System and equipment for measurement, registration of parameters and analyse of the quality of the electric energy

Gabriel VLADUT*, Ion PURCARU **, Petre-Marian NICOLAE,* Camelia COJOCARU***

** **IPA, Craiova,** office@ipacv.ro, ** **VIG IMPEX** srl, purcaruion@yahoo.com, *****University of Craiova***

***Abstract* – The paper presents the equipment used to measure some parameters that characterize the electric energy quality.**
The equipment performs test and acquisition of analogue data (U and I) and numerical data. The sampled data are recorded when preset thresholds are exceeded by the analogical inputs or when the digital inputs states change. The fixed variant is supplementary provided with 2 analogue outputs and 8 numerical outputs. The operation of equipment is simulated and the corresponding software are exemplified for the case of a highly distorting consumer, a set of electric energy quality parameters being determined for this case.

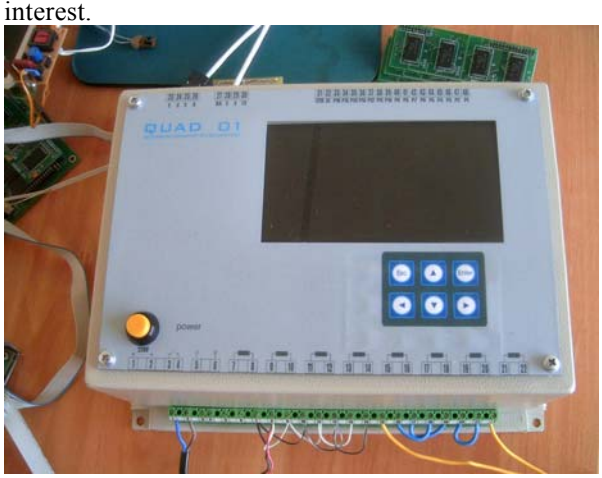
1. INTRODUCTION

The recent implementations based on power electronics provide a lot of advantages related to the designing of some high power electrical drives with variable speed, such as the increase of driving system performances. Unfortunately this kind of equipment added new quality problems to the existing ones. The new problems are related to the electric nature waveforms distortions, with direct impact over the consumers supplying.
The energetic effects that affect the electric energy quality must be precisely evaluated in order to their consecutive limitation. The quality parameters measurement is related to the existing voltage level, to the data acquisition time speed, to the employed numeric algorithms. Test and isolated implementations were recently performed in our country and abroad, but none became a market leader.

2. GENERAL DESCRIPTION OF THE EQUIPMENT

In order to determine some of the electric energy quality parameters and also to achieve a complex equipment that should be able to determine some other quantities and unpleasant phenomena, a modular portable system was conceived. The main functions provided by it are:
- determination of electric energy quality parameters that should consequently result in measures for improving of qualitative and quantitative efficiency of energetic consumptions;
- events recording, in order to detect the faults causes and the repeated connections and disconnections over electric lines.

The equipment modular designing makes possible the realization of a family of fixed and portable systems for tests and data acquisitions. Due to its modular conceiving, the system provides:
- acquisition of 9/16 analogue inputs and 6/32 numerical inputs by means of circuits that perform the conditioning of analogue signals compatible to the electric quantities supplied by the electro-energetic systems;
- portable variant are supplementary equipped with 2 analogue outputs and 8 numeric outputs for simulations, tunings and tests;
- non-volatile recording of finite number of records;
- connection through a serial line of a PC compatible computing system for data loading corresponding to the recordings that present interest.



3. EQUIPMENT FUNCTIONS

The equipment provides the following functions:
- test and acquisition of analogue data (voltages, currents and powers) and respectively of numeric data (switching apparatus state) for nodes of the electro-energetic system where the distorting regimes occur;
- numeric processing of data, in order to determine the energetic parameters, the performance indices concerning the electric energy quality;
- recording, evaluation, administering and displaying along periods of the consumptions and events concerning the deviations from the quality of the used electric energy;

- permanent monitoring of the energetic parameters; faults detection and localization;
- signalization when some quality indices standardized values are exceeded.

A series of facilities are provided, as follows:
- determination of data corresponding to the voltages and currents for phases and neutral wire. The input voltages are supplied either by voltage transformers secondary windings with a rated value of 100Vac, or by instant values transducers. The input currents are supplied either by current transformers secondary windings with a rated value of 1Aac, or by instant values transducers.
- consumptions evaluation;
- evaluation of analogue quantities, separately for each phase (RMS values, initial phases of currents and voltages harmonics, spectral analysis);
- displaying of time variations for quantities (currents, voltages), state of switches from the distribution utilities;
- real time clock, non-volatile memory, graphical display of extended sizes 75 x 140 mm;
- analysis and determination in the three phase network of the following parameters:
- phases and neutral impedances;
- direct, reversed and homopolar components of the unbalanced systems of voltages/currents;
- determination of the survived element operation regime (load, idle, voltage missing, fault, etc).

