MEASUREMENT OF THE PARAMETERS FOR ELECTRIC ENERGY QUALITY

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Abstract – The paper presents the equipment used to measure some parameters that characterize the electric energy quality.

The proposed 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 [1], [2], [5], [7].

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, etc. [9], [10] Test and isolated implementations were recently performed in our country and abroad, but none became a market leader.

2. GENERAL DESCRIPTION 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 will be 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 family 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 apparatus input voltages are supplied either by some voltage transformers secondary windings with a rated value of 100 V a.c., or by instant values transducers. The apparatus input currents are supplied either by some current transformers secondary windings with a rated value of 1 A a.c., 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 based on an unitary theory, according to European standards;
- displaying, on request, of some electric parameters: active and 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 software packet relies on the existing national and European standards and takes into account the correlations between both standards. 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 …according class 2 IEC1268
- Distortion coefficient I/U…2%
- Storing capacity: 256 KO ... 8MO (depending on variant);
- Period of recording: 3 sec - 12 min, equivalent of maximum 240 events, each of 3 seconds; the records are non volatile;
- Supplying: 230 V c.a / 50 Hz; -15% ... +15%; and battery 12V.

5. UTILIZATION OF EQUIPMENT FOR THE DETERMINATION OF SOME 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.

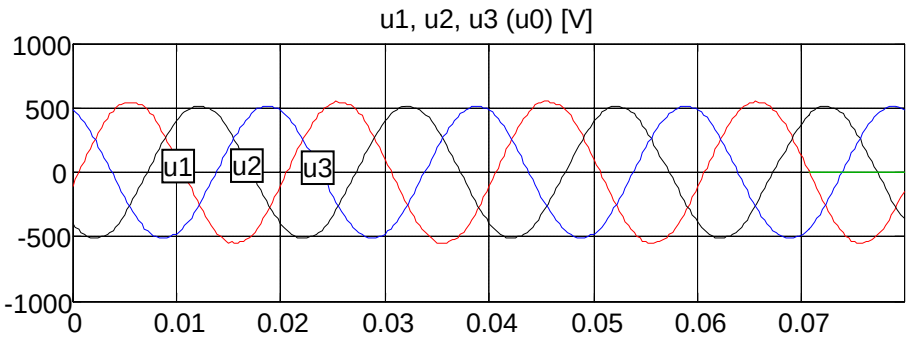
For the beginning the distorting three phase receiver voltages and currents waveforms were recorded. The recorded signals were afterward acquisitioned. Based on an original processing algorithm, the harmonics analysis was performed, considering the EU standards (in order to obey the European standards 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 some 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

(a)



(b)

