Akademia Górniczo–Hutnicza
im. Stanisława Staszica w Krakowie

Power Quality Picnic

Final report from the measurement experiment

- *comparative tests of PQ analysers*

Department of Power Electronic and Energy Control Systems
Faculty EAIiIB, AGH Krakow

TAURON Dystrybucja S.A.
Office of Innovation and New Technologies

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The Organisers of the ***Power Quality Picnic*** *would like to thank the Manufacturers of PQ analysers for participating in tests and providing their products for research purposes.*

Contents

1. Foreword

The Power Quality Picnic was organized on 23 October 2014 at the AGH University of Science and Technology in Krakow, with participation of TAURON Dystrybucja S.A. - the biggest Polish DSO. The purpose of this event was to promote the field of power quality (PQ) and to let manufacturers and users of PQ analysers exchange their experience in this area. An integral part of the Picnic was the experimental comparative tests of PQ analysers offered currently on the Polish market by the representatives of manufacturers and suppliers of measuring equipment.

The event was accompanied by a seminar session composed of lectures given by experts from the Department of Power Electronics and Energy Control Systems, TAURON Dystrybucja S.A., PSE (Polish TSO), the Energy Regulatory Office, and KGHM - one of the largers producers of cooper and silver in the world (Photo 1). The discussions focused on current challenges in the field of power quality, its influence on comfort and health of consumers, and also on formal aspects of power quality as seen from the municipal customer's perspective. Representatives of TAURON Dystrybucja S.A. presented their past experience and future plans for development of a power quality monitoring system and the latest trends and experience in the development of intelligent *"smart"* energy measurement systems.

Figure 1. Seminar session

In parallel to the seminar part, in another amphitheatre hall, a measurement experiment was conducted (Photo 2). A number of manufacturers and suppliers of measuring equipment were invited to participate in the tests. They included those operating on the Polish market, whose PQ analysers meet the requirements of Class A. Class A (advanced) is used in the case of a need for precise measurement, e.g. for contractual purposes, verification of compliance with standards, resolution of disputes, etc. Any measurements of the same signal, performed using two different instruments of Class A, should yield convergent results within a well defined uncertainty range.

It should be noted that in the last few years the market of PQ measuring equipment has grown considerably and currently a wide range of PQ analysers is offered at various price ranges. More and more often, a customer who wants to buy a PQ analyser is guided not only by its price but also by certificates of conformity related to the standards PN-EN 61000-4-30, PN-EN 61000-4-15, and PN-EN 61000-4-7. Manufacturers submit various documents providing evidence that their PQ analyser is a Class A product. At this point, however, there are some significant ambiguities regarding the selection and interpretation of standards which define the guidelines for measurements of PQ indicators, as well as the correctness of the verification process related to compliance of the particular analyser with Class A requirements. Consequently, it is possible to find a PQ analyser which, in fact, does not meet the conditions defining the correct measurement of power quality indicators. The purpose of the measurement experiment carried out at the Picnic was to verify this assertion.

2. Description of the measurement experiment

Organisers invited a number of manufacturers and suppliers of Class A PQ analysers (the analyser must have had a valid Class A certificate) to test their devices in the measurement experiment. The analysers were connected to some test signals proposed by experts from the AGH and TAURON Dystrybucja, based on the following standards:

a. PN-EN 61000-4-30:2009 Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods,
b. IEC 62586-1: Power quality measurement in power supply systems – Part 1: Power Quality Instruments (PQI),
c. IEC 62586-2: Power Quality Measurement in Power Supply Systems – Part 2: Functional tests and uncertainty requirements.

The participants were also asked to send their own suggestions for test signals which, in their opinion, could emphasize the advantages of their products.[1]

Test signals were designed in such a way that they enabled the evaluation of measurement quality of the following quantities:

a) frequency,
b) RMS voltage,
c) voltage fluctuations,
d) voltage dips, swells, and interruptions,
e) voltage unbalance,
f) voltage harmonics,
g) voltage interharmonics.

All PQ analysers were connected to a signal calibrator which provided a 3-phase test signal simultaneously to the analysers. Each signal was a composition of voltage disturbances (frequency and RMS voltage variations, distortion, unbalance, fluctuations) and events (dips, swells, interruptions). High-quality programmable laboratory calibrators were used as the source of the test signals. The total duration of the experiment was 4.5 hours. After

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[1] Certain test scenarios were also developed as a result of the project entitled *Research on developing the guidelines, techniques and technology for systems of passive power compensation, smart monitoring of internal power networks and photovoltaic cells dedicated to hybrid facilities based on only renewable sources*, co-financed by the European Regional Development Fund as part of the Operational Programme Innovative Economy 2007-2013, Priority 1 – High-tech research and development, Sub-measure 1.3.1 – Development Projects.

completing the test, each participant was asked to share the recorded measurement results on an electronic medium with the special Supervising Committee, composed of representatives of AGH and TAURON Dystrybucja.

Figure 2. Measurement experiment

Fourteen PQ analysers offered by various manufacturers were tested during the experiment (Table 1). Configuration of the measuring equipment, setting up the recording, and reading the measurement data were carried out individually by the participants.

Table 1. List of PQ analysers participating in the measurement experiment (random order)

	Manufacturer	**Model**
1	Fluke	Fluke 1760
2	Electro Industries / Gaugetech	Nexus 1500
3	Unipower AB	UP-2210
4	Dewetron	DEWE-3020
5	Alstom	iSTAT M355
6	Mikronika	SO-52v11-eME
7	Siemens	SIMEAS Q80
8	A-eberle	PQ Box 200
9	Schneider-Electric	ION7650
10	Sonel	PQM-703
11	Power Standards Lab	PQube
12	ELSPEC	G4500
13	Metrel	MI 2892
14	Dranetz	Mavowatt 270

The measurement experiment was of scientific nature. Its results cannot be used to verify the conformity of PQ analysers with Class A requirements according to PN-EN 61000-4-30 and within the meaning of the certification procedure.

During the preparation of the experiment, all participants received detailed guidelines with the information about the eligibility conditions to participate in the experiment, technical conditions of tests, requirements for configuration of PQ analyzers, simplified test procedure and rules of publication of the measurement results. Detailed procedure of the experiment was made available on the day event, an hour before the start of tests.

Also during the preparation of the final report, all participants got the opportunity to verify and compare results of their own products with other PQ analyzers with preserved anonymity. The participants were also asked to submit any observations and comments, which are included in Chapter 6.

The organizers wish to note that the quality of the results obtained from analysers are effect of both, their metrological properties, as well as valid configuration and utilisation of the analyser, which directly depended on the skills and knowledge of the personnel participating in the experiment. Good technical support form an analyser’s supplier, is in fact very valuable for a customer, especially when it comes to downloading, interpretation and analysis of measurement data.

3. Tests procedure description and results presentation

3.1 Measurements using 10-minute aggregation window

This chapter describes each test carried out during the Power Quality Picnic, according to the adopted criteria of compliance with the standard PN-EN 61000-4-30:2009 *Electromagnetic compatibility (EMC) Part 4-30: Testing and measurement techniques - Power quality measurement methods* [1] in effect on the day of the measurement experiment. The expected results correspond to the parameters pre-set in the calibrators that were used as the source of the test signal (OMICRON 256plus, Fluke 6105A) or are determined by analytical calculations.

Tables of readings from PQ analysers, included in the experiment, are presented under the description of each test. Depending on, whether the readings of a given analyser were within the permissible uncertainty interval or not, they were marked in the following way:

🟩 50.00	numerical value on a green background – the reading falls within the adopted uncertainty interval
🟧 230.62	numerical value on an orange background – the reading exceeds the adopted uncertainty interval
🟧 ---	dashed lines on an orange background – the analyser has not recorded the required value
⬜ 13.53	numerical value on a grey background – there is no reference value nor uncertainty level – a comparative test

Tables of measurement readings also include a column labelled *Compliance*, which summarises the compliance of the readings with the adopted test criterion:

🟩 YES	all readings fall with the adopted uncertainty interval
🟧 NO	the analyser has not recorded a value or at least one of its readings exceeds the adopted uncertainty interval

Tables with the results of each test are followed by figures presenting in graphical form the readings of all analysers together with uncertainty levels marked as red dotted lines. The green line marks are expected values. On some graphs, the additional symbols were introduced:

🔴	the analyser has not recorded the required value
231.12	the reading exceeds the graph range, the numbers shows the precise value

Based on the standard PN-EN 61000-4-30 the following intervals of the permissible measurement uncertainty were determined:

- the measurement uncertainty of the frequency samples averaged over 10-second period shall not exceed the ±10 MHz;
- the measurement uncertainty of the voltage ram's. value samples, aggregated over the period of 10 minutes shall not exceed ±0,1%*U*din;
- the measurement uncertainty of harmonics and interharmonics shall fall within the tolerance interval of ±5% of the measured value;
- the measurement uncertainty of voltage unbalance shall fall within the tolerance interval of ±0.15 in relation to the measured value;
- the measurement uncertainty of the short-term flicker indicator shall fall within the tolerance interval of ±5% of the measured value;
- the measurement uncertainty of the duration of a voltage dip, a voltage swell or a voltage interruption in a polyphone system shall not exceed the sum of the uncertainty of determining a voltage event start (1 half cycle) and uncertainty of determining voltage event end (1 half cycle);
- the measurement uncertainty of the amplitude of a voltage dip, a voltage swell or a voltage interruption shall not exceed ±0.2%*U*din;
- no explicit requirements for the uncertainty of the THD – a comparative test

List of symbols and explanations

f	frequency
U_{din}	declared input voltage
U_{rms}	root mean square (r.m.s.) value of the voltage magnitude
U_{res}	minimum value of U_{rms}, measured over 1-cycle and refreshed each half-cycle, recorded during a voltage dip, swell or interruption
L1, L2, L3	phase voltages
$U_{(1)}$, $U_{(n)}$	root mean square value of the fundamental harmonic and the n-th order harmonic, where n is a natural number
$U_{(h)}$	root mean square value of the interharmonic component with frequency $f=50\cdot h$, where h is a rational number
$U_{(f\ \mathrm{Hz})}$	root mean square value of a spectral component with frequency expressed in hertz
$U_{\mathrm{h.f.}}$	root mean square value of a high frequency spectral component, used in tests of antialiasing
U_{h1}, U_{h2}, $U_{\mathrm{h}n}$	root mean square value of harmonic component 1, 2 and n (where n is a natural number) determined according to definitions of groups in IEC 61000-4-7
U_{ih1}, U_{ih2}, $U_{\mathrm{ih}n}$	root mean square value of interharmonic group 1, 2 and n (where n is a natural number) determined according to definitions of groups in IEC 61000-4-7
k_{u}	unbalance factor: the negative-sequence symmetrical component to positive-sequence symmetrical component ratio
P_{st}	short-term flicker severity index evaluated according to IEC 61000-4-15
T	duration of voltage event aggregated in a polyphase system
T_{L1}, T_{L2}, T_{L3},	duration of voltage event aggregated in a single phase system
THD	total harmonic distortion factor
$\angle$	phase angle

<table>
<tr><th colspan="2">TEST 1</th></tr>
<tr><th>Time: 9:50-10:00</th><th>Measurement of voltage in the absence of PQ disturbances</th></tr>
<tr><td>Test signal parameters</td><td>Three phase sinusoidal voltage with U_{rms}=230 V, f = 50 Hz.
No PQ disturbances.</td></tr>
<tr><td>Test criterion</td><td>
<table>
<tr><th>Parameter</th><th>Expected result</th></tr>
<tr><td>f</td><td>50.00±0.01 Hz</td></tr>
<tr><td>$U_{rms\ L1}$</td><td>230±0.23 V</td></tr>
<tr><td>$U_{rms\ L2}$</td><td>230±0.23 V</td></tr>
<tr><td>$U_{rms\ L3}$</td><td>230±0.23 V</td></tr>
</table>
</td></tr>
</table>

Analyser		Results				
		f [Hz]	$U_{rms\ L1}$ [V]	$U_{rms\ L2}$ [V]	$U_{rms\ L3}$ [V]	Compliance
1	Fluke 1760	50.00	229.92	229.85	229.83	YES
2	Nexus 1500	50.00	230.03	229.98	230.01	YES
3	UP-2210	50.00	230.02	229.92	230.00	YES
4	DEWE-3020	50.00	229.91	229.94	229.94	YES
5	iSTAT M355	50.00	229.95	229.95	229.91	YES
6	SO-52v11-eME	50.00	230.04	229.99	230.04	YES
7	SIMEAS Q80	50.00	230.06	230.02	230.01	YES
8	PQ Box 200	50.00	229.79	229.78	229.78	YES
9	ION7650	---	---	---	---	NO
10	PQM-703	50.00	230.00	230.00	230.00	YES
11	PQube	50.00	230.04	229.90	229.84	YES
12	G4500	50.00	230.62	229.67	231.12	NO
13	MI 2892	50.00	230.04	230.03	230.01	YES
14	Mavowatt 270	50.00	230.00	230.00	230.00	YES

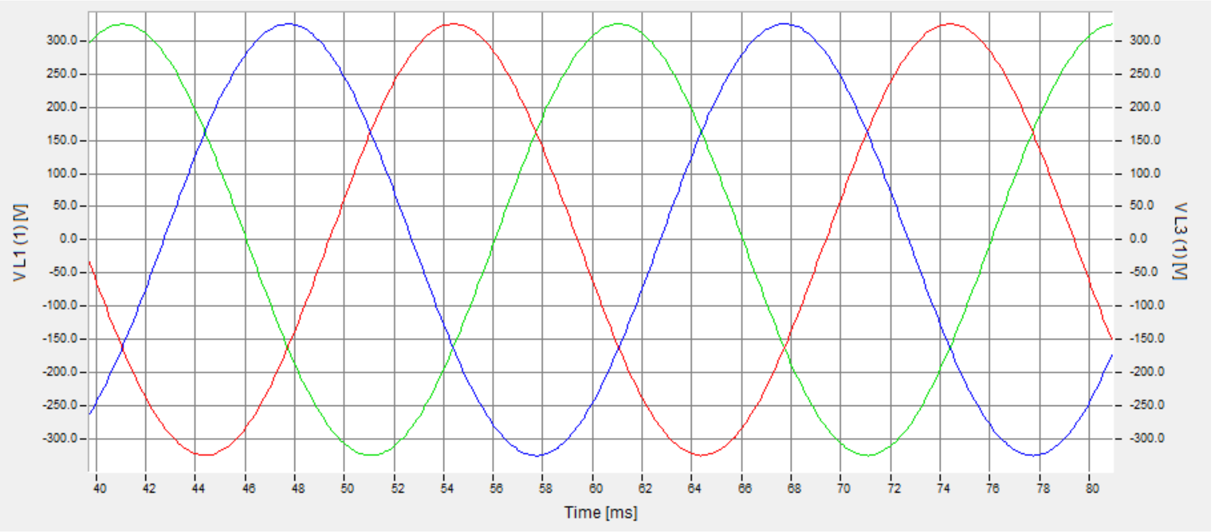
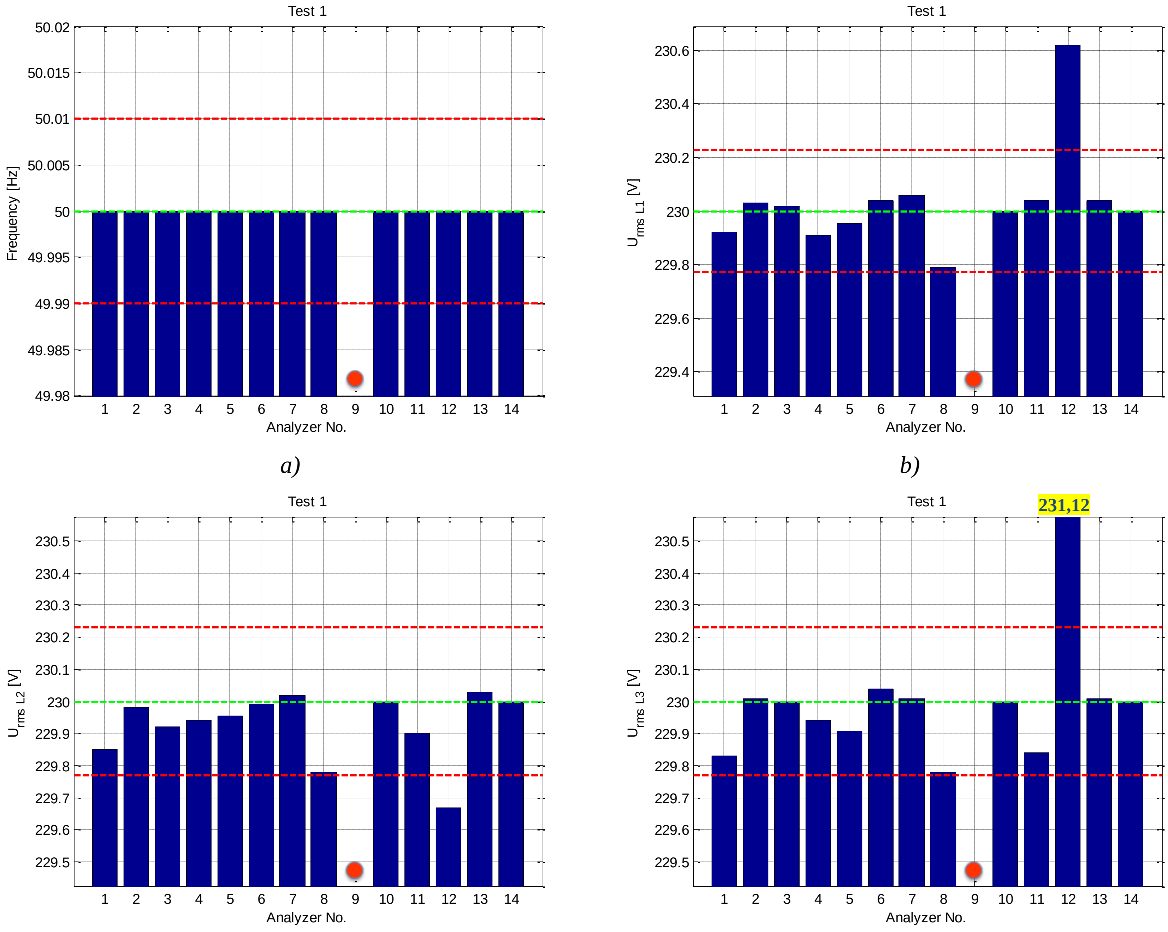


Fig. 2.1 Oscilloscope recording of voltages - Test 1



a)

b)

c)

d)

Fig. 2.2 a)-d) Comparison of analysers readings - Test 1

Summary of Test 1

As a result of measurement data analysis it was found that twelve out of fourteen analysers performed a proper measurement, i.e. all tested parameters were within the permissible range of uncertainty as defined in the test criterion.

The measurement database taken from ION7650 analyser contained no data. This situation was repeated for other tests included in the report.

According to the information provided by the manufacturer (see Chapter 6), the failure of G4500 analyser to meet the test criterion was caused by the fact that the last calibration of the analyser took place in 2010, while it is recommended to perform calibration at least once per every two years.

TEST 2	
Time:10:00-10:10	**Measurement of short-term flicker P_{st} during voltage sags**
Test signal parameters	Three phase sinusoidal voltage with U_{rms}=230 V, f = 50 Hz. The reference voltage generator produces symmetrical voltage dips with residual voltage U_{res}=80%U_{din} and durations: 20, 30, 50, 200, 600, 3000 ms, respectively. Intervals between subsequent dips are equal to 20 s.
Test criterion	The P_{st} samples are flagged. No criterion for P_{st} measurement accuracy - a comparative test.

Analyser		Results				
		$P_{st\ L1}$	$P_{st\ L2}$	$P_{st\ L3}$	Flag	Compliance
1	Fluke 1760	13.53	13.41	6.98	YES	YES
2	Nexus 1500	13.77	13.45	6.93	YES	YES
3	UP-2210	13.84	13.30	7.17	YES	YES
4	DEWE-3020	---	---	---	---	---
5	iSTAT M355	14.58	13.75	7.31	YES	YES
6	SO-52v11-eME	13.64	13.49	6.94	YES	YES
7	SIMEAS Q80	---	---	---	---	---
8	PQ Box 200	13.52	13.41	6.99	YES	YES
9	ION7650	---	---	---	---	---
10	PQM-703	13.61	13.24	6.89	YES	YES
11	PQube	0.05	0.05	0.05	YES	YES
12	G4500	17.81	17.80	7.99	YES	YES
13	MI 2892	0.00	0.00	0.00	YES	YES
14	Mavowatt 270	---	---	---	---	---

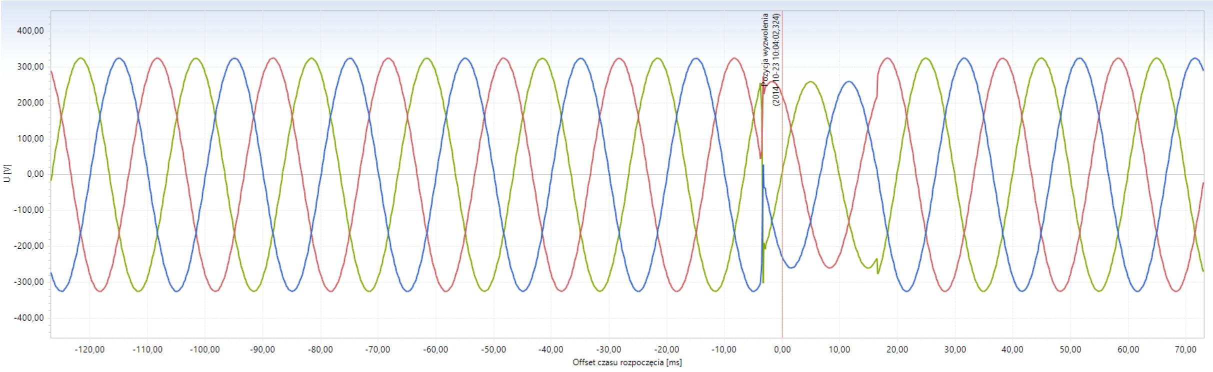


Fig. 2.3 Oscilloscope recording of a voltage sag (T=20 ms) - Test 2

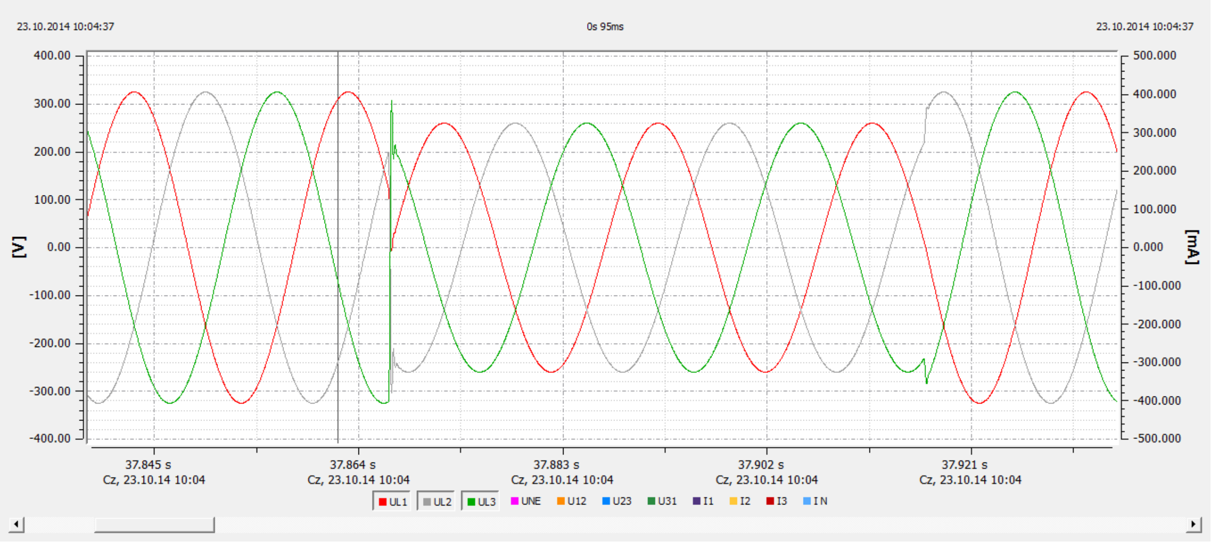


Fig. 2.4 Oscilloscope recording of a voltage sag (T=50 ms) - Test 2

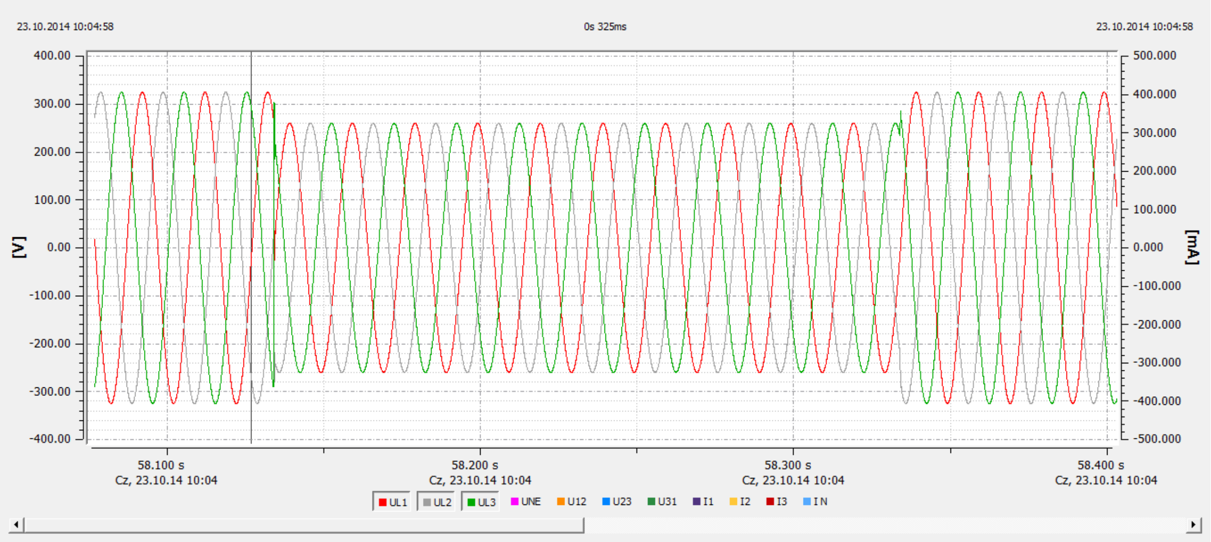
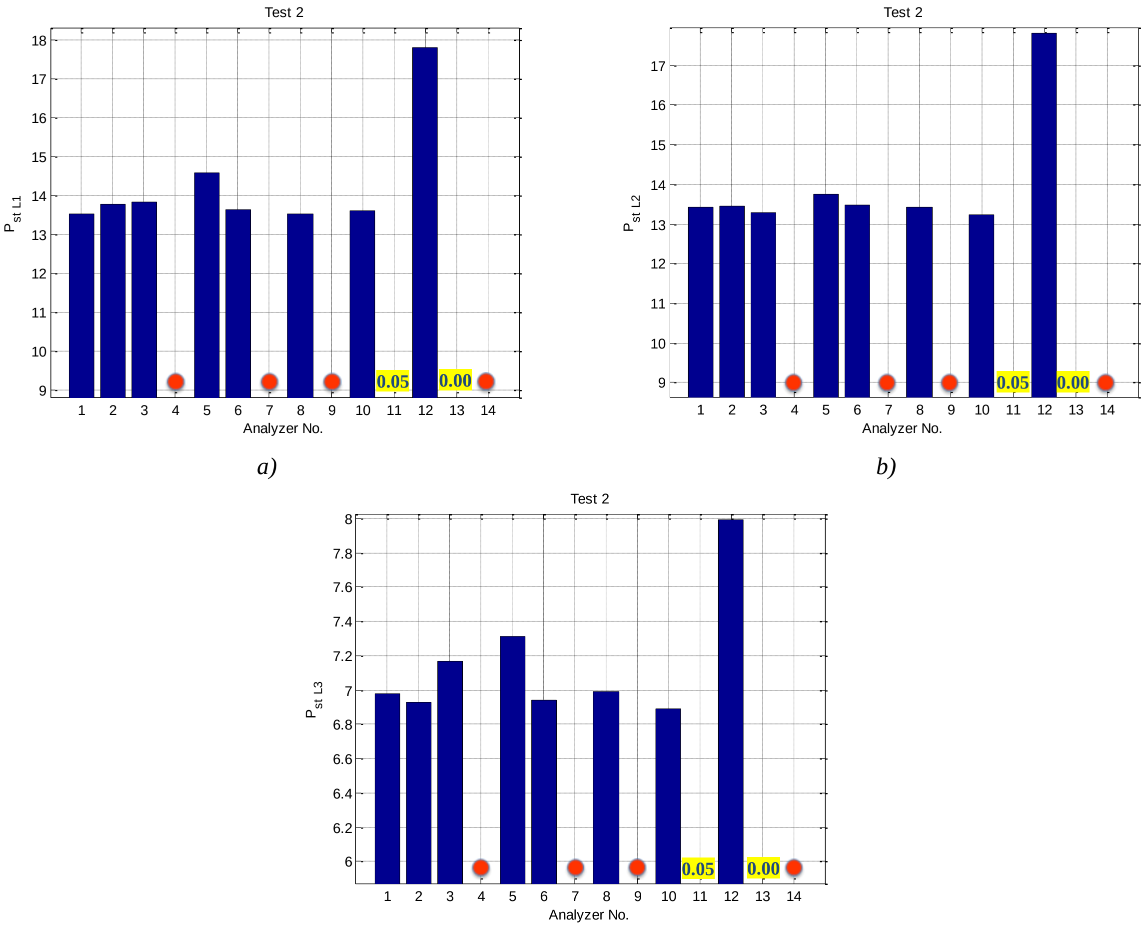


Fig. 2.5 Oscilloscope recording of a voltage sag (T=200 ms) - Test 2



a)

b)

c)

Fig. 2.6 a)-c) Comparison of analysers readings - Test 2

Summary of Test 2

As a result of measurement data analysis it was found that P_{st} samples of ten analysers were flagged.

In the case of DEWE-3020 analyser the measurement database covering the whole duration of tests contained only readings of U_{rms} and harmonics, with no other PQ results. According to the information provided by the manufacturer, the reason for this was a mismatch between the configuration of the analyser and the conditions of individual tests. A detailed explanation is included in the formal comment from DEWETRON in Chapter 6 of this report.

According to the information provided by the manufacturer, the reason why Mavowatt 270 analyser did not register any P_{st} samples was the considerable burden of computing power caused by the necessity of recording an excessive number of voltage dips.

<table>
<tr><th colspan="2">TEST 3</th></tr>
<tr><th>Time: 10:10-10:20</th><th>Combination of PQ disturbances 1</th></tr>
<tr><td>Test signal parameters</td><td>
<table>
<tr><th></th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>f</td><td colspan="3">57,5 Hz</td></tr>
<tr><td>$U_{(1)}$</td><td>230 V ∠0°</td><td>203 V ∠-122°</td><td>230 V ∠+118°</td></tr>
<tr><td>$U_{(1,5)}$</td><td>20.70 V</td><td>18.27 V</td><td>0</td></tr>
<tr><td>$U_{(2)}$</td><td>10%$U_{(1)}$</td><td>10%$U_{(1)}$</td><td>0</td></tr>
<tr><td>$U_{(11)}$</td><td>10%$U_{(1)}$</td><td>10%$U_{(1)}$</td><td>0</td></tr>
<tr><td>$U_{(29)}$</td><td>5%$U_{(1)}$</td><td>5%$U_{(1)}$</td><td>0</td></tr>
<tr><td>$U_{(50)}$</td><td>3%$U_{(1)}$</td><td>3%$U_{(1)}$</td><td>0</td></tr>
<tr><td>U_{rms}</td><td>233.59 V</td><td>206.17 V</td><td>230 V</td></tr>
</table>
Generated signal $U_{rms\ L2}$=206.17 V, mainly due to the presence of $U_{(1.5)}$ component, was causing cyclic crossing the voltage dip threshold during the whole test period.
</td></tr>
<tr><td>Test criterion</td><td>
<table>
<tr><th>Parameter</th><th>Expected result</th><th>Parameter</th><th>Expected result</th></tr>
<tr><td>$U_{ih1.5\ L1}$</td><td>20.70±1.04 V</td><td>$U_{h29\ L2}$</td><td>5±0.25%$U_{(1)}$</td></tr>
<tr><td>$U_{rms\ L2}$</td><td>206.17±0.23 V</td><td>$U_{h50\ L2}$</td><td>3±0.15%$U_{(1)}$</td></tr>
<tr><td>$U_{h1\ L2}$</td><td>203±10.15 V</td><td>THD_{L1}</td><td>15.30% (15.00%)*</td></tr>
<tr><td>$U_{ih1.5\ L2}$</td><td>18.27±0.91 V</td><td>THD_{L2}</td><td>15.30% (15.00%)*</td></tr>
<tr><td>$U_{h2\ L2}$</td><td>10±0.5%$U_{(1)}$</td><td>THD_{L3}</td><td>0%</td></tr>
<tr><td>$U_{h11\ L2}$</td><td>10±0.5%$U_{(1)}$</td><td>k_u</td><td>3.07±0.15</td></tr>
</table>
* value in parentheses indicates the expected value of THD taking into account only harmonics with orders from 2 to 40.
** the measurement uncertainty of components U_{h1} and $U_{ih\ 1.5}$ was calculated as 5% of measuring value.
</td></tr>
</table>

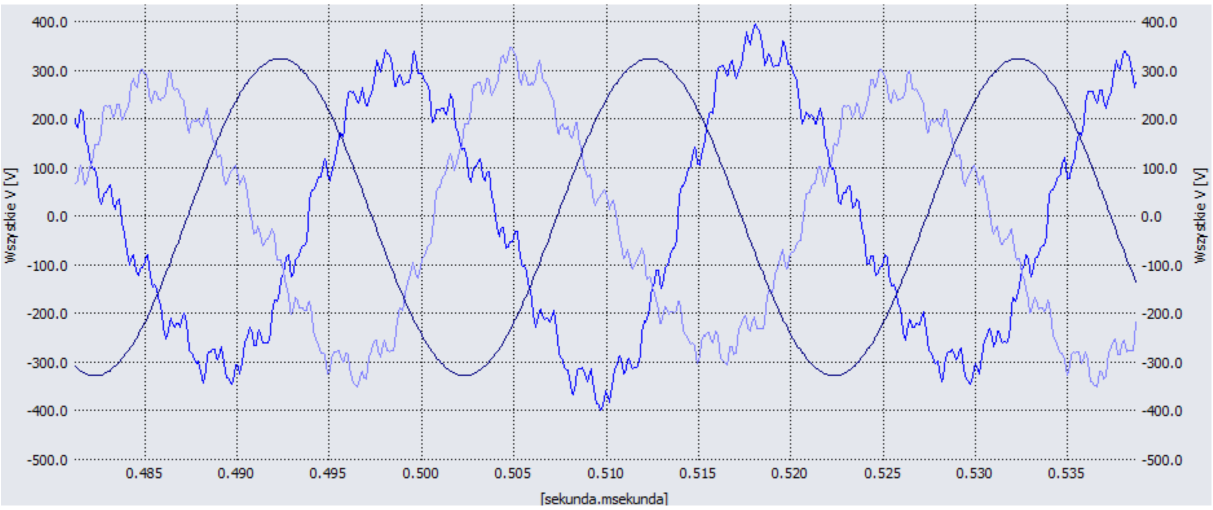


Fig. 2.7 Oscilloscope recording of voltages - Test 3

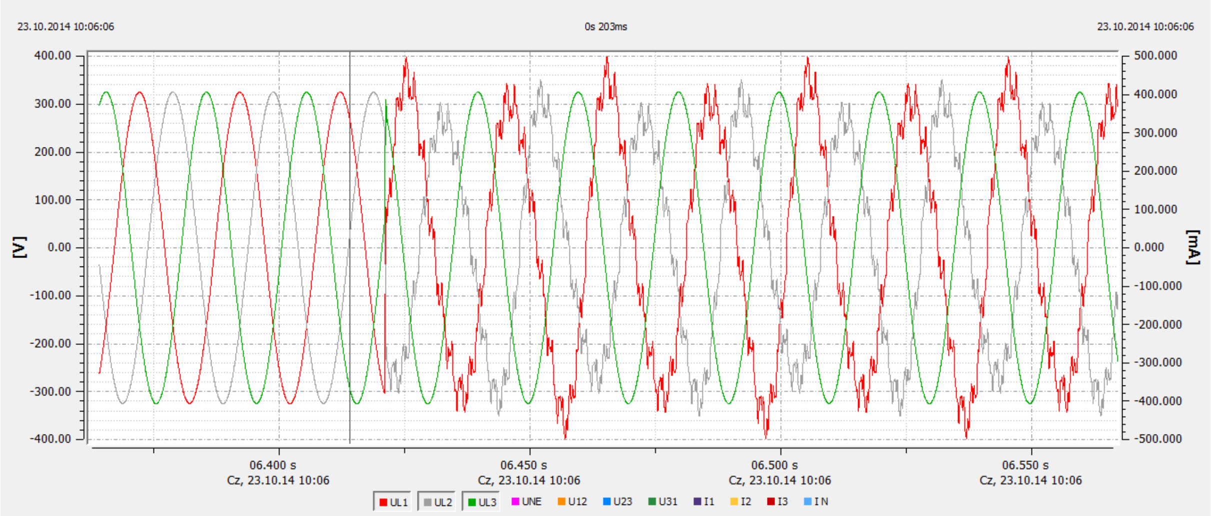


Fig. 2.8 Oscilloscope recording of voltages - change in the voltage signals from Test 2 to Test 3

