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A SYSTEM FOR CALIBRATION OF POWER QUALITY ANALYSERS

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Abstract: Power quality analyzers utilized in the measurements have to be calibrated and a system for both developing proper methodologies and for their calibration is now under development at I.N.RI.M. The system can supply two synchronized voltage and current signals, with the possibility of generating both calibrated periodic distorted waveforms and suitable preprogrammed aperiodic events.

Keywords: Power quality, power calibrator, waveform generator.

1. INTRODUCTION

The diffusion of power electronics in both domestic and industrial environment facilities has increased the economic losses due to insufficient power quality. In fact, electronics is now widely utilized in many applications such as machine tools, lighting, heating and cooling equipment.

Electronics provides expanded features and flexibility to modern equipment, but needs careful attention to its interactions with the power system, which is designed to operate with sinusoidal voltages of assigned values and sinusoidal currents. However, not all waveforms supplied to users are sine waves. Electronic loads can be non linear and often draw current only for a part of the period, due for example to an equipment controlled by SCR. This means that the current is distorted by the load characteristics and also the supplied voltage may be distorted. Furthermore, sudden events may happen, such as the switching of equipment or interference with other systems through both the electromagnetic field or the ground and supply wires, which temporary modify either the supplying system or the load conditions.

For a steady condition resulting in distorted waveforms, a convenient way to describe the signals is to make a list of the harmonic components (spectra of the voltage and the current). For other events instead the classification given by the standards can be applied [1].

In order to identify the applications that impair the quality of the power supply, verify that the power facilities are within the limits set by the standards and support the adoption of policies for quality maintenance, measurements of the power quality have to be introduced. For this purpose suitable tests analyzers are utilized and metrological laboratories are asked to calibrate these instruments deriving the traceability from the national electrical standards (resistance and voltage), though an unbroken chain of comparisons.

For these reasons at the laboratory for the precision measurement of electrical power at Istituto Nazionale di Ricerca Metrologica (I.N.RI.M.), Italy, a new activity for developing a system for the calibrations of the most common types of power quality analyzers has been undertaken.

Standards [1], [2] provide procedures for controlling harmonics on the power system, recommended limits for customer harmonic injection and power system harmonic levels and practice for monitoring electric power quality.

The I.N.RI.M. activity has been addressed to implement the requirements of these standards, while maintaining at the best level the traceability developed in the power and energy laboratory [3], [4].

2. THE SYSTEM

2.1. Purpose of the system

The activity aims at organizing a proper set of instruments in a system that will be employed to investigate the most appropriate methodologies for producing, with a high level of accuracy, the signals that are typically existing in real power distribution systems.

This set of instruments will be eventually utilized as a composite calibrator for generating the signals for the characterization of the power quality analyzers.

To fulfill both purposes the system has to be sufficiently flexible and re-configurable and, at the same time, its main hardware components should be sufficiently stable and easy to calibrate.

2.2. Basic circuit

The preliminary system consists of reference generators and amplifiers for obtaining the voltage and the current necessary to calibrate the instruments under test. The basic circuit of this system is shown in Fig. 1.

The reference generators, one for the voltage and one for the currents, are built with precision DACs controlled by a computer. A suitable sequence of samples is programmed and sent to the DACs producing two voltage waveforms. One of the two generators is applied to a high voltage wideband amplifier and the other to a transconductance amplifier, for supplying respectively the voltage and the current outputs.

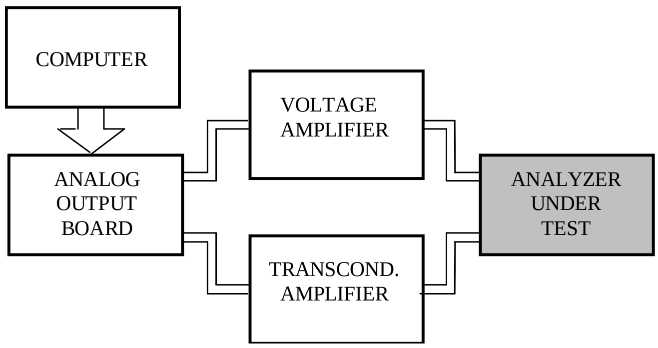

Fig. 1. Basic circuit of the system for the calibration of power quality analyzers.