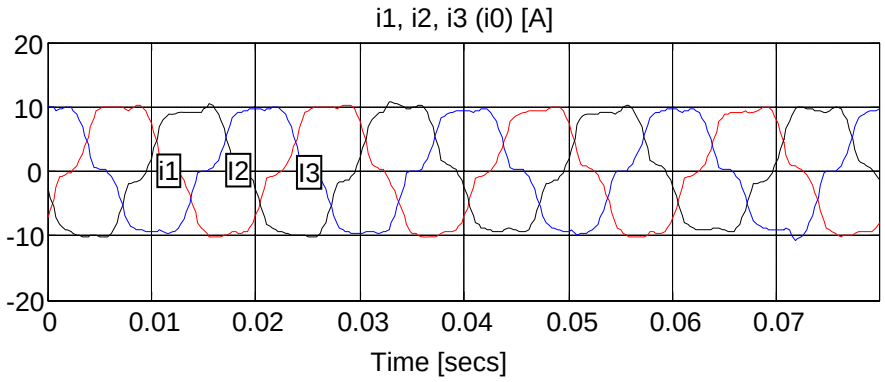


Fig. 1. Three-phase voltages and currents from system

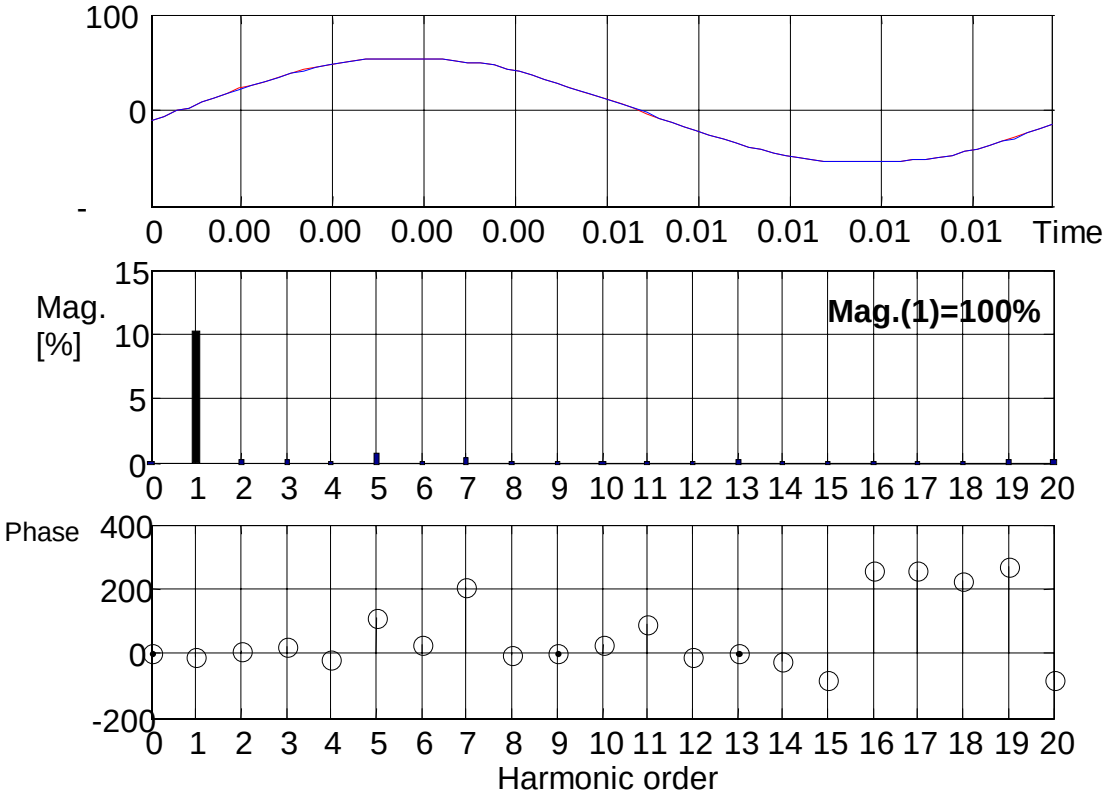


Fig. 2 Voltage u1 – Signal reconstructed from 40 harmonics superposed over the original signal

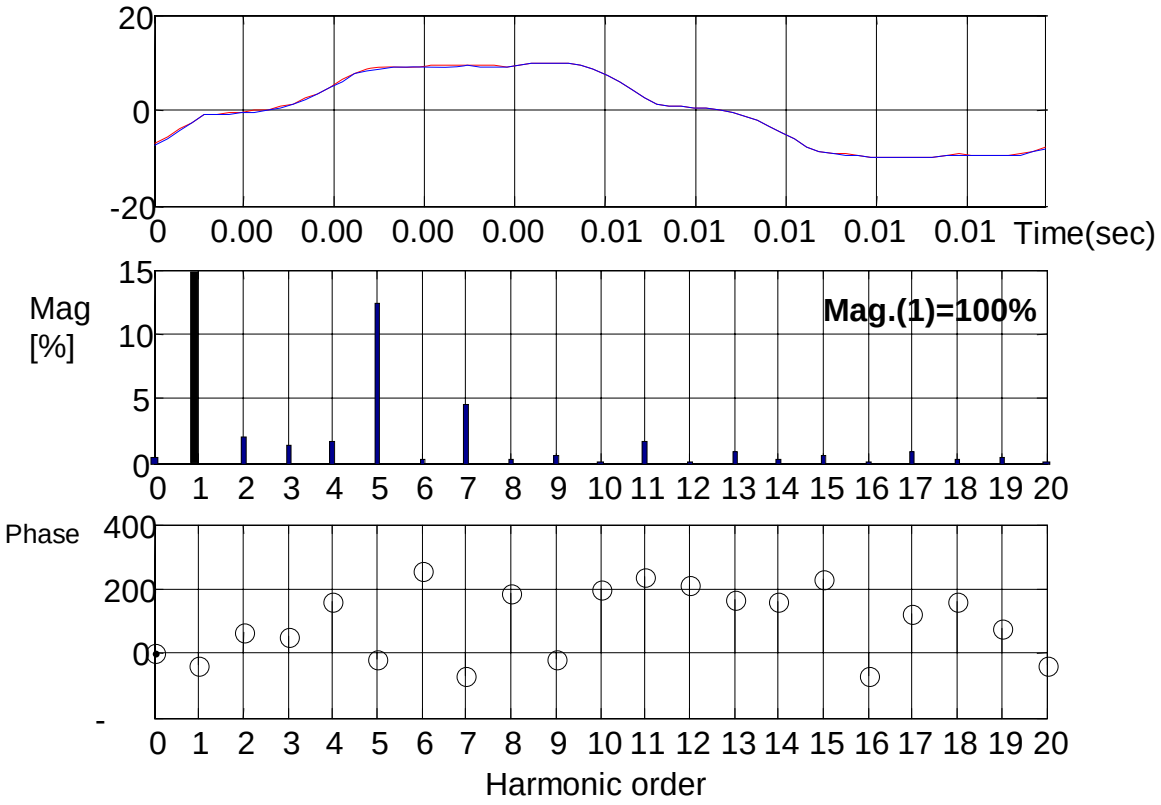


Fig. 3. Current i1 signal reconstructed from 40 harmonics superposed over the original signal

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 [8].

4. CONCLUSIONS

As far as we are awared, in Romania there is no equipment similar to the one presented in this paper. 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.[3], [4]. This test principle results in an increase of test accuracy, operation safeness and improved reliability.

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