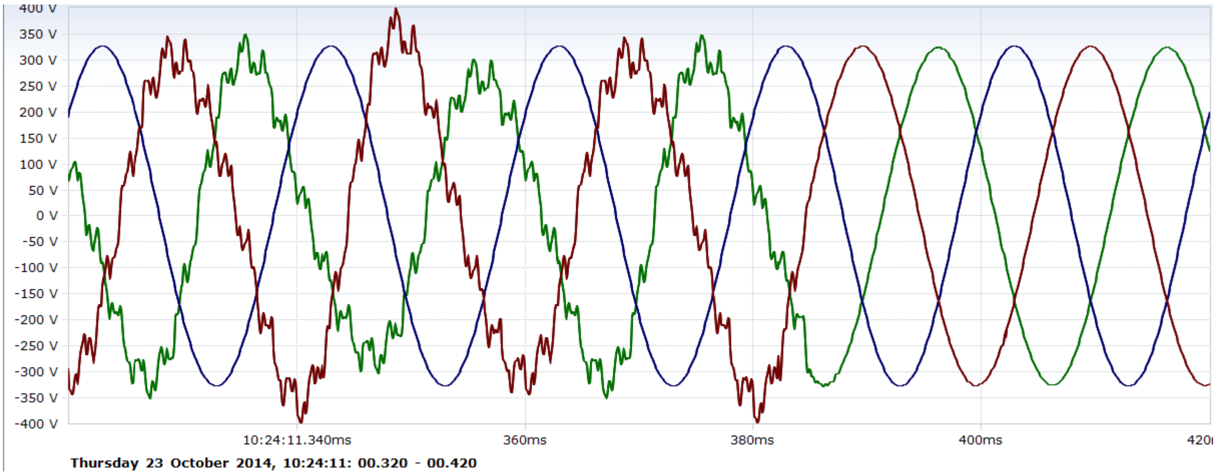
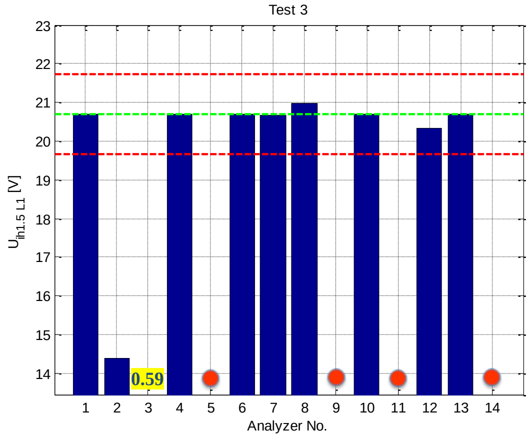


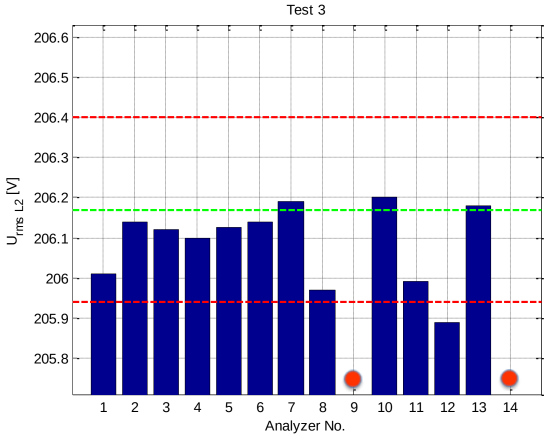
Fig. 2.9 Oscilloscope recording of voltages - the end of the Test 3

Analyser		Results						
		$U_{\text{ih1.5 L1}}$ [V]	$U_{\text{rms L2}}$ [V]	$U_{\text{h1 L2}}$ [V]	$U_{\text{ih1.5 L2}}$ [V]	$U_{\text{h2 L2}}$ [%]	$U_{\text{h11 L2}}$ [%]	Compliance
1	Fluke 1760	20.69	206.01	202.86	18.25	10.00	9.96	YES
2	Nexus 1500	14.38	206.14	---	14.35	9.99	9.99	NO
3	UP-2210	0.59	206.12	229.67	0.50	0.66	0.63	NO
4	DEWE-3020	20.69	206.10	202.93	18.26	10.00	9.00	NO
5	iSTAT M355	---	206.13	---	---	---	---	NO
6	SO-52v11-eME	20.71	206.14	203.00	18.28	10.00	10.00	YES
7	SIMEAS Q80	20.66	206.19	203.01	18.25	10.00	10.01	YES
8	PQ Box 200	20.99	205.97	205.97	18.53	10.00	9.99	YES
9	ION7650	---	---	---	---	---	---	NO
10	PQM-703	20.71	206.2	203.00	18.28	10.00	9.98	YES
11	PQube	---	205.99	---	---	---	---	NO
12	G4500	20.33	205.89	202.75	17.88	10.00	9.99	NO
13	MI 2892	20.69	206.18	203.02	18.26	9.99	9.99	YES
14	Mavowatt 270	---	---	---	---	---	---	NO

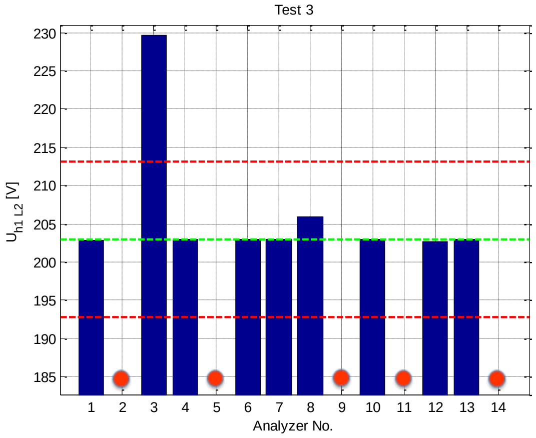
Analyser		Results						
		$U_{\text{h29 L2}}$ [%]	$U_{\text{h50 L2}}$ [%]	THD_{L1} [%]	THD_{L2} [%]	THD_{L3} [%]	k_u [%]	Compliance
1	Fluke 1760	4.98	2.97	14.97	14.96	0.04	3.08	YES
2	Nexus 1500	5.01	3.01	15.28	15.30	0.00	2.99	YES
3	UP-2210	0.31	0.19	1.12	1.00	0.30	0.04	NO
4	DEWE-3020	5.01	3.01	---	---	---	---	NO
5	iSTAT M355	---	---	14.84	14.85	0.7	3.07	NO
6	SO-52v11-eME	5.00	3.01	15.00	15.00	0.00	3.07	YES
7	SIMEAS Q80	5.01	3.01	14.98	15.01	0.26	3.09	YES
8	PQ Box 200	4.99	2.99	14.98	14.99	0.02	3.07	YES
9	ION7650	---	---	---	---	---	---	NO
10	PQM-703	4.98	3.00	15.00	14.97	0.02	3.07	YES
11	PQube	---	---	17.60	15.60	0.40	3.00	NO
12	G4500	4.98	2.98	15.29	15.28	0.24	3.23	NO
13	MI 2892	5.00	3.00	15.00	14.99	0.08	3.07	YES
14	Mavowatt 270	---	---	---	---	---	---	NO


Test 3
$U_{ih1.5\ L1}$ [V]
23
22
21
20
19
18
17
16
15
14
0.59
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

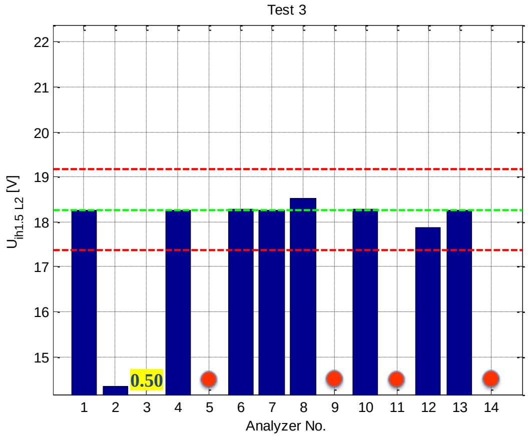
a)


Test 3
$U_{rms\ L2}$ [V]
206.6
206.5
206.4
206.3
206.2
206.1
206
205.9
205.8
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

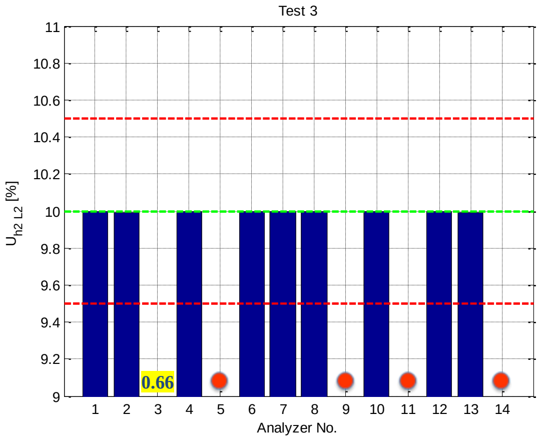
b)


Test 3
$U_{h1\ L2}$ [V]
230
225
220
215
210
205
200
195
190
185
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

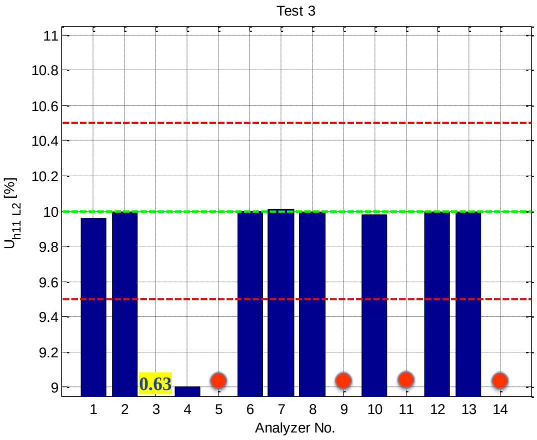
c)


Test 3
$U_{ih1.5\ L2}$ [V]
22
21
20
19
18
17
16
15
0.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

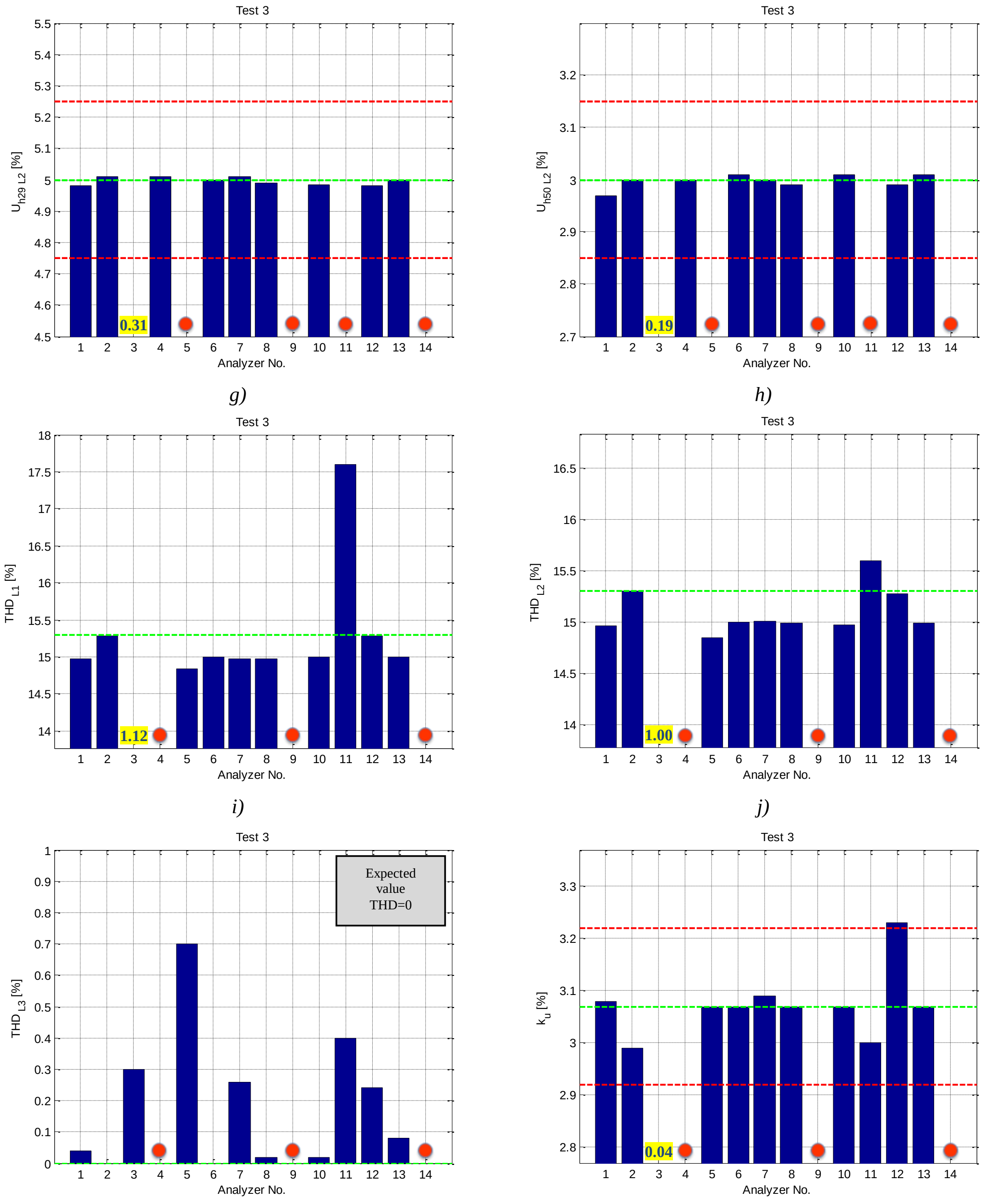
d)


Test 3
$U_{h2\ L2}$ [%]
11
10.8
10.6
10.4
10.2
10
9.8
9.6
9.4
9.2
9
0.66
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

e)


Test 3
$U_{h11\ L2}$ [%]
11
10.8
10.6
10.4
10.2
10
9.8
9.6
9.4
9.2
9
0.63
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

f)



g) *h)*

i) *j)*

k) *l)*

Fig. 2.10 a)-l) Comparison of analysers readings - Test 3

Summary of Test 3

During the analysis of the test results it was found that readings of six analysers fully complied with the test criterion.

In the case of iSTAT M355 analyser, according to the information provided by the manufacturer, the lack of measurement results of all required parameters was caused by limitations introduced at the stage of configuration, as well as the adopted methodology of measurement data aggregation whereby 10-minute values are recorded only when the permissible PQ limits are exceeded.

Nexus 1500 analyser provided a value of the 1st harmonic only in a relative form (in percentage). Based on the recorded measurement data, it was not possible to obtain this value in volts.

Measurement readings of UP-2210 analyser, according to the information provided by the manufacturer, are a consequence of the applied testing signal in which the component $U_{(1.5)\ \mathrm{L1}}$ exceeded the permissible limit for Class A certification testing signals, defined in the standard PN-EN 61000-4-30. A detailed explanation is provided in point 1.1 of the formal comment submitted by IPP Unipower. It should be noted, however, that the standard PN-EN 50160 allows the presence of signalling voltages in LV and MV networks, with frequencies up to 500 Hz, at levels up to 9% of the rated voltage.

It should also be noted that the character of the test signal, in particular the cyclic triggering of voltage sags in phase L2, was a big challenge for analysers and in many cases it forced the use of significant computing power resources in order to conduct continuous recording of events. In the opinion of the authors of this report, the obtained information about analysers' behaviour in such specific test conditions is interesting. It can be seen that after applying the voltage signal of Test 3 some analysers were conducting continuous recording of all events (both *rms* and oscilloscope recording), while in some of them the recording was stopped.

<table>
<tr><th colspan="2">TEST 4</th></tr>
<tr><th>Time: 10:30-10:40</th><th>Combination of PQ disturbances 2</th></tr>
<tr><td>Test signal parameters</td><td>
<table>
<tr><th></th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>f</td><td colspan="3">42.5 Hz</td></tr>
<tr><td>$U_{(1)}$</td><td>73%U_{din}</td><td>80%U_{din}</td><td>87%U_{din}</td></tr>
<tr><td>$U_{(2)}$</td><td>5%$U_{(1)}$</td><td>5%$U_{(1)}$</td><td>0%$U_{(1)}$</td></tr>
<tr><td>$U_{(1,5)}$</td><td>0</td><td>11,5 V</td><td>0</td></tr>
<tr><td>$U_{(90 Hz)}$</td><td>0</td><td>0</td><td>9,2 V</td></tr>
<tr><td>$U_{(95 Hz)}$</td><td>0</td><td>0</td><td>13,8 V</td></tr>
<tr><td>U_{rms}</td><td>168.11 V</td><td>184.59 V</td><td>200.79 V</td></tr>
</table>
Generated test signals $U_{rms\ L1}$, $U_{rms\ L2}$, $U_{rms\ L3}$ correspond to the steady reduction in voltage below the voltage sag threshold.
</td></tr>
<tr><td>Test criterion</td><td>
.
<table>
<tr><th>Parameter</th><th>Expected result</th><th>Parameter</th><th>Expected result</th></tr>
<tr><td>f</td><td>42.5±0.01 Hz</td><td>$U_{h2\ L3}$</td><td>9.55±0,48 V</td></tr>
<tr><td>$U_{rms\ L3}$</td><td>200.79±0.23 V</td><td>THD_{L2}</td><td>5.00%*</td></tr>
<tr><td>$U_{h2\ L2}$</td><td>5.00±0.25%</td><td>THD_{L3}</td><td>4.77%*</td></tr>
<tr><td>$U_{ih1.5\ L2}$</td><td>11.50±0.58 V</td><td>k_u</td><td>5.05±0.15%</td></tr>
</table>
* standard PN-EN 61000-4-30 does not define the limit value of THD
</td></tr>
</table>

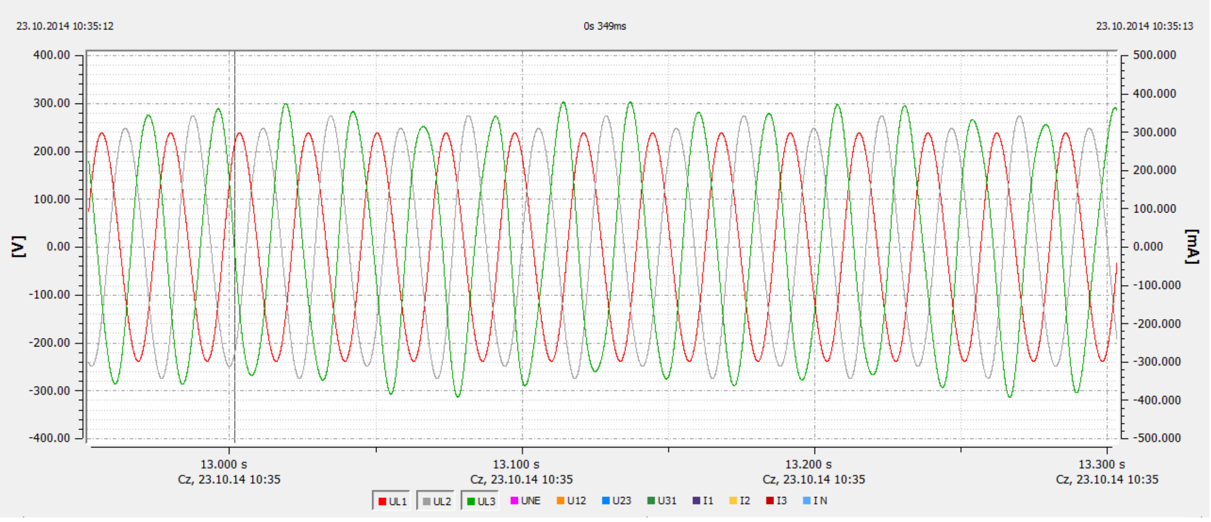


Fig. 2.11 Oscilloscope recording of voltages - Test 4

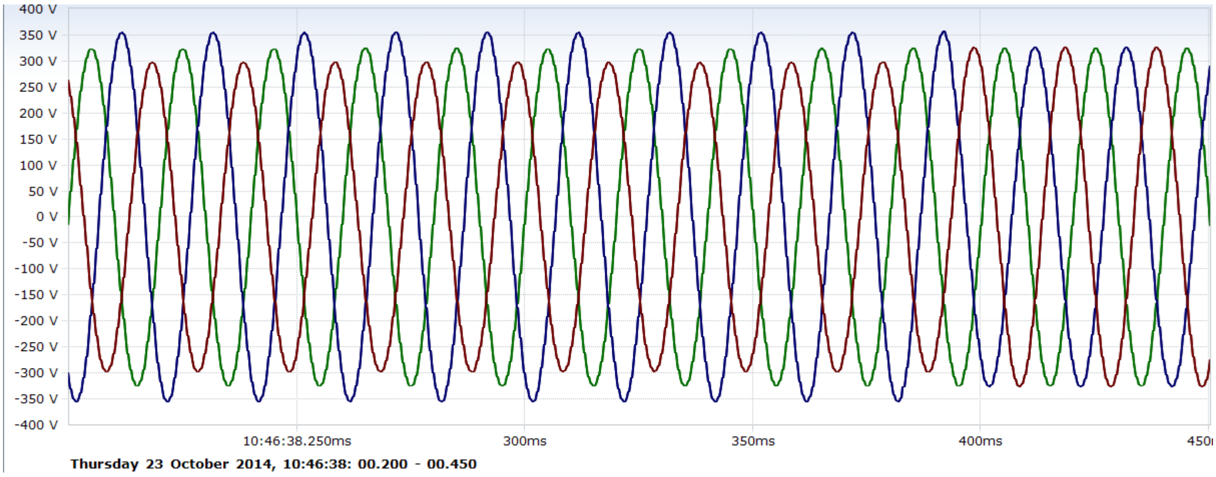
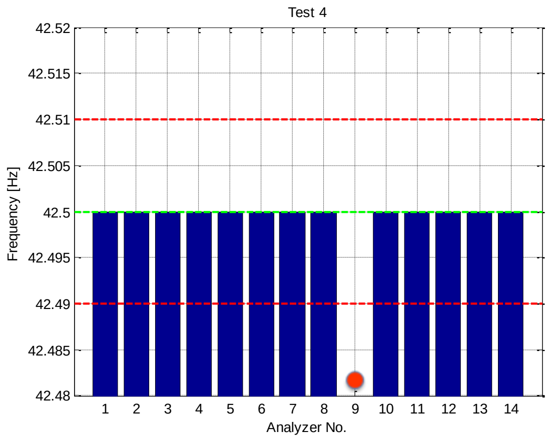


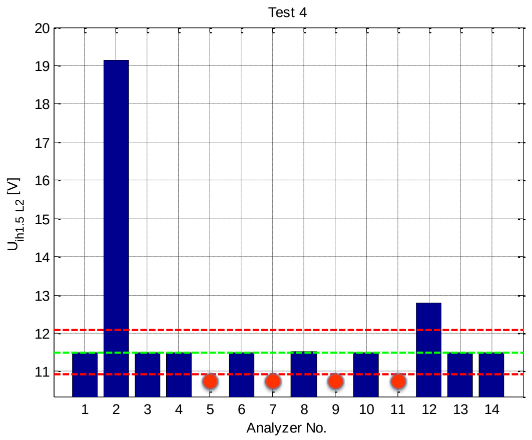
Fig. 2.12 Oscilloscope recording of voltages - the end of Test 4

Analyser		Results				
		f [Hz]	$U_{ih1.5\ L2}$ [V]	$U_{h2\ L2}$ [%]	$U_{rms\ L3}$ [V]	Compliance
1	Fluke 1760	42.5	11.49	5.00	200.60	YES
2	Nexus 1500	42.5	19.15	0.01	200.53	NO
3	UP-2210	42.5	11.49	5.02	200.78	YES
4	DEWE-3020	42.5	11.49	5.00	200.72	YES
5	iSTAT M355	42.5	---	---	200.72	NO
6	SO-52v11-eME	42.5	11.49	5.00	200.81	YES
7	SIMEAS Q80	42.5	---	5.00	200.77	NO
8	PQ Box 200	42.5	11.53	5.00	200.57	YES
9	ION7650	---	---	---	---	NO
10	PQM-703	42.5	11.49	5.00	200.80	YES
11	PQube	42.5	---	---	200.70	NO
12	G4500	42.5	12.80	5.00	201.80	NO
13	MI 2892	42.5	11.49	5.00	200.78	YES
14	Mavowatt 270	42.5	11.49	4.99	200.76	YES

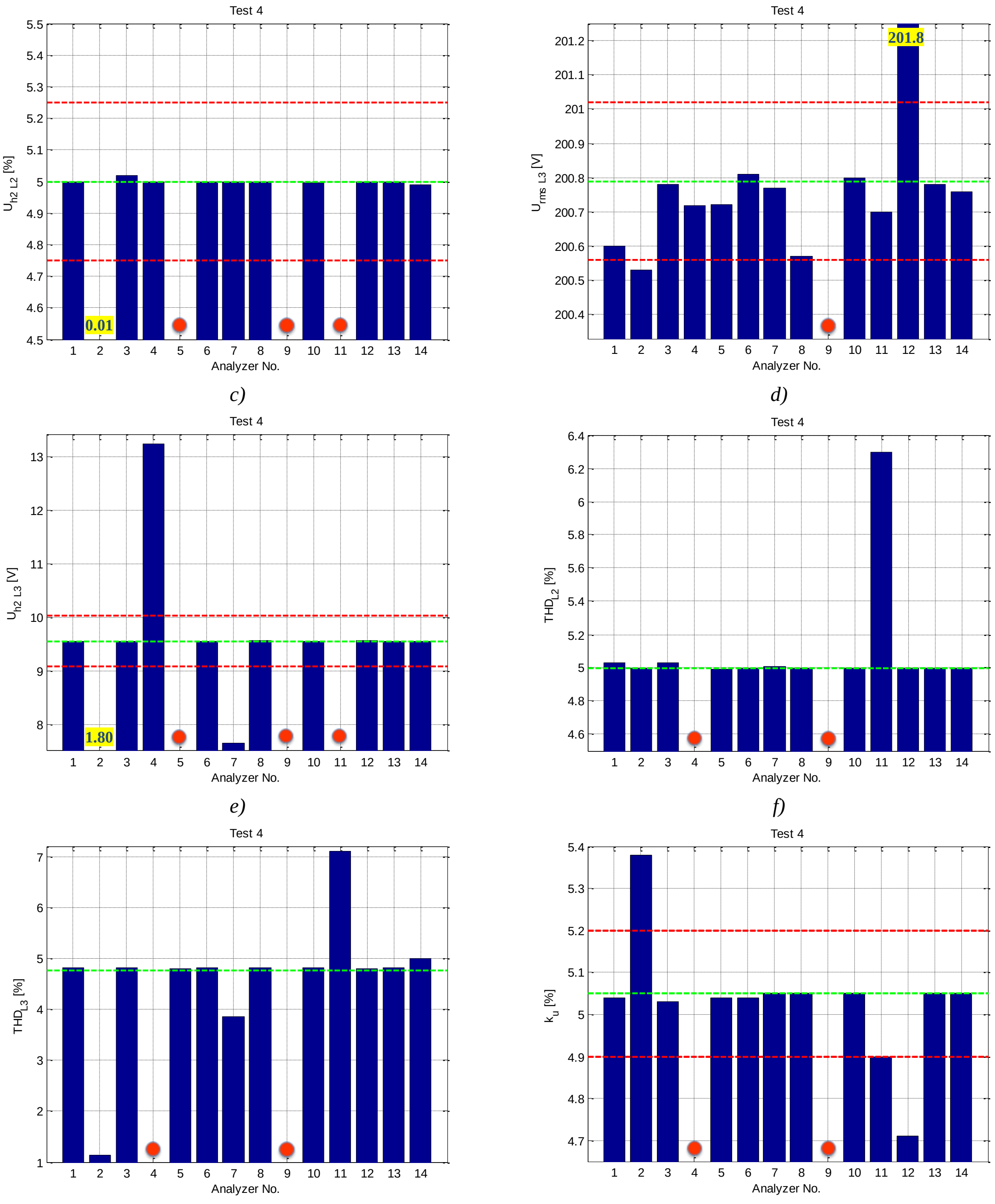
Analyser		Results				
		$U_{h2\ L3}$ [V]	THD_{L2} [%]	THD_{L3} [%]	k_u [%]	Compliance
1	Fluke 1760	9.54	5.03	4.81	5.04	YES
2	Nexus 1500	1.80	5.00	1.14	5.38	NO
3	UP-2210	9.55	5.03	4.81	5.03	YES
4	DEWE-3020	13.24	---	---	---	NO
5	iSTAT M355	---	4.99	4.79	5.04	NO
6	SO-52v11-eME	9.54	5.00	4.81	5.04	YES
7	SIMEAS Q80	7.65	5.01	3.86	5.05	NO
8	PQ Box 200	9.56	5.00	4.81	5.05	YES
9	ION7650	---	---	---	---	NO
10	PQM-703	9.55	5.00	4.81	5.05	YES
11	PQube	---	6.30	7.10	4.90	NO
12	G4500	9.56	5.00	4.80	4.71	NO
13	MI 2892	9.54	5.00	4.81	5.05	YES
14	Mavowatt 270	9.54	5.00	5.00	5.05	YES



a)



b)



c) *d)*

e) *f)*

g) *h)*

Fig. 2.13 a)-h) Comparison of analysers readings - Test 4

Summary of Test 4

During the analysis of the test results it was found that indications of seven analysers were fully in accordance with the test criterion.

All analysers (except ION 7650, already discussed in the summary of Test 1) performed a proper measurement of frequency at 42.5 Hz. Various discrepancies in measurements, or missing measurements, were found in the case of several analysers. The latter, according to the information provided by the manufacturers, were caused most frequently by mistakes at the analysers' configuration stage.

<table>
<tr><th colspan="2">TEST 5</th></tr>
<tr><th>Time: 10:50-11:00</th><th>Voltage fluctuations 1</th></tr>
<tr><td>Test signal parameters</td><td>
<table>
<tr><th></th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>f</td><td colspan="3">50 Hz</td></tr>
<tr><td>U_{rms}</td><td>215 V</td><td>230 V</td><td>245 V</td></tr>
<tr><td>P_{st}</td><td colspan="3">0.2</td></tr>
</table>
Frequency and modulation (rectangular) amplitude: 33,3333 Hz, 0,4682% U_{rms}
</td></tr>
<tr><td>Test criterion</td><td>
<table>
<tr><th>Parameter</th><th>Expected result</th></tr>
<tr><td>$U_{rms\ L1}$</td><td>215±0.23 V</td></tr>
<tr><td>$P_{st\ L1}$</td><td>0.2±0.01</td></tr>
<tr><td>$P_{st\ L2}$</td><td>0.2±0.01</td></tr>
<tr><td>$P_{st\ L3}$</td><td>0.2±0.01</td></tr>
<tr><td>k_u</td><td>3.77±0.15%</td></tr>
</table>
</td></tr>
</table>

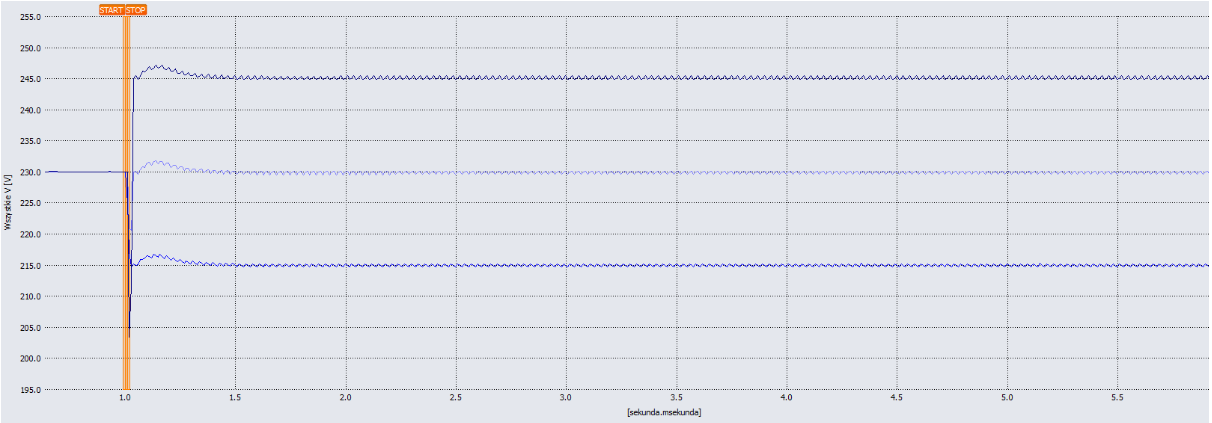


Fig. 2.14 RMS recording of voltages - Test 5

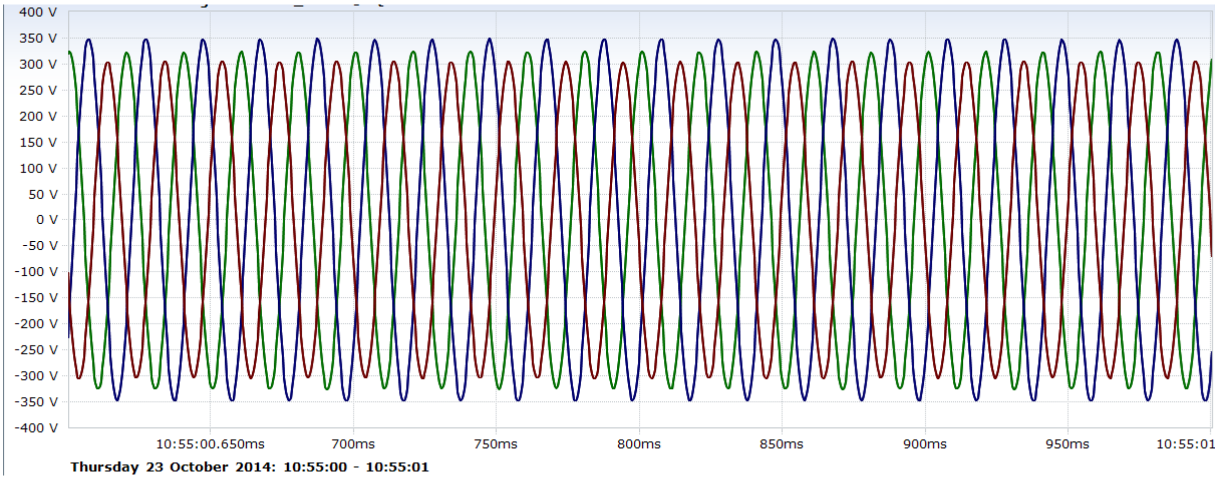
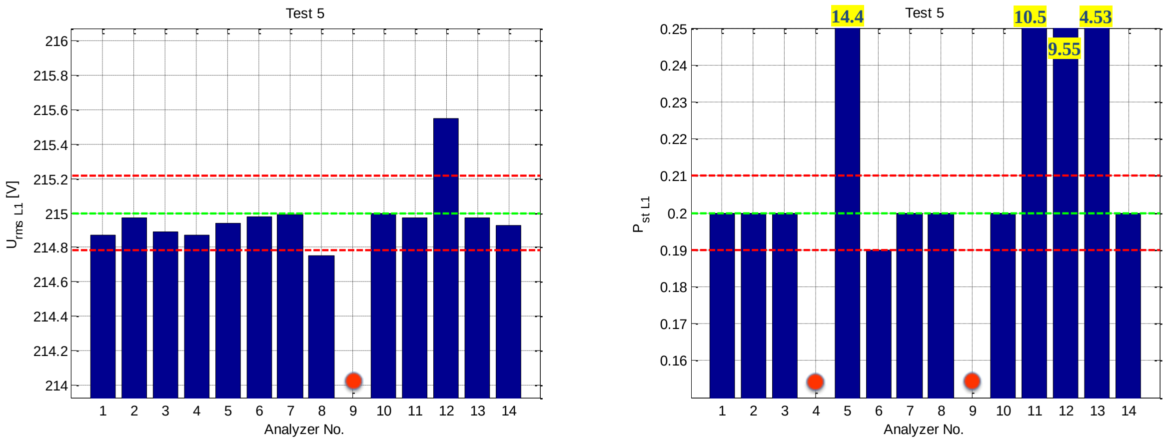
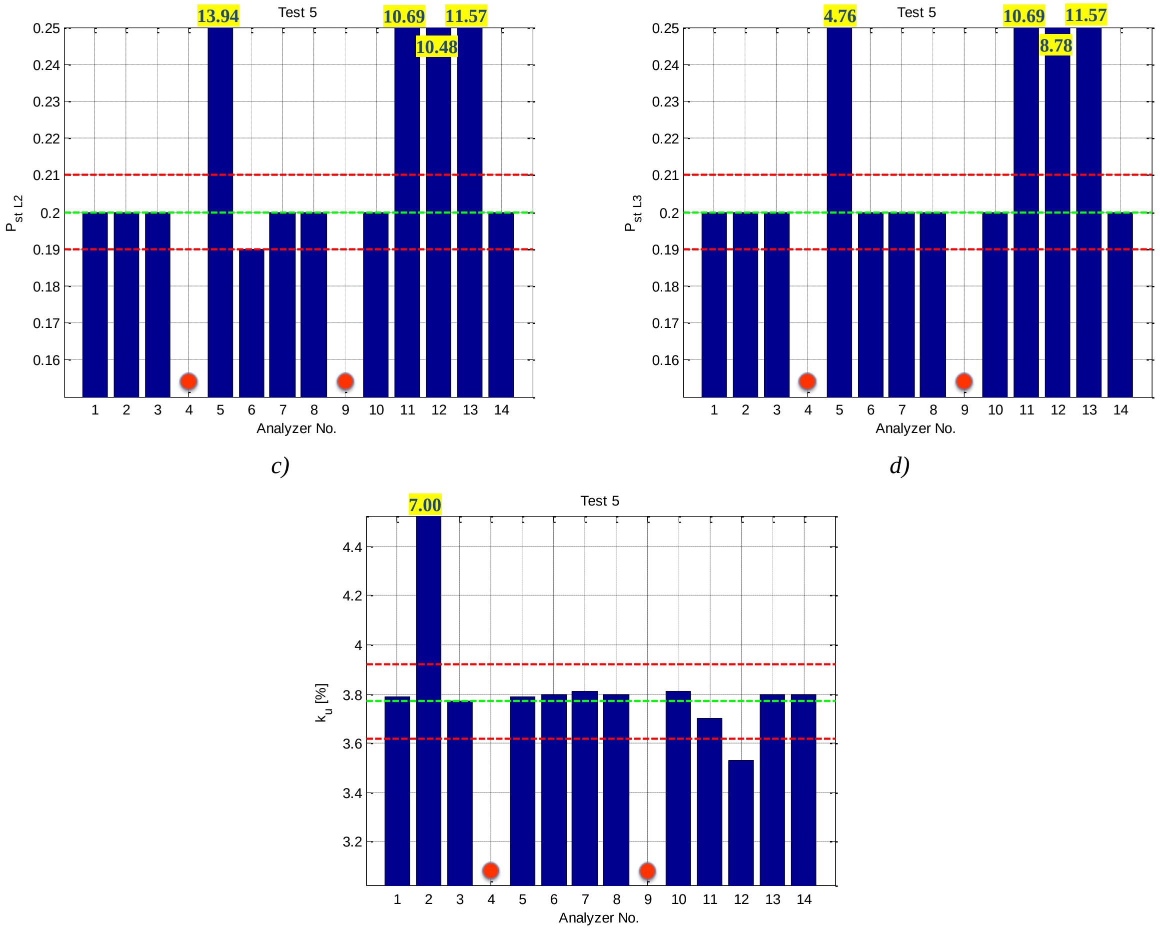


Fig. 2.15 Oscilloscope recording of voltages - Test 5

Analyser		Results					
		$U_{\mathrm{rms\ L1}}$ [V]	$P_{\mathrm{st\ L1}}$	$P_{\mathrm{st\ L2}}$	$P_{\mathrm{st\ L3}}$	k_u [%]	Compliance
1	Fluke 1760	214.87	0.20	0.20	0.20	3.79	YES
2	Nexus 1500	214.97	0.20	0.20	0.20	7.00	NO
3	UP-2210	214.89	0.20	0.20	0.20	3.77	YES
4	DEWE-3020	214.87	---	---	---	---	NO
5	iSTAT M355	214.94	14.4	13.94	4.76	3.79	NO
6	SO-52v11-eME	214.98	0.19	0.19	0.19	3.80	YES
7	SIMEAS Q80	214.99	0.20	0.20	0.20	3.81	YES
8	PQ Box 200	214.75	0.20	0.20	0.20	3.80	NO
9	ION7650	---	---	---	---	---	NO
10	PQM-703	215.00	0.20	0.20	0.20	3.81	YES
11	PQube	214.97	10.50	10.69	10.69	3.70	NO
12	G4500	215.55	9.55	10.48	8.78	3.53	NO
13	MI 2892	214.97	4.53	11.57	11.57	3.80	NO
14	Mavowatt 270	214.93	0.20	0.20	0.20	3.80	YES



a) *b)*



c)

d)

e)

Fig. 2.16 a)-e) Comparison of analysers readings - Test 5

Summary of Test 5

During the analysis of the test results it was found that P_{st} readings of eight analysers complied with the test criterion.

