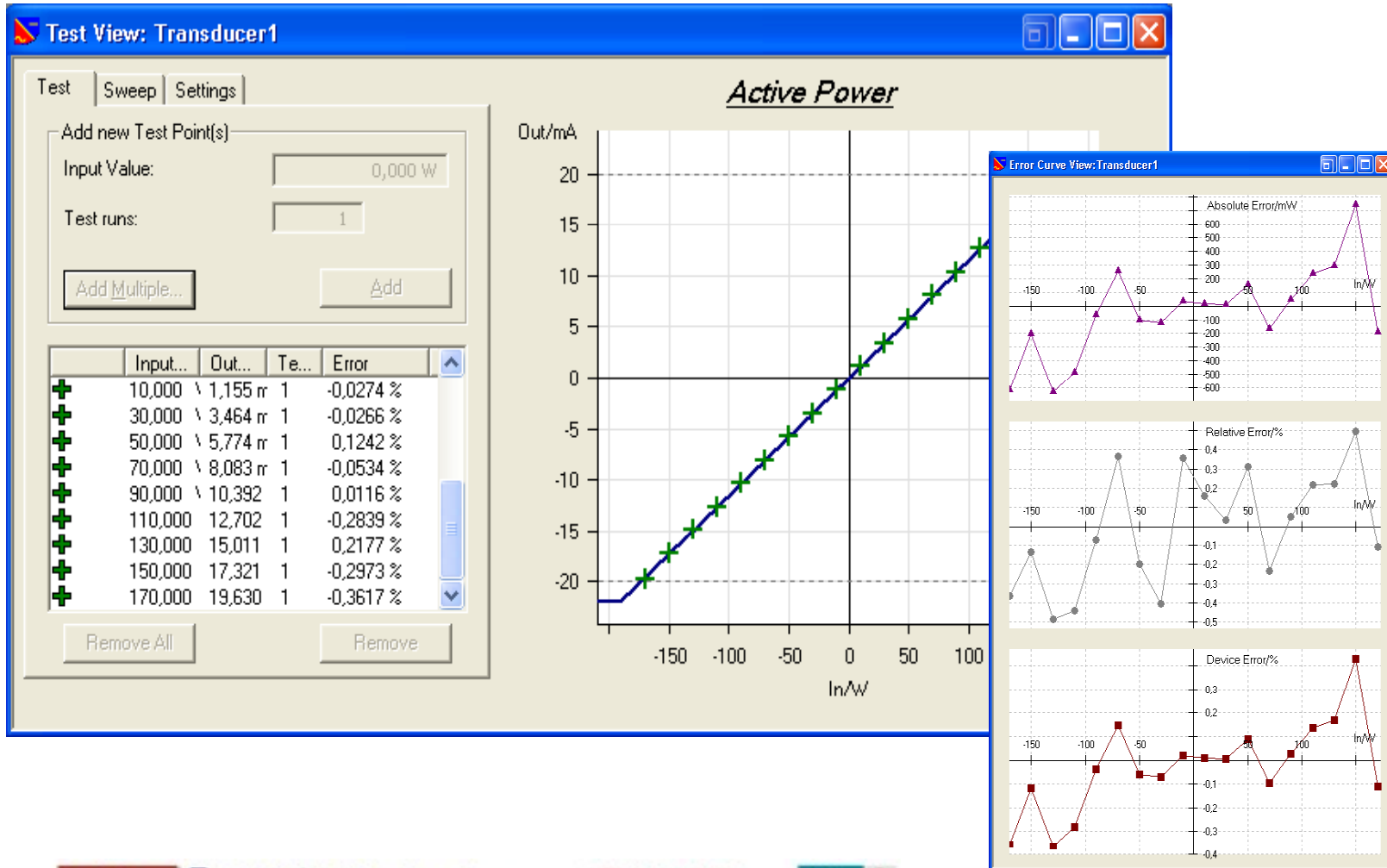
Test Modes

- 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

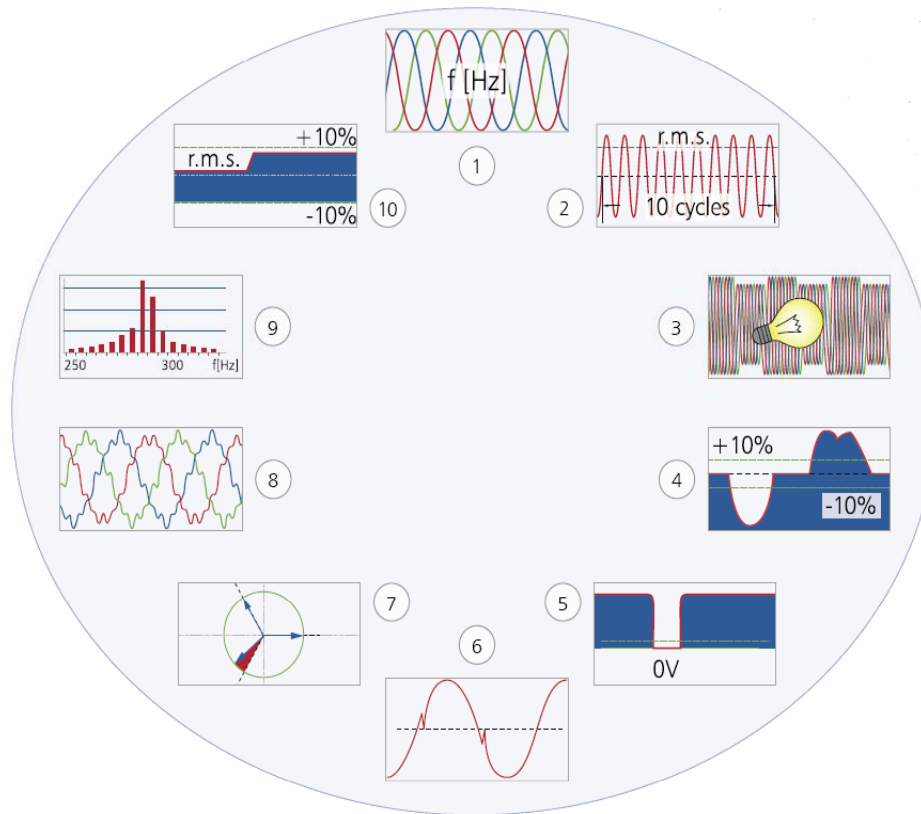
open loop: result reading (manual test)

closed loop: analog, 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 interruptions
- 6... Transient voltages
- 7... Supply voltage unbalance
- 8... Voltage (current) harmonics
- 9... Voltage (current) interharmonics
- 10... Rapid voltage changes

PQ Test Software

AWT Praxis Seminar.pqt

Name	Type	Group	No. of Loops
11	Voltage Magnitudes 20	Voltage Magnitudes	11
12	Assessment 6	Assessment	12
13	Voltage Magnitudes 23	Voltage Magnitudes	13
14	Assessment 7	Assessment	14
16	Voltage Magnitudes 26	Voltage Magnitudes	16
18	Assessment 8	Assessment	18
17	Flicker sin 1 Hz Pst 1	Flicker	17
18	Assessment 9	Assessment	18
19	Flicker sin 8,8 Hz Pst	Flicker	19
20	Assessment 10	Assessment	20
