Acquisition System for Generation of the Test Signals with Standard Harmonic Disturbances

Milan Simić[1], Dragan Živanović[2], Dragan Denić[3] and Goran Miljković[4]

Abstract – **Data acquisition system, developed for generation of the reference voltage test waveforms with standard high-order signal harmonic disturbances, is presented in this paper. This software supported acquisition system, functionally based on the LabVIEW application software, includes standard computer and acquisition card NI PCIe 6343. The basic purpose of this system is to provide standard voltage waveforms applicable for testing of instruments for measurement of basic electrical power quality parameters and high-order signal harmonics, according to the European power quality standard EN 50160. Specific level of the high-order harmonics in test signals can be individually defined and generated. Continuous variation of the percentage amplitude level in input control segment can be performed separately for each individual signal harmonic or at the same time for all levels of the high-order signal harmonics. Developed solution is verified using the sophisticated instrument for measurement and analysis of the standard power quality parameters - Fluke 435 Series II. Some obtained measurement results are presented in the paper.**

Keywords – **Acquisition system, Voltage test signals, Standard harmonic disturbances, LabVIEW software support.**

I. INTRODUCTION

Signal disturbances, present in the form of the RMS voltage value variations or high-order signal harmonics, directly cause decreasing of the energy efficiency level in electrical power production, distribution and consumption process. Increased concern for problems of electrical power quality distribution, indicated in the recent years, primarily is caused by limitation of the natural resources used for energy production, followed by widespread using of the alternative energy resources. In order to reduce possibilities for potential power distribution network disturbances and to prevent failures of the customer equipment, highly sensitive to various quality degradation and problems, companies for electrical power delivery are forced to assure efficient monitoring of the power delivery networks. Such monitoring process involves measurement and detailed analysis of the basic power quality parameters and network disturbances, defined by the relevant international documents and quality standards [1,2]. Relevant information necessary for providing optimal power quality level can be obtained by measurement and detailed analysis of the basic power quality parameters at specific locations in power distribution network. Various types of instruments and equipment for measurement and software processing of the standard quality parameters are commercially available at the market. These instruments are developed for continuous monitoring of the voltage supply quality in power distribution networks. By measurement of the relevant quality parameters and by performing software supported analysis in single or three-phase power distribution networks, these instruments are capable to verify compliance of the measured quality parameters with relevant standards, such as the European power quality standard EN 50160 [3,4].

Solution of the data acquisition system described in this paper is developed using LabVIEW [5] software package for generation of the reference voltage test waveforms, including special functions for simulation of the various signal harmonic disturbances, typical for real power distribution networks. Procedure for signal generation is functionally based on the virtual instrumentation concept, which includes application software developed in LabVIEW environment and acquisition card NI PCIe 6343. Software support of the generation system provides definition and presentation of the reference voltage signal waveforms. Number of control functions and switches, implemented on front panel of developed virtual instrument, provides adjustment of the basic parameters for definition, presentation and signal generation. Complex test waveforms, defined directly from control block diagram of the virtual instrument, according to requirements of the quality standard EN 50160, can be used for generation of the various voltage test sequences. Generally, using this data acquisition system is possible to generate various voltage test sequences. For this specific purpose are generated voltage waveforms with some typical combinations of the high-order harmonic disturbances. Generated voltage test waveforms are used for testing of the three-phase power quality analyzer Fluke 435 Series II [6].

II. SOFTWARE SUPPORT OF THE SYSTEM

Developed acquisition system includes standard computer, supported by control application in LabVIEW programming environment and data acquisition card NI 6343, equipped with the standard connector block SCB-68A. Complete procedure includes two connected functional segments. First segment of this process provides definition and simulation of the standard voltage signal waveforms, with specified amplitude levels of the signal harmonic disturbances for generation. Definition of the basic signal parameters for various classes of individual disturbances can be performed during programming process, directly inside front panel and block diagram of the LabVIEW