In the case of MI 2892 analyser it could be noticed that the measurement database contained correct P_{st} values but they were shifted by 10 minutes in relation to the actual time of measurement. This fact clearly indicates the reason for the observed discrepancies. At 11:10, MI 2892 analyser recorded $P_{st\ L1}$=$P_{st\ L2}$=$P_{st\ L3}$=0.2, which is in line with the test criterion.

The readings of G4500 analyser, according to the information provided by the manufacturer, do not comply with the test criterion due to the presence of voltage of approximately 20 V between the lines N and PE. A detailed explanation of this issue is included in the formal comment from Elspec in Chapter 6.

<table>
<tr><th colspan="2">TEST 6</th></tr>
<tr><th>Time: 11:10-11:20</th><th>Voltage fluctuations 2</th></tr>
<tr><td>Test signal parameters</td><td>
<table>
<tr><th></th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>f</td><td colspan="3">50 Hz</td></tr>
<tr><td>U_{rms}</td><td colspan="3">230 V</td></tr>
<tr><td>P_{st}</td><td colspan="3">10</td></tr>
</table>
Frequency and modulation (rectangular) amplitude: 33.33 Hz and 23.41%U_{rms}
</td></tr>
<tr><td>Test criterion</td><td>After the test, it was found that the generated signal did not match the desired parameters (Fig. 2.18, 2.19a-c). The difference is especially visible in the U_{rms} recordings. Voltage unbalance is particularly characteristic, which occurred despite the fact that the given voltage settings were 3x230 V.

A comparative test.</td></tr>
</table>

Analyser		Results							
		$U_{rms\ L1}$ [V]	$U_{rms\ L2}$ [V]	$U_{rms\ L3}$ [V]	$P_{st\ L1}$	$P_{st\ L2}$	$P_{st\ L3}$	k_u [%]	Compliance
1	Fluke 1760	229.38	227.83	236.88	10.03	10.17	9.39	2.49	---
2	Nexus 1500	229.58	230.02	236.37	10.12	10.20	9.44	7.64	---
3	UP-2210	229.43	227.93	237.02	9.87	10.01	9.24	2.46	---
4	DEWE-3020	229.40	227.91	236.98	---	---	---	---	---
5	iSTAT M355	229.06	228.28	237.06	9.63	9.75	8.67	2.47	---
6	SO-52v11-eME	229.51	227.98	237.09	10.13	10.29	9.48	2.49	---
7	SIMEAS Q80	229.98	228.48	237.11	9.96	10.00	9.16	2.48	---
8	PQ Box 200	229.26	227.78	236.82	9.86	10.00	9.23	2.47	---
9	ION7650	---	---	---	---	---	---	---	---
10	PQM-703	229.50	228.00	237.10	10.02	10.19	9.4	2.50	---
11	PQube	229.28	227.64	236.68	9.13	9.35	9.63	2.40	---
12	G4500	229.53	227.07	237.65	18.23	19.75	18.76	2.17	---
13	MI 2892	229.52	228.00	237.06	9.82	9.71	8.90	2.49	---
14	Mavowatt 270	229.22	227.70	236.82	10.00	9.58	8.79	2.50	---

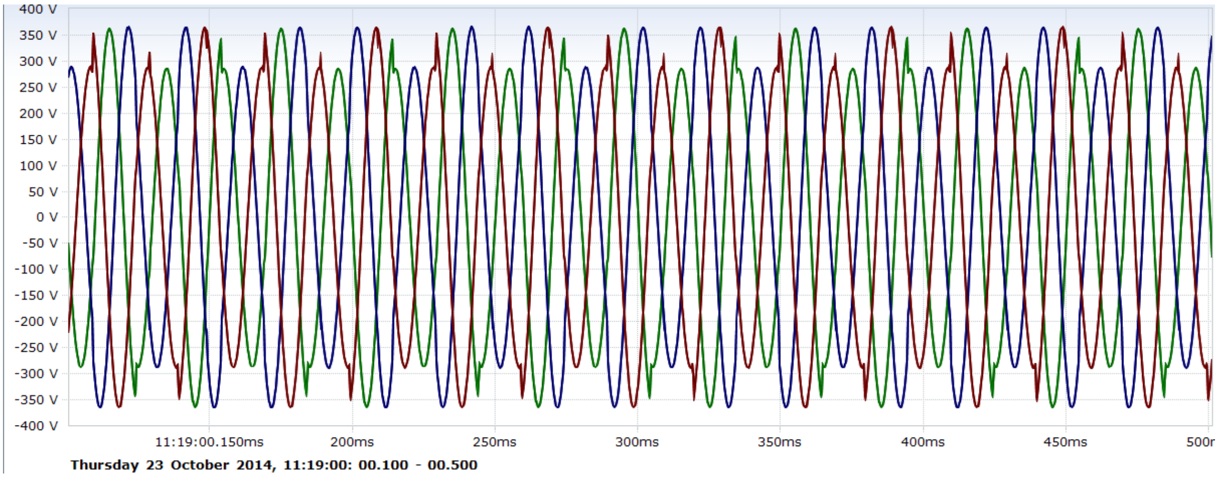


Fig. 2.17 Oscilloscope recording of voltages - Test 6

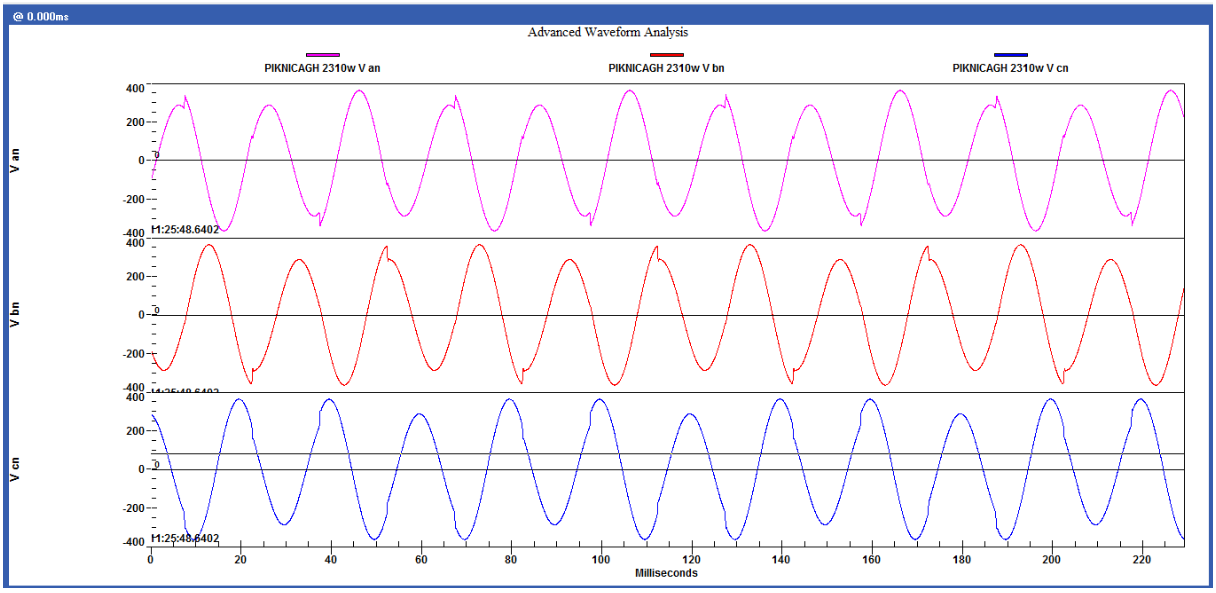
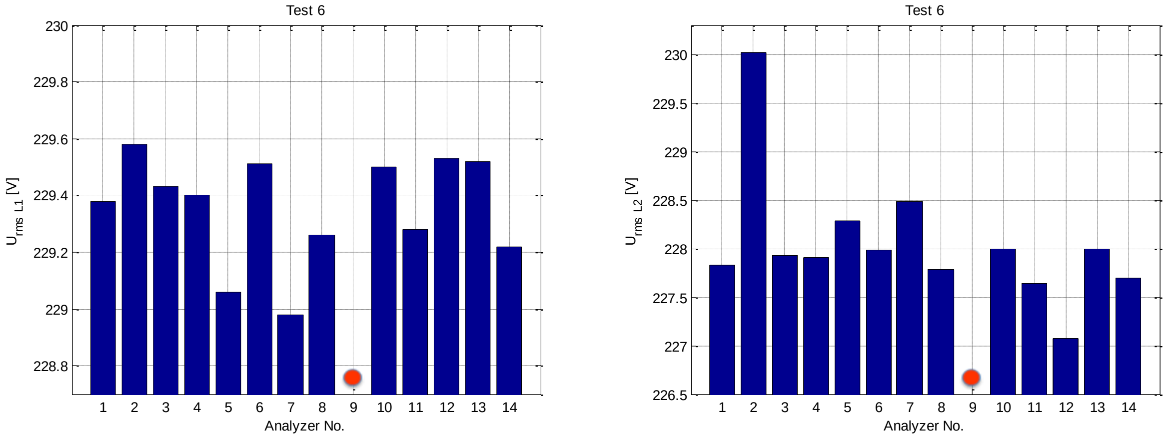
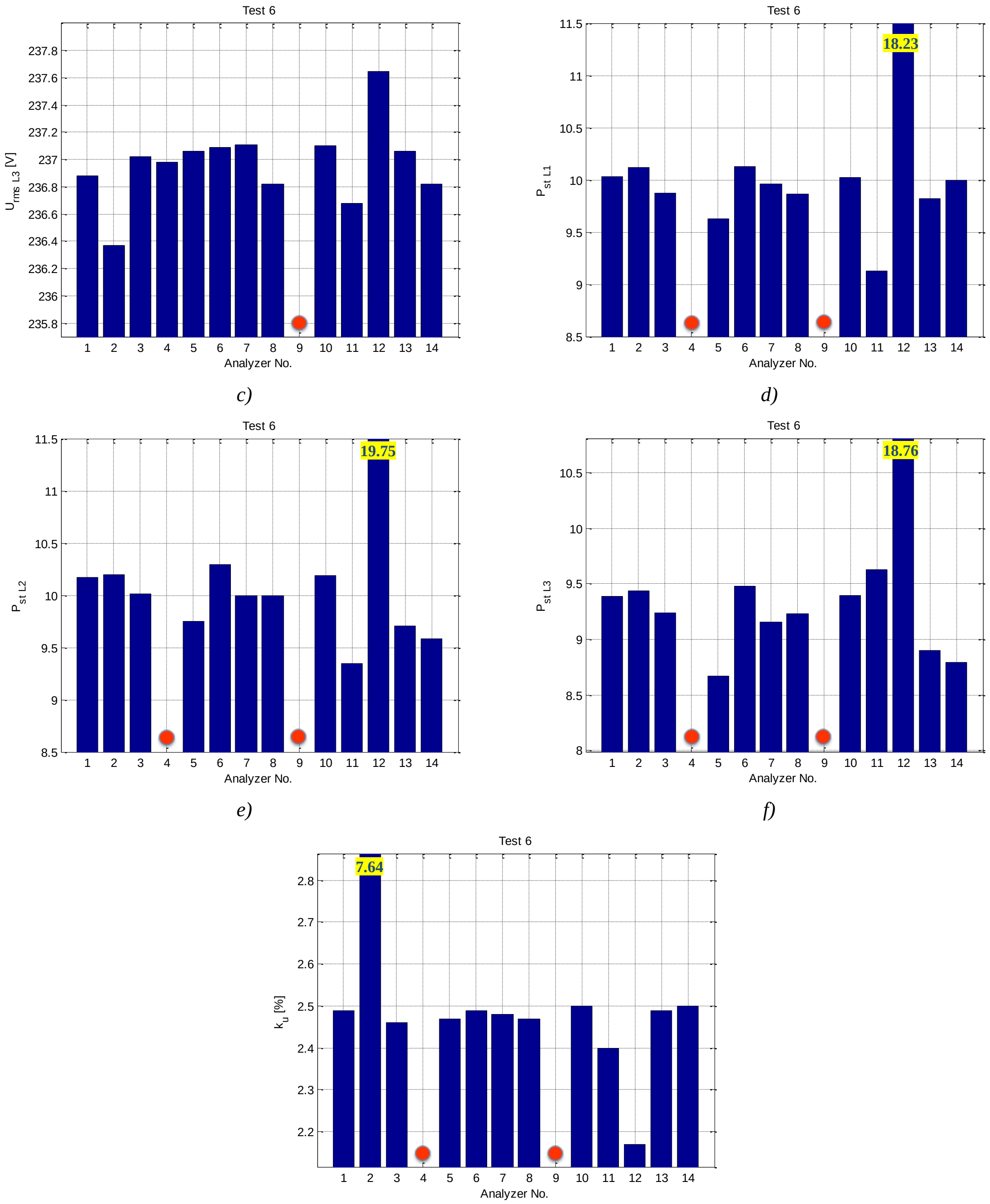


Fig. 2.18 Oscilloscope recording of voltages - Test 6



a) *b)*



c)

d)

e)

f)

g)

Fig. 2.19 a)-g) Comparison of analysers readings - Test 6

Summary of Test 6

During the analysis of the test results it was found that there was the discrepancy between the set test conditions and the readings taken from all PQ analysers.

Due to difficulties with reliable determination of the expected results, the test was treated as a comparative test. An explanation of the discrepancies observed between the readings and the expected values of U_{rms} and P_{st} is contained in a formal comment received from the manufacturer of the generator – OMICRON electronics. It shows that it is a physically correct phenomenon that artificial introduction of a rectangular three-phase modulation with a frequency of 33.333 Hz always causes different indications of U_{rms}, and thus different indications of P_{st}. This effect is clearly visible in Fig. 2.17.

<table>
<tr><th colspan="2">TEST 7</th></tr>
<tr><th>Time: 11:30-11:40</th><th>Combination of PQ disturbances 3</th></tr>
<tr><td>Test signal parameters</td><td>
<table>
<tr><th></th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>f</td><td colspan="3">57.5 Hz</td></tr>
<tr><td>$U_{(1)}$</td><td>95%U_{din} ∠0°</td><td>100%U_{din} ∠-123°</td><td>105%U_{din} ∠+119°</td></tr>
<tr><td>P_{st}</td><td>1,05</td><td>0,99</td><td>0,95</td></tr>
<tr><td>$U_{(11)}$</td><td>5%$U_{(1)}$ ∠0°</td><td>10%$U_{(1)}$ ∠0°</td><td>0.5%$U_{(1)}$ ∠0°</td></tr>
<tr><td>$U_{(16)}$</td><td>5%$U_{(1)}$ ∠30°</td><td>5%$U_{(1)}$ ∠60°</td><td>5%$U_{(1)}$ ∠90°</td></tr>
<tr><td>$U_{(41)}$</td><td>3%$U_{(1)}$ ∠180°</td><td>3%$U_{(1)}$ ∠180°</td><td>3%$U_{(1)}$ ∠180°</td></tr>
<tr><td>$U_{(44)}$</td><td>1%$U_{(1)}$ ∠120°</td><td>2%$U_{(1)}$ ∠150°</td><td>0.1%$U_{(1)}$ ∠180°</td></tr>
<tr><td>$U_{(520\ Hz)}$</td><td>5 V</td><td>5 V</td><td>5 V</td></tr>
<tr><td>$U_{(567\ Hz)}$</td><td>5 V</td><td>5 V</td><td>5 V</td></tr>
<tr><td>U_{rms}</td><td>219.26 V</td><td>231.68 V</td><td>242.01 V</td></tr>
</table>
</td></tr>
<tr><td>Test criterion</td><td>
<table>
<tr><th>Parameter</th><th>Expected result</th><th>Parameter</th><th>Expected result</th></tr>
<tr><td>f</td><td>57.5±0.01 Hz</td><td>$U_{ih9.5\ L1}$</td><td>3.09±0.15%</td></tr>
<tr><td>$U_{rms\ L3}$</td><td>242.01±0.23 V</td><td>THD$_{L3}$</td><td>6.38* (5.85)**</td></tr>
<tr><td>$U_{h10\ L2}$</td><td>4.06±0.2%</td><td>k_u</td><td>1.52±0.15%***</td></tr>
<tr><td>$U_{h11\ L2}$</td><td>10±0.5%</td><td>$P_{st\ L1}$</td><td>1.05±0.05</td></tr>
<tr><td>$U_{h44\ L2}$</td><td>2±0.1%</td><td>$P_{st\ L2}$</td><td>0.99±0.05</td></tr>
<tr><td>$U_{h44\ L3}$</td><td>0.1±0.05%U_{din}=0.1±0.05%</td><td>$P_{st\ L3}$</td><td>0.95±0.05</td></tr>
</table>

* standard PN-EN 61000-4-30 does not define the measurement uncertainty of THD
** value in parentheses indicates the expected value of THD taking into account only harmonics with orders from 2 to 40.
*** according to the standard PN-EN 61000-4-30:2009, the additional condition of Pst<0.1 should be preserved when testing the voltage unbalance, however, this requirement is abolished in the new version of this standard, which is currently being prepared for final release. The test criterion has been determined based precisely on this standard.
</td></tr>
</table>

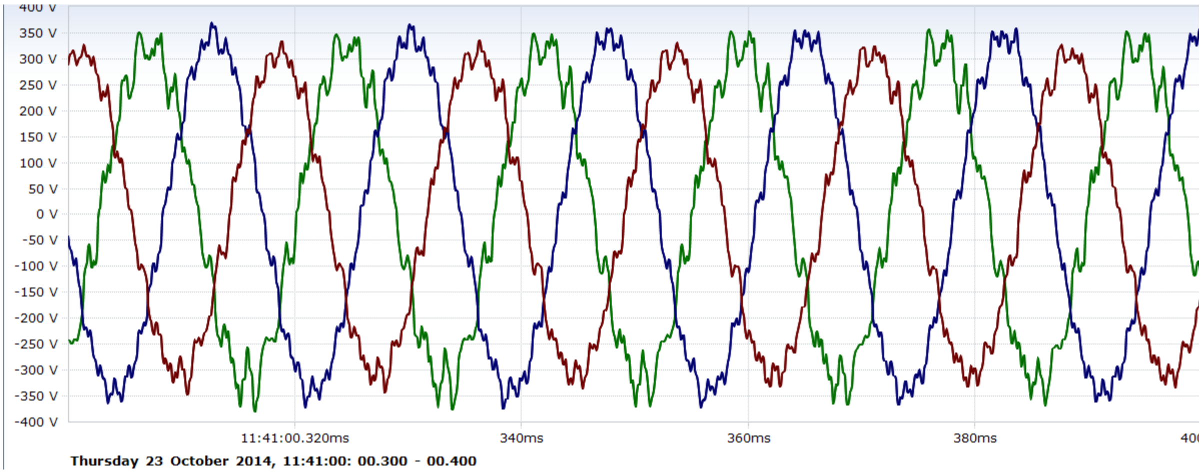
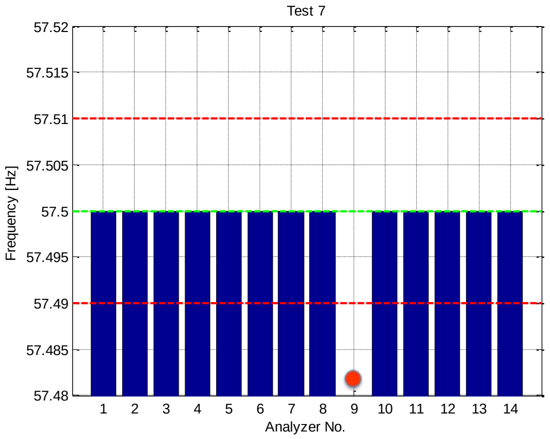


Fig. 2.20 Oscilloscope recording of voltages - Test 7

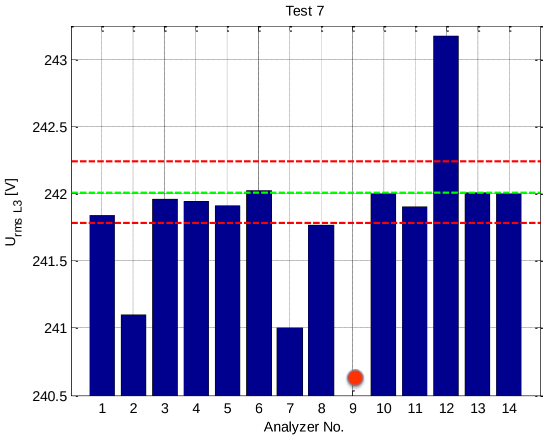
Analyser		Results				
		f [Hz]	$U_{\mathrm{rms\ L3}}$ [V]	$U_{\mathrm{h10\ L2}}$ [%]	$U_{\mathrm{h11\ L2}}$ [%]	Compliance
1	Fluke 1760	57.50	241.84	4.02	9.95	YES
2	Nexus 1500	57.50	241.10	1.04	9.97	NO
3	UP-2210	57.50	241.96	4.06	10.07	YES
4	DEWE-3020	57.50	241.94	4.03	9.98	YES
5	iSTAT M355	57.50	241.91	3.93	9.73	YES
6	SO-52v11-eME	57.50	242.02	4.04	9.97	YES
7	SIMEAS Q80	57.50	241.00	4.23	9.97	NO
8	PQ Box 200	57.50	241.77	4.03	9.97	NO
9	ION7650	---	---	---	---	NO
10	PQM-703	57.50	242.00	4.04	10.00	YES
11	PQube	57.50	241.90	---	---	NO
12	G4500	57.50	243.17	3.95	9.98	NO
13	MI 2892	57.50	242.01	4.04	9.92	YES
14	Mavowatt 270	57.50	242.00	4.06	9.99	YES

Analyser		Results				
		$U_{\mathrm{h44\ L2}}$ [%]	$U_{\mathrm{h44\ L3}}$ [%]	$U_{\mathrm{ih9.5\ L1}}$ [V]	$\mathrm{THD}_{\mathrm{L3}}$ [%]	Compliance
1	Fluke 1760	2.00	0.10	3.07	5.60	YES
2	Nexus 1500	1.97	0.09	1.18	6.03	NO
3	UP-2210	1.71	0.09	3.10	6.35	NO
4	DEWE-3020	2.00	0.10	3.06	---	NO
5	iSTAT M355	---	---	3.04	6.35	NO
6	SO-52v11-eME	1.99	0.10	3.08	5.63	YES
7	SIMEAS Q80	1.94	0.12	---	5.60	NO
8	PQ Box 200	2.00	0.10	3.13	5.62	YES
9	ION7650	---	---	---	---	NO
10	PQM-703	2.00	0.11	3.08	5.64	YES
11	PQube	---	---	---	6.80	NO
12	G4500	1.97	0.05	1.82	6.35	NO
13	MI 2892	2.01	0.10	3.08	5.64	YES
14	Mavowatt 270	2.00	0.10	3.09	6.40	YES

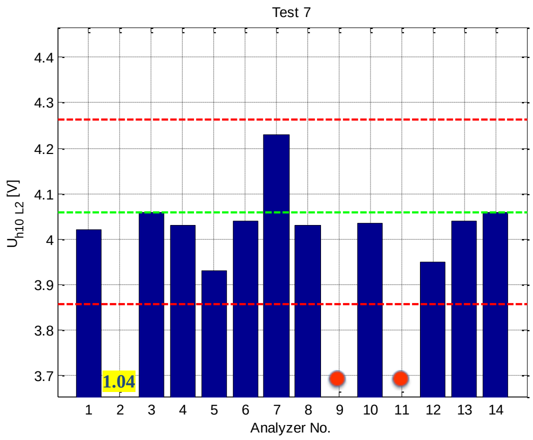
Analyser		Results				
		$P_{\mathrm{st\ L1}}$	$P_{\mathrm{st\ L2}}$	$P_{\mathrm{st\ L3}}$	k_u [%]	Compliance
1	Fluke 1760	1.11	1.04	1.00	1.51	NO
2	Nexus 1500	1.05	1.00	0.98	4.24	NO
3	UP-2210	1.05	1.00	0.97	1.49	YES
4	DEWE-3020	---	---	--	---	NO
5	iSTAT M355	9.69	9.36	8.66	1.50	NO
6	SO-52v11-eME	1.03	0.97	0.93	1.52	YES
7	SIMEAS Q80	1.06	0.99	0.96	0.51	NO
8	PQ Box 200	1.06	1.00	0.96	1.52	YES
9	ION7650	---	---	---	**---**	NO
10	PQM-703	1.02	0.96	0.93	1.53	YES
11	PQube	10.29	10.25	10.76	1.40	NO
12	G4500	41.60	41.48	37.29	1.55	NO
13	MI 2892	9.94	9.82	9.18	1.52	NO
14	Mavowatt 270	1.03	0.98	0.95	1.52	YES



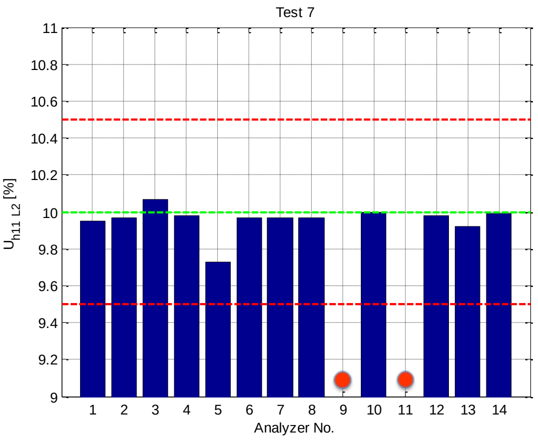
a)



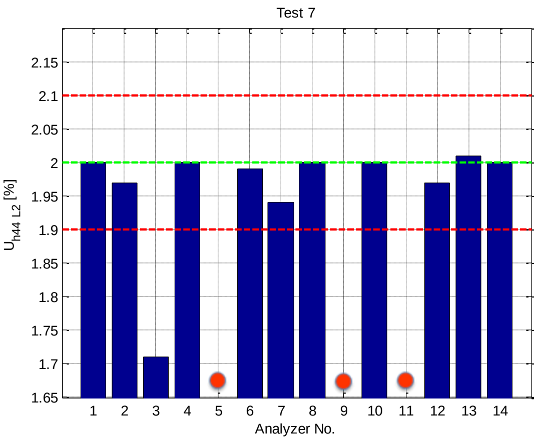
b)


Test 7
$U_{h10\ L2}$ [V]
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
1.04
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

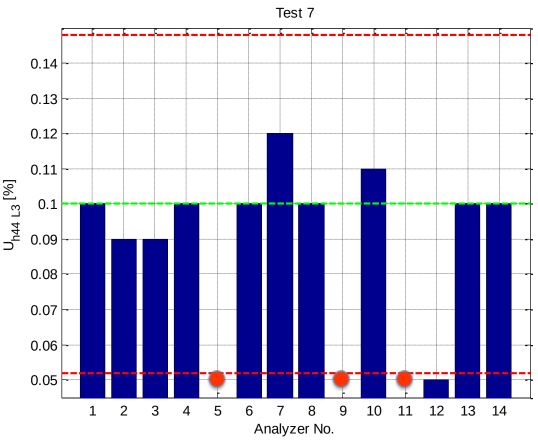
c)


Test 7
$U_{h11\ L2}$ [%]
11
10.8
10.6
10.4
10.2
10
9.8
9.6
9.4
9.2
9
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

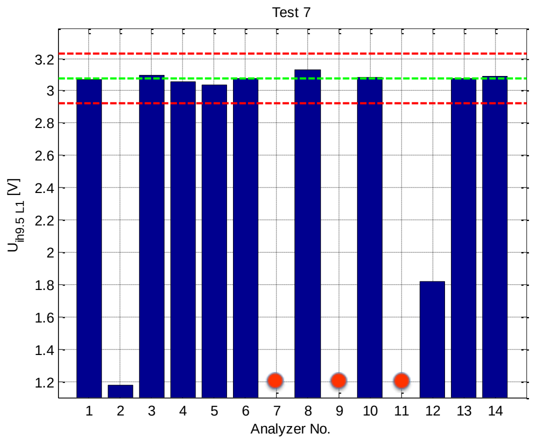
d)


Test 7
$U_{h44\ L2}$ [%]
2.15
2.1
2.05
2
1.95
1.9
1.85
1.8
1.75
1.7
1.65
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

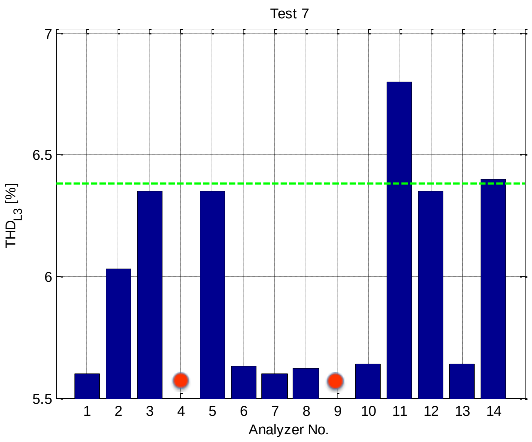
e)


Test 7
$U_{h44\ L3}$ [%]
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

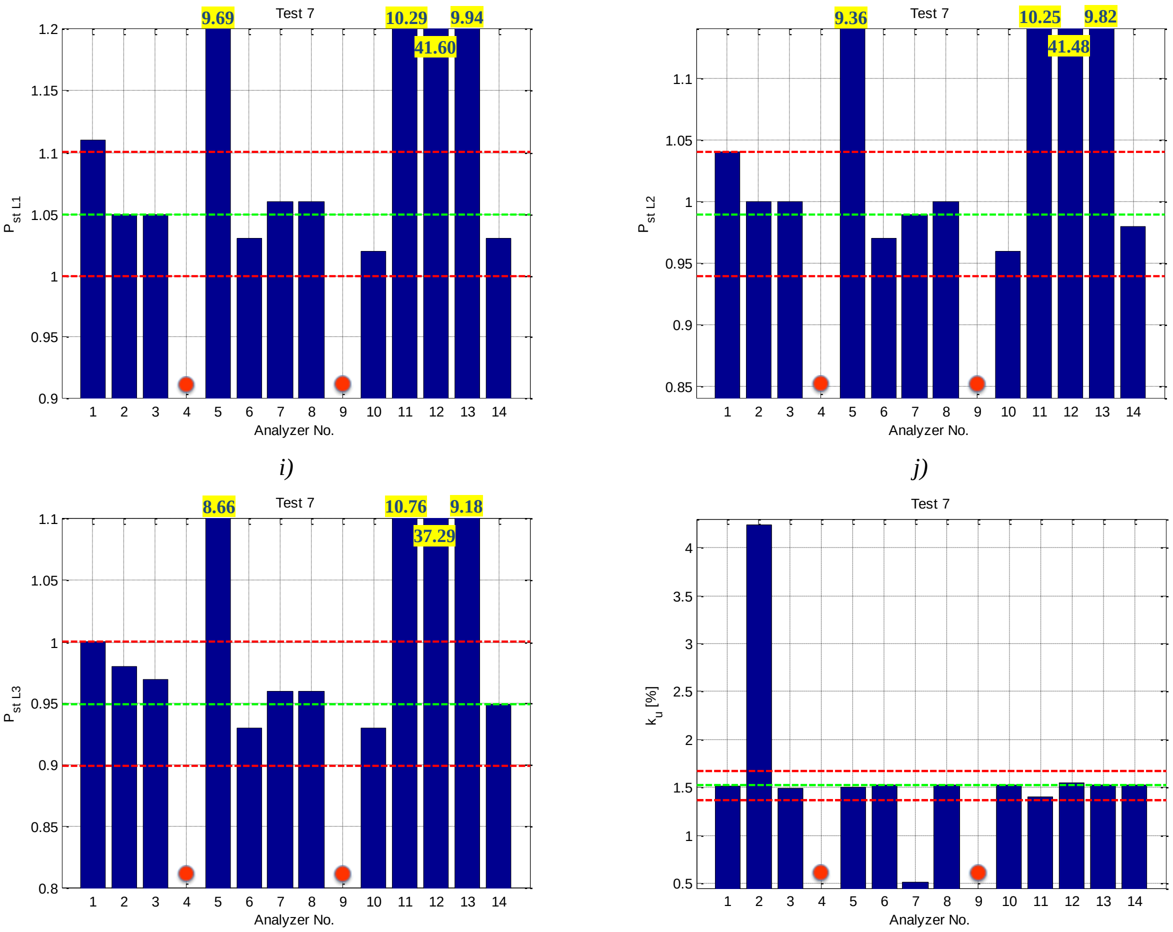
f)


Test 7
$U_{ih9.5\ L1}$ [V]
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

g)


Test 7
THD_{L3} [%]
7
6.5
6
5.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Analyzer No.

h)



i) *j)*

k) *l)*

Fig. 2.21 a)-l) Comparison of analysers readings - Test 7

Summary of Test 7

During the analysis of the test results it was found that readings of three analysers fully complied with the test criterion.

All analysers (except ION 7650, already discussed in the summary of Test 1) performed a proper measurement of frequency at 57.5 Hz.

Relatively wide disparity was found in the readings of P_{st} which was correctly measured by seven analysers.

In the case of MI 2892 analyser it could be noticed that the measurement database contained correct P_{st} values but they were shifted by 10 minutes in relation to the actual time of measurement. At 11:50, MI 2892 analyser recorded $P_{st\ L1}$=1.09, $P_{st\ L2}$=1.03, $P_{st\ L3}$=0.99, which is in line with the test criterion.

The voltage unbalance indicator k_u was measured correctly by nine analysers, despite the fact that the level of voltage fluctuations presented in the test signal was P_{st}=1.