21	Flicker sin 25 Hz Pst	Flicker	21
22	Assessment 11	Assessment	22
23	Harmonics 10% 60. Hz	Harmonics	23
24	Assessment 12	Assessment	24

Detail View: Flicker sin 25 Hz Pst 14,277 - Flicker

Pre-incident time: 0.000 s
 Incident time: 1'00 s
 Post-incident time: 0.000 s

Flicker Type: Sine Rectangular
 Flicker magnitude: 20.50 V
 Flicker frequency: 8.800 Hz

Detail View: Voltage Notches 1 - Voltage Notches

Pre-incident time: 0.000 s
 Incident time: 1.000 s
 Post-incident time: 0.000 s

Notch depth: 150.0 V
 Notch duration: 500.0 µs
 Inception angle: 30.00°

Detail View: Interharmonics 1 - Interharmonics

Pre-incident time: 1.000 s
 Incident time: 1.000 s
 Post-incident time: 1.000 s

Frequency	V A-N (THD: 6.39 %)	V B-N	V C-N
256.0 Hz	10.00 V	0.00 *	10.00 V
542.0 Hz	8.000 V	0.00 *	8.000 V
895.0 Hz	6.000 V	0.00 *	6.000 V
1.654 kHz	4.000 V	0.00 *	4.000 V
0.000 Hz			