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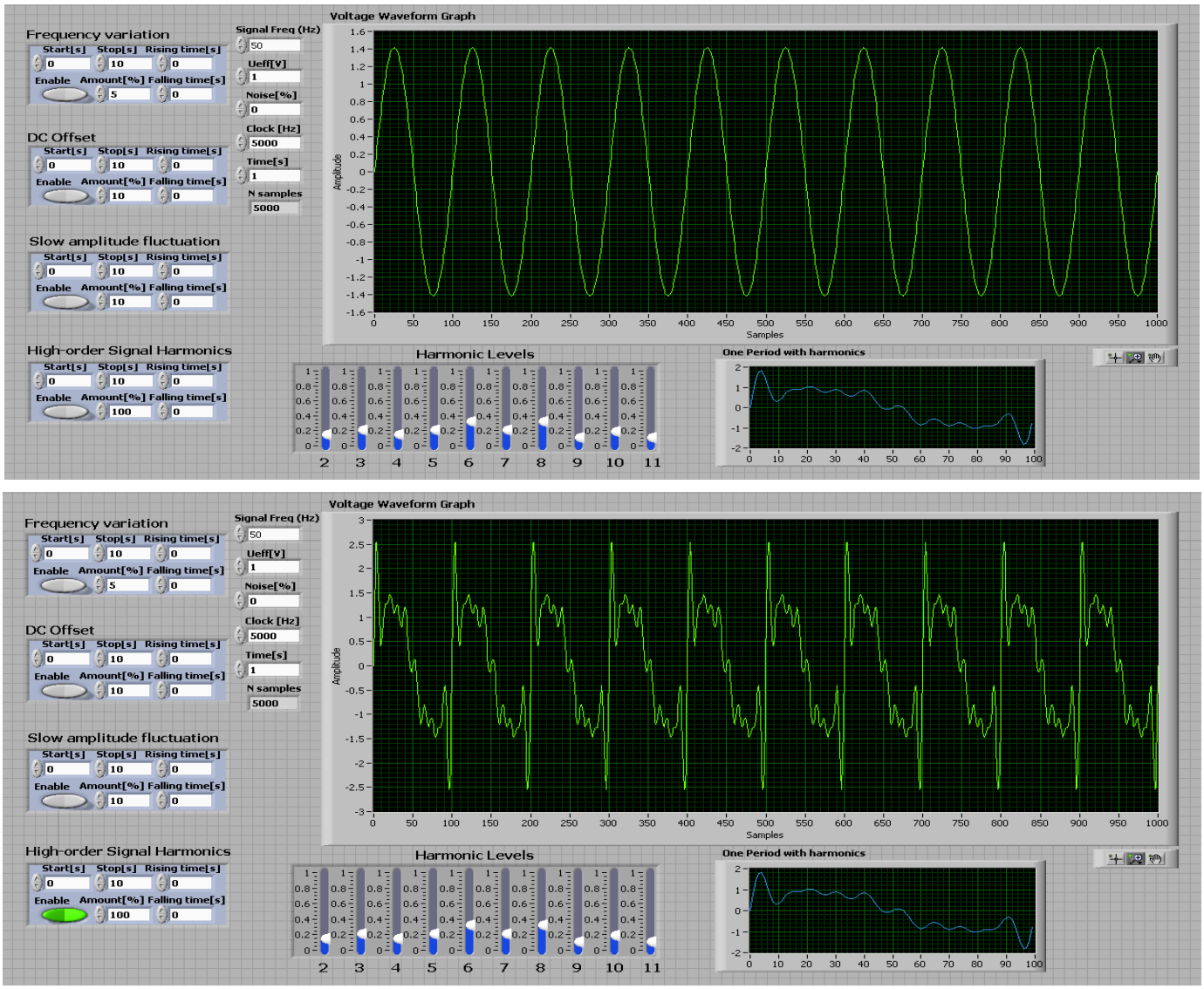

Fig. 1. LabVIEW panel for generation of the voltage waveform: undisturbed signal (above) and signal with harmonic disturbances (below)

virtual instrument [7]. Control front panel gives possibility for fast and simple correction of the basic waveform parameters, according to specific user requirements and purposes. Second functional segment of this procedure is focused on real-time generation of the previously defined and selected waveforms with harmonic disturbances, using analog outputs of the data acquisition card NI 6343. This is 32-channel PCIe acquisition card, capable for digital to analog signal conversion, designed for output voltage range of ±10V and with 16-bit resolution.