<table>
<tr><th colspan="2">TEST 8</th></tr>
<tr><th>Time: 12:30-14:10</th><th>Verification of the proper operation of the antialiasing filter</th></tr>
<tr><td>Test signal parameters</td><td>
<table>
<tr><th></th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>f</td><td colspan="3">50 Hz</td></tr>
<tr><td>U_{rms}</td><td colspan="3">210 V (signal from 1-phase generator Fluke 6105A applied simultaneously at the 3-phase analysers' inputs)</td></tr>
</table>
High frequency components:
<table>
<tr><th></th><th>U_{rms}</th><th>f</th><th>start-stop</th></tr>
<tr><td>$U_{h.f.}$</td><td>17 V</td><td>a) 6400 Hz
b) 10199 Hz
c) 10390 Hz
d) 12758 Hz
e) 12950 Hz
f) 25050 Hz
g) 38960 Hz
h) 41110 Hz
i) 46919 Hz
j) 49200 Hz</td><td>12:30-12:40
12:40-12:50
12:50-13:00
13:00-13:10
13:10-13:20
13:20-13:30
13:30-13:40
13:40-13:50
13:50-14:00
14:00-14:10</td></tr>
</table>
</td></tr>
<tr><td>Test criterion</td><td>
<table>
<tr><th>Parameter</th><th>Expected result</th></tr>
<tr><td>THD_{L1}</td><td>0*</td></tr>
<tr><td>$P_{st\ L1}$</td><td>0÷0.2*</td></tr>
<tr><td>$U_{rms\ L1}$</td><td>210±0.23 V</td></tr>
</table>
* the standard PN-EN 61000-4-30 does not define the measurement uncertainty of THD and P_{st} for the conditions of this test. However, for the purposes of this report it was assumed that a proper value of P_{st} shall not exceed 0.2, which is the lowest level required by the standard for this measurement.
</td></tr>
</table>

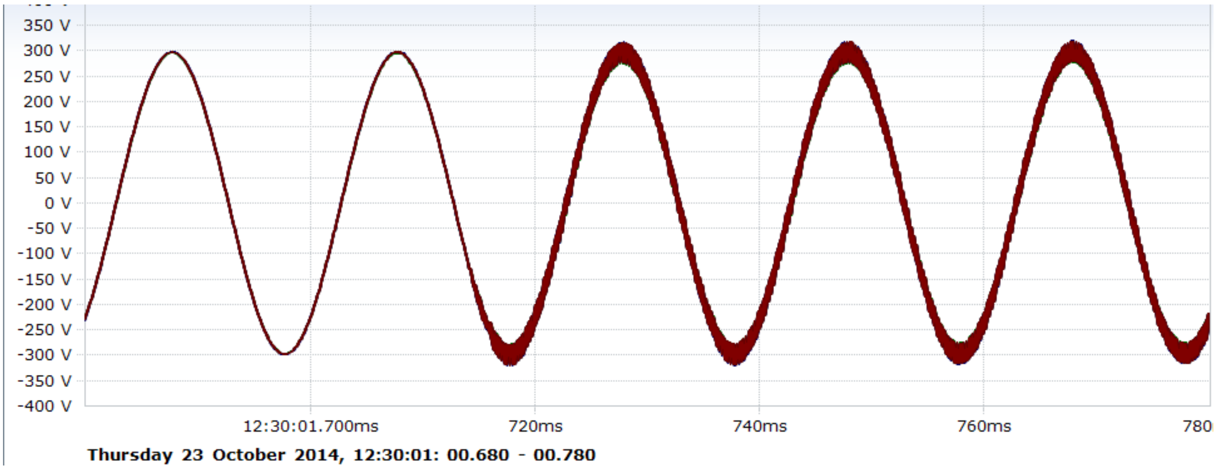


Fig. 2.22 Example of oscilloscope voltage recording - the beginning of the Test 8a (the apparent lack of filtration of $U_{h.f.}$ component)

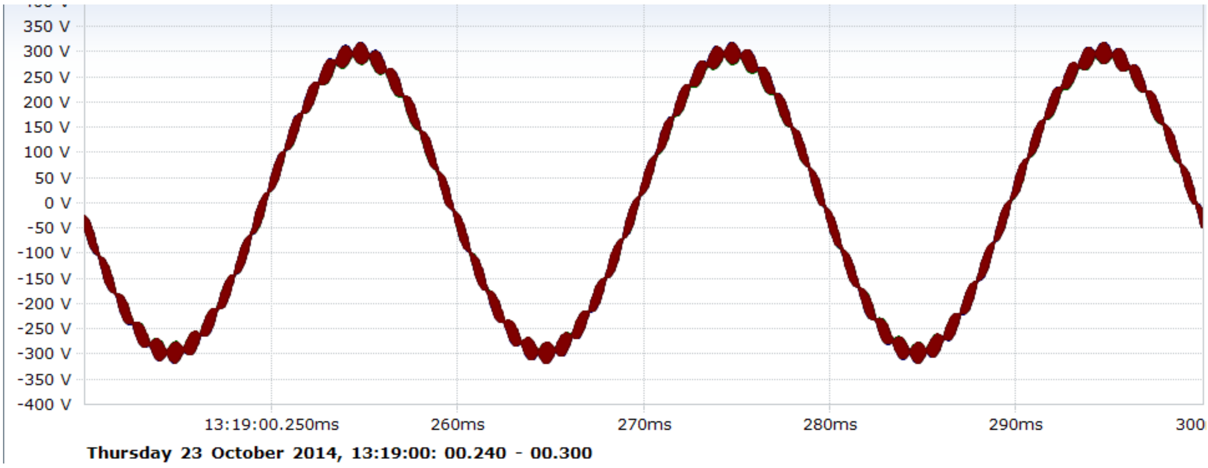


Fig. 2.23 Example of oscilloscope voltage recording - Test 8e (the apparent lack of filtration of $U_{h.f.}$ component)

Analyser		THD_{L1} [%]					
		a)	b)	c)	d)	e)	Compliance
1	Fluke 1760	0.02	0.02	0.02	0.02	0.02	---
2	Nexus 1500	0.00	0.00	0.00	0.00	0.00	---
3	UP-2210	0.05	0.05	0.05	0.05	0.05	---
4	DEWE-3020	---	---	---	---	---	---
5	iSTAT M355	316.74	289.44	266.57	300.36	294.9	---
6	SO-52v11-eME	0.00	0.00	0.00	0.00	0.00	---
7	SIMEAS Q80	0.05	0.26	0.27	0.07	0.27	---
8	PQ Box 200	0.01	0.02	0.01	0.01	0.01	---
9	ION7650	---	---	---	---	---	---
10	PQM-703	0.00	0.00	0.00	0.00	0.00	---
11	PQube	0.41	0.40	0.40	0.40	0.40	---
12	G4500	0.02	0.02	0.06	0.03	0.02	---
13	MI 2892	0.99	15.83	1.25	0.21	15.75	---
14	Mavowatt 270	0.01	0.01	0.01	0.01	0.01	---

Analyser		THD$_{L1}$ [%]					
		f)	*g)*	*h)*	*i)*	*j)*	Compliance
1	Fluke 1760	0.02	0.02	0.02	0.06	0.06	---
2	Nexus 1500	0.16	0.25	0.18	0.08	0.08	---
3	UP-2210	0.05	0.05	0.05	0.08	0.07	---
4	DEWE-3020	---	---	---	---	---	---
5	iSTAT M355	224.04	0.1	0.1	0.5	0.4	---
6	SO-52v11-eME	0.00	0.00	0.00	0.58	0.05	---
7	SIMEAS Q80	0.25	0.16	0.03	0.15	---	---
8	PQ Box 200	0.01	0.01	0.01	0.06	0.05	---
9	ION7650	---	---	---	---	---	---
10	PQM-703	0.00	0.00	0.00	0.06	0.05	---
11	PQube	0.40	0.40	0.40	0.40	0.40	---
12	G4500	0.02	0.02	0.03	5.03	4.96	---
13	MI 2892	1.68	15.13	3.73	0.51	14.36	---
14	Mavowatt 270	0.01	0.01	0.01	0.06	0.05	---

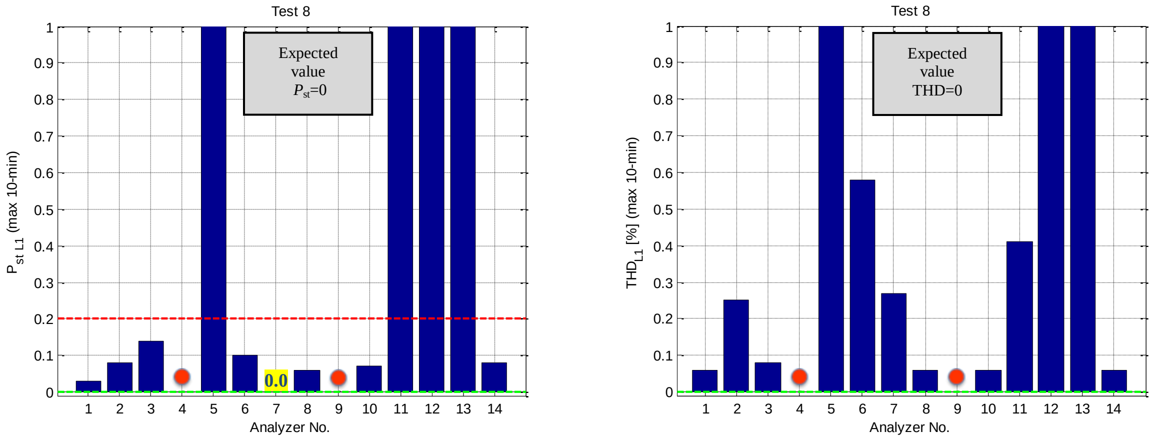
Analyser		P$_{st\ L1}$					
		a)	*b)*	*c)*	*d)*	*e)*	Compliance
1	Fluke 1760	0.03	0.03	0.03	0.03	0.03	YES
2	Nexus 1500	0.08	0.01	0.01	0.01	0.01	YES
3	UP-2210	0.14	0.00	0.00	0.00	0.00	YES
4	DEWE-3020	---	---	---	---	---	NO
5	iSTAT M355	86.27	0.14	0.08	0.09	0.07	NO
6	SO-52v11-eME	0.10	0.00	0.02	0.02	0.04	YES
7	SIMEAS Q80	0.00	0.00	0.00	0.00	0.00	YES
8	PQ Box 200	0.06	0.01	0.01	0.01	0.01	YES
9	ION7650	---	---	---	---	---	NO
10	PQM-703	0.07	0.02	0.02	0.02	0.02	YES
11	PQube	7.99	0.05	0.05	0.11	0.05	NO
12	G4500	15.68	3.55	16.37	5.44	0.33	NO
13	MI 2892	5.13	15.64	3.89	0.09	0.00	NO
14	Mavowatt 270	0.08	0.02	0.02	0.02	0.02	YES

Analyser		$P_{st\ L1}$					
		f)	*g)*	*h)*	*i)*	*j)*	Compliance
1	Fluke 1760	0.03	0.03	0.03	0.03	0.00	YES
2	Nexus 1500	0.00	0.00	0.00	0.01	0.01	YES
3	UP-2210	0.00	0.00	0.00	0.00	0.00	YES
4	DEWE-3020	---	---	---	---	---	NO
5	iSTAT M355	0.07	0.65	0.03	0.32	0.21	NO
6	SO-52v11-eME	0.00	0.04	0.04	0.0	0.04	YES
7	SIMEAS Q80	0.00	0.00	0.00	0.00	---*	YES
8	PQ Box 200	0.01	0.01	0.01	0.01	0.01	YES
9	ION7650	---	---	---	---	---	NO
10	PQM-703	0.02	0.02	0.02	0.02	0.02	YES
11	PQube	0.05	0.05	0.05	0.04	0.05	YES
12	G4500	0.23	0.36	0.41	0.26	0.30	NO
13	MI 2892	0.04	0.04	0.06	0.75	0.29	NO
14	Mavowatt 270	0.02	0.02	0.02	0.02	0.02	YES

Analyser		$U_{rms\ L1}$ [V]					
		a)	*b)*	*c)*	*d)*	*e)*	Compliance
1	Fluke 1760	209.90	209.89	209.89	209.89	209.89	YES
2	Nexus 1500	210.05	210.04	210.01	210.01	210.00	YES
3	UP-2210	209.99	210.01	209.99	210.00	210.00	YES
4	DEWE-3020	210.18	210.17	210.05	210.08	209.93	YES
5	iSTAT M355	210.13	210.13	210.04	210.04	209.94	YES
6	SO-52v11-eME	210.03	210.03	210.03	210.03	210.03	YES
7	SIMEAS Q80	209.98	209.98	209.98	209.98	209.98	YES
8	PQ Box 200	209.76	209.76	209.76	209.76	209.76	NO
9	ION7650	---	---	---	---	---	NO
10	PQM-703	210.00	210.00	210.00	210.00	210.00	YES
11	PQube	210.00	210.00	210.00	210.00	210.00	YES
12	G4500	210.48	210.49	210.50	210.50	210.49	NO
13	MI 2892	210.57	210.56	210.55	210.55	210.54	NO
14	Mavowatt 270	210.00	210.00	210.00	210.00	210.00	YES

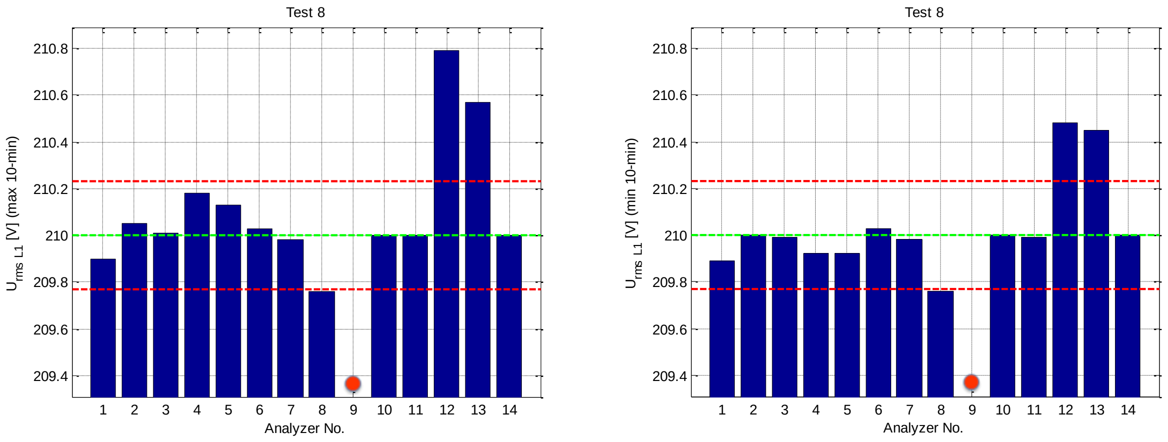
Analyser		$U_{\text{rms L1}}$ [V]					
		f)	*g)*	*h)*	*i)*	*j)*	Compliance
1	Fluke 1760	209.90	209.90	209.90	209.90	209.89	YES
2	Nexus 1500	210.00	210.00	210.00	210.02	210.05	YES
3	UP-2210	210.00	210.01	209.99	209.99	209.99	YES
4	DEWE-3020	209.93	209.92	209.92	209.92	209.92	YES
5	iSTAT M355	209.92	209.94	209.94	209.94	209.9	YES
6	SO-52v11-eME	210.03	210.03	210.03	210.03	210.03	YES
7	SIMEAS Q80	209.98	209.98	209.98	209.98	---*	YES
8	PQ Box 200	209.76	209.76	209.76	209.76	209.76	NO
9	ION7650	---	---	---	---	---	NO
10	PQM-703	210.00	210.00	210.00	210.00	210.00	YES
11	PQube	210.00	210.00	210.00	210.00	209.99	YES
12	G4500	210.49	210.50	210.49	210.78	210.79	NO
13	MI 2892	210.51	210.50	210.48	210.46	210.45	NO
14	Mavowatt 270	210.00	210.00	210.00	210.00	210.00	YES

* the indication was excluded from the analysis due to the lack of synchronization between 10-min sample with a given time interval of the test



a) *b)*

Fig. 2.24 a)-b) Comparison of analysers readings (max 10-min values) of $P_{\text{st }L1}$ *and* THD_{L1} *- Test 8*



c)

Fig. 2.25 c) Comparison of analysers readings (max and min values) of $U_{rms\ L1}$*(10-min) - Test 8*

Summary of Test 8

According to the standard PN-EN 61000-4-30, frequencies outside the measuring range of the analyser should be suppressed, so as to eliminate their influence on the measurement results. In order to achieve adequate suppression, an anti-aliasing low-pass filter with attenuation of -3 dB for frequencies above the measuring range should be used. Attenuation in the stop band should be greater than 50 dB. This means that the measured amplitudes of $U_{h.f.}$ generated in the test should be less than ~0.003 of their real amplitude, and thus should not have a noticeable impact on the indications of U_{rms}, THD, and P_{st}.

During the analysis of the test results it was found that the Pst readings of eight analysers complied with the test criterion. The test requirement related to Urms was met by ten analysers.

In the case of Urms readings from PQ Box 200 analyser it can be seen that they are lower than the expected 210 V in the test criterion. However, even though the test criterion Urms=210±0.23 V is not fulfilled, it can be excluded that this discrepancy is caused by the lack of effective filtering of $U_{h.f.}$. component, because this would result in an Urms increase.

It should also be noted that, despite treating THD samples as a comparative test, it is clearly seen that THD indications of some analysers differ significantly from zero and point to the lack of effective filtering of $U_{h.f.}$

3.2 Measurement of voltage events

<table>
<tr><th colspan="2">TEST 9</th></tr>
<tr><th>Time: 10:00-10:10</th><th>Measurement of voltage events 1</th></tr>
<tr><td>Test signal parameters</td><td>Three phase sinusoidal voltage with U_{rms}=230 V and f = 50 Hz.
The reference voltage generator produces voltage dips labelled as Z_1, Z_2, Z_3, Z_4, Z_5, Z_6 with durations: 20, 30, 50, 200, 600, 3000 ms, respectively and residual voltage 80%U_{din}. Intervals between subsequent dips are 20 s.</td></tr>
<tr><td>Test criterion</td><td>The measurement uncertainty of the duration of a voltage dip, a voltage swell or a voltage interruption shall not exceed the sum of the uncertainty of determining a voltage event start (1 half cycle) and uncertainty of determining voltage event end (1 half cycle).
<table>
<tr><th>Event label</th><th>Sag duration [ms]</th><th>Expected result <i>T</i> [ms]</th></tr>
<tr><td>Z_1</td><td>20</td><td>30±20</td></tr>
<tr><td>Z_2</td><td>30</td><td>40±20</td></tr>
<tr><td>Z_3</td><td>50</td><td>60±20</td></tr>
<tr><td>Z_4</td><td>200</td><td>210±20</td></tr>
<tr><td>Z_5</td><td>600</td><td>610±20</td></tr>
<tr><td>Z_6</td><td>3000</td><td>3010±20</td></tr>
</table>
No requirements in the standard PN-EN 61000-4-30 for measurement of voltage events aggregated in a single phase – a comparative test.
The analysis of oscilloscope recordings revealed the presence of step phase shifts at the beginning of each voltage sag (well illustrated in Fig. 2.26 and 2.27). Therefore, evaluation of the residual voltage U_{res} measurement was abandoned due to impossibility of unambiguous determination of the expected value.
An additional observation from the test is the dispersion of the time synchronization between PQ analysers. This is shown in the comparison of voltage event timestamps.</td></tr>
</table>

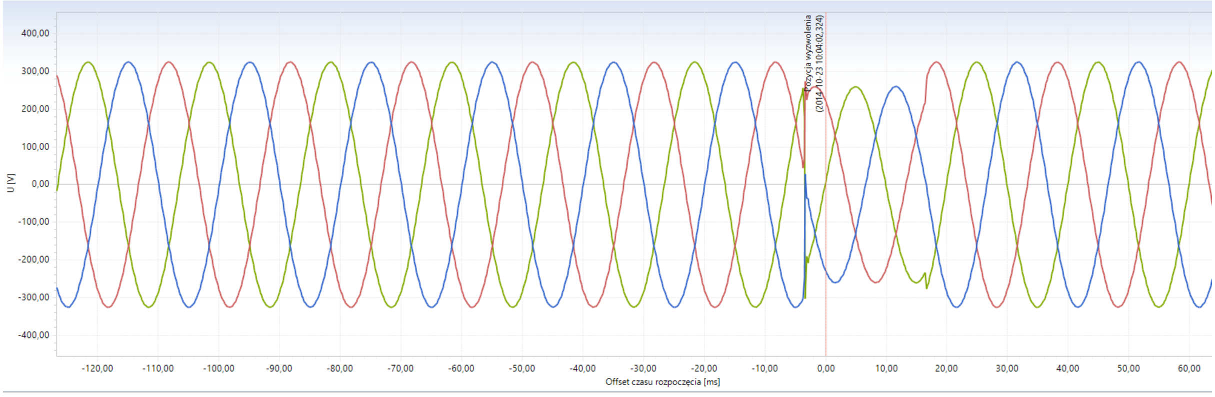


Fig. 2.26 Oscilloscope recording of a voltage sag (T= 20 ms) - Test 9

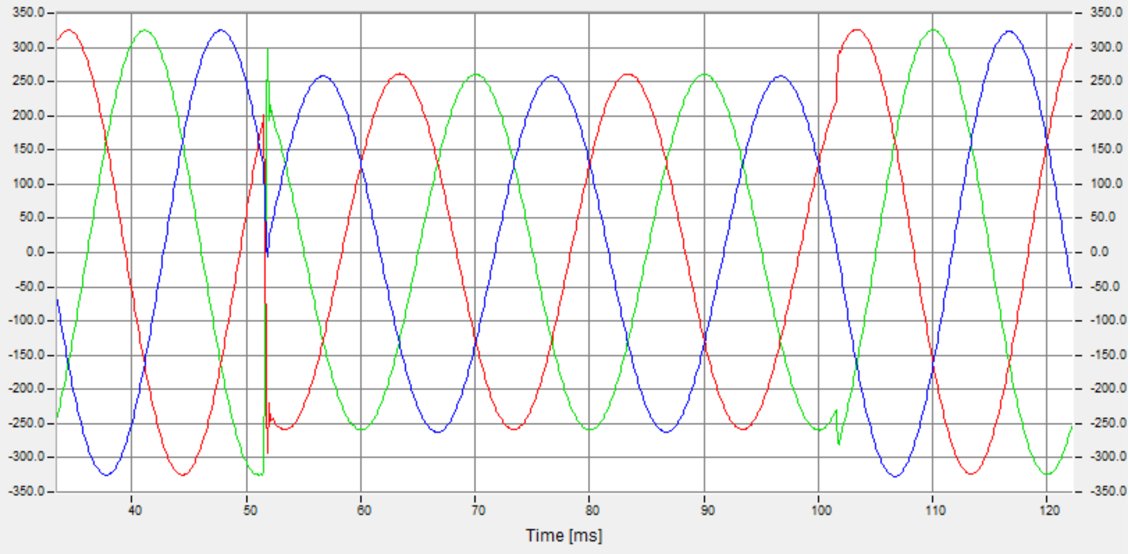


Fig. 2.27 Oscilloscope recording of a voltage sag (T=50 ms) - Test 9

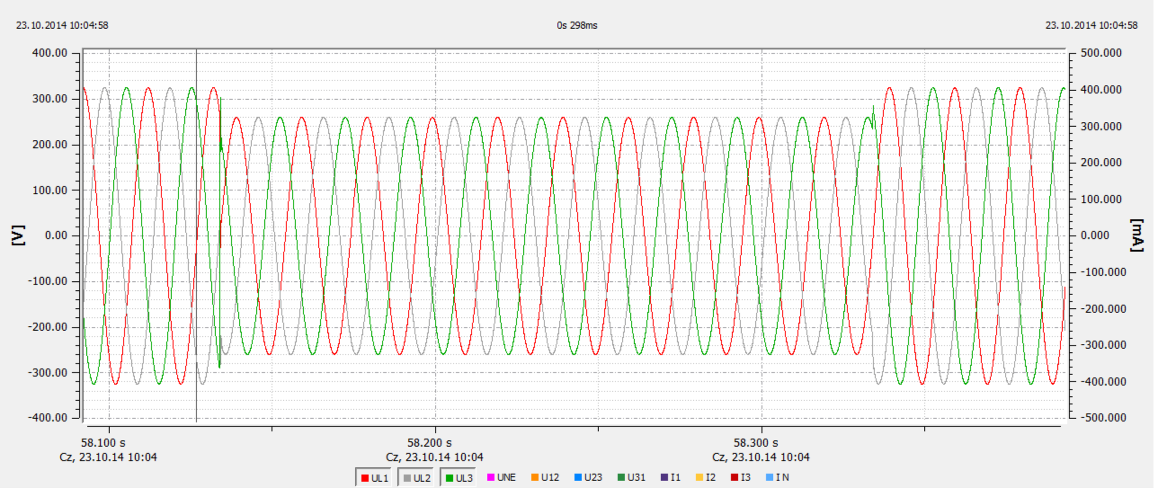


Fig. 2.28 Oscilloscope recording of a voltage sag (T= 200 ms) - Test 9

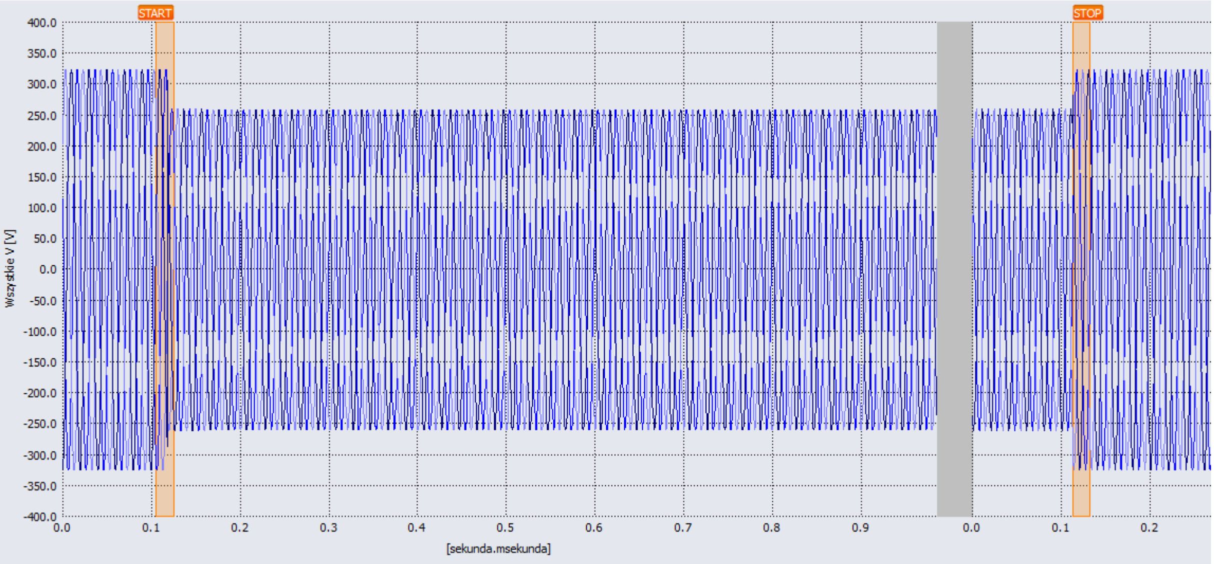
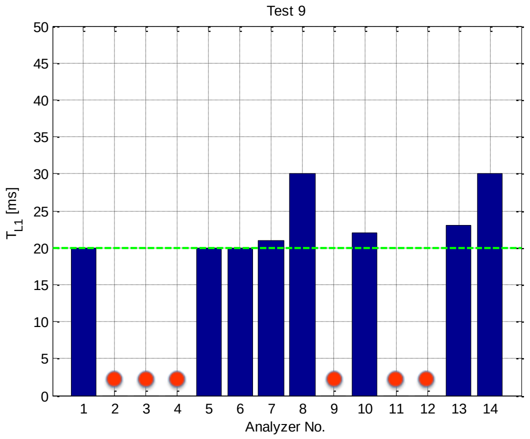


Fig. 2.29 Oscilloscope recording of a voltage sag (T= 300 ms) - Test 9

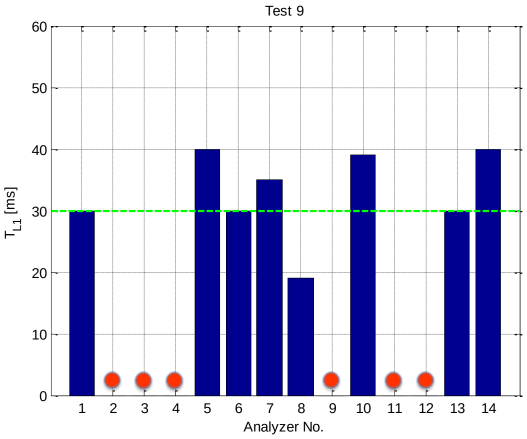
Analyser		Event timestamp (start) [hour:min:sec]						
		Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Compliance
1	Fluke 1760	10:03:58	10:04:19	10:04:39	10:04:59	10:05:20	10:05:40	---
2	Nexus 1500	---	---	---	---	---	---	---
3	UP-2210	10:04:02	10:04:22	10:04:42	10:05:03	10:05:23	10:05:44	---
4	DEWE-3020	---	---	---	---	---	---	---
5	iSTAT M355	10:04:29	10:04:49	10:05:09	10:05:30	10:05:50	10:06:11	---
6	SO-52v11-eME	10:04:02	10:04:22	10:04:42	10:05:03	10:05:23	10:05:44	---
7	SIMEAS Q80	10:04:02	10:04:22	10:04:42	10:05:03	10:05:23	10:05:44	---
8	PQ Box 200	10:03:57	10:04:17	10:04:37	10:04:58	10:05:18	10:05:39	---
9	ION7650	---	---	---	---	---	---	---
10	PQM-703	10:04:02	10:04:22	10:04:42	10:05:03	10:05:23	10:05:44	---
11	PQube	09:04:02	09:04:22	09:04:42	09:05:02	09:05:23	09:05:44	---
12	G4500	10:04:02	10:04:22	10:04:42	10:05:03	10:05:23	10:05:44	---
13	MI 2892	10:04:02	10:04:22	10:04:42	10:05:03	10:05:23	10:05:44	---
14	Mavowatt 270	10:04:02	10:04:22	10:04:42	10:05:03	10:05:23	10:05:44	---

Analyser		*T* [ms] - Phase L1						
		20	30	50	200	600	3000	Compliance
1	Fluke 1760	20.02	29.98	50.36	196.65	596.22	2996.50	---
2	Nexus 1500	---	---	---	---	---	---	---
3	UP-2210	---	---	---	---	---	---	---
4	DEWE-3020	---	---	---	---	---	---	---
5	iSTAT M355	20	40	50	210	606	3004	---
6	SO-52v11-eME	20	30	50	210	600	3010	---
7	SIMEAS Q80	21	35	56	203	601	3002	---
8	PQ Box 200	30	19	40	190	609	2990	---
9	ION7650	---	---	---	---	---	---	---
10	PQM-703	22	39	48	195	605	2996	---
11	PQube	---	---	---	---	---	---	---
12	G4500	---	---	---	---	---	---	---
13	MI 2892	23	30	56	206	606	2989	---
14	Mavowatt 270	30	40	60	210	610	3014	---

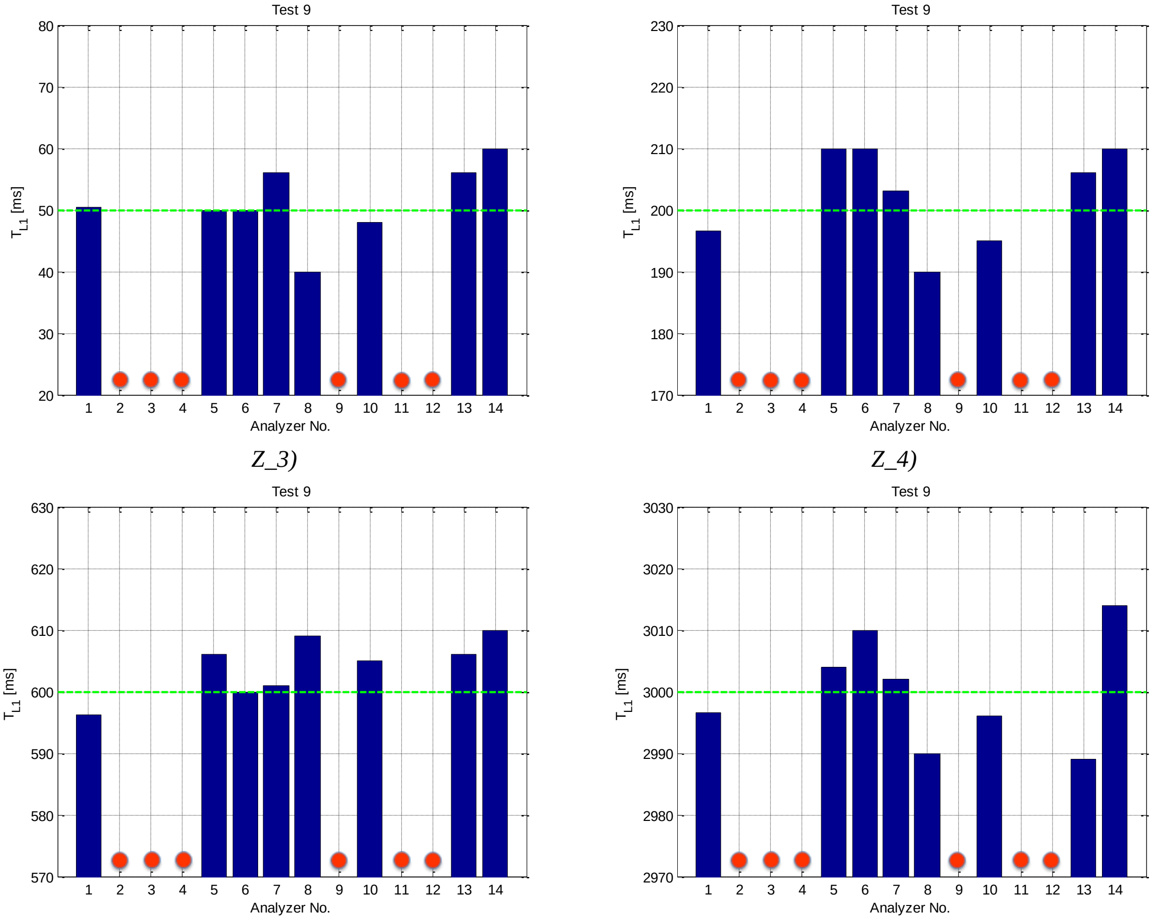
Analyser		*T* [ms] - value aggregated in a polyphase system						
		30	40	60	210	610	3010	Compliance
1	Fluke 1760	---	---	---	---	---	---	NO
2	Nexus 1500	---	---	---	---	---	---	NO
3	UP-2210	30.11	39.98	60.08	210.03	610.00	2994	YES
4	DEWE-3020	---	---	---	---	---	---	NO
5	iSTAT M355	33	47	63	216	613	3012	YES
6	SO-52v11-eME	---	---	---	---	---	---	NO
7	SIMEAS Q80	---	---	---	---	---	---	NO
8	PQ Box 200	---	---	---	---	---	---	NO
9	ION7650	---	---	---	---	---	---	NO
10	PQM-703	32	39	51	212	612	3013	YES
11	PQube	34	47	66	217	613	3013	YES
12	G4500	30	40	60	210	610	3020	YES
13	MI 2892	34	36	63	210	616	3016	YES
14	Mavowatt 270	---	---	---	---	---	---	NO



Z_1)



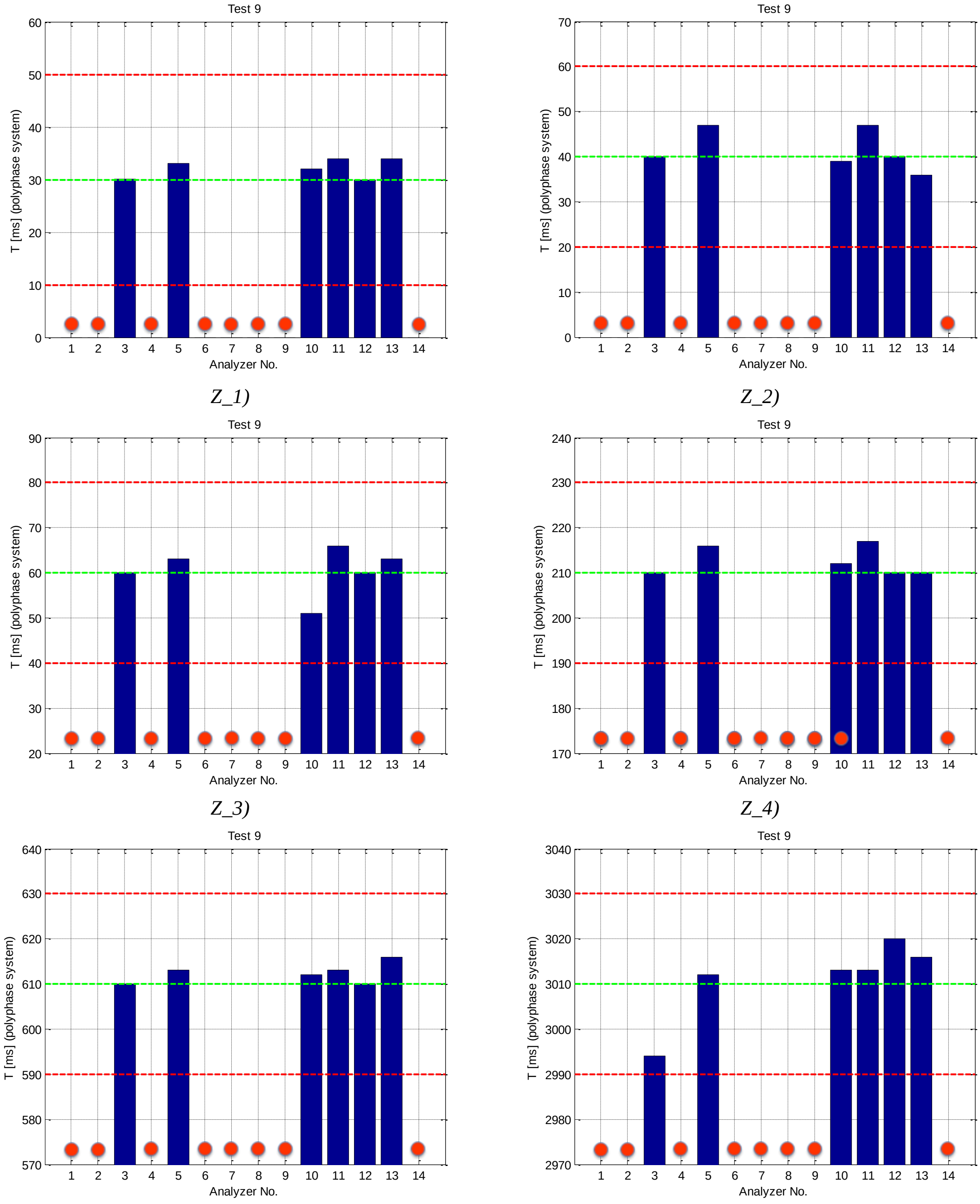
Z_2)



Z_3) *Z_4)*

Z_5) *Z_6)*

Fig. 2.30 Z_1-Z_6) Comparison of analysers readings (Phase L1) - Test 9



Z_1) Z_2)

Z_3) Z_4)

Z_5) Z_6)

Fig. 2.31 Z_1)-Z_6) Comparison of analysers readings (polyphase system) - Test 9

Summary of Test 9

During the analysis of the test results it was found that measurement results of eleven analysers provide information about the occurrence of events Z_1-Z_6. However, the event timestamps recorded by various analysers do not coincide with one another. This is the case despite the fact that, according to the guidelines of the measurement experiment, analysers should have been synchronized with the Coordinated Universal Time (UTC). It was found that 7 analysers marked the start of event Z_1 with the following time: 10:04:02, while others indicated the following times: 10:03:58, 10:04:29, 10:03:57, or 09:04:02.

Of eleven analysers which registered event detection, eight provided information about their parameters (duration, residual voltage) determined for a single-phase system (each phase separately). This is not a requirement of the standard PN-EN 61000-4-30:2009. However, it is a recommendation indicated in its next edition, which is now being prepared for final release.

Of eleven analysers which registered event detection, only six provided the information (required by PN-EN 61000-4-30) about event duration aggregated in a polyphase system. In each case, these durations stayed within the permissible uncertainty range.

According to the information provided by A-Eberle, it appears that the functionality of event aggregation in a polyphase system is available through WinPQ software used for analysis of data from stationary analysers.