The estimated and recorded data are processed by means of a soft package that allows:
- harmonic analysis of measured quantities (voltages and currents) ;
- computation of electric energy quality indices;
- displaying, on request, of electric parameters: active/reactive electric energies, active/reactive and distorting powers, power factor, currents, voltages, frequency;
- displaying on request of superior harmonics weights for voltages and/or currents;
- detection of normal rapid variations and of accidental unbalancies from the three phase systems of voltages and currents;
- recording, evaluation and displaying for a month of the events corresponding to the electric energy quality deviations;
- prescription of thresholds both for the quantities estimated in the system and respectively for the estimated quantities; when the respective thresholds are reached, sound and optic alarms are generated;
- obtaining of the main energetic parameters situation.

The considered standards are: PE 143/94, IEC 60664, ANSI-IEEE 519, CEI 1000-2-4 [9].

4. TECHNICAL FEATURES

The equipment presents the following characteristics:
- Number of monitored and evaluated lines:
3 (test variant 3 voltages and 2 currents) ;
2 (test variant 3 voltages and 3 currents) ;
- Analogue outputs (fixed variant): 2;
- Tests accuracy:
- U, I……..0,5%
- P, Q, S, D…1%
- Frequency…0,05%
- Active/reactive energy cf class 2 IEC1268
- Distortion coefficient I/U…2%
- Storing capacity: 1MO ... 16MO;
- Period of recording: 3 sec – 4 hours, the records are non volatile; triggering facility
- Supplying: 230 V c.a / 50 Hz; -15%...+15%; and battery 12V.

5. EQUIPMENT'S UTILIZATION FOR THE DETERMINATION OF ELECTRIC ENERGY QUALITY PARAMETERS

The equipment was tested under normal operation conditions, taking data from a connection point of a major distorting three phase consumer. The sampling frequency was 3,6 kHz.

For the beginning the distorting three phase receiver voltages and currents waveforms were recorded. Based on an original processing algorithm, the harmonics analysis was performed, considering the EU standards (in order to obey the European standards while considering the specific of Romanian consumers and networks) [6]. The recorded three phase voltages waveforms are depicted by fig,1(a) and those corresponding to currents are depicted by fig. 1(b).

Using the decomposition algorithm mentioned above, the first 40 harmonics of current and voltage were determined. The signals recomposed from the first 40 harmonics of the first phase voltage together with the significant harmonics from the u1 waveform and their initial phases are depicted by fig. 2.

In fig.3 we represented the signal recomposed from the current through phase 1, compared to the initial signal (Fig. 3(a)), along with the harmonics magnitudes from the i1 waveform (Fig,3(b)) and their initial phases (Fig.3(c)).

Based on the harmonic decomposition we could determine coefficients related to the electric energy quality corresponding to phase 1 [3]:
- for u1: RMS value: 3.8984e+002 V; peak factor: 1.4024e+000; shape factor: 1.0988e+000; VTHD 1: 1.0264e+000;
- for i1: RMS value 7.2715e+000 A; peak factor : 1.3890e+000; shape factor: 1.1534e+000; ITHD 1: 1.3631e+001