Virtual instrumentation is based on the standard computers, hardware components for acquisition and software packages for graphical presentation and software processing of obtained results [5]. Front panel of the virtual instrument in LabVIEW software environment, developed for generation and graphical presentation of the standard voltage waveform, is presented in Fig. 1. Shown control panel of the virtual instrument provides selection and adjustment of the basic waveform parameters, by number of the control functions and knobs, implemented in block diagram of the virtual instrument. Presented voltage waveform is generated with nominal frequency value of 50Hz and normalized RMS voltage level of 1V. Separated segment of the control functions on front panel is used for selection and adjustment of the specific maximum levels regarding to the individual high-order voltage harmonics. Content of the specific high-order signal harmonics can be precisely defined by number of the control knobs used for regulation of the harmonic amplitude levels. In Fig. 1. are presented two cases of the generated voltage waveform. Above picture shows undisturbed voltage waveform without signal disturbances, while below picture presents standard voltage waveform generated with certain levels of the high-order harmonic disturbances. In order to be more realistic in generation of the signal waveforms, for particular disturbances is enabled separate definition of the nominal frequency variations, signal DC offset, amplitude fluctuations, start and stop times of the disturbances, rising and falling times and percentage amounts of the disturbance amplitude levels. Specified precise levels of the individual high-order signal harmonics, from 2^{nd} to 11^{th} voltage harmonic orders, are indicated on separate segment of the control front panel, which is in detail shown in Fig. 2.

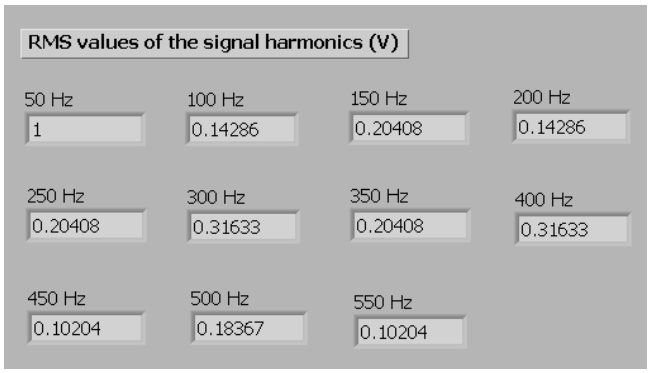

Fig. 2. Front panel for indication of the selected signal harmonics (RMS voltage values from 2nd to 11th high-order harmonics)

III. Using of the System

Presented solution of the data acquisition system can be used for generation of the reference signals, applicable in testing of instruments for measurement and analysis of the standard power quality parameters and high-order harmonic disturbances. As an example, in this specific case generated voltage waveforms with harmonic disturbances are used for testing of three-phase power quality analyzer Fluke 435 Series II. Hardware block configuration of this testing procedure is presented in Fig. 3. Reference voltage waveforms, generated with desired level of the harmonic disturbances, from analog output channels of the data acquisition card NI 6343 are sent directly to voltage inputs of the tested instrument Fluke 435, using standard connector block SCB 68A (line 1). Instrument is set to work in mode for measurement of the high-order signal harmonic components. Direct communication from instrument output to computer is provided using standard USB communication interface (line 2), so measurement data

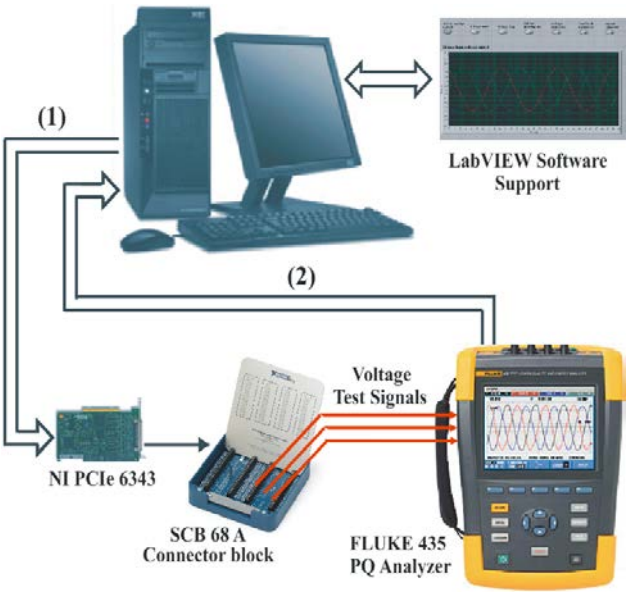

Fig. 3. Hardware configuration of the software supported procedure for testing of the power quality (PQ) analyzer Fluke 435

obtained during testing process can be easily transferred to computer, recorded and processed for graphical presentation. Some characteristic results obtained from described testing procedure are presented in following section of this paper.