<table>
<tr><th colspan="2">TEST 10</th></tr>
<tr><th>Time: 14:10-14:20</th><th>Measurement of voltage events 2</th></tr>
<tr><td>Test signal parameters</td><td>Three phase sinusoidal voltage with U_{rms}=230 V and f = 50 Hz.
The reference voltage generator produces voltage dips labelled as Z_1, Z_2, Z_3, Z_4, Z_5 with durations: 20, 30, 50, 200, 3000 ms, respectively and residual voltage 80%U_{din}. Intervals between subsequent dips are equal to 20 s.</td></tr>
<tr><td>Test criterion</td><td>The measurement uncertainty of the duration of a voltage dip, a voltage swell or a voltage interruption in a polyphase system shall not exceed the sum of the uncertainty of determining a voltage event start (1 half cycle) and uncertainty of determining voltage event end (1 half cycle).
The measurement uncertainty of the residual voltage shall not exceed ±0.2% U_{din}. For cases of this test, residual voltage should be in the range of U_{res}=184±0.46 V.
<table>
<tr><th>Event label</th><th>Sag duration [ms]</th><th>Expected result <i>T</i> [ms]</th></tr>
<tr><td>Z_1</td><td>30</td><td>40±20</td></tr>
<tr><td>Z_2</td><td>50</td><td>60±20</td></tr>
<tr><td>Z_3</td><td>200</td><td>210±20</td></tr>
<tr><td>Z_4</td><td>600</td><td>610±20</td></tr>
<tr><td>Z_5</td><td>3000</td><td>3010±20</td></tr>
</table>
No uncertainty requirements for measurement of voltage events aggregated in a single phase - a comparative test.</td></tr>
</table>

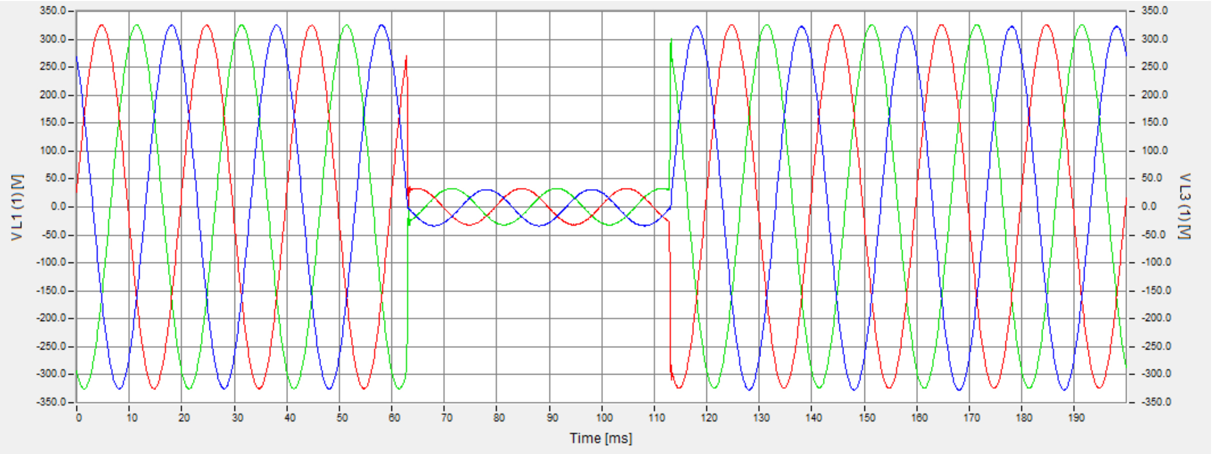


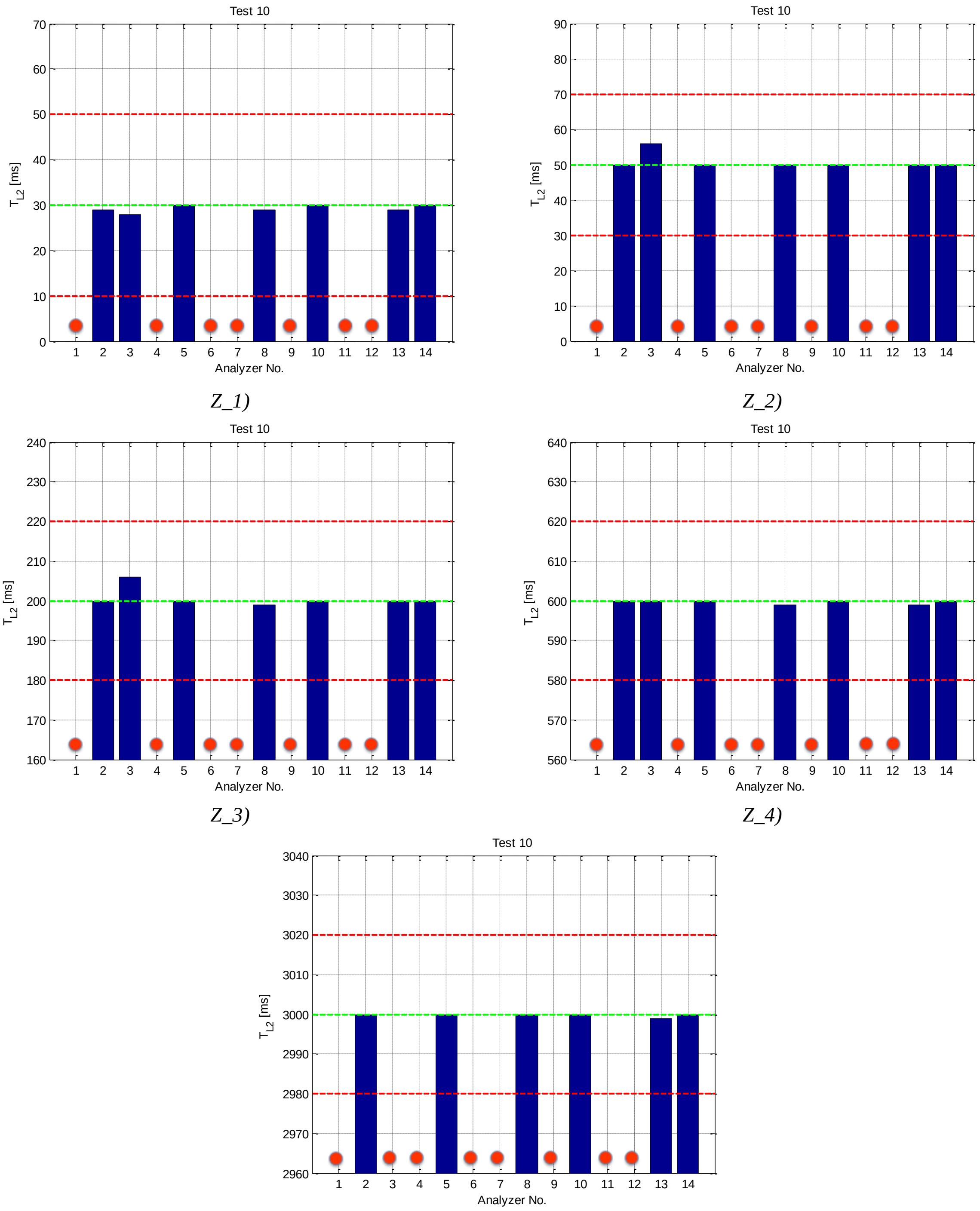
Fig. 2.32 Oscilloscope recording of a voltage sag (T= 50 ms, U_{res}=10%U_{din}) - Test 10

Analyser		T_{L2} [ms]					
		Z_1	Z_2	Z_3	Z_4	Z_5	Compliance
1	Fluke 1760	---	---	---	---	---	---
2	Nexus 1500	29	50	200	600	3000	---
3	UP-2210	28	56	206	600	---	---
4	DEWE-3020	---	---	---	---	---	---
5	iSTAT M355	30	50	200	600	3000	---
6	SO-52v11-eME	---	---	---	---	---	---
7	SIMEAS Q80	---	---	---	---	---	---
8	PQ Box 200	29	50	199	599	3000	---
9	ION7650	---	---	---	---	---	---
10	PQM-703	30	50	200	600	3000	---
11	PQube	---	---	---	---	---	---
12	G4500	---	---	---	---	---	---
13	MI 2892	29	50	200	599	2000	---
14	Mavowatt 270	30	50	200	600	3000	---

Analyser		$U_{res\ L2}$ [V]					
		Z_1	Z_2	Z_3	Z_4	Z_5	Compliance
1	Fluke 1760	---	---	---	---	---	---
2	Nexus 1500	184.44	183.70	183.54	183.90	183.90	---
3	UP-2210	184.07	184.10	184.06	184.07	184.06	---
4	DEWE-3020	---	---	---	---	---	---
5	iSTAT M355	184	184	183.98	184	183.98	---
6	SO-52v11-eME	---	---	---	---	---	---
7	SIMEAS Q80	---	---	---	---	---	---
8	PQ Box 200	183.84	183.82	183.83	183.83	183.83	---
9	ION7650	---	---	---	---	---	---
10	PQM-703	184	184	184	184	184	---
11	PQube	184.1	183.8	183.8	183.9	183.7	---
12	G4500	---	---	---	---	---	---
13	MI 2892	184.00	183.99	183.97	183.97	183.99	
14	Mavowatt 270	184	184	184	184	184	---

Analyser		T [ms] - value aggregated in a polyphase system					
		Z_1	Z_2	Z_3	Z_4	Z_5	Compliance
1	Fluke 1760	---	---	---	---	---	NO
2	Nexus 1500	---	---	---	---	---	NO
3	UP-2210	40	60	210	610	3020	YES
4	DEWE-3020	---	---	---	---	---	NO
5	iSTAT M355	39	60	209	610	3009	YES
6	SO-52v11-eME	37	57	207	607	3007	YES
7	SIMEAS Q80	---	---	---	---	---	NO
8	PQ Box 200	---	---	---	---	---	NO
9	ION7650	---	---	---	---	---	NO
10	PQM-703	36	56	206	606	3006	YES
11	PQube	39	60	209	610	3009	YES
12	G4500	40	60	210	610	3000	YES
13	MI 2892	36	56	206	606	3006	YES
14	Mavowatt 270	---	---	---	---	---	NO

Analyser		U_{res} [V] - value aggregated in a polyphase system					
		Z_1	Z_2	Z_3	Z_4	Z_5	Compliance
1	Fluke 1760	---	---	---	---	---	NO
2	Nexus 1500	---	---	---	---	---	NO
3	UP-2210	184.03	184.04	184.02	184.02	184.04	YES
4	DEWE-3020	---	---	---	---	---	NO
5	iSTAT M355	183.93	183.95	183.93	183.93	183.95	YES
6	SO-52v11-eME	184	184	184	184	184	YES
7	SIMEAS Q80	---	---	---	---	---	NO
8	PQ Box 200	---	---	---	---	---	NO
9	ION7650	---	---	---	---	---	NO
10	PQM-703	184	184	184	184	184	YES
11	PQube	183.24	183.15	183.10	183.10	183.06	NO
12	G4500	183.75	183.86	183.73	183.78	183.75	YES
13	MI 2892	---	---	---	---	---	NO
14	Mavowatt 270	---	---	---	---	---	NO

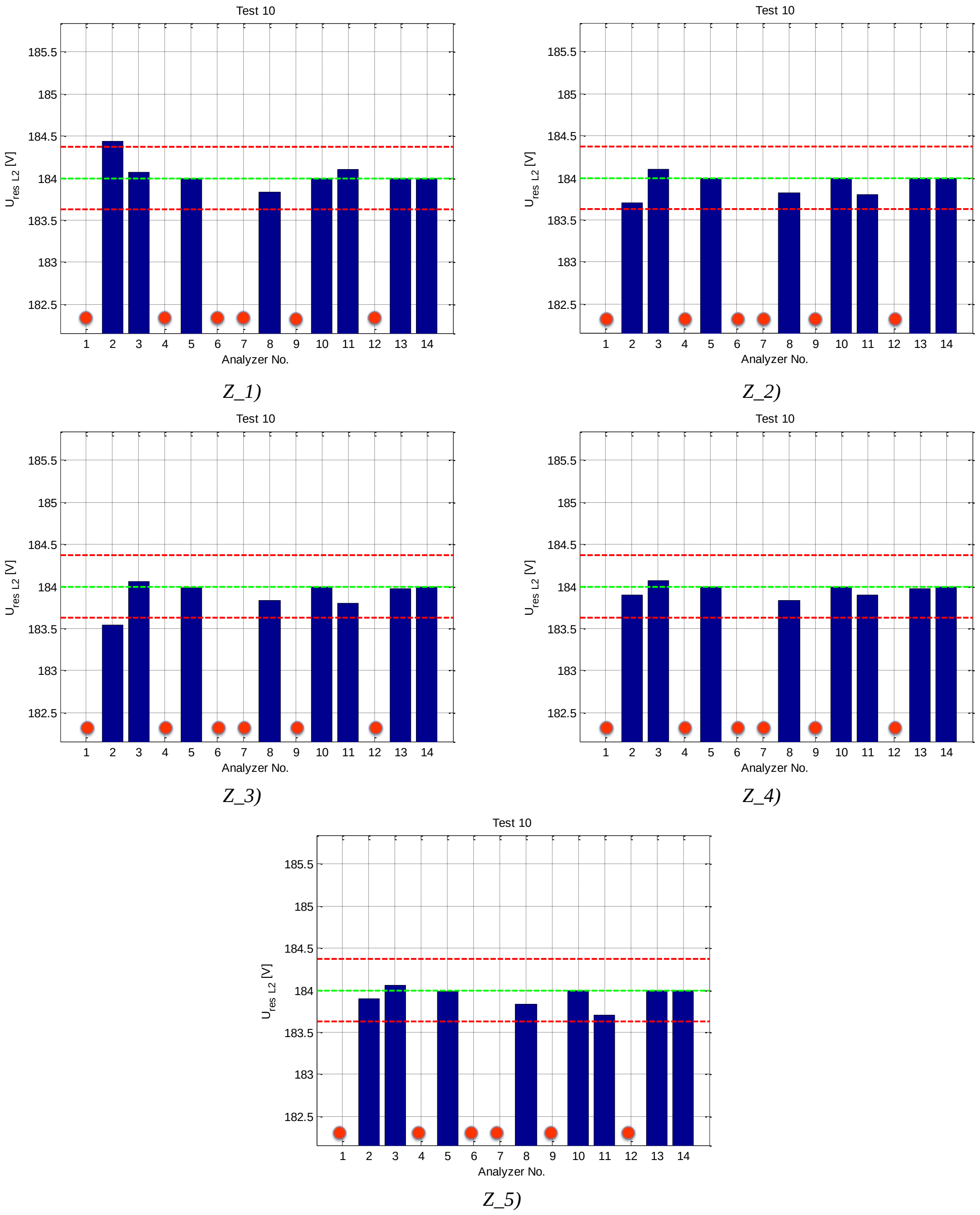


Z_1) *Z_2)*

Z_3) *Z_4)*

Z_5)

Fig. 2.33 Z_1)-Z_5) Comparison of analysers readings (phase L2) - Test 10



Z_1)

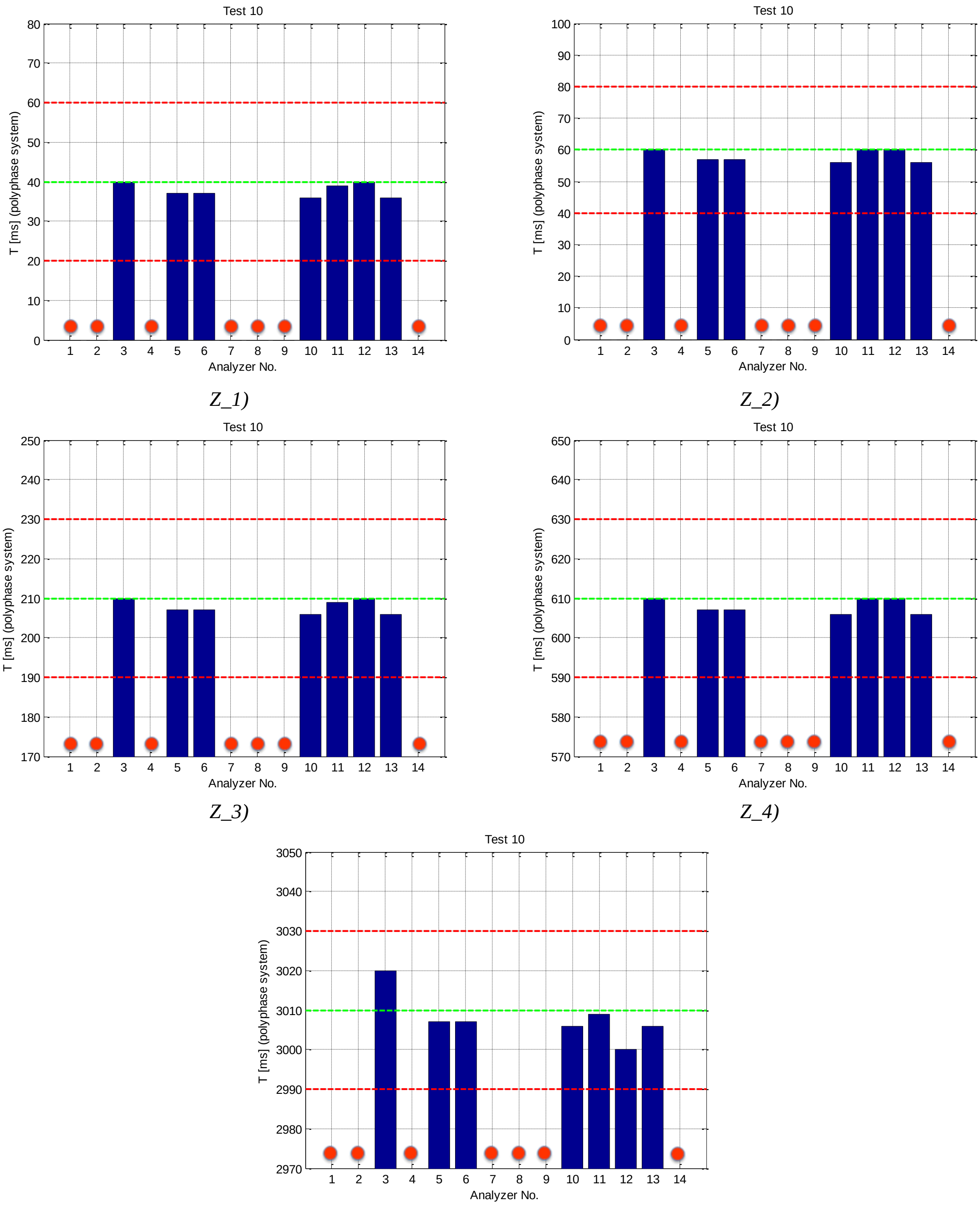
Z_2)

Z_3)

Z_4)

Z_5)

Fig. 2.34 Z_1)-Z_5) Comparison of analysers readings (phase L2) - Test 10



Z_1)

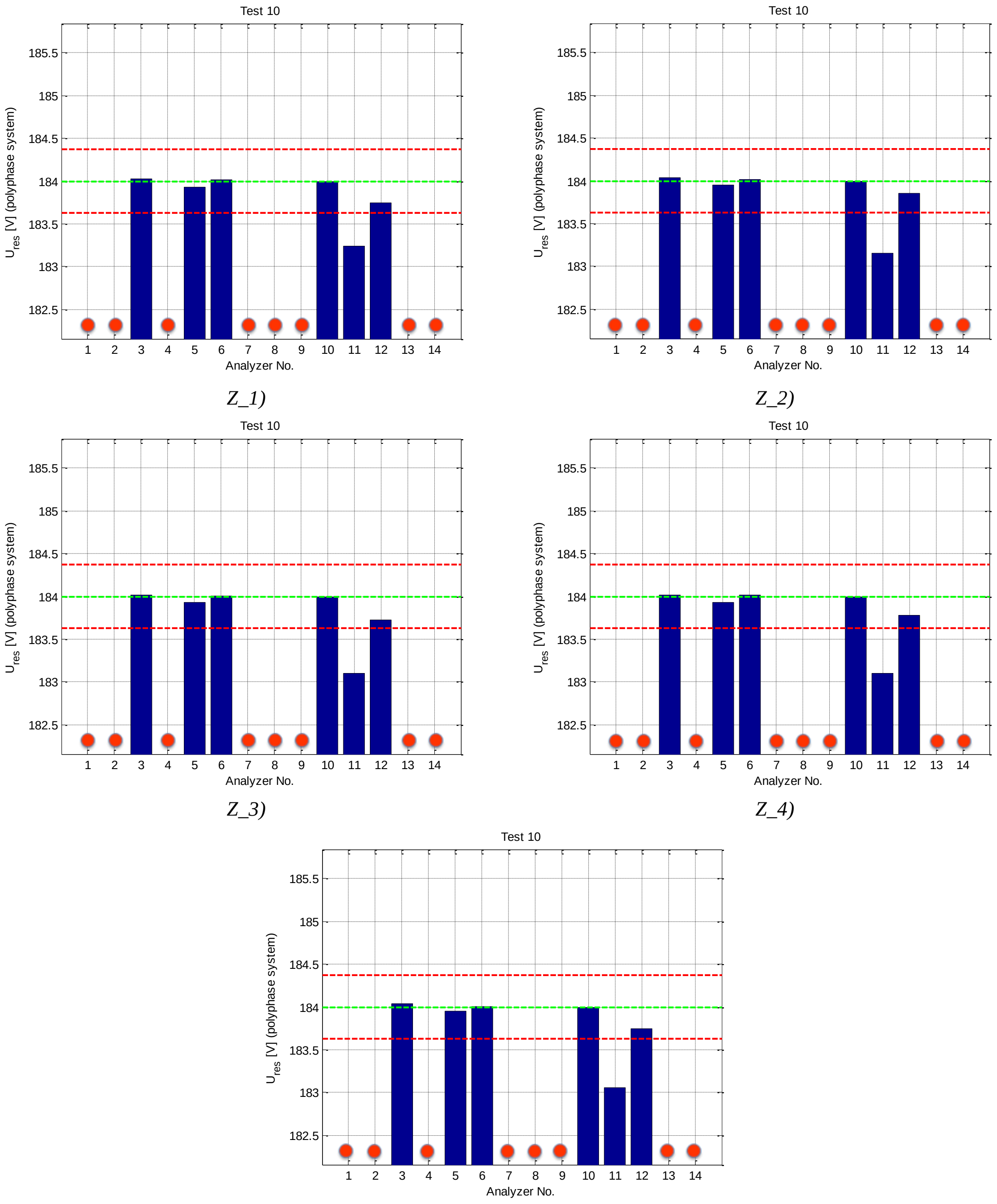
Z_2)

Z_3)

Z_4)

Z_5)

Fig. 2.35 Z_1)-Z_5) Comparison of analysers readings (polyphase system) - Test 10



Z_1)

Z_2)

Z_3)

Z_4)

Z_5)

Fig. 2.36 Z_1)-Z_5) Comparison of analysers readings (polyphase system) - Test 10

Summary of Test 10

During the analysis of the test results it was found that ten analysers recorded the occurrence of events Z_1-Z_5.

In the case of Fluke 1760 analyser, according to the information provided by the manufacturer, the reason for the lack of event data was the exceeding of the total memory allocated for event recording, set to 1000 events.

Of ten analysers which registered events detection, eight provided information about their parameters (duration, residual voltage) determined for a single-phase system (each phase separately). This is not a requirement of the standard PN-EN 61000-4-30:2009. However, it is a recommendation indicated in its next edition.

Of ten analysers which registered events detection, seven provided information (required by PN-EN 61000-4-30) about event duration aggregated in a polyphase system. In each case, these durations stayed within the permissible uncertainty range.

Six analysers (of which five correctly) provided the value of U_{res}. In the case of PQube analyser, the reason of the observed discrepancies in U_{res} was explained in the formal comment received from Protrade Technologies. According to the information provided by the manufacturer of MI 2892 analyser, the instrument recorded values of U_{res} but the product software version available at the Picnic did not read these data. The manufacturer confirms that this functionality has already been implemented in a new version of the software.

TEST 11

Time: 14:10-14:20

Measurement of voltage events 3

Test signal parameters

Three phase sinusoidal voltage with U_{rms}=230 V and f = 42,5 Hz.

The reference voltage generator produces the following voltage events:

Z_1 – voltage swell with duration 50 ms and amplitude 120%U_{din},
Z_2 – voltage sag with duration 50 ms and residual voltage 10% U_{din},
Z_3 – voltage interruption with duration 50 ms and residual voltage 5% U_{din},
Z_4 – voltage interruption with duration 50 ms and residual voltage 0% U_{din},

Intervals between subsequent events are equal to 20 s.

Test criterion

The measurement uncertainty of the duration of a voltage dip, a voltage swell or a voltage interruption in a polyphase system shall not exceed the sum of the uncertainty of determining a voltage event start (1 half cycle) and uncertainty of determining voltage event end (1 half cycle) The measurement uncertainty of the residual voltage shall not exceed ±0.2%U_{din}.

No specific requirements for measurement uncertainty of residual voltage during a voltage interruption.

Event label	**Event duration [ms]**	**Expected result T [ms]**	**Expected result U_{res} [V]**
Z_1	50	60±20	276±0.46
Z_2	50	60±20	23±0.46
Z_3	50	26±20	11.5
Z_4	50	26±20	0

The differences in the expected results of events Z_1 and Z_2 versus events Z_3 and Z_4 are the consequence of different guidelines, contained in the PN-EN 61000-4-30, referred to the methods of determining durations of voltage sags/swells and voltage interruptions.

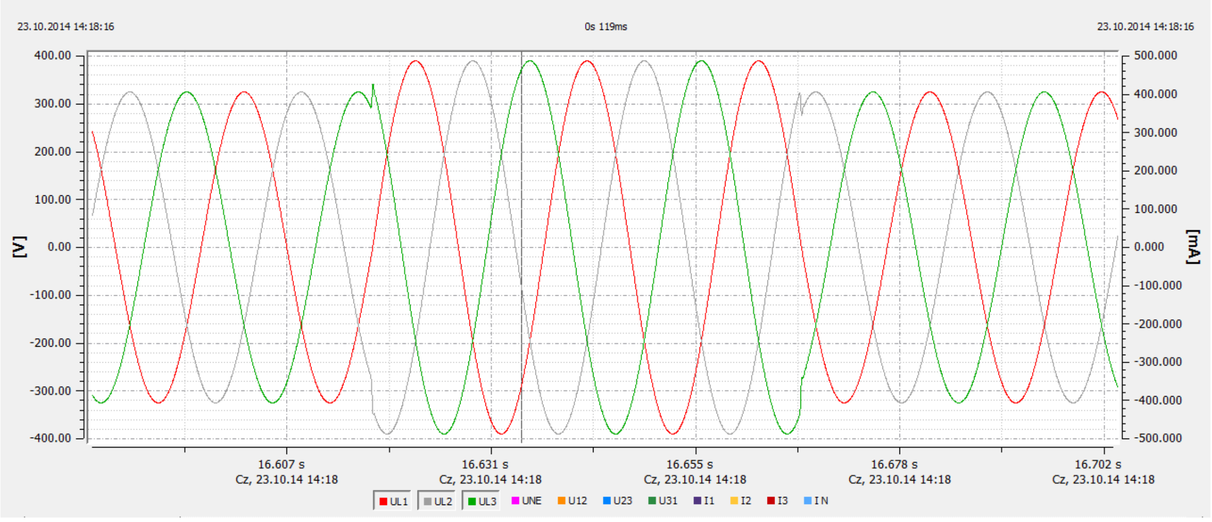
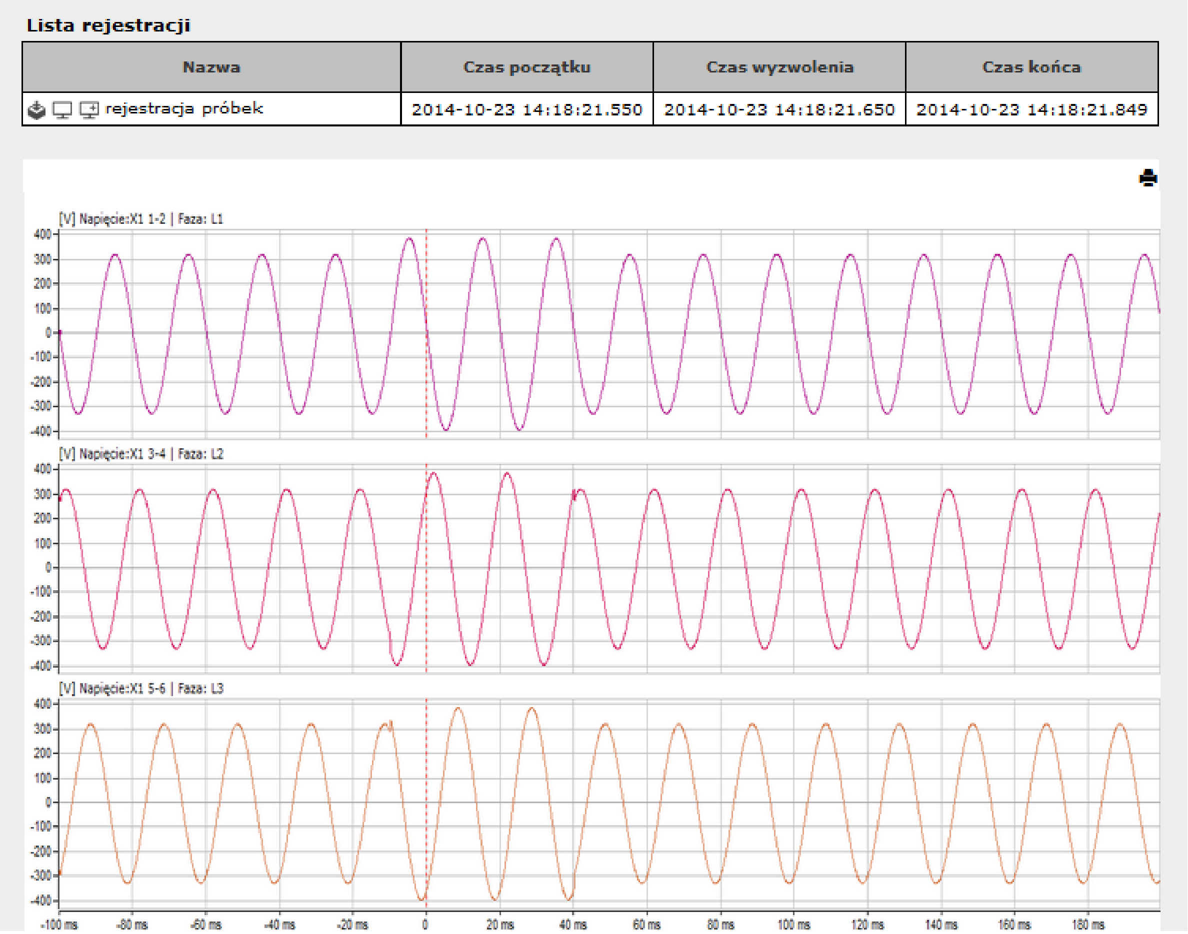


Fig. 2.37 Oscilloscope recording of the event Z_1 - Test 11



Lista rejestracji

Nazwa	Czas początku	Czas wyzwolenia	Czas końca
rejestracja próbek	2014-10-23 14:18:21.550	2014-10-23 14:18:21.650	2014-10-23 14:18:21.849

Fig. 2.38 Oscilloscope recording of the event Z_1 - Test 11

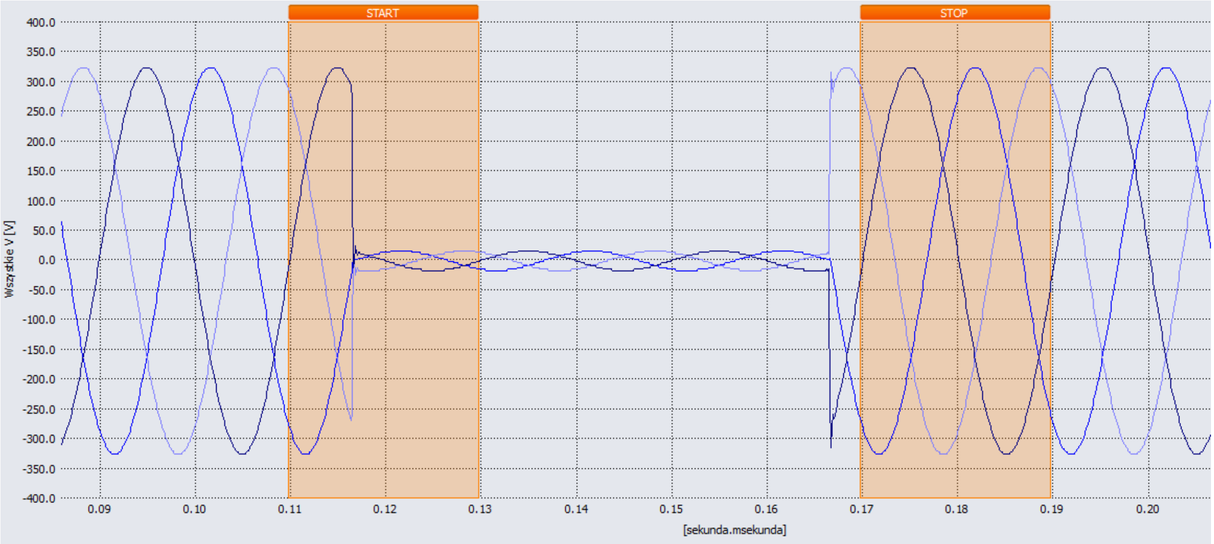


Fig. 2.39 Oscilloscope recording of the Z_3 - Test 11

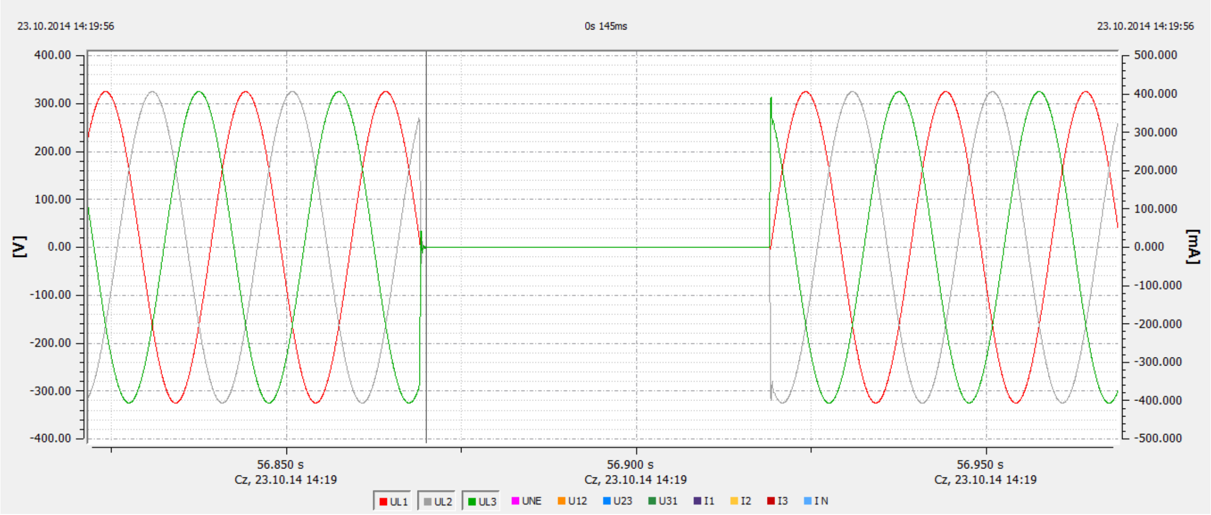
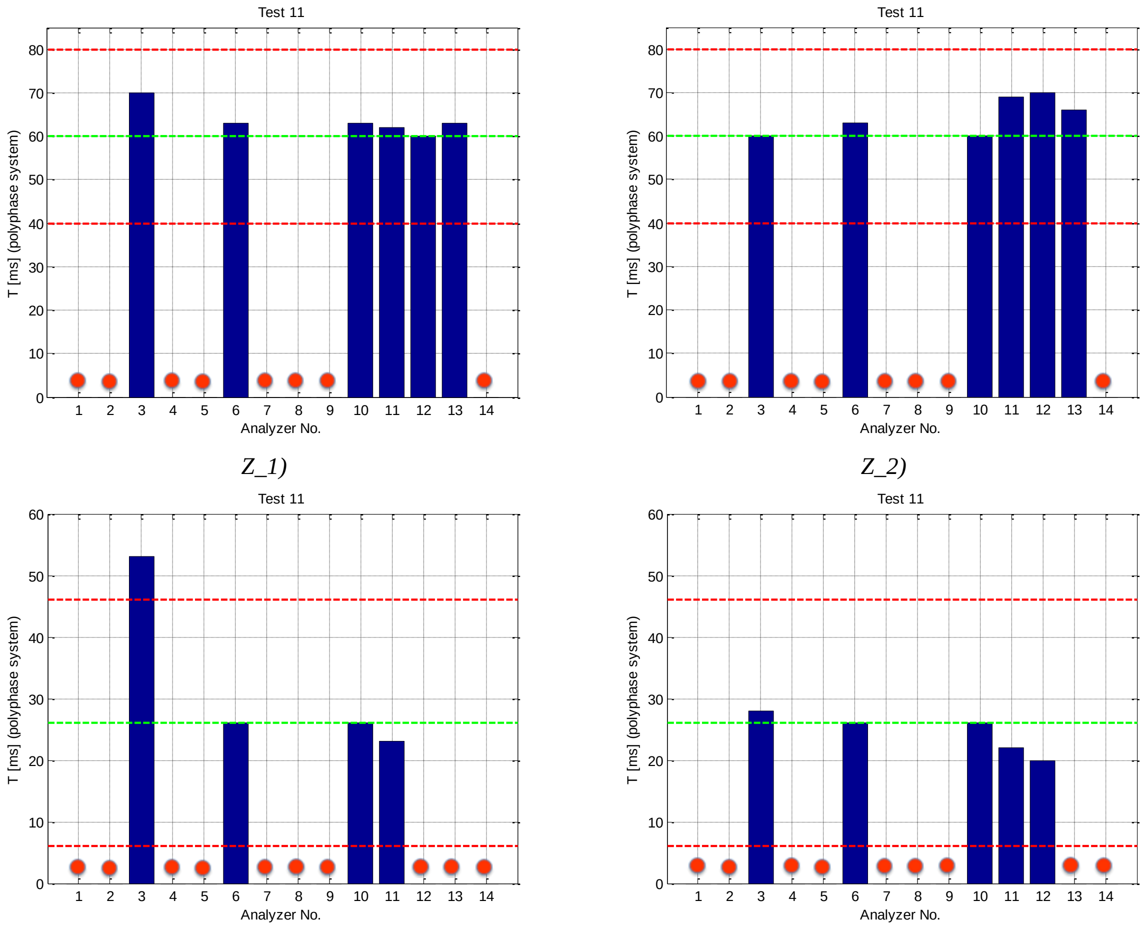


Fig. 2.40 Oscilloscope recording of the event Z_4 - Test 11

Analyser		T [ms] - value aggregated in a polyphase system				
		Z_1	Z_2	Z_3	Z_4	Compliance
1	Fluke 1760	---	---	---	---	---
2	Nexus 1500	---	---	---	---	---
3	UP-2210	70	60	53	28	NIE
4	DEWE-3020	---	---	---	---	---
5	iSTAT M355	63	67	17	27	TAK
6	SO-52v11-eME	63	63	26	26	TAK
7	SIMEAS Q80	---	---	---	---	---
8	PQ Box 200	---	---	---	---	---
9	ION7650	---	---	---	---	---
10	PQM-703	63	60	26	26	TAK
11	PQube	62	69	23	22	TAK
12	G4500	60	70	---	20	NIE
13	MI 2892	63	66	---	---	NIE
14	Mavowatt 270	---	---	---	---	---

Analyser		U_{res} [V] - value aggregated in a polyphase system				
		Z_1	Z_2	Z_3	Z_4	Compliance
1	Fluke 1760	---	---	---	---	NIE
2	Nexus 1500	---	---	---	---	NIE
3	UP-2210	276.11	22.99	11.51	0.15	TAK
4	DEWE-3020	---	---	---	---	NIE
5	iSTAT M355	276	22.98	11.48	0.07	TAK
6	SO-52v11-eME	276	23	11.50	0.08	TAK
7	SIMEAS Q80	---	---	---	---	NIE
8	PQ Box 200	---	---	---	---	NIE
9	ION7650	---	---	---	---	NIE
10	PQM-703	276	23	11.49	0.03	TAK
11	PQube	276	22.28	---	---	NIE
12	G4500	277.59	22.96	---	0.10	NIE
13	MI 2892	---	---	---	---	NIE
14	Mavowatt 270	---	---	---	---	NIE

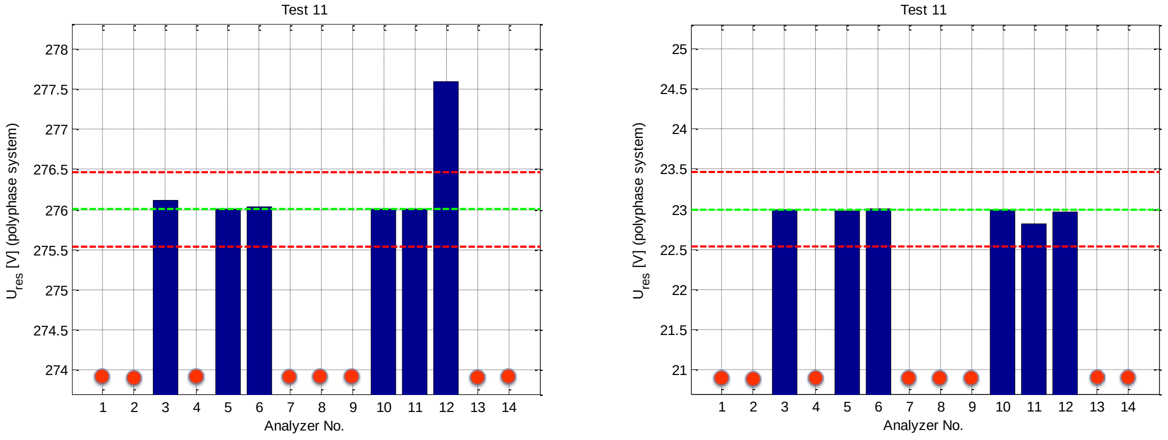
Analyser		Event timestamp (start) [hour:min:sec]				
		Z_1	Z_2	Z_3	Z_4	Compliance
1	Fluke 1760	---	---	---	---	---
2	Nexus 1500	14:18:21	14:19:21	14:19:41	14:20:01	---
3	UP-2210	14:18:21	14:19:21	14:19:41	14:20:01	---
4	DEWE-3020	---	---	---	---	---
5	iSTAT M355	14:18:48	14:19:48	14:20:08	14:20:28	---
6	SO-52v11-eME	14:18:21	14:19:21	14:19:41	14:20:01	---
7	SIMEAS Q80	---	---	---	---	---
8	PQ Box 200	14:18:16	14:19:16	14:19:36	14:19:56	---
9	ION7650	---	---	---	---	---
10	PQM-703	14:18:21	14:19:21	14:19:41	14:20:01	---
11	PQube	13:18:21	13:19:21	13:19:41	13:20:01	---
12	G4500	14:18:21	14:19:21	14:19:41	14:20:01	---
13	MI 2892	14:18:21	14:19:21	14:19:41	14:20:01	---
14	Mavowatt 270	14:18:21	14:19:21	14:19:41	14:20:01	---



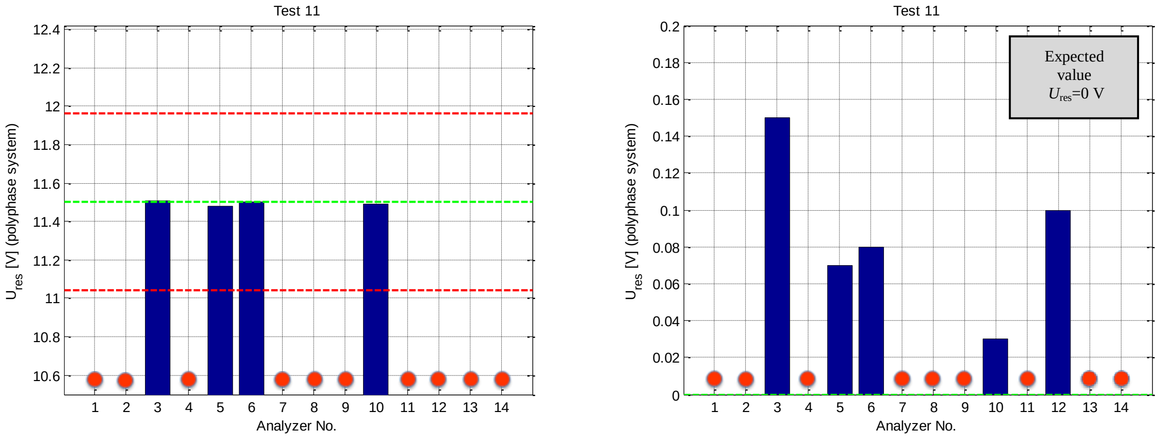
Z_1) Z_2)

Z_3) Z_4)

Fig. 2.41 Z_1)-Z_4) Comparison of analysers readings- Test 11



Z_1) Z_2)



Z_3) *Z_4)*

Fig. 2.42 Z_1)-Z_4) Comparison of analysers readings - Test 11

Summary of Test 11

During the analysis of the test results it was found that ten analysers recorded the occurrence of events Z_1-Z_4.