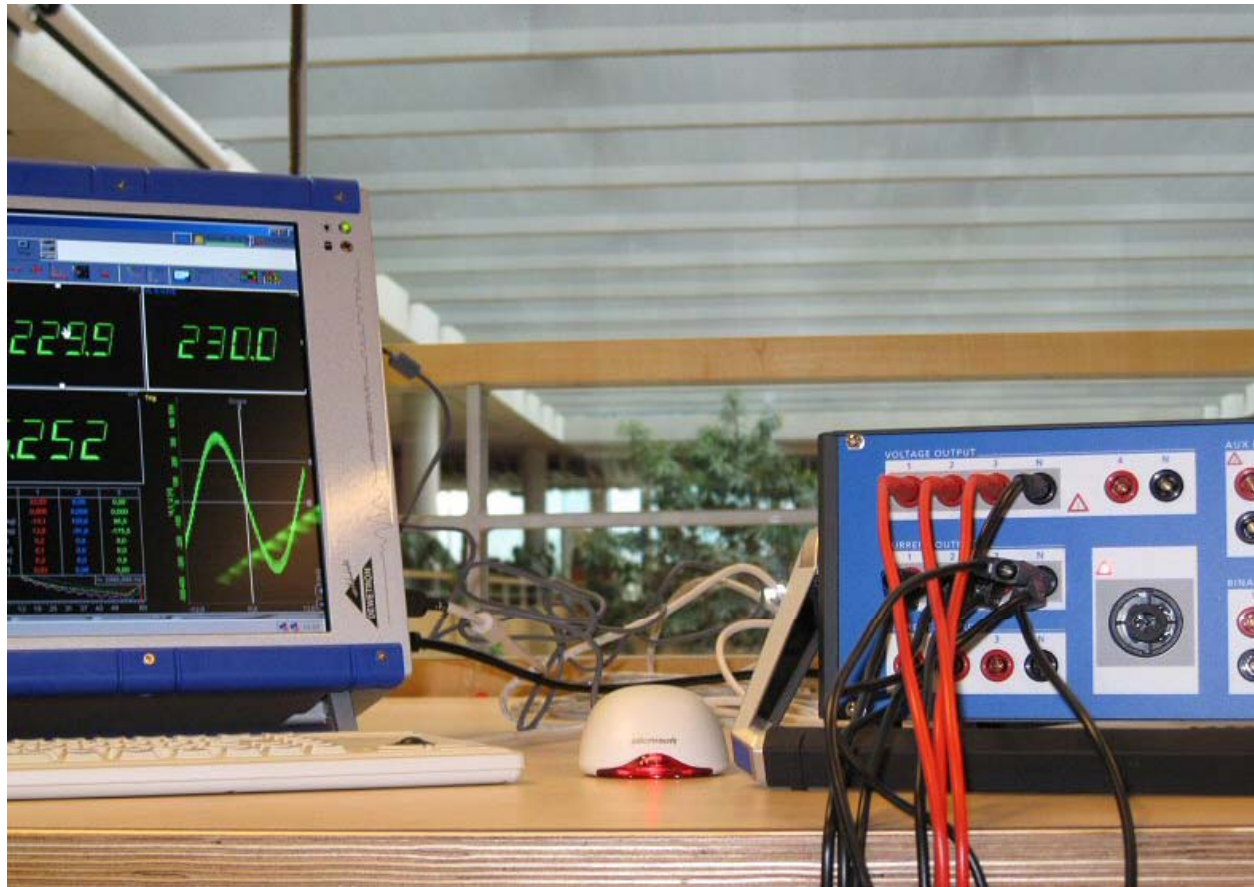


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Special PQ Test: automatic calibration of a PQ analyzer