2.3. The reference generators

The reference generators of the system are realized by means of a multichannel analog output board put in a computer. The analog output board can supply eight outputs channels, even if in this present configuration the system utilizes only two of them. The analog outputs have a 16 bits resolution and can be driven in parallel with a sampling rate of 1 Msample/s. For all channels the board has an internal FIFO buffer for fast operation, where the digital data can be uploaded in parallel.

2.4. The amplifiers

In the first realization of the system both the voltage amplifier and the transconductance amplifier are commercial instruments. The voltage amplifier has a fix gain of 100, a possible output voltage up to 1500 V and a slew-rate greater than 1000 V/µs. The transconductance amplifier has a maximum output of 30 A and a bandwidth of 1 MHz, even if at such frequency the distortion in non negligible.
Both the amplifiers can be calibrated in their input/output characteristics as a function of the frequency by means of ac/dc transfer standards for voltage up to 1000 V RMS and for current up to 20 A.

3. THE SOFTWARE

The software program that controls the board has been developed in Real Time Labview. The basic logic structure of the program and their relations can be represented as in Fig. 2.
Two buffers BUFF_I and BUFF_V respectively for the voltage and the current channels are loaded at every period of the waveform by a vector of samples.

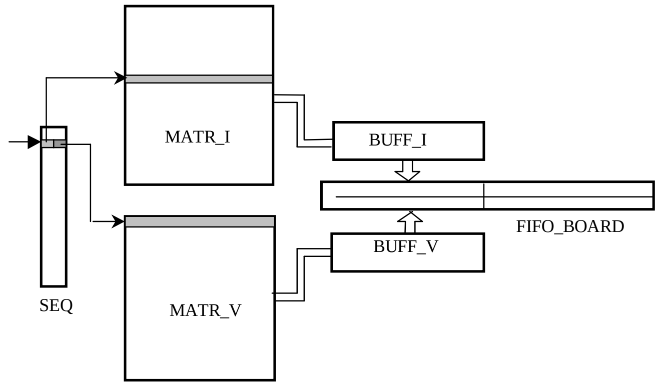

Fig. 2. The logic structure of the program for the generation of the signals for the calibration of power quality analyzers .

Each period the two buffers are filled with the samples stored in two matrix (MATR_I and MATR_V) having the same number of columns of the buffers and a number of rows sufficient to represent all the types of events that can be programmed to check the analyzers.
The two matrix are charged by proper program before the beginning of the operation and a matrix (SEQ) with two columns gives the desired sequence of the events at the two outputs.
The row zero of the two matrixes is reserved for the ordinary steady behavior, which can be preprogrammed. The other rows store the samples of other waveforms, such as for example spikes, transitions and others events.
These vectors in the matrix are formed in the preliminary stage by additional programs that evaluate and write in the two matrixes the proper samples.

4. TESTS AND RESULTS

4.1 Programming the signals

For testing the reproduction of the waveforms with the best time definition the sampling rate of the DACs has been selected at 1 Msamples/s. The two matrixes have consequently 20000 columns and up to 50 different types of events have been programmed. The steady state for the voltage and the current (steady condition) is built starting from assigned number of harmonic components and their phase differences. The value of the samples computed for the voltage and the current signal have been then stored in the first row of the two matrixes.
The other events are in principle free. However, as it is very difficult to select each sample of any specific event, so an automatic program has been developed. Up to now the program allows a combination of the normal waveform by multiplying or adding proper shapes (An example is represented in Fig. £).
Interruptions, sags, swell, noise can be programmed by multiplying the steady waveforms by suitable shapes, while spikes by ore obtained by adding to the steady waveforms proper shapes.
By using this program the sequences of events for the testing have been programmed.