However, not all of them provided the parameters of these events aggregated in a three-phase system. Moreover, events Z_3 and Z_4 were not always classified in the group of voltage interruptions, which is additionally related to the procedure of determining the event duration that is different than in the case of voltage dips.

According to the information provided by IPP UNIPOWER, the duration of event Z_3 recorded by UP-2210 analyser, determined on the basis of the analysis of the samples of U_{rms} shown in Fig. 2.43, is 30 ms.

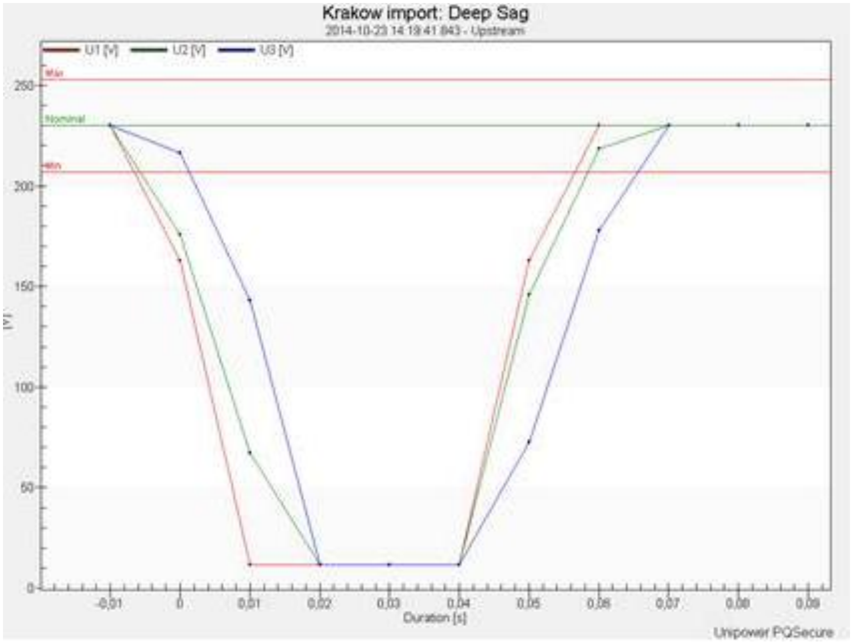


Fig. 2.43 Preview of samples U_{rms} of event Z_3- analyser UP-2210

<table>
<tr><th colspan="2">TEST 12</th></tr>
<tr><th>Time: 14:20-14:30</th><th>Influence of frequency variations on the measurement of voltage events</th></tr>
<tr><td>Test signal parameters</td><td>Event 1 (Z_1):
Three phase sinusoidal voltage with U_{rms}=230 V and f = 42,5 Hz.
The reference voltage generator produces voltage events with duration 30 ms and the following voltage levels in the individual phases:
<table><tr><th></th><th>L1</th><th>L2</th><th>L3</th></tr><tr><td>U_{rms}</td><td>10% U_{din}</td><td>50% U_{din}</td><td>110% U_{din}</td></tr></table>Event 2 (Z_2):
Three phase sinusoidal voltage with U_{rms}=230 V and f = 57,5 Hz.
The reference voltage generator produces voltage events with duration 30 ms and the following voltage levels in the individual phases:
<table><tr><th></th><th>L1</th><th>L2</th><th>L3</th></tr><tr><td>U_{rms}</td><td>10% U_{din}</td><td>50% U_{din}</td><td>110% U_{din}</td></tr></table></td></tr>
<tr><td>Test criterion</td><td>No uncertainty requirements for measurement of voltage events aggregated in a single phase - a comparative test.</td></tr>
</table>

<table>
<tr><th colspan="2" rowspan="3">Analyser</th><th colspan="5">Results- Phase L2</th></tr>
<tr><th colspan="2">Z_1</th><th colspan="2">Z_2</th><th rowspan="2">Compliance</th></tr>
<tr><th>$U_{\mathrm{res\ L2}}$ [V]</th><th>T_{L2} [ms]</th><th>$U_{\mathrm{res\ L2}}$ [V]</th><th>T_{L2} [ms]</th></tr>
<tr><td>1</td><td>Fluke 1760</td><td>---</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>2</td><td>Nexus 1500</td><td>114.80</td><td>67</td><td>115.13</td><td>38</td><td>---</td></tr>
<tr><td>3</td><td>UP-2210</td><td>115.96</td><td>48</td><td>115.05</td><td>39</td><td>---</td></tr>
<tr><td>4</td><td>DEWE-3020</td><td>---</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>5</td><td>iSTAT M355</td><td>116.06</td><td>47</td><td>114.95</td><td>35</td><td>---</td></tr>
<tr><td>6</td><td>SO-52v11-eME</td><td>---</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>7</td><td>SIMEAS Q80</td><td>---</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>8</td><td>PQ Box 200</td><td>---</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>9</td><td>ION7650</td><td>---</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>10</td><td>PQM-703</td><td>116.1</td><td>45</td><td>115.00</td><td>34</td><td>---</td></tr>
<tr><td>11</td><td>PQube</td><td>114.9</td><td>---</td><td>114.8</td><td>---</td><td>---</td></tr>
<tr><td>12</td><td>G4500</td><td>---</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>13</td><td>MI 2892</td><td>116.05</td><td>47</td><td>114.97</td><td>34</td><td>---</td></tr>
<tr><td>14</td><td>Mavowatt 270</td><td>115</td><td>47</td><td>114.9</td><td>44</td><td>---</td></tr>
</table>

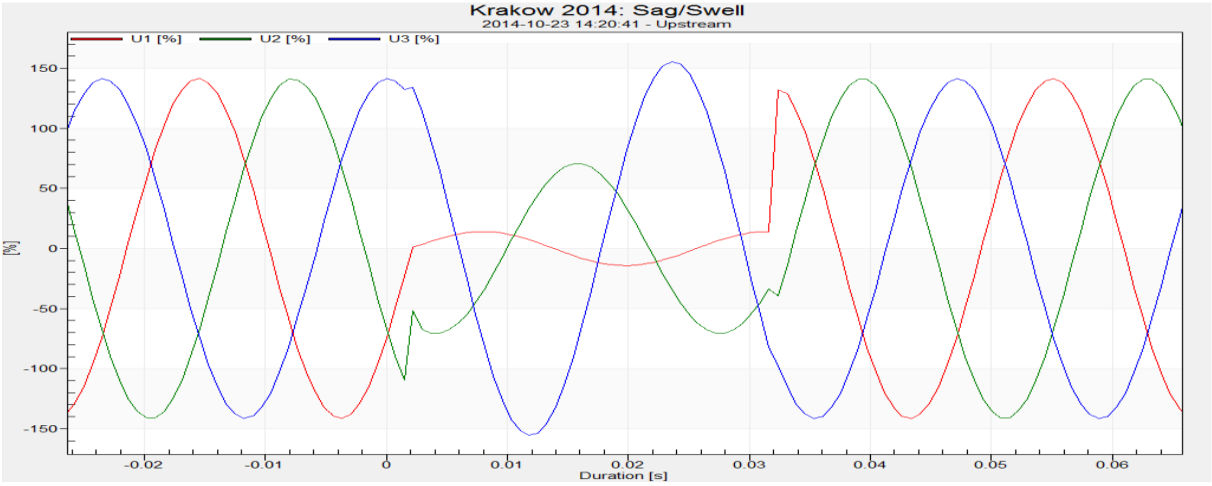


Fig. 2.44 Oscilloscope recording of a voltage event (f=42,5 Hz) - Test 12

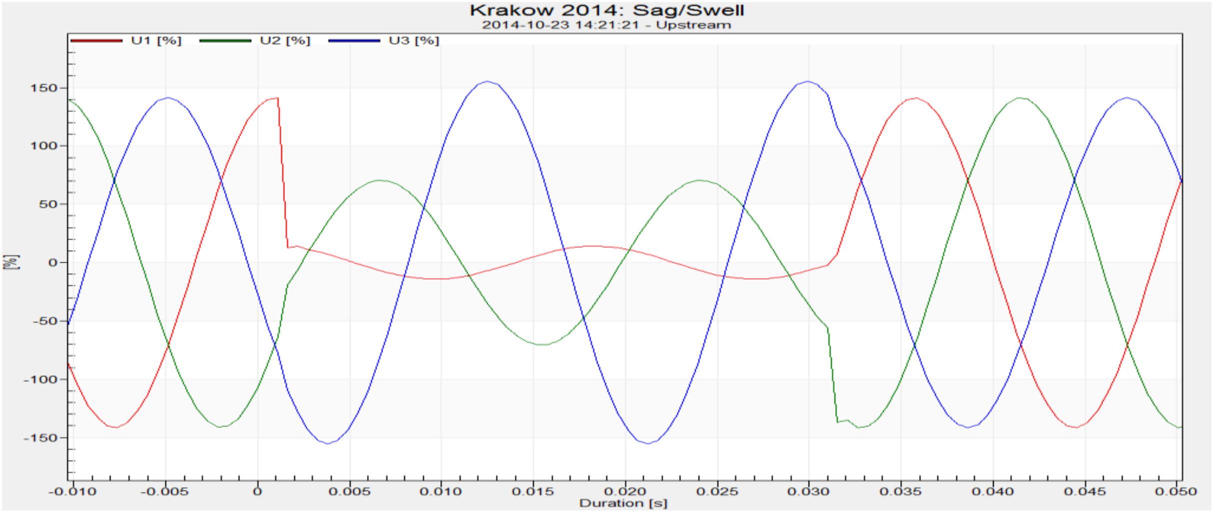
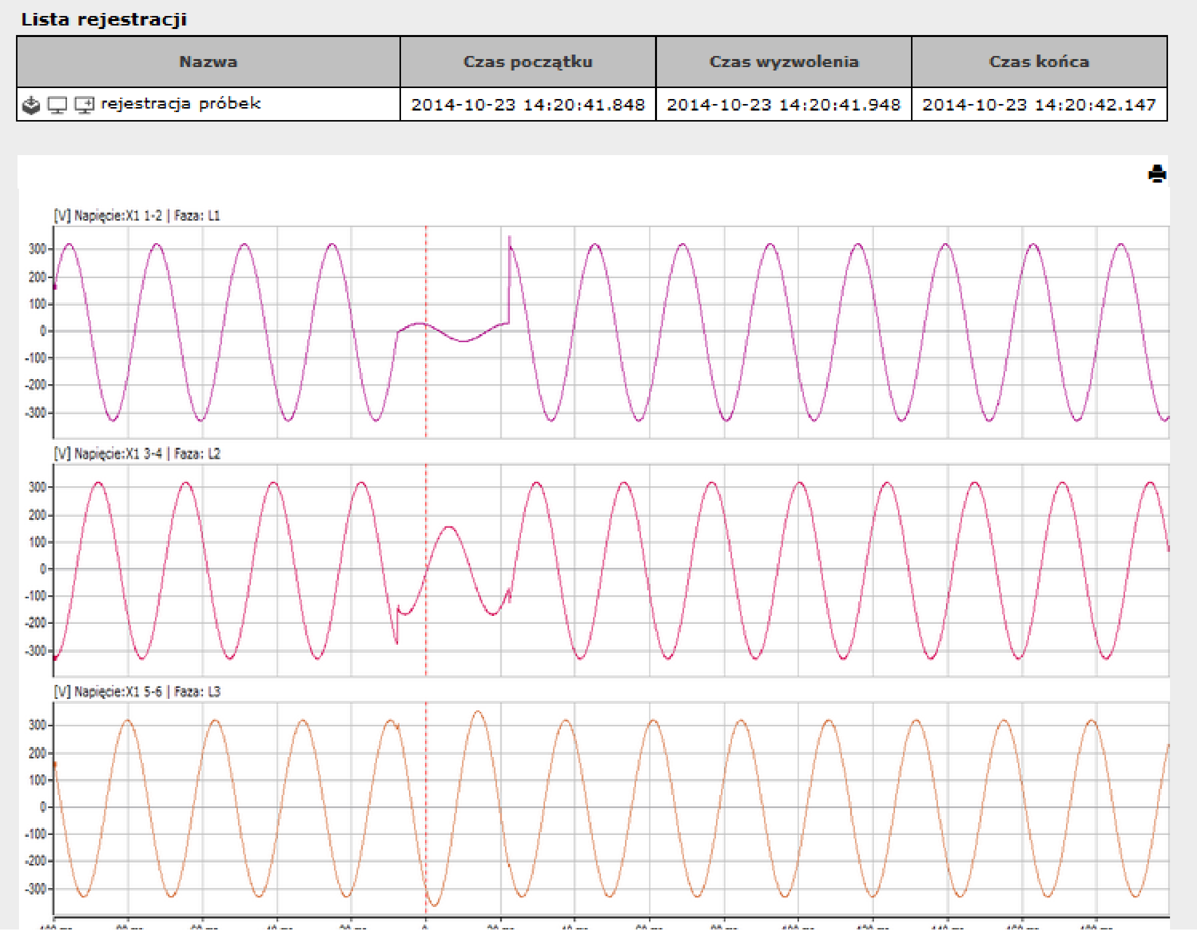


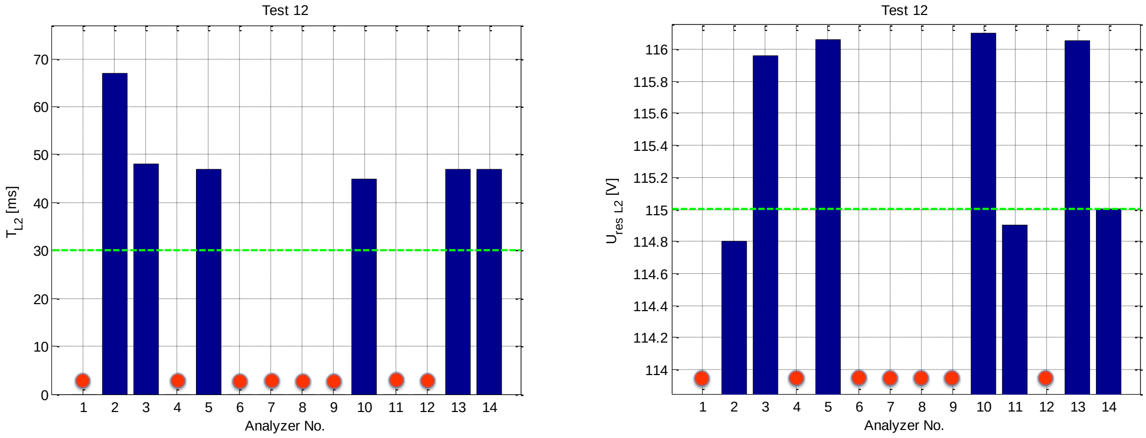
Fig. 2.45 Oscilloscope recording of a voltage event (f=57,5 Hz) - Test 12



Lista rejestracji

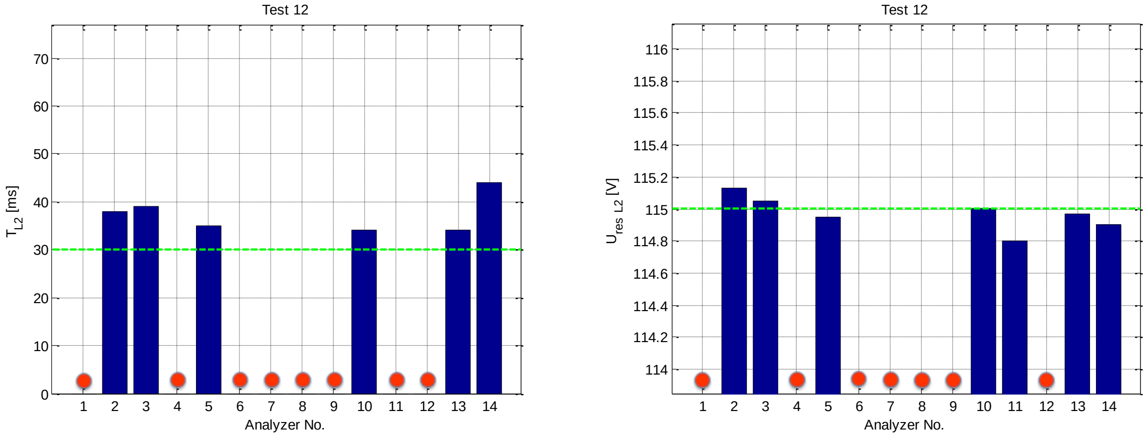
Nazwa	Czas początku	Czas wyzwolenia	Czas końca
rejestracja próbek	2014-10-23 14:20:41.848	2014-10-23 14:20:41.948	2014-10-23 14:20:42.147

Fig. 2.46 Oscilloscope recording of a voltage event (f=57,5 Hz) - Test 12



a) *b)*

Fig. 2.47 a)-b) Comparison of analysers readings - Test 12, event Z_1



a) *b)*

Fig. 2.48 a)-b) Comparison of analysers readings - Test 12, event Z_2

Summary of Test 12

During the analysis of the test results it was found that the measurement results of seven analysers provided information about events Z_1 and Z_2 determined for a single-phase system (each phase separately). This is not a requirement of the standard PN-EN 61000-4-30, so the test is presented only for comparison purposes.

3.3 Additional information

Table 2 presents the size of measurement databases created by PQ analysers during the measurement experiment. The data are only informative. It should be emphasized that the presented sizes are not comparable to one another, and it is not possible to make a clear assessment of the quality of PQ measurements taking the occupied disk space as a criterion. This is caused by different ways of configuring the analysers, especially in relation to recording of events. However, it should be noted that the most desirable scenario, especially for building a distributed PQ monitoring system, is to gather as much information about the grid as possible, in the smallest possible database size.

Table 2. The size of measurement databases from the measurement experiment

Analyser		**Volume of measurement database [MB]**	**Analyser**		**Volume of measurement database [MB]**
1	Fluke 1760	88.4	8	PQ Box 200	70.1
2	Nexus 1500	422	9	ION7650	---
3	UP-2210	1.15	10	PQM-703	108
4	DEWE-3020	1150*	11	PQube	24.7
5	iSTAT M355	5.92	12	G4500	44.5
6	SO-52v11-eME	126	13	MI 2892	430
7	SIMEAS Q80	1040	14	Mavowatt 270	171

Another important aspect attesting the quality of a PQ analyser is the ergonomics of the software used for reading and analysing the measurement data. For its assessment, the following aspects should be considered:

- visual clarity, i.e. whether the displayed information is transparent, well-organised, and readable,
- consistency of dialogue, i.e. whether the behaviour and appearance of the system is always consistent,
- ease of understanding, i.e. whether the system is intuitive at the stage of user learning,
- efficiency, i.e. whether the system is an efficient tool for achieving the user’s objectives,
- user guiding and support, i.e. whether the system provides the user with appropriate operating support.

The assessment of the above-mentioned criteria was not the subject of the measurement experiment, however it should be noted that they constitute an important determinant of the quality of every PQ analyser.

4. Summary

The Power Quality Picnic has become – as intended by the organisers – a wide forum for discussion on the issues of contemporary electric power systems. The event was met with a great interest from both manufacturers of PQ analysers and their users representing various sectors of industry.

The measurement experiment made it possible to obtain a lot of relevant information on PQ analysers, reliability of measurements, as well as cognitive knowledge concerning the methodology and conditions of Class A certification process. The organisers are convinced that the measurement results included in this report will positively impact the development of PQ analysers.

The AGH University, recognising the technical and economic importance of power supply quality, expressed their will to establish a Centre of Quality of Power Supply as a platform for cooperation between universities and industry in the field of contemporary electric power systems.

The organisers would like to invite everyone to the next event of this type – AMI Picnic, which will be devoted to smart electricity meters. The event will be held in autumn of 2015.

5. Contact

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6. Comments from participants of measurement experiment

This chapter provides formal comments received from participants of the measurement experiment – manufacturers and distributors of PQ analysers participating in the comparative tests. The order of comments is consistent with Table 3. The last presented comment was received from OMICRON Electronics – the manufacturer of the calibrator used in testing as the test signal source.

Table 3. List of formal comments received from participants of measurement experiment

Manufacturer (Supplier)	**Model**
DEWETRON (Tespol)	DEWE-3020
Electro Industries / Gaugetech	Nexus 1500
ELSPEC (Biall)	G4500
Fluke	Fluke 1760
Metrel (Merserwis)	MI 2892
Mikronika	SO-52v11-eME
Power Standards Lab (Poltrade Technologies)	PQube
Unipower AB (IPP)	UP-2210

OMICRON Electronics	Omicron 256plus

Attachments

[1] The measurement experiment protocol of the Supervising Comitee

[2] The requirements for the configuration of PQ analyzers for the measurement experiment

[3] Copies of Class A certificates of PQ analyzers participated in the measurement experiment

[4] Technical data of calibrator Omicron 256plus

[5] Technical data of calibrator Fluke 6105A

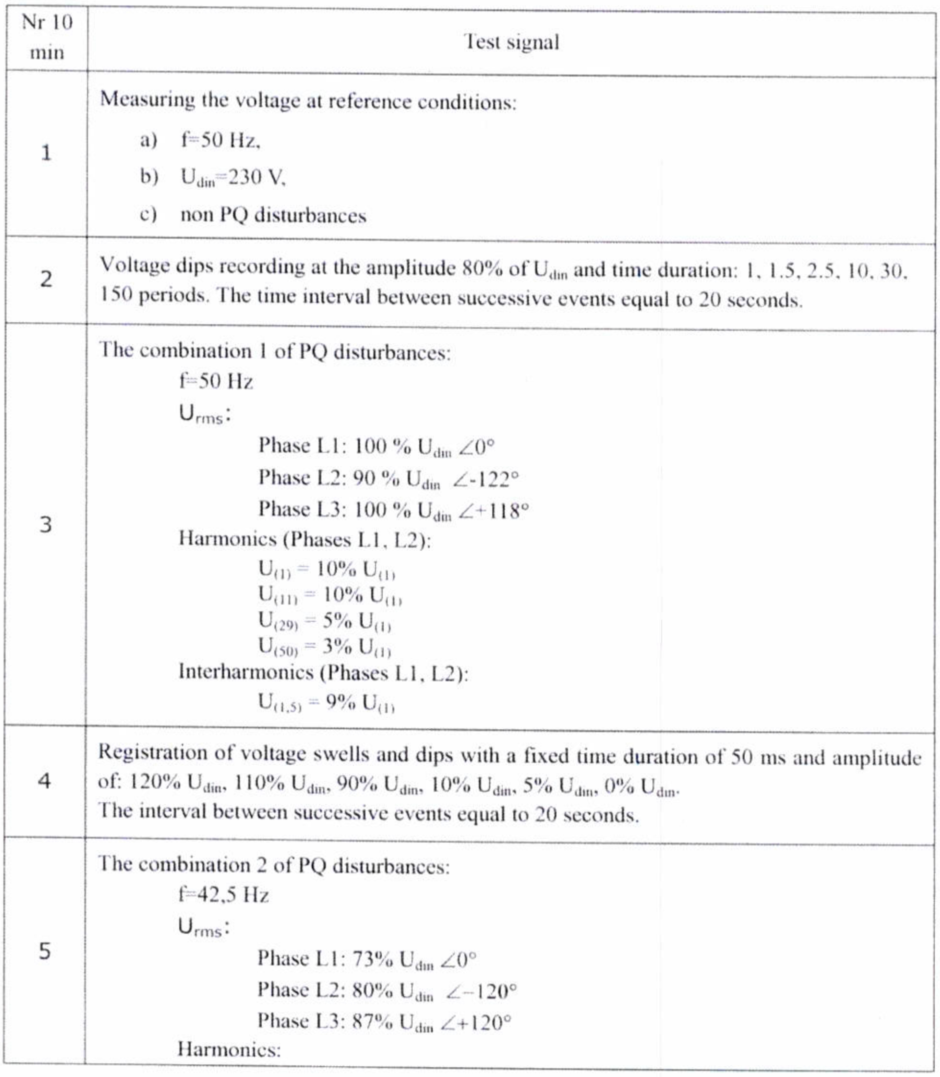
Statement Power Quality Picnic

1. Foreword

Herewith we would like to confirm that the tests and results that DEWETRON performed according to the Power Quality Picnic Test Procedure (Chapter 2) could be fully achieved, with satisfying results, already communicated to you and attached, for your convenience and for your own evaluation. DEWETRON has carefully verified and analysed the results of the test internally. All the parameters, procedures and test equipment are identical (Procedure Chapter 2, Equipment Chapter 3).

2. Test and Test Procedures

We refer to the test procedure of the Power Quality Picnic of 23. Of October 2014.



Nr 10 min	Test signal
1	Measuring the voltage at reference conditions: a) f=50 Hz, b) U_{din}=230 V, c) non PQ disturbances
2	Voltage dips recording at the amplitude 80% of U_{din} and time duration: 1, 1.5, 2.5, 10, 30, 150 periods. The time interval between successive events equal to 20 seconds.
3	The combination 1 of PQ disturbances: f=50 Hz U_{rms}: Phase L1: 100 % U_{din} ∠0° Phase L2: 90 % U_{din} ∠-122° Phase L3: 100 % U_{din} ∠+118° Harmonics (Phases L1, L2): $U_{(1)}$ = 10% $U_{(1)}$ $U_{(11)}$ = 10% $U_{(1)}$ $U_{(29)}$ = 5% $U_{(1)}$ $U_{(50)}$ = 3% $U_{(1)}$ Interharmonics (Phases L1, L2): $U_{(1,5)}$ = 9% $U_{(1)}$
4	Registration of voltage swells and dips with a fixed time duration of 50 ms and amplitude of: 120% U_{din}, 110% U_{din}, 90% U_{din}, 10% U_{din}, 5% U_{din}, 0% U_{din}. The interval between successive events equal to 20 seconds.
5	The combination 2 of PQ disturbances: f=42,5 Hz U_{rms}: Phase L1: 73% U_{din} ∠0° Phase L2: 80% U_{din} ∠−120° Phase L3: 87% U_{din} ∠+120° Harmonics:

Figure 1 Test Procedure Part 1

	Phase L1: $U_{(2)}$=5% $U_{(1)}$ Interharmonics: Phase L2: $U_{(1,5)}$=5% $U_{(1)}$ Phase L3: $U_{(90\ Hz)}$=4% $U_{(1)}$, $U_{(95\ Hz)}$=6% $U_{(1)}$
6	Registration of voltage swells and dips at different voltage frequency: a) 42,5 Hz U_{rms}: Phase L1: 10% U_{din} Phase L2: 50% U_{din} Phase L3: 100 % U_{din} b) 57,5 Hz U_{rms}: Phase L1: 5% U_{din} Phase L2: 100% U_{din} Phase L3: 120 % U_{din}
7	Voltage fluctuations 1 - rectangular voltage changes: Frequency modulation: 8,8 Hz Pst=1 U_{rms}: Phase L1: 210 V $\angle 0^\circ$ Phase L2: 230 V $\angle -120^\circ$ Phase L3: 250 V $\angle +120^\circ$
9	Voltage fluctuations 2 - rectangular voltage changes: Frequency modulation: 33,33 Hz Pst=0,2 U_{rms}: Phase L1: 215 V $\angle 0^\circ$ Phase L2: 230 V $\angle -120^\circ$ Phase L3: 245 V $\angle +120^\circ$
11	Voltage fluctuations 3 - rectangular voltage changes: Frequency modulation: 33,33 Hz Pst=10
12	Measurement of mains signaling voltage on the supply voltage Amplitude of signaling voltage 3% U_{din} and frequency respectively: Phase A: 315 Hz and 320 Hz Phase B: 310 Hz and 325 Hz Phase C: 305 Hz and 330 Hz
13	The combination 3 of PQ disturbances: f=57,5 Hz U_{rms}: Phase L1: 95 % U_{din} $\angle 0^\circ$ Phase L2: 100 % U_{din} $\angle -123^\circ$ Phase L3: 105 % U_{din} $\angle +119^\circ$ Voltage fluctuations: Frequency modulation: 0,5 Hz

Figure 2 Test Procedure Part 2

	Pst=1 Harmonics $U_{(11)}$: Phase L1: 5 % $U_{(1)} \angle 0^\circ$, Phase L2: 10% $U_{(1)} \angle 0^\circ$, Phase L3:0.5% $U_{(1)} \angle 0^\circ$ $U_{(16)}$: Phase L1: 5 % $U_{(1)} \angle 30^\circ$, Phase L2: 5% $U_{(1)} \angle 60^\circ$, Phase L3:5% $U_{(1)} \angle 90^\circ$ $U_{(41)}$: Phase L1: 3% $U_{(1)} \angle 180^\circ$, Phase L2: 3% $U_{(1)} \angle 180^\circ$, Phase L3:3% $U_{(1)} \angle 180^\circ$ $U_{(44)}$: Phase L1: 1% $U_{(1)} \angle 120^\circ$, Phase L2: 2% $U_{(1)} \angle 150^\circ$, Phase L3:0.1% $U_{(1)} \angle 180^\circ$ Interharmonics: $U_{(520\ \mathrm{Hz})}$: Phase L1: 5 V $\angle 0^\circ$, Phase L2: 5 V $\angle -120^\circ$, Phase L3: 5 V $\angle 120^\circ$ $U_{(567\ \mathrm{Hz})}$: Phase L1: 5 V $\angle 0^\circ$, Phase L2: 5 V $\angle -120^\circ$, Phase L3: 5 V $\angle 120^\circ$
14	Verification of the 10-minute aggregation procedure. Signals from point 1 and point 13 with the 50/50 time share
15	PQ events from points 2, 4, 6 above. Events start at zero crossing.
16	Technical break - change the signal generator
17	Voltage fluctuations 4 Phase jump: $\Delta\beta=45^\circ$
18-27	The antialiasing low-pass filter verification Fundamental component parameters: $U_{(1)} = 210$ V, $f_{(1)}=50$ Hz High frequency component parameters: Amplitude: 16 V Frequency between 10 - 55 kHz (10-minutes step changes)

Figure 3 Test Procedure Part 3

3. Test Equipment

- OMICRON CMC 256
- DEWE-3020-PNA
    - DEWESoft 7, PMT4 with SQL Database

4. Conclusions and internal Tests

To verify our measurement equipment we also tried to verify the test with the same equipment (OMICRON CMC 256) and Test Procedure in our power lab. We run the test with settings (trigger limits) according to the Power Quality Standard and the official standards for power quality meters.

We run the test with settings used at the Picnic (e.g. Trigger settings pretime = 1500ms, posttime=3500ms, holdoff=0ms) and with adapted settings to (pretime=100ms, posttime=300ms, holdoff=500ms) verify the reason of missing values in our measurement result.

We have set a holdoff time due to our internal test because our system is also triggering on the **interrupts between the different cycles of the test procedure**. With this adapted settings we are able to ignore these interrupts and to reduce the number of Transients to a minimum (only Transients that are caused by the test procedure itself).

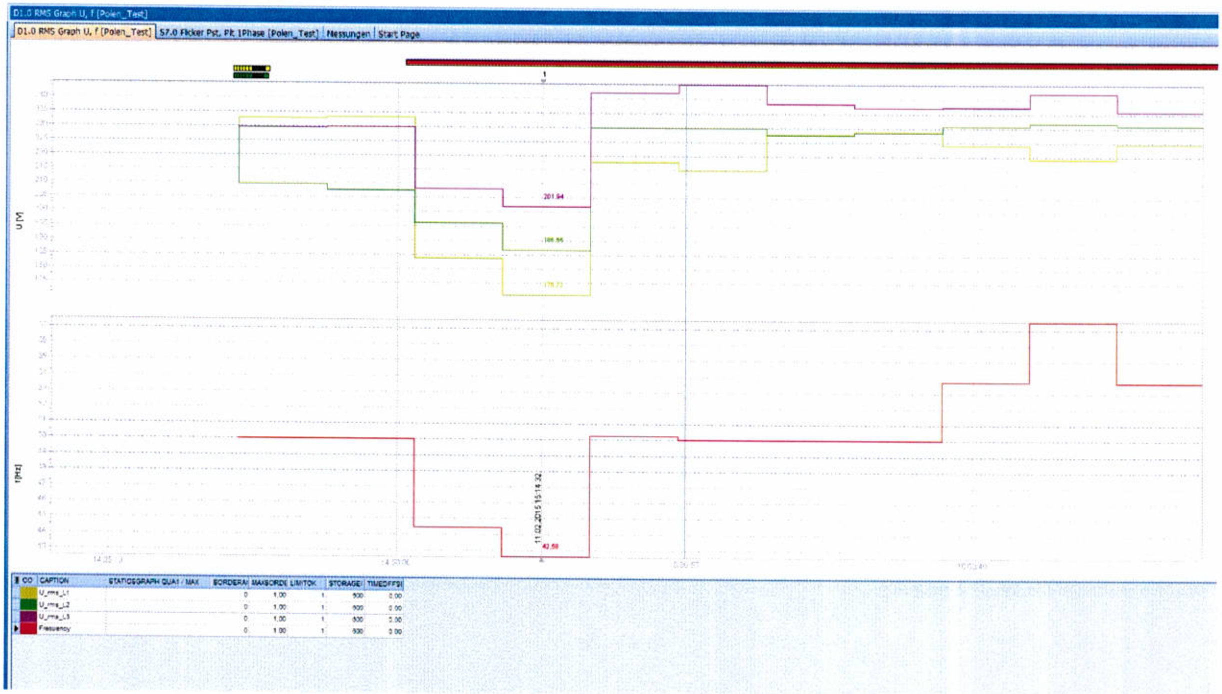
Finally we can explain why some values and parameters are missing.

Every Event is stored in high resolution (acquisition rate e.g. 20kHz/Channel) with a maximum length of 10 seconds. Therefore every event needs about 4 to 7 MB of storage. During the Picnic the streaming option (transfer RMS values and Transients to the SQL Database) was used. The limit of the speed/performance of data transfer is given by the SQL Database. The Transfer of 40 events (e.g. detected within 1 min) may take 10 minutes to be stored completely in the database. Our system was creating thousands of transients (due to the wrong settings) during the Test Procedure. Because of this huge number of transients, our system was not able to write all this data to the database. With the adapted settings the DEWETRON System is able to measure and store all requested values and parameters (Voltage, Frequency, Pst, symmetrical components, unbalance THD and Harmonics up to the 50th order).

On the following pages you will find our results verified in our lab (Data and result are communicated to you).

5. Procedure Voltage and Frequency

The following figure shows the voltage and frequency recorded during the test procedure.