Software supported testing process includes three basic segments. First segment is recording of the three-phase test voltage waveforms on graphical display of the tested device. Second part is recording of the high-order signal harmonic graphs. Third part of the process involves measurement of the high-order harmonic RMS values for generated test voltage waveforms. Voltage signal waveforms for all three phases, recorded on graphical display of the tested instrument, power quality (PQ) analyzer Fluke 435 Series II, are shown in Fig. 4. Presented voltage waveforms correspond to the test signal with harmonic disturbances, previously illustrated in Fig. 1.

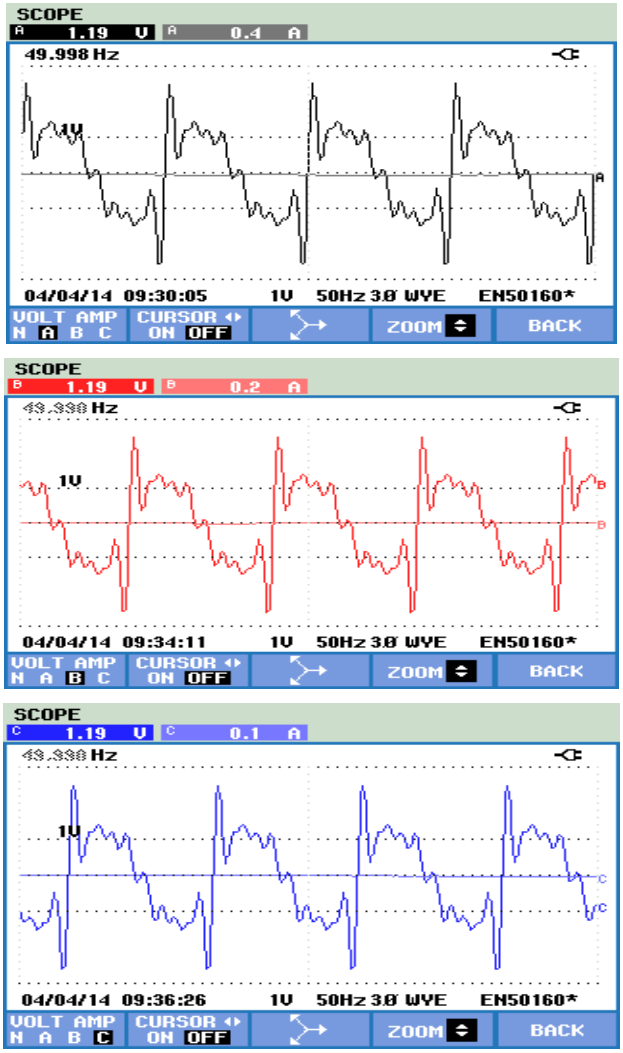

Fig. 4. Three-phase voltage waveforms recorded on display of the tested instrument - power quality analyzer Fluke 435

Graphs of the measured high-order harmonics, recorded on graphical display of the tested instrument for all three phases of the test signals, are presented in Fig. 5. Shown harmonic graphs indicate maximum measured percentage values of individual high-order voltage harmonics in test waveforms. Obtained harmonic levels, shown on instrument display, fully