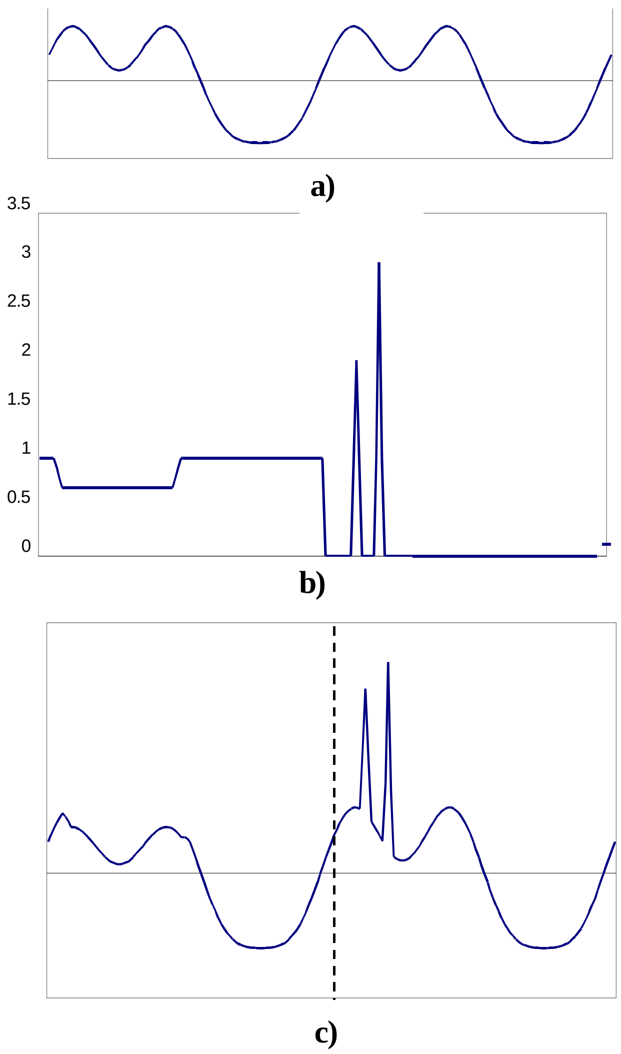

Fig. 3. Examples of the testing signals produced by addition and multuplication by given shapes a) steady condition b) shapes to be multiplied or added c) resulting aperiodic event.

4.2 Reference generators

The reference generators have been tested for their functionality in the normal operation and calibrated for limited bandwidth and low distorted signals by means of the system for the power measurements [3].
For the generation aperiodic signals the reference generators have been checked by a wideband storage oscilloscope.

4.3 The e system

At present the whole system has been analyzed only for its functionality. It can generate stable voltage and current signals with transients of respectively over 1000 V and 30 A. It can also produce periodic signals with harmonics in a wide bandwidth, limited only by the sampling rate of the generators and the slew-rate of the amplifiers.
The construction of a correct traceability chain from the national standards to all types of signals generated is now under investigation.

5. CONCLUSION

A system for the calibration of power quality analyzers has been developed at I.N.RI.M.. The system can supply two synchronized voltage and current signals, with the possibility of generating both calibrated periodic distorted waveforms with suitable aperiodic events superimposed. The sequence of these events can be programmed and compared with that obtained by the analyzers under test in order to verify the correctness of their response.

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REFERENCES

[1] IEEE Standard 1159-1995, IEEE Recommended Practice for Monitoring Electric Power Quality -Description.

[2] IEEE Standard 519-1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

[3] U. Pogliano, "Use of Integrative Analog to Digital Converters for High Precision Measurement of Electrical Power", IEEE Trans. on Instrum. and Measur., vol. 50, no. 4, pp.1315-1318, 2001.

[4] U. Pogliano, G. La Paglia, D. Serazio: "Construction of the traceability for electrical power", 14th IMEKO Symposium Symposium on New Technologies in Measurement and Instrumentation – 10th Workshop on ADC Modelling and Testing, pp. 321-324, Jurata-Gdynia (Poland), September 2005.