	CO	CAPTION	STATIOSGRAPH QUA1 / MAX	BORDERA	MAXBORDE	LIMITOK	STORAGE	TIMEOFFSI
	🟨	U_rms_L1		0	1,00	1	500	0,00
	🟩	U_rms_L2		0	1,00	1	500	0,00
	🟪	U_rms_L3		0	1,00	1	500	0,00
▶	🟥	Frequency		0	1,00	1	500	0,00

Figure 4 Voltage and Frequency

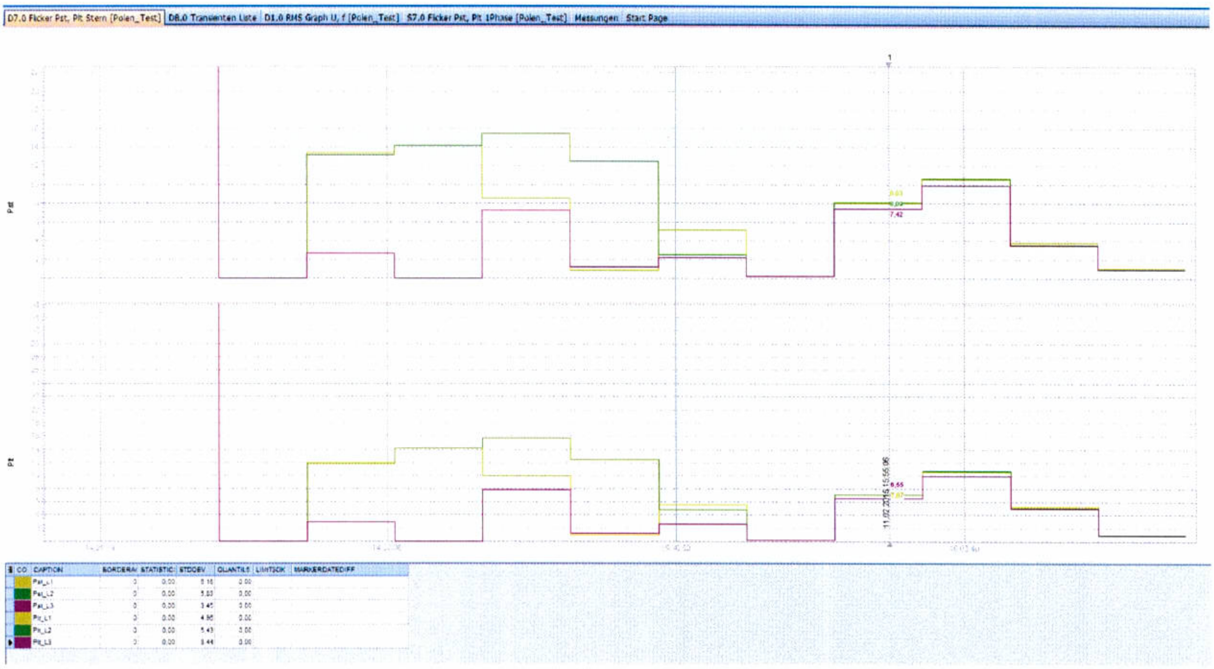
6. Procedure Flicker

The following figure shows the Flicker for Line 1 (Pst and Plt) during the Test Procedure.

	CO	CAPTION	BORDERA	STATISTIC	STDDEV	QUANTILS	LIMITSOK	MARKERDATEDIFF
	🟨	Pst_L1	0	0,00	5,10	0,00		
▶	🟨	Plt_L1	0	0,00	4,95	0,00		

Figure 5 Flicker Pst_L1 and Plt_L1

Figure 6 shows the Flicker values for all three phases.

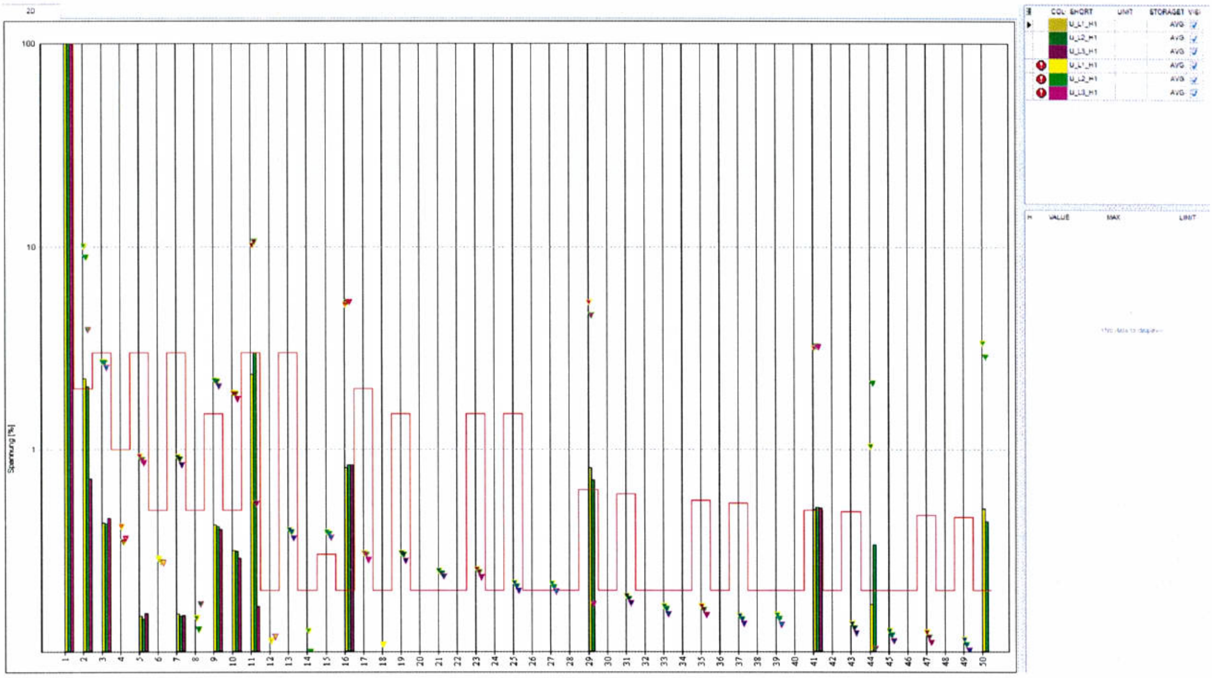


CO	CAPTION	BORDERA	STATISTIC	STDDEV	QUANTILE	LIMITSOK	MARKERDATEDIFF
🟨	Pst_L1	0	0,00	5.16	0.00		
🟩	Pst_L2	0	0,00	5.83	0,00		
🟪	Pst_L3	0	0,00	3.45	0.00		
🟨	Plt_L1	0	0.00	4.86	0.00		
🟩	Plt_L2	0	0,00	5.43	0.00		
🟪	Plt_L3	0	0,00	3.44	0.00		

Figure 6 3 Phase Flicker Pst and Plt

7. Procedure Harmonics

Figure 7 shows the Harmonics during the Test Procedure.



COL	SHORT	UNIT	STORAGET	VISI
🟨	U_L1_H1		AVG	☑
🟩	U_L2_H1		AVG	☑
🟪	U_L3_H1		AVG	☑
🟨	U_L1_H1		AVG	☑
🟩	U_L2_H1		AVG	☑
🟪	U_L3_H1		AVG	☑

H	VALUE	MAX	LIMIT

Figure 7 Harmonics

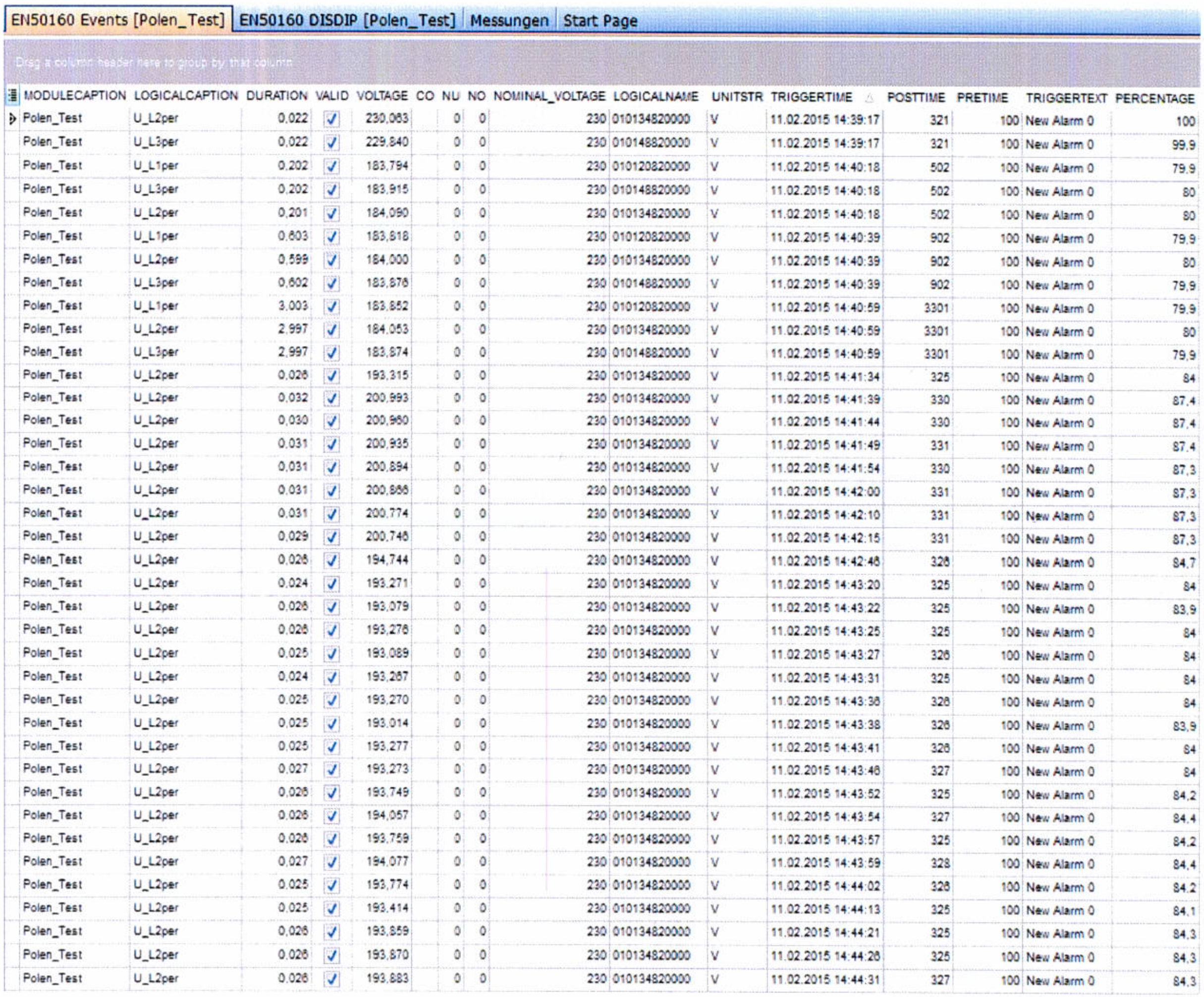
The following figure shows the Harmonics H1, H11, H29 and H50 of Line 1 during the Test Procedure.

CO	CAPTION	UNIT	CURVAL	CURVAL2	STATICGRAPH QUA1 - MAX	BORDERA	MIN	MAX	AVG	QUANTIL3	STATISTIC	LIMITOK	MARKERDI
🟥	U_L1_H1	V	229.81			0	170.46	229.81	213.56	0.00	1		
🟩	U_L1_H11	V	21.85			0	0.00	21.85	4.61	0.00	1		
🟨	U_L1_H50	V	7.16			0	0.00	7.16	0.77	0.00	1		
🟪	U_L1_H29	V	0.04			0	0.01	0.43	0.10	0.00	1		

Figure 8 Harmonics H1, H11, H29 and H50 of Line 1

8. Events

The following figure shows an extract of the events during our internal test.



MODULECAPTION	LOGICALCAPTION	DURATION	VALID	VOLTAGE	CO	NU	NO	NOMINAL_VOLTAGE	LOGICALNAME	UNITSTR	TRIGGERTIME	POSTTIME	PRETIME	TRIGGERTEXT	PERCENTAGE
Polen_Test	U_L2per	0,022	☑	230,063		0	0	230	010134820000	V	11.02.2015 14:39:17	321	100	New Alarm 0	100
Polen_Test	U_L3per	0,022	☑	229,840		0	0	230	010148820000	V	11.02.2015 14:39:17	321	100	New Alarm 0	99,9
Polen_Test	U_L1per	0,202	☑	183,794		0	0	230	010120820000	V	11.02.2015 14:40:18	502	100	New Alarm 0	79,9
Polen_Test	U_L3per	0,202	☑	183,915		0	0	230	010148820000	V	11.02.2015 14:40:18	502	100	New Alarm 0	80
Polen_Test	U_L2per	0,201	☑	184,090		0	0	230	010134820000	V	11.02.2015 14:40:18	502	100	New Alarm 0	80
Polen_Test	U_L1per	0,603	☑	183,818		0	0	230	010120820000	V	11.02.2015 14:40:39	902	100	New Alarm 0	79,9
Polen_Test	U_L2per	0,599	☑	184,000		0	0	230	010134820000	V	11.02.2015 14:40:39	902	100	New Alarm 0	80
Polen_Test	U_L3per	0,602	☑	183,876		0	0	230	010148820000	V	11.02.2015 14:40:39	902	100	New Alarm 0	79,9
Polen_Test	U_L1per	3,003	☑	183,852		0	0	230	010120820000	V	11.02.2015 14:40:59	3301	100	New Alarm 0	79,9
Polen_Test	U_L2per	2,997	☑	184,053		0	0	230	010134820000	V	11.02.2015 14:40:59	3301	100	New Alarm 0	80
Polen_Test	U_L3per	2,997	☑	183,874		0	0	230	010148820000	V	11.02.2015 14:40:59	3301	100	New Alarm 0	79,9
Polen_Test	U_L2per	0,026	☑	193,315		0	0	230	010134820000	V	11.02.2015 14:41:34	325	100	New Alarm 0	84
Polen_Test	U_L2per	0,032	☑	200,993		0	0	230	010134820000	V	11.02.2015 14:41:39	330	100	New Alarm 0	87,4
Polen_Test	U_L2per	0,030	☑	200,960		0	0	230	010134820000	V	11.02.2015 14:41:44	330	100	New Alarm 0	87,4
Polen_Test	U_L2per	0,031	☑	200,935		0	0	230	010134820000	V	11.02.2015 14:41:49	331	100	New Alarm 0	87,4
Polen_Test	U_L2per	0,031	☑	200,894		0	0	230	010134820000	V	11.02.2015 14:41:54	330	100	New Alarm 0	87,3
Polen_Test	U_L2per	0,031	☑	200,866		0	0	230	010134820000	V	11.02.2015 14:42:00	331	100	New Alarm 0	87,3
Polen_Test	U_L2per	0,031	☑	200,774		0	0	230	010134820000	V	11.02.2015 14:42:10	331	100	New Alarm 0	87,3
Polen_Test	U_L2per	0,029	☑	200,746		0	0	230	010134820000	V	11.02.2015 14:42:15	331	100	New Alarm 0	87,3
Polen_Test	U_L2per	0,026	☑	194,744		0	0	230	010134820000	V	11.02.2015 14:42:46	326	100	New Alarm 0	84,7
Polen_Test	U_L2per	0,024	☑	193,271		0	0	230	010134820000	V	11.02.2015 14:43:20	325	100	New Alarm 0	84
Polen_Test	U_L2per	0,026	☑	193,079		0	0	230	010134820000	V	11.02.2015 14:43:22	325	100	New Alarm 0	83,9
Polen_Test	U_L2per	0,026	☑	193,276		0	0	230	010134820000	V	11.02.2015 14:43:25	325	100	New Alarm 0	84
Polen_Test	U_L2per	0,025	☑	193,089		0	0	230	010134820000	V	11.02.2015 14:43:27	326	100	New Alarm 0	84
Polen_Test	U_L2per	0,024	☑	193,267		0	0	230	010134820000	V	11.02.2015 14:43:31	325	100	New Alarm 0	84
Polen_Test	U_L2per	0,025	☑	193,270		0	0	230	010134820000	V	11.02.2015 14:43:36	326	100	New Alarm 0	84
Polen_Test	U_L2per	0,025	☑	193,014		0	0	230	010134820000	V	11.02.2015 14:43:38	326	100	New Alarm 0	83,9
Polen_Test	U_L2per	0,025	☑	193,277		0	0	230	010134820000	V	11.02.2015 14:43:41	326	100	New Alarm 0	84
Polen_Test	U_L2per	0,027	☑	193,273		0	0	230	010134820000	V	11.02.2015 14:43:46	327	100	New Alarm 0	84
Polen_Test	U_L2per	0,026	☑	193,749		0	0	230	010134820000	V	11.02.2015 14:43:52	325	100	New Alarm 0	84,2
Polen_Test	U_L2per	0,026	☑	194,057		0	0	230	010134820000	V	11.02.2015 14:43:54	327	100	New Alarm 0	84,4
Polen_Test	U_L2per	0,026	☑	193,759		0	0	230	010134820000	V	11.02.2015 14:43:57	325	100	New Alarm 0	84,2
Polen_Test	U_L2per	0,027	☑	194,077		0	0	230	010134820000	V	11.02.2015 14:43:59	328	100	New Alarm 0	84,4
Polen_Test	U_L2per	0,025	☑	193,774		0	0	230	010134820000	V	11.02.2015 14:44:02	326	100	New Alarm 0	84,2
Polen_Test	U_L2per	0,025	☑	193,414		0	0	230	010134820000	V	11.02.2015 14:44:13	325	100	New Alarm 0	84,1
Polen_Test	U_L2per	0,026	☑	193,859		0	0	230	010134820000	V	11.02.2015 14:44:21	325	100	New Alarm 0	84,3
Polen_Test	U_L2per	0,026	☑	193,870		0	0	230	010134820000	V	11.02.2015 14:44:26	325	100	New Alarm 0	84,3
Polen_Test	U_L2per	0,026	☑	193,883		0	0	230	010134820000	V	11.02.2015 14:44:31	327	100	New Alarm 0	84,3

Figure 9 extract of events

9. Abstract

The Power Quality Picnic was a very good possibility to show the performance of PQ Measurement Systems and to match with different competitors. We would like to say thank you for this opportunity! DEWETRON Systems are reliable and high quality Measurement Systems. And we are sure, If all settings are done in the right way DEWETRON Systems are measuring, recording and analysing all Parameters according to PQ Standards (IEC61000-4-30, IEC41000-4-15:2010, IEC61000-4-7 and EN50160) for Power Quality Measurements in a very high quality and a high accuracy.

Sincerely Yours

18.5.2015

Christoph Wiedner

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Wrocław 08.05.2015

Sz. P.
Krzysztof Chmielowiec
AGH Kraków

Poniżej przekazuję swoje uwagi do raportu wstępnego z eksperymentu pomiarowego - badania porównawcze analizatorów JEE:

1. Miernik Nexus 1500 w trakcie eksperymentu nie był podłączony do komputera jako bazy danych. Miernik w tej konfiguracji miał pojemność pamięci 128 MB. Parametry te umożliwiły zarejestrowanie 526 przebiegów. Dlatego też zarejestrowano przebiegi począwszy od godz. 11:24:49,5144 do godz. 14:46:07,3308. Przebiegi wcześniejsze zostały nadpisane. Nexus 1500 może posiadać maksymalnie 4 GB pamięci.

2. Miernik został tak skonfigurowany że rejestrował do pamięci 456 wartości mierzonych oraz 7 kanałów analogowych (4 napięcia i 3 prądy). Skutkowało to zwiększeniem obszaru pamięci. Plik wynikowy, w tym przypadku, miał wielkość 423 MB.

3. W trakcie eksperymentu miernik obliczał wartość THD mierząc harmoniczne od 0 do 127.

Informacja ogólna:

- W najbliższym czasie będzie dostępny następca obecnego miernika NEXUS 1500 o nazwie NEXUS 1500+. Miernik ten będzie posiadał znacznie większe możliwości pomiarowe **(między innymi transient recorder o częstotliwości próbkowania 55 MHz w każdym kanale)** oraz ekran z predefiniowanym językiem polskim.

Pozdrawiam

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The Leader In Web Accessed Power Monitoring

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Gdańsk, 2015.06.01

AGH Kraków
Krzysztof Chmielowiec
Katedra Energoelektroniki i Automatyki Systemów Przetwarzania Energii
Wydział Elektrotechniki, Automatyki, Informatyki i Inżynierii Biomedycznej

Szanowni Państwo

W odpowiedzi na informacje zawarte we „Raporcie wstępnym z eksperymentu pomiarowego badania porównawcze analizatorów JEE" chcielibyśmy wnieść następujące uwagi oraz sugestie, które naszym zdaniem miały wpływ na uzyskane wyniki pomiarów zarejestrowane przez analizator Elspec G4500, wykorzystany do Eksperymentu. Uwagi podajemy w wersji przesłanej przez producenta oraz w tłumaczeniu na j.polski:

1. **Measurement readings** : In our unit, each channel reading is in reference to the neutral (which it's reference is ground). As can be seen in the recordings (Appen.No1), the neutral waveform is in the range of the 10V to 50V, and when zoom in, even higher. Obviously this will have a big effect on all readings and especially on the flickering readings. We did not get similar complaints regarding flickering readings from many thousands of devices which are located all over the world.

   Odczyty pomiarów: *W naszym urządzeniu, pomiar w każdym kanale jest dokonywany w odniesieniu do przewodu neutralnego (którego odniesieniem jest uziemienie). Jak możemy zauważyć w wynikach pomiarów (Załącznik nr 1), przebieg w przewodzie neutralnym jest w osiąga wartości przedziale 10 do 50V a nawet jeszcze wyższe. Ma to, oczywiście, wpływ na wszystkie wyniki pomiarów a w szczególności na odczyty wartości migotania światła. Nie zanotowaliśmy podobnych zastrzeżeń co do nieprawidłowych pomiarów migotania światła od użytkowników tysięcy sprzedanych urządzeń na całym świecie.*

   The G4500 measure and record 4 physical channels with 1 common reference, the ground. Phase voltage and differential voltages are calculate based on the physical channels. Assuming you connected V1 to Channel 1, V2 to channel 2,…, V_N to channel 4 and ground to ground, the channel map will looks as follow:

   Analizator G4500 mierzy oraz rejestruje 4 kanały fizyczne oraz 1 wspólny kanał odniesienia, uziemienie. Napięcia fazowe oraz międzyfazowe są obliczane bazując na kanałach fizycznych. Przy założeniu, iż V1 podłączymy do kanału 1, V2 do kanału 2, …, napięcie V_N do kanału 4, uziemienie do uziemienia, układ połączeń będzie wyglądał następująco:

Physical channels	
Channel 1	V1 to Ground
Channel 2	V2 to ground
Channel 3	V3 to ground
Channel 4	VN to ground
Virtual channels	
V1n	Channel 1 – channel 4
V2n	Channel 2 – channel 4
V3n	Channel 3 – Channel 4
VN	Channel 4
V12	Channel 2 – channel 1
V23	Channel 3 – channel 2
V31	Channel 3 – channel 1

Therefore the importance of not having channel 4 float. In PQZIP from measurements we notices that V_N has significant signal therefore we assuming that channel 4 is floating and affect the accuracy. We recommend you to connect channel 4 to the ground and repeat the test.

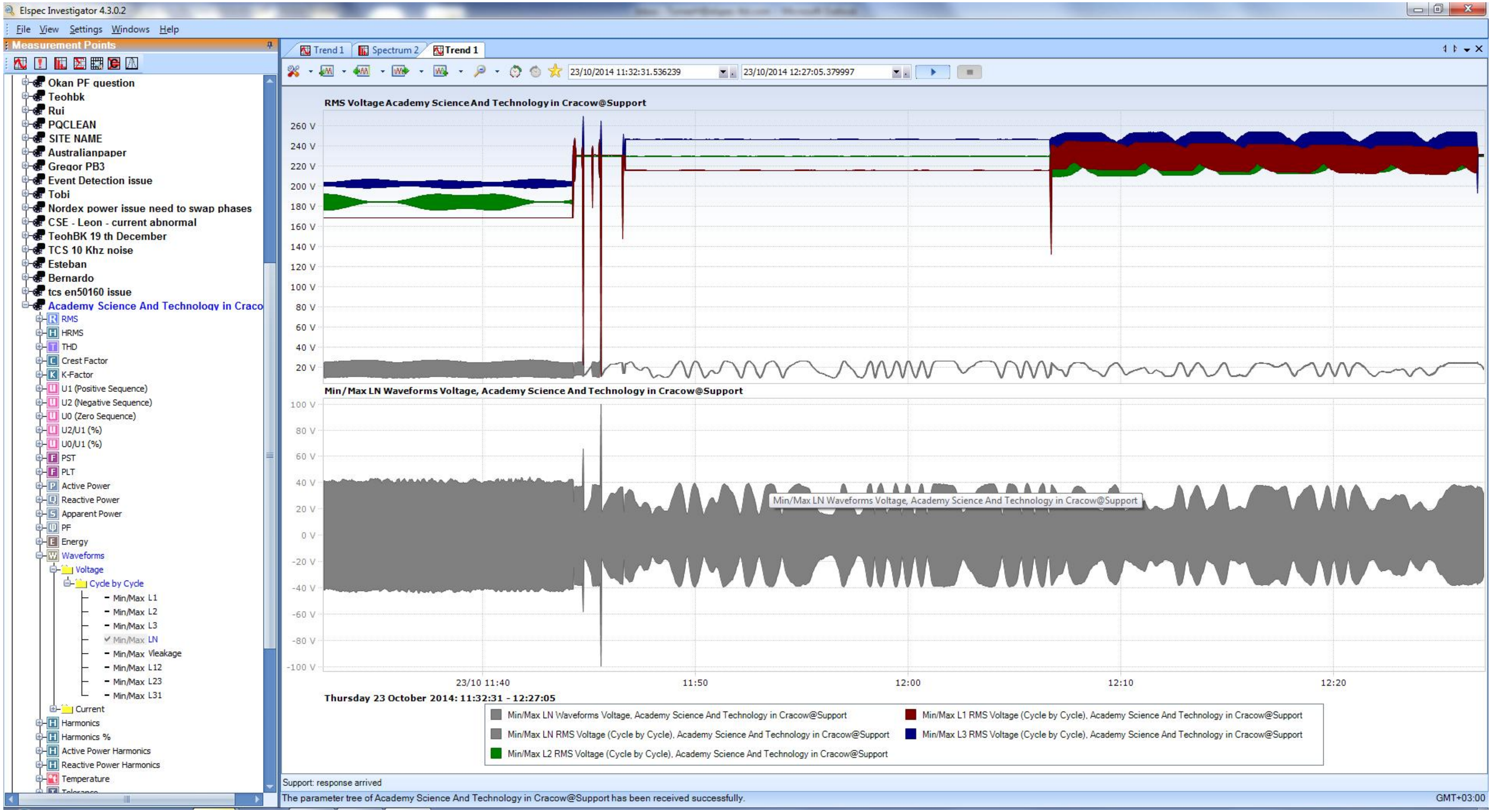
Dlatego też bardzo istotny jest brak "pływającego" kanału 4. W otrzymanych plikach PQZIP z pomiarów znajdujemy zauważalny sygnał w kanale V_N *dlatego tez zakładamy, iż kanał 4 „pływający" co ma wpływ na dokładność pomiarów. Zalecamy podłączenie kanału 4 do uziemiania i powtórzenie pomiarów.*

2. **Calibration** : This device was last calibrated at 2010 (about 5 years ago), Elspec recommendations for calibration are every 2 years (not necessary need to be calibrated, but it need to be verified every 2 years, and if needed, calibration should be done).
   Kalibracja: *Urządzenie używane do testów było poddane kalibracji w 2010r. (ok.. 5 lat temu) Elspec zaleca przeprowadzenie kalibracji co 2 lata (a jeżeli kalibracja nie jest konieczna – należy zweryfikować poprawność pomiarów).*

3. **Storage usage** : G4500 (or any other model of the G4K series) biggest strength is the compression method (about X 1000 more than without compression). The G4500 only used 70MB-80MB for about 7 hours of recording because of our PQZIP compression algorithm (should be quite a lot of GBs at any other standard device). Our patented compression algorithm enables our units to retain electrical data at a very high resolution (1024 SPC) including waveform onboard the internal memory for more than one year
   Objętość bazy danych pomiarowych: *Największą zaletą Elspec G4500 (lub inny model z serii G4K) jest algorytm kompresji danych pomiarowych (kompresja w stosunku 1000:1). Całkowita objętość bazy danych dla 7 godzin pomiarów to 70-80MB dzięki algorytmowi PQZIP (w standartowych urządzeniach zajęłoby to GB danych). Nasza opatentowana technologia kompresji umożliwia uzyskanie bardzo wysokiej rozdzielczości pomiarów (1024 próbki/okres) wraz w rejestracją przebiegów z okresu do 1 roku.*

Z Poważaniem

Adrian Wieczorkowski



Support: response arrived

The parameter tree of Academy Science And Technology in Cracow@Support has been received successfully.

FLUKE

KOMENTARZ DO WYNIKU EKSPERYMENTALNEGO BADANIA PORÓWNAWCZEGO ANALIZATORÓW

Pan Krzysztof Chmielowiec
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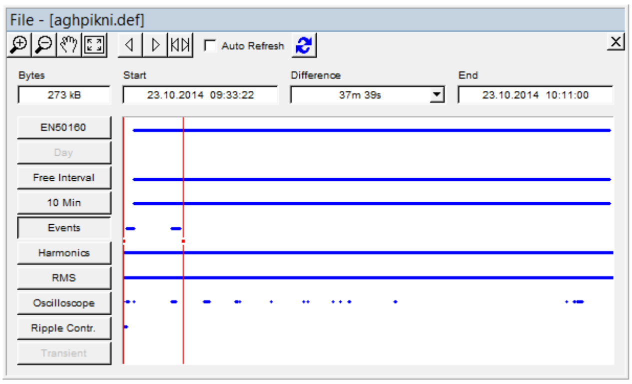
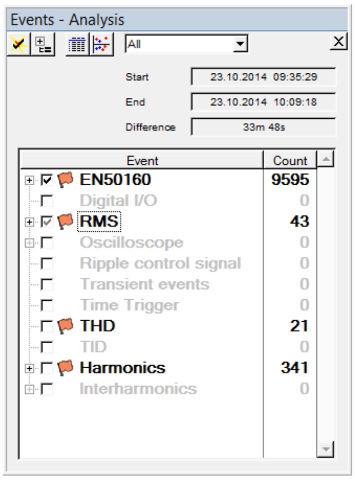
Warszawa dn. 12.05.2015

Dziękujemy za możliwość wzięcia udziału w eksperymencie pomiarowym Piknik JEE. Otrzymaliśmy od Państwa wstępny raport z eksperymentu. Widać na podsumowaniu poniżej, że nasz analizator po wcześniejszym zarejestrowaniu 10000 zdarzeń przestał rejestrować zdarzenia. Ponieważ organizator nie podał w warunkach uczestnictwa możliwości wystąpienia tak dużej ilości zaburzeń, nasz analizator nie został zaprogramowany na taką ewentualność. Po zarejestrowaniu 10000 zdarzeń przestał programowo rejestrować zdarzenia, ale dalej rejestrował dane JEE w formie przebiegów oscylograficznych. Widać więc, że zgłoszone do uczestnictwa urządzenie do końca pracowało poprawnie. Dla zainteresowanych gotowi jesteśmy udostępnić zarejestrowane przebiegi oscyloskopowe po zakończeni rejestracji typowych zdarzeń dla normy EN/PN 50160.



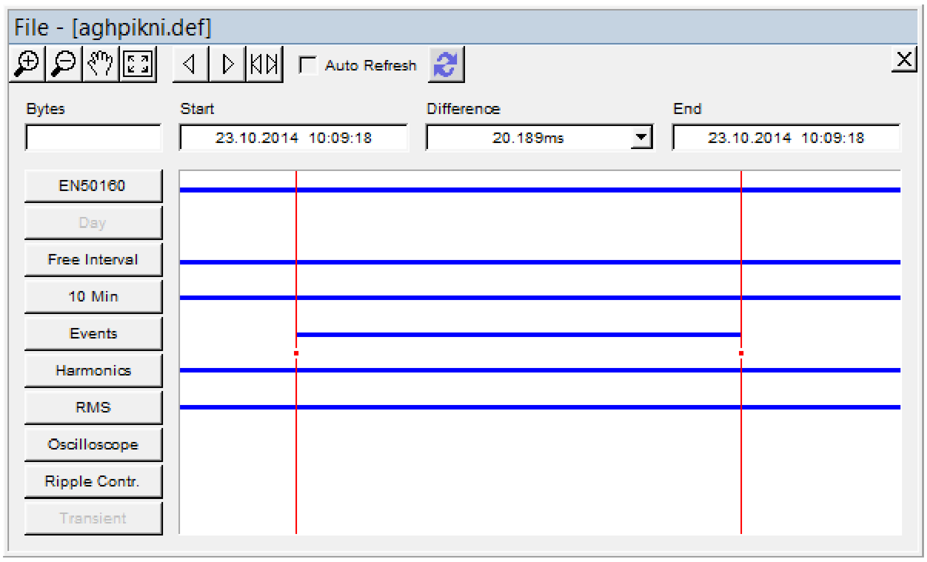
Bytes: 273 kB
Start: 23.10.2014 09:33:22
Difference: 37m 39s
End: 23.10.2014 10:11:00



Start: 23.10.2014 09:35:29
End: 23.10.2014 10:09:18
Difference: 33m 48s

Event	Count
☑ **EN50160**	**9595**
☐ Digital I/O	0
☑ **RMS**	**43**
☐ Oscilloscope	0
☐ Ripple control signal	0
☐ Transient events	0
☐ Time Trigger	0
☐ **THD**	**21**
☐ TID	0
☐ **Harmonics**	**341**
☐ Interharmonics	0

Ostatnie zdarzenie zarejestrowane zdarzenie widać poniżej:

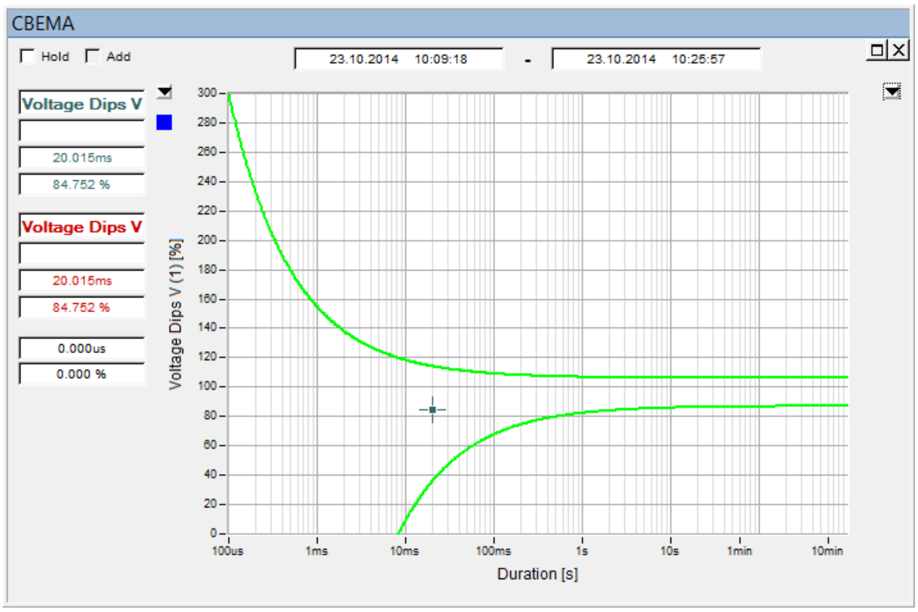


Bytes

Start: 23.10.2014 10:09:18

Difference: 20.189ms

End: 23.10.2014 10:09:18



23.10.2014 10:09:18 - 23.10.2014 10:25:57

Voltage Dips V
20.015ms
84.752 %

Voltage Dips V
20.015ms
84.752 %

0.000us
0.000 %

Robert Olkiewicz

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MERSERWIS
PROFESJONALNA APARATURA
KONTROLNO - POMIAROWA

Warszawa, 08.05.2015

Comment of the experiment participant

With respect to the results of the measurement experiment - JEE analyzers comparative studies conducted at the Power Quality Picnic in Cracow, on behalf of Merserwis and the manufacturer of the instrument we operated – the company Metrel – our position is shown below:

At the outset, we would like to thank the organisers for the opportunity to participate in such an interesting project. The nature of the tests, even though it partially deviated from the specific character of the measurements performed in real conditions (due to the limited duration and "concentrated" disturbances), has provided very valuable data and certainly contributed to the further development of the important subject, which is the power quality.

The MI 2892 instrument was introduced to the Polish market at the beginning of 2014 and at the time of the experiment there were still some minor tweaks being implemented in order to improve the firmware, ensuring that the instrument measures and records power quality parameters according to the class A regardless of potentially difficult working conditions or unusual specificity of disturbances in the grid. Having knowledge of some minor issues in the firmware the company Metrel in the period between the experiment and the announcement of its results, introduced the necessary corrections completely eliminating all of the problems that the results of the experiment highlighted. We, together with the manufacturer, ensure that the device in its current version is fully compliant with the stringent requirements of 61000-4-30 Class A standard. These words should soon be confirmed by a certificate issued by an independent and renowned in the field of power quality analysis laboratory - Power Standards Lab in the US, in which the MI 2892 Power Master enters the last phase of the testing. Measuring experiment showed, above all, that there is no perfect instrument. Successfully competing with devices which prices are often a multiple of the cost of our solution, we confirmed ourselves in the belief that the MI 2892 Power Master is an excellent proposition for professionals looking for a reliable power quality analyzer.

Marcin Barczyk, M.Sc., Eng.