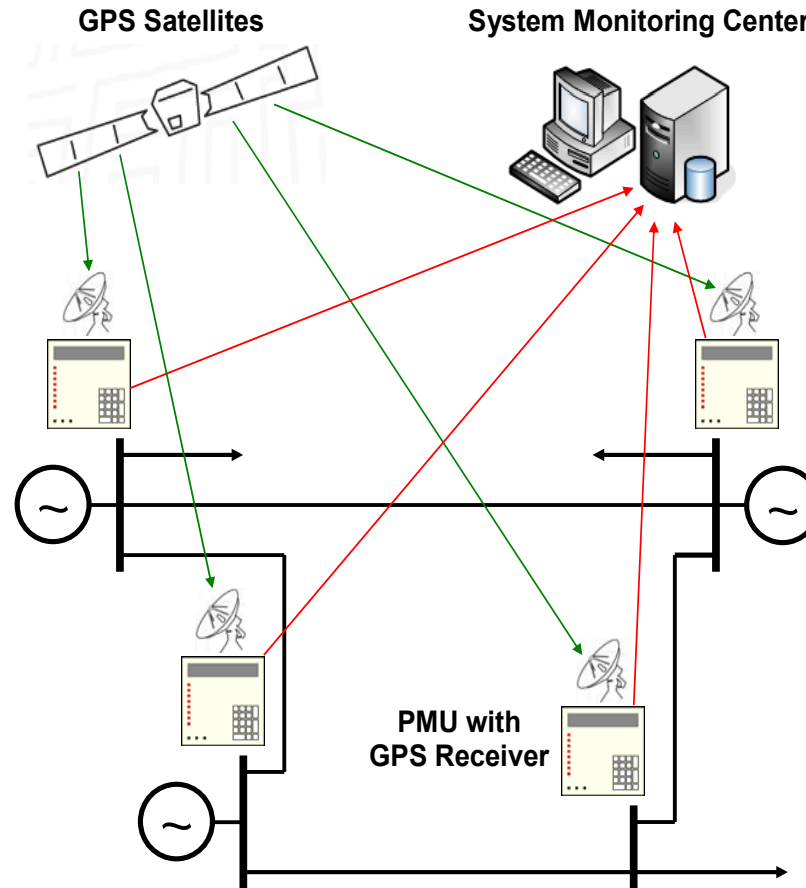


Automatic calibration routine with a customized software

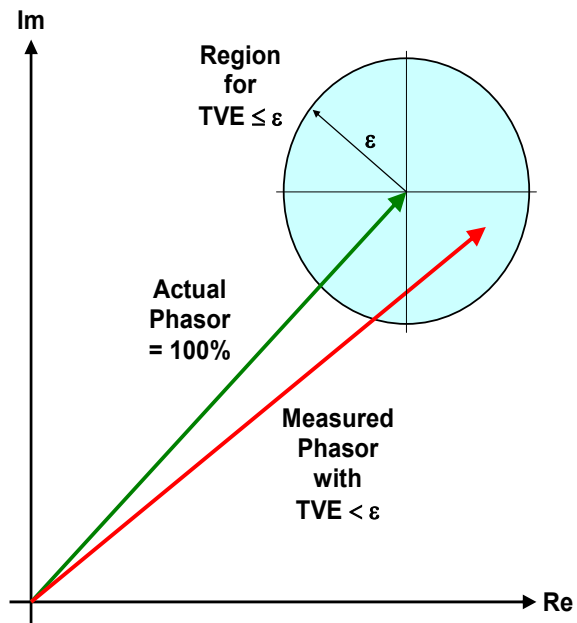
MEAORDER	NAME	LOWERLIMIT	UPPERLIMIT	ACTUALVA...	EVALUATION
10	Frequency	49.93315	50.06685	49.99985	passed
11	Frequency	54.92795	55.07205	55.00004	passed
15	Frequency	59.9277	60.0723	59.9999	passed
16	Frequency	16.62987	16.77014	16.69768	passed
20	U_rms_L1	107.6555	112.3445	109.9953	passed
21	U_rms_L2	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

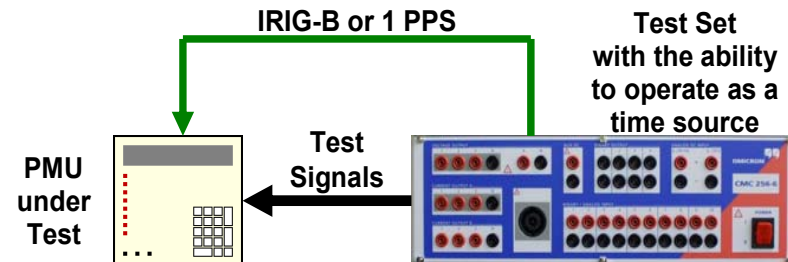
Calibration of Phasor Measurement Units



Calibration of Phasor Measurement Units: requirements



- $\epsilon = 0,25\%$ ($\sim 0,1\%$ / $0,1^\circ$ 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