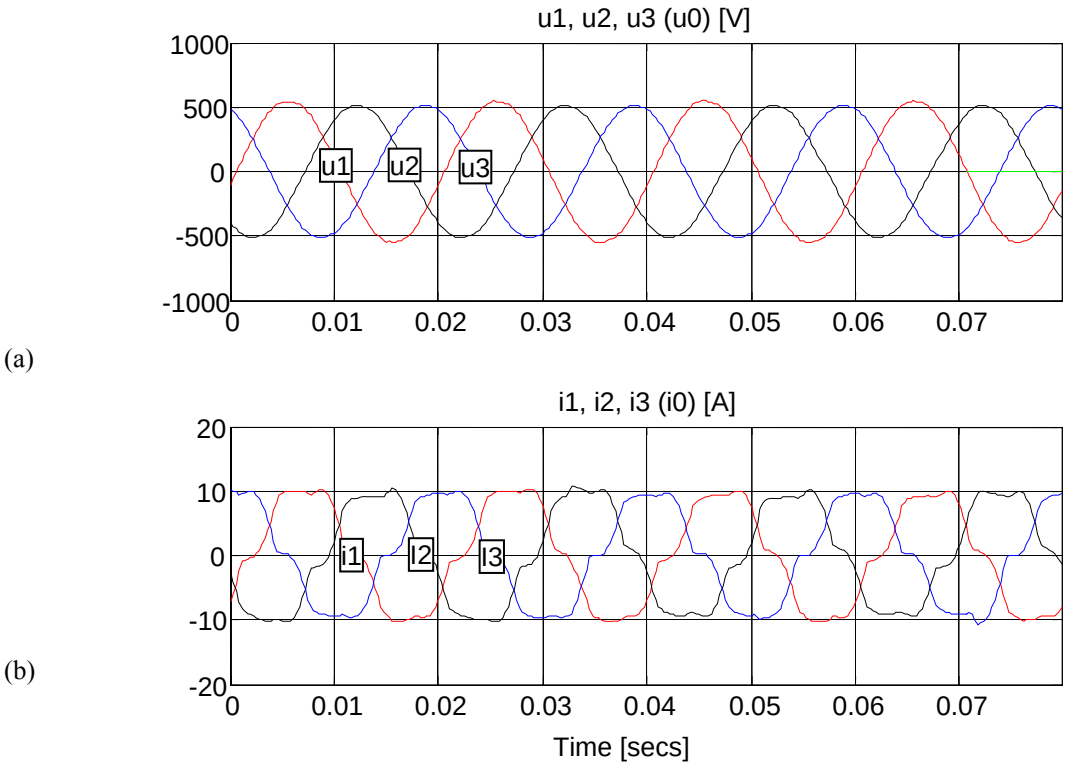


Fig. 1. Three-phase voltages and currents from system

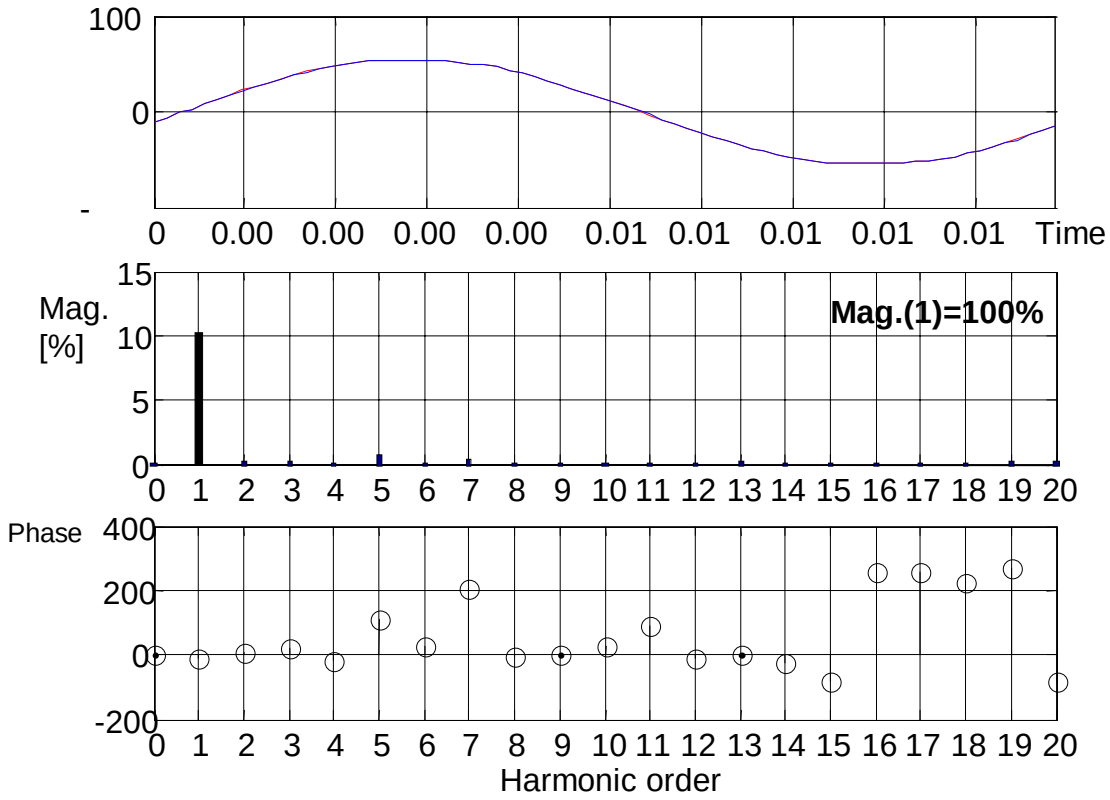
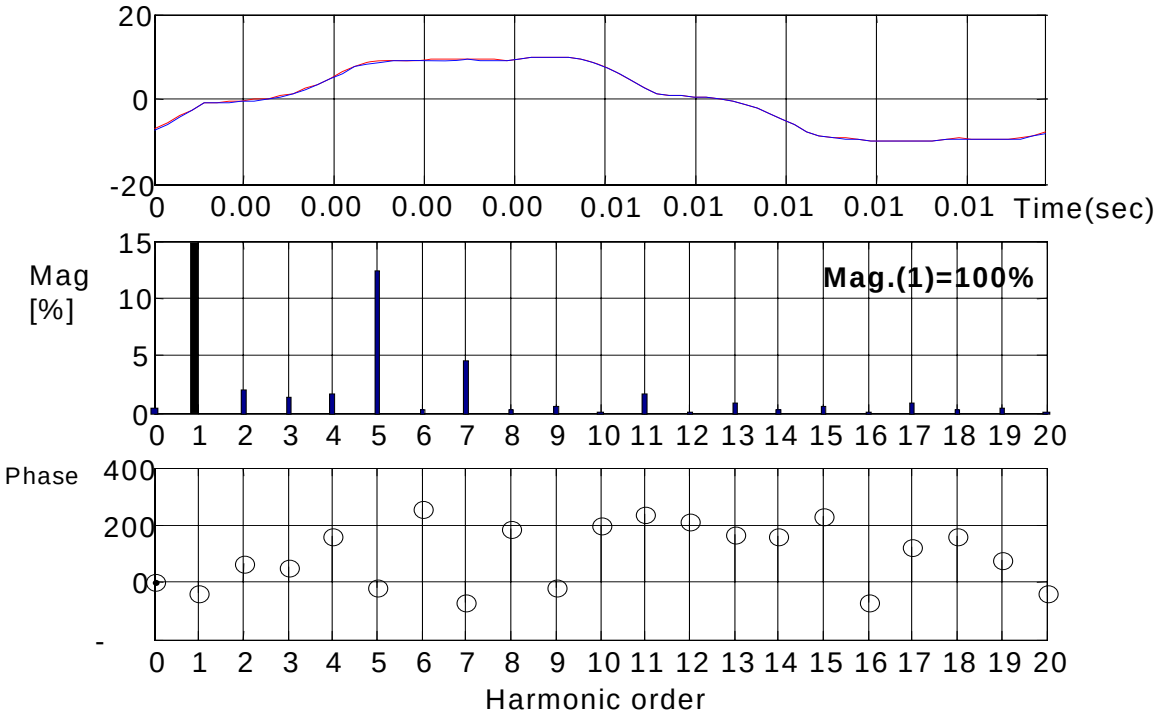


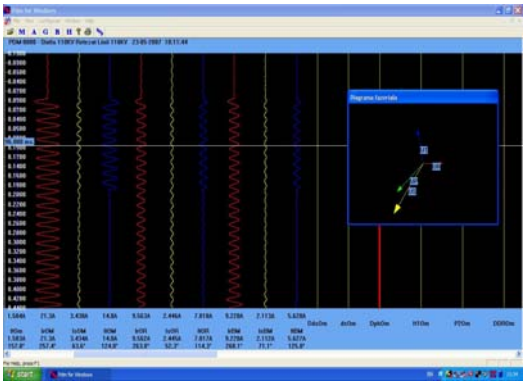
Fig. 2 Voltage u1 – Signal reconstructed from 40 harmonics superposed over the original signal



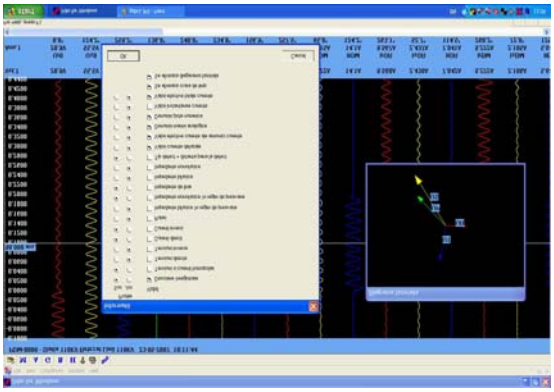
The harmonic analysis for the phases 2 and 3 revealed an evolution similar to that of the first phase.
The analysis also proved that the three-phase system is symmetric, so that for the analyzed consumer the problems related to the electric energy quality are actually those related to the distorting regime.