DYREKTOR ZAKŁADU
inż. Jan Sałata

Mikronika
Tomasz Kałek
Wiesław Gil

Poznań, 27.05.2014

Comments to the report of the measurement experiment carried on during the Power Quality Picnic

Ladies And Gentlemen,

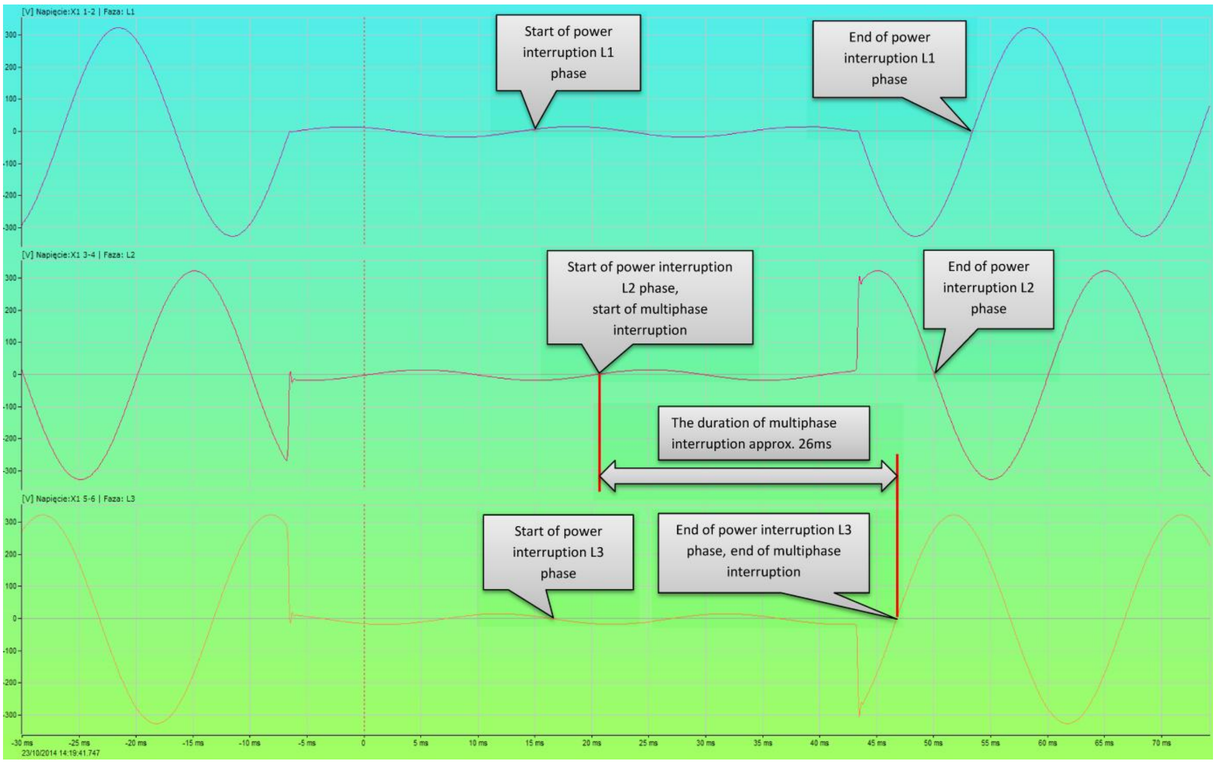
In reference to the received draft version of the report on the measurement experiment which was carried out within framework of the Power Quality Picnic, we hereby pass our comments to the several points.

Comment 1

In the test 11, in accordance with the description of the Z_3 and Z_4 test signals, there were generated 50ms power interruptions with residual voltages 5% and 0% of Udin, respectively. The value 60 ms was given as the expected duration of these events. Since the interruptions were investigated (as indicated by the event description), this means, their analysis should be performed with the use of the data contained in the list of power interruptions, not the dips.

In our opinion, a translation mistake was made in the Polish edition of EN 61000-4-30:2009 standard – with PN-EN 61000-4-30: 2011 in point 5.5.2, paragraph 2 of the source text. The phrase "on any one channel" has been translated as "w każdym kanale pomiarowym" (in each measurement channel) but should be translated as "w którymkolwiek kanale pomiarowym" (on any measurement chanel). Because the translation completely changes the meaning of the definition which determines the duration of multiphase power interruptions, we would apply here the European version of the standard. In our opinion, the second version of the translation is better in terms of language and makes a more appropriate sense for multiphase disturbances analysis.

Thus, in accordance with the section 5.5.2 of EN 61000-4-30:2009, the voltage interruption (in multiphase systems) begins when half wave RMS voltages in all the channels decrease below the interruption threshold. The interruption ends in the moment, when the RMS voltage in any channel is equal to or greater than the threshold voltage, enlarged by hysteresis. This means, that the expected duration of the multi-phase power interruption should be designated differently from that for dip or swell. Based on the analysis of voltage waveforms recorded during the test, it can be concluded that the expected values for durations of interruptions Z_3 and Z_4 signals should be 26.7ms. The figure below explains the rules determining the duration of a multiphase interruption.



Reconsider the suggestions from the report or comment our conclusions, please.

The answer from the organizers: The correction was introduced – the events Z_3 and Z4 are treated as the power interruption. The analyzer SO-52v11-eME passes the test 11 with a positive result.

Comment 4

In tests 9, 10, 12, there are gaps in the event data. They occurred because, to facilitate observation and analysis of the events, we provided SYNDIS PQ server system, installed on a laptop computer without the typical professional database of the data concentrator module. Please, note that the significantly large number of faults in events registration occurred also at other manufacturers' measurements.

Nonetheless, our analyzer SO-52v11-eME registered all events in its internal memory. Data records containing all the events recorded in the analyzer, were delivered to the Power Quality Picnic organizers. They are available in the form of files called evt ###.csv (where ### represents the date and time of the file creation). We also passed the information how to open and read these files.

Below you will find data events - omitted in the report - which were extracted by us from the files delivered to the organizers. Furthermore, we declare readiness to provide any further clarification and assistance in the analysis of the recorded data.

TEST 9

The following events can be read from the analyzer SO-52v11-eME recorded files:

description	phase	duration [s]	Ures [V]	Start	file	position
Z_1	L1	0,020	189,199663	10:04:02.434000	evtk141023100455.csv	1
	L2	0,020	184,872288	10:04:02.441000	evtk141023100455.csv	3
	L3	0,030	168,1792	10:04:02.428000	evtk141023100455.csv	2
Z_2	L1	0,030	184,023375	10:04:22.661000	evtk141023100455.csv	6
	L2	0,040	178,70135	10:04:22.647000	evtk141023100455.csv	5
	L3	0,040	181,929	10:04:22.644000	evtk141023100455.csv	4
Z_3	L1	0,050	184,0238	10:04:42.909000	evtk141023100455.csv	9
	L2	0,060	180,17655	10:04:42.896000	evtk141023100455.csv	8
	L3	0,050	184,03415	10:04:42.902000	evtk141023100455.csv	7
Z_4	L1	0,210	184,0179	10:05:03.168000	evtk141023100555.csv	3
	L2	0,210	181,40065	10:05:03.164000	evtk141023100555.csv	2
	L3	0,210	170,846888	10:05:03.161000	evtk141023100555.csv	1
Z_5	L1	0,600	184,0154	10:05:23.575000	evtk141023100555.csv	4
	L2	0,600	183,99705	10:05:23.582000	evtk141023100555.csv	6
	L3	0,610	167,712375	10:05:23.568000	evtk141023100555.csv	5
Z_6	L1	3,010	184,012663	10:05:44.381000	evtk141023100555.csv	9
	L2	3,000	182,913763	10:05:44.388000	evtk141023100555.csv	8
	L3	3,010	169,857688	10:05:44.374000	evtk141023100555.csv	7

After loading the files into the Syndis PQ, the following multiphase events were extracted:

description	duration [s]	Ures [V]	start	phase
Z_1	0,033	168,179	10:04:02.428	L1,L2,L3
Z_2	0,047	178,701	10:04:22.644	L1,L2,L3
Z_3	0,063	180,177	10:04:42.896	L1,L2,L3
Z_4	0,217	170,847	10:05:03.161	L1,L2,L3
Z_5	0,614	167,712	10:05:23.568	L1,L2,L3
Z_6	3,017	169,858	10:05:44.374	L1,L2,L3

As it can be seen, all the event durations are consistent with the test criterion expected values.

TEST 10

Only the events occurring in the phase L2 were analyzed in this test.
The following events can be read from the files:

description	duration [s]	Ures [V]	start	file	position
Z_1	0,03	184,01429	14:16:37.776000	evtk141023141655.csv	5
Z_2	0,05	184,01236	14:16:57.806000	evtk141023141755.csv	2
Z_3	0,20	184,0063	14:17:17.856000	evtk141023141755.csv	5
Z_4	0,60	184,00298	14:17:38.056000	evtk141023141755.csv	8
Z_5	3,00	183,99883	14:17:58.656000	evtk141023141855.csv	2

TEST 12

Only the events occurring in the phase L2 were analyzed in this test.
The following events can be read from the files

Oznaczenie zapadu	Czas trwania [s]	Ures [V]	Start	Plik	Pozycja w pliku
Z_1	0,047	116,06435	14:20:41.948000	evtk141023142055.csv	8
Z_2	0,034	115,0072	14:21:21.980000	evtk141023142155.csv	2

Therefore, make an adjustment to the results of the report, please.
If you are assuming no adjustment of the report, please place our explanations in the final version of the report.

Best Regards,
Tomasz Kałek
Wiesław Gil
Mikronika

poltrade
TECHNOLOGIES

Siemianowice Śl 03.06.2015

AGH Kraków
Katedra Energoelektroniki i Automatyki
Systemów Przetwarzania Energii
Wydział Elektrotechniki, Automatyki,
Informatyki i Inżynierii Biomedycznej

do rąk: Sz. Pan Krzysztof Chmielowiec

Dotyczy: prośba o komentarz do wyników pomiarowych z analizatora PQube produkcji PSL podczas pikniku JEE zorganizowanym przez AGH

Szanowni Państwo,

Odnośnie otrzymanych pytań dotyczących interpretacji pomiarów wykonanych analizatorem PQube P0105539 podczas imprezy „Piknik JEE” informujemy co następuje (nasz komentarz):

1. Prośba o dostarczenie oprogramowania do odczytu wartości 10 minutowych

Dostarczyliśmy Panu odpowiedni program w Visual Basic**.**

2. Prośba o przekazanie informacji gdzie znajdując się zapisane zdarzenia

Zdarzenia są dostępne w katalogu zdarzeń i przesłaliśmy jego zawartość i są do wglądu w różnych formatach w tym PQDIF.

3. Pytanie dotyczy odczytu wartości napięcia resztkowego zapadu napięcia.

   Jako przykład podajemy następujący zapad:

PQube-Informacja

Lokalizacja:	KrakÃ³w AGH
PQube Identyfikacja:	AGH
Uwaga 1:	PQ picnic
Uwaga 2:	(note not set)
PQube Numer Seryjny:	P010539
WzÃ³r:	PQube 02-0000
Wersja oprogramowania wbudowanego:	2.1.4 #2893
Adres IP:	192.168.0.105

Konfiguracja

Konfiguracja ukÅ‚adu zasilania:	TrÃ³jkÄ…t/Gwiazda
Znamionowe napiÄ™cie fazowe:	230V
Znamionowe napiÄ™cie miÄ™dzyfazowe:	400V
CzÄ™stotliwoÅ›Ä‡ znamionowa:	50Hz

Zdarzenie

Typ zdarzenia:	Zapad napiÄ™cia
WielkoÅ›Ä‡ zdarzenia:	79.67%
czas trwania zdarzenia:	0.039
Data wyzwolenia:	2014/10/23
Wyzwolenie zdarzenia - dzieÅ„ tygodnia:	Czwartek
Wyzwolenie zdarzenia - czas:	T 13:16:37.609 CET
KanaÅ‚ wyzwolenia :	L3-L1
PrÃ³g wyzwolenia:	90.0% of nominal

Z przedstawionych powyżej danych wnioskuję, że wartość napięcia resztkowego zapadu napięcia wynosi Ures=230*79.67%=183.241V. Chciałbym uprzedzić, że wynik ten jest niezgodny z zadanym kryterium testu Ures=184+/-0.46V.

Ponadto chciałbym zapytać dlaczego odczyty "Min" dla faz L1-N, L2-N oraz L3-N są większe niż wyznaczone powyżej Ures=183.241V. Wnioskowałbym, że wartość Ures dla zapadu napięcia powinna być równa najmniejszej wartości "Min" wyznaczonej dla faz L1,L2 oraz L3.

Opowiedź od firmy producenckiej PSL w oryginale:

The 79.67% represents the lowest (or minimum) value recorded during the event. This could have occurred on any of the L-N channels or any of the L-L channels.

If you look carefully, the event was triggered on L3-L1.

If you look at the minimum value recorded on all of the L-N phases, you'll see that L1-N, L2-N, and L3-N are all 184V, or 80% of nominal 230V L-N. This aligns perfectly with their expectations.

But if you look at the minimum value recorded on all of the L-L phases, you'll see that L1-L2, L2-L3, and L3-L1 are all approximately 318.7V. This is 79.67% of nominal

400V. This is why the PQube reported 79.67% as the depth of this event.

Now technically the nominal probably should be 398V (230V multiplied by square root 3 is 398, not 400) but we made a conscious decision to auto-detect 400V nominal instead of 398. They could always set the nominal L-L voltage to 398 and the PQube will report a depth that is very, very close to 80% for this particular test.

For best results, I would recommend firing the event on just 1 phase at a time, it's extremely rare "in nature" for a sag to occur on all 3 phases simultaneously.

Dodatkowy komentarz podsumowujący od firmy producenckiej Power Standards Lab w oryginale:

1) The harmonic data has not been collected because the data has not been generated by the PQube.

It has not been generated because it has not been properly configured.
See below the RED highlights

2) The event data has not been reported in the tests , however the event data is present in the data set and corresponds to what has been injected.
   See attachments in this email.
   We believe the testers have just omitted to report event information which has been captured by the PQube.

Regarding the harmonics data, look at the following tags in their setup file:

```
;------------------------------------------
[Snapshot_Events]
;-----------------------------------------------------

; ------ Valid values: OFF, 3, 6, 24
Waveform_Snapshot_Interval_In_Hours=24

; ------ Valid values: ON, OFF
Waveform_Snapshot_At_Startup=OFF

; Turns on spectrum graphs, CSV's for voltage and current waveforms.
; ------ Valid values: ON, OFF
Enable_Snapshot_Harmonics=OFF



;-----------------------------------------------------
[Trend_Settings]
;-----------------------------------------------------

; ------ Valid Values: ON, OFF
Enable_Daily_Trends=ON
Enable_Weekly_Trends=OFF
Enable_Monthly_Trends=OFF

; Individual phase recordings - if OFF, your PQube records worst-case and
```

```
average of phases.
; If ON, your PQube also records the values of individual phases.
; ------ Valid Values: ON, OFF
Trend_Individual_Phases=ON

; ------ Valid Values: ON, OFF
Omit_Flagged_Mains_Voltages_From_Stats=OFF

; ------ Valid values: NEGATIVE, ZERO - only applies if IEC or GB unbalance
method selected
Unbalance_Component_To_Trend=NEGATIVE

; ------ Valid values:  OFF, 10, 15
Trend_Harmonic_Interval_In_Minutes=OFF
```

W razie dodatkowych pytań służymy pomocą i dodatkowymi wyjaśnieniami. Jednocześnie zapraszamy do zapoznania się z najnowszym produktem PSL PQube 3 w pełni zgodnym z 3-cią najnowszą edycją normy IEC 61000-4-30. Mamy go już u siebie i możemy udostępnić do przebadania w dogodnym trybie (niestety podczas Piknik'u jeszcze nie był dostępny):

W imieniu własnym oraz Power Standards Lab z poważaniem,

Przemysław Widziewicz/POLTRADE TECHNOLOGIES

IDEA PROJEKT PRODUKT

UNIPOWER

Warsaw, 30th April 2015

Mr. Krzysztof Chmielowiec
AGH University of Science and Technology
in Cracow
Department of Power Electronics
and Energy Control Systems
ul. Adama Mickiewicza 30
30-059 Kraków

Our ref. AGH/PNA/2015/04/30/0034v2

Dear Sirs,

1. While referring to your request for commenting on the preliminary report of the measurement experiment, below please find our remarks.
    1.1. Test 3, page 15 – A signal was being fed to the analyzer which caused event over triggering (each of the green vertical line in the below figure represents one dip). This led to flagging of stored data samples, and at the same time as the

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al. Stanów Zjednoczonych 32 lokal U15, 04-036 Warszawa
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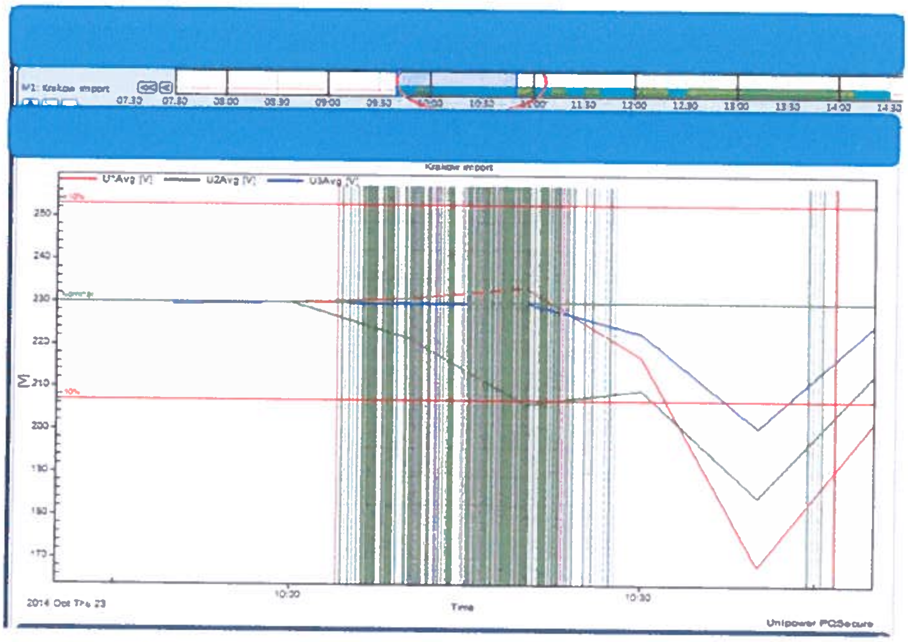
component was being fed inter-harmonics (U1.5=20 V, 9%) **<u>with levels exceeding by 50% the level recommended in IEC 61000-4-30 norm (up to 6%).</u>**


[redacted]
[redacted]

PQSecure system contains safeguards against such situations and during not natural number of events it marks the time samples in a way enabling a user to see it as flagged values. In addition, a field is available in the system where a user is able to eliminate the samples flagged this way from the report. Additionally norm PN-EN 61000-4-30 in section 4.7 defines that events (such as sags, swells and interruptions) should trigger flagging of statistical data (such as harmonics, flicker, unbalance, slow variations of voltage etc.) as they will be affected by the events and thus unreliable. Flagged data is to be disregarded not to count the same event twice. Our system has done precisely that (flagging marked in in data time line). As a consequence of this we request that <u>test no. 3 be changed to comparative,</u> in the same way as for many other tests found in this experiment which have been treated this way due to the characteristics of the input signal which are non-compliant with the norm. We can clearly see in that point, what is going on with units with bad design, without protection against such situation and bad internal software algorithms few tests later. Please look on the unit number 1 and 7 which stopped measuring during test number 9, and didn't registered anything in remaining tests number 10, 11, 12. Which shows clearly that those unit have problems with number of gathered data. One also should look in these moment also on the page 61 with volumes of data gathered by those units and on which point of the test they had stopped.

1.2. Test 9, page 41 and 42 – Graphs on the page 41 and 42 should be removed from the report because they represent single phase sags data which are not required by the norm IEC 61000-4-30. Mentioned graphs may suggest not advance user that unit UNIPOWER unit number 3 is not registering data which should be registered. UNIPOWER unit registered all data required by norm IEC 61000-4-30. This norm requires only registering polyphase sags and all those data were registered properly which can be seen in the table on the page 41 and on the page 43. Per phase information (not required by norm!) is available in UNIPOWER system only when such waveform data is stored. In this case waveforms of these single phase sags due to very sharp memory management in UNIPOWER units were overwritten due to the non-normal situation caused by not realistic test signal. The protection mechanism is the same like in the test 3 in the point 1.1 of this letter.

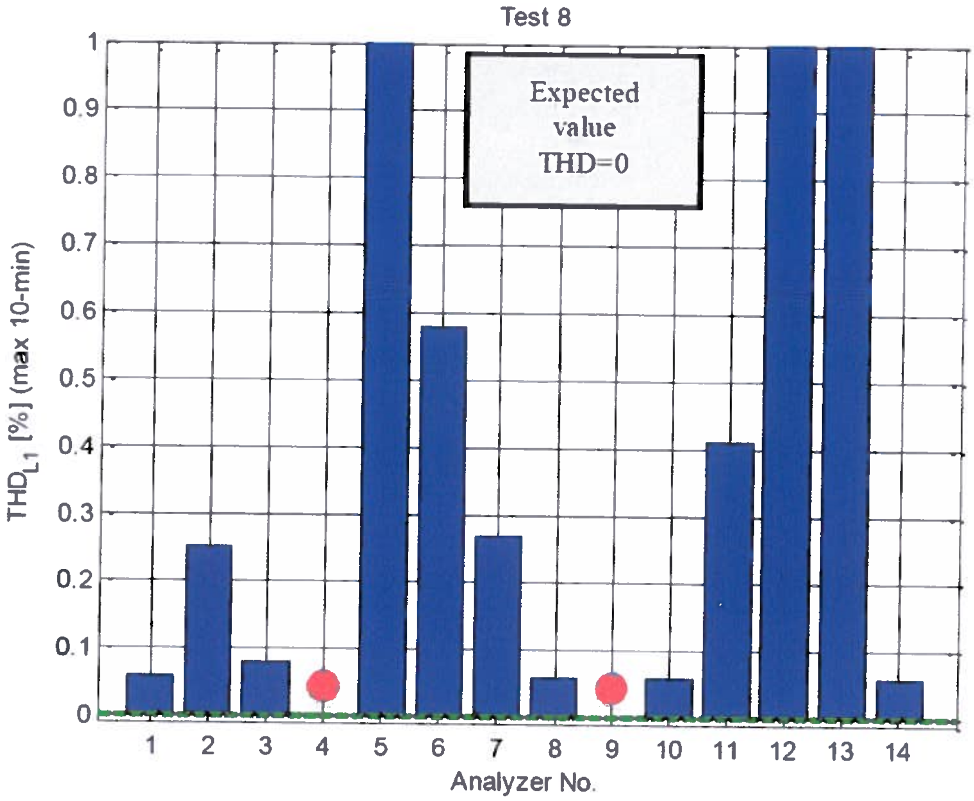
1.3. Test 7, page 29 – A signal with a base frequency of **57.5 Hz** is fed to the analyzer. This test can be perceived only as an academic case since in a real-life electrical power system the network "ceases to exist" when frequency differences reach ±2Hz, hence when designing and optimizing the Unipower system, which is installed for users in 50 countries worldwide, an assumption has been made that the system's operation in the basic frequency range of 48-52 Hz is sufficient in 100%.

1.4. On the one hand tests have been carried out purely academic, just like the one cited above, but on the other hand the tests are performed for a voltage level of around 230V, although the real value of the voltage measured on the secondary side of the voltage transformer is 57.7 V. We would like to emphasize, once again, that it is much more difficult to maintain the relevant measurement class, e.g. for the measurement flicker (PST and PLT), for lower voltage values. We hope that in the future, further tests will be performed for a voltage level of 57.7 V, i.e. the actual voltage which poses a much bigger challenge for the designers.

1.5. The document lacks a summary several /dozen or so sentences is included after each section which would refer to the matter in a descriptive manner and also provide a comparison. By presenting the data alone, without such a summary, the document is not a report. For example, to demonstrate the impact of such a lack of a comparison we will now focus more particularly on test no. 8: "Verification of correct operation of the anti-aliasing filter".

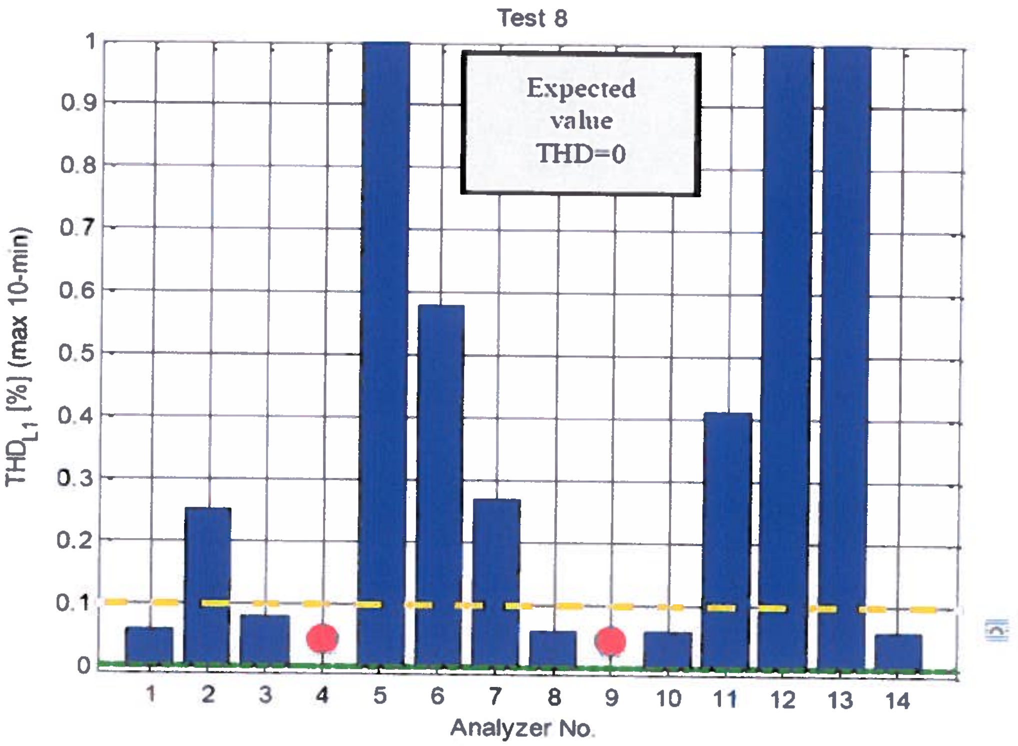
1.5.1. A user who is not advanced and is browsing this section of the report while looking for the answer to a simple question, namely whether the device meets the requirements of class A, will see that on page 36 the orange marks only accompany devices no. 12 and 13 as well as 9. Thus he will conclude that the remaining devices are correct, since they are marked green and are accompanied by the word YES. There could be nothing more misleading than this. Once the mathematical-only errors are corrected in the preliminary report send for verification, to the group of devices marked with the orange color will be joined by devices no. 5 and 8. So, just only after analysis of section with Urms on page 36 we have 5 "orange" devices 5, 8, 9, 12, 13 rather than 3 as indicated originally, where the device number 9 didn't collected any data, and devices 5,8,12,13 for sure experience problems with correct operation of the anti-aliasing filter, or which are not fitted with such a filter at all.

1.5.2. The next step, should be looking on THD [%] and Pst parameters which should be around zero. Due to the fact that the standard signal is a purely sinusoidal with THD L1 [%] = 0,0, hence one can clearly conclude that in no place in the test will the measured THD L1 [%] value exceed 0.1. Range for measuring harmonics (and thus THD) goes down to 0.1% according to IEC 61000-4-30 class A. So we are adding the criterion related to the table found on page 34 which contains the results of measurements for factor THD [%].



b)

On the chart below we can draw a horizontal dashed line (orange one) on the level of 0.1 which clearly distinguish between units which seems to have adequate anti-aliasing filters and those who don't.



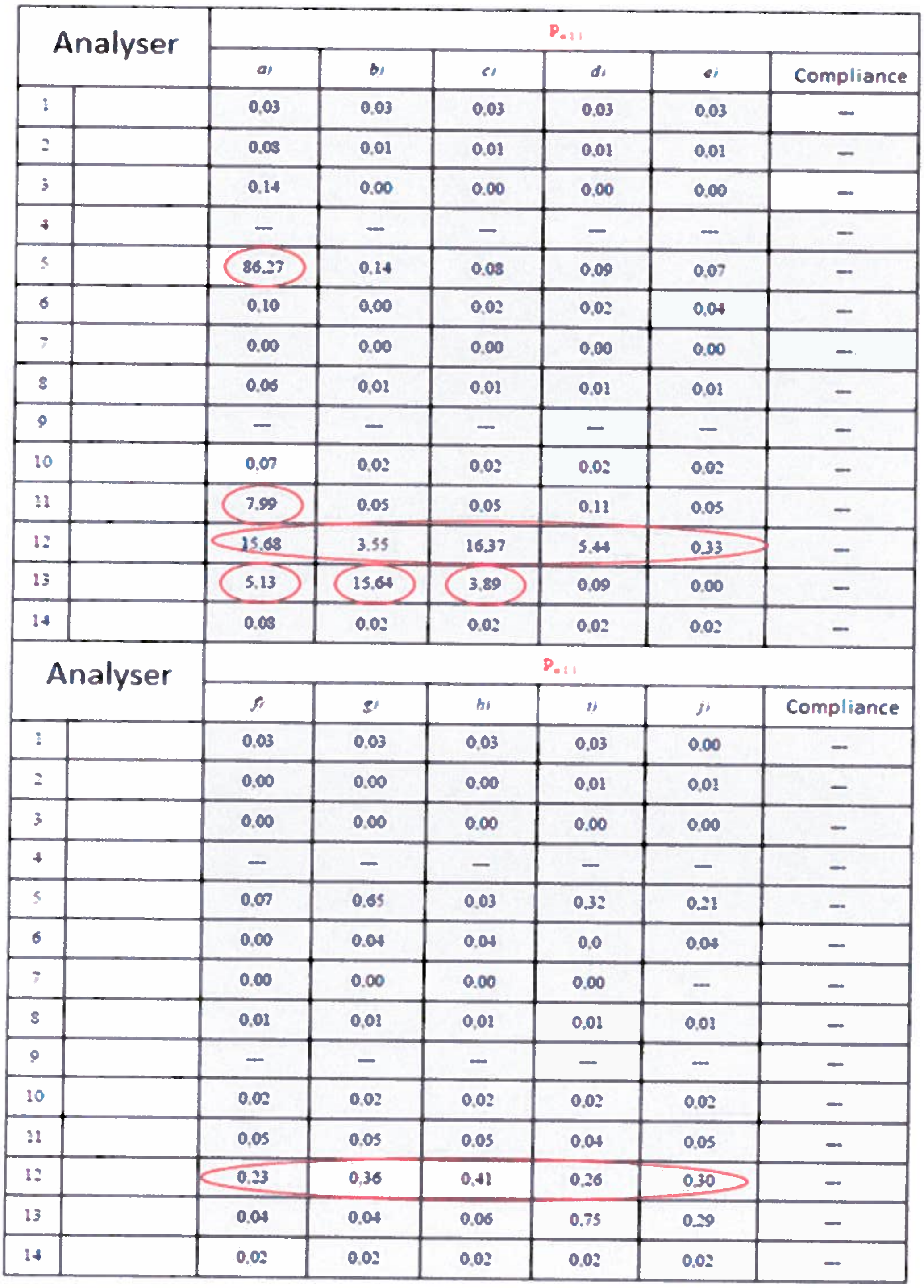
b)

1.5.3. Upon applying this condition to the section containing the results, when looking at the tables (on page 34) we can see that the problems with the correct operation of the filter (if present at all) in devices, namely no. 2, 5, 6, 7, 11, 12, 13 where THD L1 [%] values exceed 0.1, in spite of a sinusoidal signal being fed to the input terminals of the meters THD L1 [%] = 0.0. So to sum up, group of meters marked in orange, due to a defective anti-aliasing filter contains not only devices with the numbers 5, 8, 12, 13 but also in this section with 2, 5, 6, 7, 11, 12, 13 and 4 and 9 who did not register data. After analyzing section of test with Urms and THD [%] we have in total units number 2, 5, 6, 7, 8, 11, 12, 13 which for sure experience problems with correct operation of the anti-aliasing filter, or which are not fitted with such a filter at all, and units 4 and 9 which didn't register any data.

Analyser		THD [%]					
		a)	b)	c)	d)	e)	Compliance
1		0.02	0.02	0.02	0.02	0.02	—
2		0.00	0.00	0.00	0.00	0.00	—
3		0.05	0.05	0.05	0.05	0.05	—
4		—	—	—	—	—	—
5		316.74	289.44	266.57	300.36	294.9	—
6		0.00	0.00	0.00	0.00	0.00	—
7		0.05	0.26	0.27	0.07	0.27	—
8		0.01	0.02	0.01	0.01	0.01	—
9		—	—	—	—	—	—
10		0.00	0.00	0.00	0.00	0.00	—
11		0.41	0.40	0.40	0.40	0.40	—
12		0.02	0.02	0.06	0.03	0.02	—
13		0.99	15.83	1.25	0.21	15.75	—
14		0.01	0.01	0.01	0.01	0.01	—

Analyser		THD [%]					
		f)	g)	h)	i)	j)	Compliance
1		0.02	0.02	0.02	0.06	0.06	—
2		0.16	0.25	0.18	0.08	0.08	—
3		0.05	0.05	0.05	0.08	0.07	—
4		—	—	—	—	—	—
5		224.04	0.1	0.1	0.5	0.4	—
6		0.00	0.00	0.00	0.58	0.05	—
7		0.25	0.16	0.03	0.15	—	—
8		0.01	0.01	0.01	0.06	0.05	—
9		—	—	—	—	—	—
10		0.00	0.00	0.00	0.06	0.05	—
11		0.40	0.40	0.40	0.40	0.40	—
12		0.02	0.02	0.03	5.03	4.96	—
13		1.68	15.13	3.73	0.51	14.36	—
14		0.01	0.01	0.01	0.06	0.05	—

1.5.4. Then we should specify the criterion for Pst, relating to the values on the 35 page. So looking at the Pst chart on page 35.



Analyser		P_{st}					
		a)	b)	c)	d)	e)	Compliance
1		0,03	0,03	0,03	0,03	0,03	—
2		0,08	0,01	0,01	0,01	0,01	—
3		0,14	0,00	0,00	0,00	0,00	—
4		—	—	—	—	—	—
5		86,27	0,14	0,08	0,09	0,07	—
6		0,10	0,00	0,02	0,02	0,04	—
7		0,00	0,00	0,00	0,00	0,00	—
8		0,06	0,01	0,01	0,01	0,01	—
9		—	—	—	—	—	—
10		0,07	0,02	0,02	0,02	0,02	—
11		7,99	0,05	0,05	0,11	0,05	—
12		15,68	3,55	16,37	5,44	0,33	—
13		5,13	15,64	3,89	0,09	0,00	—
14		0,08	0,02	0,02	0,02	0,02	—

Analyser		P_{st}					
		f)	g)	h)	i)	j)	Compliance
1		0,03	0,03	0,03	0,03	0,00	—
2		0,00	0,00	0,00	0,01	0,01	—
3		0,00	0,00	0,00	0,00	0,00	—
4		—	—	—	—	—	—
5		0,07	0,65	0,03	0,32	0,21	—
6		0,00	0,04	0,04	0,0	0,04	—
7		0,00	0,00	0,00	0,00	—	—
8		0,01	0,01	0,01	0,01	0,01	—
9		—	—	—	—	—	—
10		0,02	0,02	0,02	0,02	0,02	—
11		0,05	0,05	0,05	0,04	0,05	—
12		0,23	0,36	0,41	0,26	0,30	—
13		0,04	0,04	0,06	0,75	0,29	—
14		0,02	0,02	0,02	0,02	0,02	—

We can clearly see that devices no 5,11,12,13 very high (some extreme) values, and devices 4 and 9 has not recorder any values. We propose in this place value of Pst =0.2 which is the lowest required value for Pst measurements in accordance with the norm for class A of devices and we expect values . As we can see, the section with Pst failed units 5, 11, 12,13 which also failed previous section with THD [%].

After taking into account all sections Urms, Pst, THD [%] collection of devices with incorrect results will includes devices with the following numbers: 2, 5, 6, 7, 8, 11, 12, 13. Those devices at 100%, doesn't have properly functioning filter and it is susceptible to interferences. Additionally provides performing measurements incorrect data. Units 4 and 9 didn't collected any data.

Summing up, we can clearly state here that only units 1, 3, 10 and 14 maybe have properly functioning anti-alias filter and they are maybe able to produce credible results according to class A.

1.5.5. The document contains only samples from two of ten 10-minute sessions so we do not know whether remaining devices did not experience problems during the remaining 10-minute sessions. In our opinion the data should be supplemented in the report and the entire data must be presented with pointing out points were values are beyond values.

1.5.6. In our opinion the test's structure unfortunately does not offer an opportunity for verifying the correctness of a filter's operation due to application of specific frequencies only and their subsequent averaging. The test should start from the frequency of 6.4 kHz, as has been proposed, and should continue until at least the frequency of 150 kHz is reached. While the test is in progress, the growth of Pst and THD as well as the voltage value should be observed in real time. If we wanted to see potential problems with anti-alias filters in 10 minutes aggregated values the test should last at least for 24 hours of continuous frequency sweeping. The PLC transmission used for SMART METERING could be one of the many sources of high frequency signals which generate the above problems. In accordance with the norm EN 500065, PLC signals is the frequency band ranging from 3 to 148.5 kHz. So the problem is not a virtual one.

1.5.7. We propose that the name of test 8 be changed to "General verification of correct operation of the anti-aliasing filter" and that a summary table be added, with a note that the time provided for the experiment was too short to perform full and reliable tests of correct operation of anti-aliasing filters and even the devices with no. 1, 3,10, 14, which theoretically passed the tests, should be subjected to precise tests to check whether the filter operates correctly and guarantees reliable measurements, which are compliant with the requirements of class A.

1.5.8. Due to its key role in ensuring that the measurements are reliable the test of operation of the anti-aliasing filter should be performed first and should be done very carefully. The devices which do not pass the test should be subjected to further testing because the results they demonstrate are unreliable (because too little amount of time for testing) and such devices will incorrectly measure such parameters as flicker, harmonics, effective voltage...as well as other parameters.

2. As regards the volume of measurement data, a comment should be added that the smaller the volume of the data, the better. On the table on the page 61 should be added a comment that those values are only up to test number 9 for unit 1 and 7 which didn't registered any data.

Nasile

3. Summing up – looking on all results we can clearly state that Unipower unit number 3 3 has only one real competitor and this is number 10. Only these units passed the tests with flying colors and show big maturity of those products. We are eager to find out the name of our real competitor.

Yours faithfully:
Piotr Naszkowski

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AGH University in Krakow

Mr Krzysztof Chmielowiec
Department of Power Electronic and Energy Control Systems
The Faculty of Electrical Engineering, Automatics,
Computer Science and Biomedical Engineering

12 May 2015

Dear Mr Chmielowiec,

Thank you for the preliminary report from the measurement experiment during the Power Quality Picnic on 23 OCT 2014. Please find the requested comments about Test 6 and Test 9.

a) Test 6 - where the majority of PQ analyzers recorded different Pst results that you expected from the test procedure

A modulation frequency of 33.333 Hz leads to a periodic signal, it repeats all 1.5 periods of the fundamental 50 Hz signal. This means that we do not get any compensation effects. The voltage-time area is different for each phase.

Phase 2 signal leads to a quite accurate Pst of nearly 10. If we shifted the angle of the modulation we would get the same signal over time and the same Pst. However, this does not reflect reality. If there is a flicker phenomenon the impact on the signal deformation happens at the same time for all phases.

The artificial generation of a sine wave with either sinusoidal or rectangular modulation leads to uneven Pst at certain frequencies (33.333 Hz but also 25 Hz) as a natural phenomenon.
When we carry out the test with a modulation frequency of 21.5 Hz, the Pst in all three phases is exactly the same.

Comments on this issue are appreciated, please also from the participating manufacturers.

b) Test 9 - where we observed phase shifts at the beginning of each voltage event

These phase shifts only occur when a time source is used. There are no phase jumps within one state, they are only displayed when the test moves from one state to the next one. Without using a time source, no phase jumps are observed. The problem will be resolved in a future TU software release.

With best regards,

OMICRON electronics GmbH

Ana Garcia

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Technical Support & Applications
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