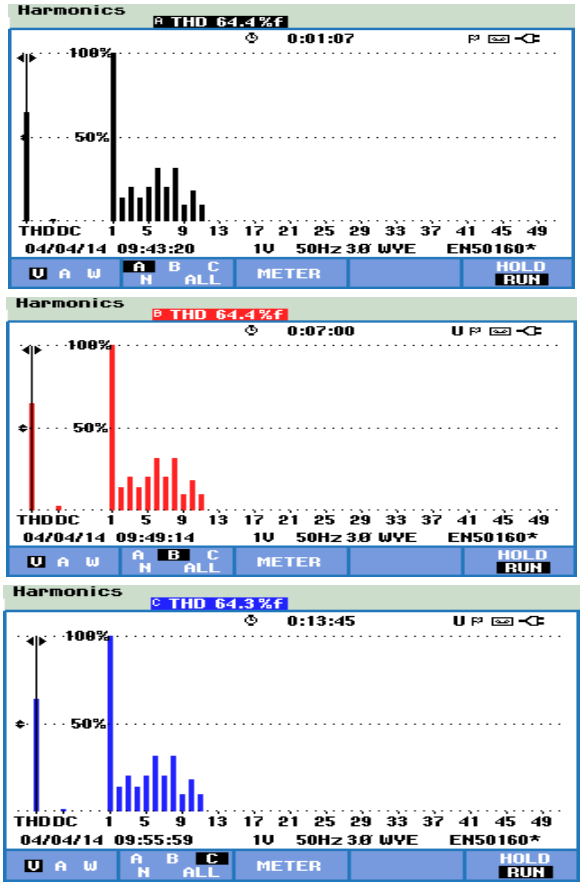

Fig. 5. Recorded graphs of the high-order signal harmonics

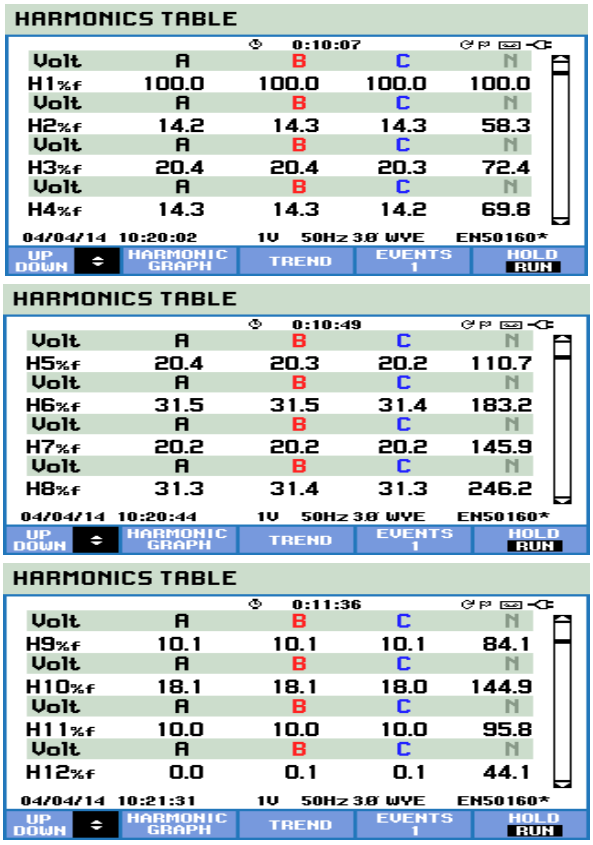

Fig. 6. Measured percentage values of the signal harmonics

correspond to the previously selected harmonic values in test waveforms, from 2nd to 11th harmonic orders, given in Fig. 2.

Finally, measurement results related to percentage values of the high-order signal harmonic components in test signals, obtained using tested instrument Fluke 435, are presented in Fig. 6. Shown measurement results, obtained during testing process, are completely matching to previously defined values of the high-order harmonic components in test waveforms.

IV. Conclusion

Software supported procedure, applied for generation of the test voltage signals with certain level of the standard harmonic disturbances, is described in this paper. Generation process is functionally based on the virtual instrumentation concept, which includes control application developed in LabVIEW software environment and data acquisition card NI PCIe 6343. Variation of the basic parameters for definition, presentation and signal generation is provided by various control functions and switches, implemented on front panel of developed virtual instrument. For specific harmonic disturbances is possible to define percentage amounts of the harmonic amplitude levels, nominal frequency variations, amplitude fluctuations, start and stop times, rising and falling times of the disturbances. Presented data acquisition system is verified by means of the software controlled procedure used for testing of the power quality analyzer Fluke 435 Series II. Using described solution of the acquisition system, can be provided various voltage test sequences with standard harmonic disturbances. In this case for testing purposes are used some characteristic voltage test waveforms with harmonic disturbances. Basic measurement results and recorded three-phase voltage waveforms, obtained from testing process, are presented and analyzed in this paper.

Acknowledgement

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