Fig. 3. Current i1 signal reconstructed from 40 harmonics superposed over the original signal

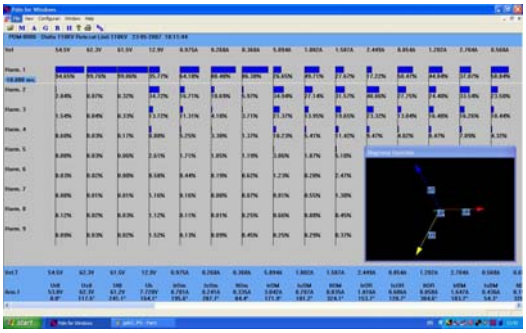
In Fig 4 we present the monitoring, registration and analyse of parameters at one defalt of an 110kV grid



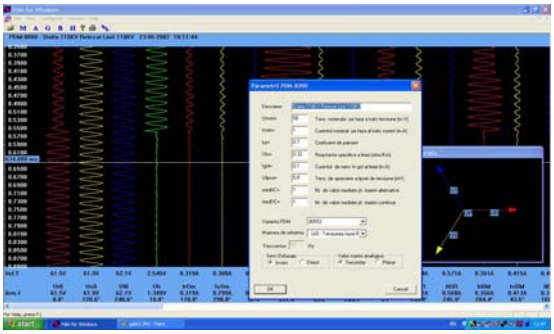
Monitoring of a event on an 110kV grid, we calculate default parameters, including the phazorial diagramme



Configuration of calculate parameters at one defalt analyse



Armonic analyse



Analyse of one default; configuration of paramethers that caracterize the electric grid affect by the default

Fig 4: Monitoring and analyse of parameters at one defalt of an 110kV grid

4. CONCLUSIONS

As far as we are awared, in Romania there is no equipment similar to the one presented in this paper (as stationary equipment).

Famous manufacturers as Chauvin Arnoux/ Enerdis France, Siemens Germany, Schneider France, General Electric SUA, Circutor Spain produce equipment that provide only partial similarities to it.

The manufacturers we analyzed make efforts to modernize the test principles, to use small size transducers, provided with local intelligence and respectively to increase the number of facilities provided by the equipment: functions for rapid electric events recording, simultaneously with the recording of electric parameters along long periods, SCADA compatibility, electric energy quality analysis, etc..

This test principle results in an increase of test accuracy, operation safeness and improved reliability.

5. REFERENCES

[1] Budeanu, C., *Rolul fizic al marimilor instantanee in fenomenele de conservare*, Energetica, '86, p.277-281

[2] Depenbrock, M., *The FDB-Method a Generally Applicable Tool for Analyzing Power Relations*, IEEE Trans. on Power Systems, vol.8, no.2/93, p.380-386

[3] Emanuel, A.E., a.o., *New Concepts of Instantaneous Active and Reactive Powers in Electrical Systems with Generic Loads*, IEEE Tr. on Power Del., no.3/93, p.697-703

[4 Nicolae, P.M., *Calitatea energiei electrice in sisteme electroenergetice de putere limitatá*, Ed. Tehnicá, Buc. 1998

[5] Nicolae, P.M., Mandache, L., Nicolae, I.D., *About The Correlation Between The Power Quality Parameters and The Number of Fourier Series Terms*, ATEE 2002, Politehnica University, Bucuresti, 2002

[6] Tugulea, A., *Consideratii privind efectele energetice in regimuri deformante*, Energetica, no. 1/'86, p.27-31

[7] Tugulea, A., *Factorul de putere in regim deformant si nesimetric*, Energetica, no. 9/'86, p.407-414

[8] Tugulea, A., *Criteria for the Definitions of the Electric Power Quality and its Measurement Systems*, ETEP,

[9] Mircea, I., Ciontu, M., Ruşinaru, D., *Aspects about abnormal operation of the fast overcurent protections in the short-circuit conditions, the 7-th International Symposium on Short-circuit Currents in Power Systems*, Warszawa, Poland, 1996;

[10] IEEE Working Group on Nesinusoidal Situations – *Practical Definitions for Powers in Systems with Nonsinusoidal Waveforms and Unbalanced Loads*, IEEE Tr. on Power Del., no.1/96, p.'79-101

[11] G. Vladut, P.M. Nicolae, L. Mandache, C. Cojocaru, I. Purcaru Equipment for measuring of parameters that characterize the electric energy quality, ICATE 2004, Baile Herculane International Conference.