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Internet-Ready Power Network Analyzer for Power Quality Measurements and Monitoring

by Petr Bilik, Senior Lecturer; Jan Zidek, Associate Professor; Daniel Kaminsky, Associate Professor; Jiri Hula, Software Developer; Martin Starzyk, Software Developer VSB TU Ostrava, Department of Electrical Measurements/ELCOM, a.s. Division of Virtual Instrumentation, PC-based instruments group

The Challenge: Designing a PC-based power quality analyzer, including the set of instruments in one hardware system, capable of running all instruments in parallel. We also had to develop the software system based on modular concept for easy extensions in the future, design the measurement and data processing algorithms according to the latest IEC and EN standards, and design the remote-controlled instrument via Ethernet according to SCIPI standard. In addition, we needed to design two concepts in one firmware – simple field instrument and distributed system.

The Solution: Developing a software application in National Instruments LabVIEW graphical development environment to act as the instrument firmware, providing the instrument GUI, and implementing the remote commands set running on the portable industrial PC. Eight instruments – FFT analyzer, power flow monitor, Flickermeter, EN50160 voltage monitor, transient recorder, symmetrical components analyzer of 3-phase system, telegram monitor, and alarm monitor can run, capture data, and do all processing and data storage in parallel. Data is stored locally or in a central database, depending on instrument purpose. The post-processing data module, developed in LabVIEW, for one instrument is processing local binary data. For the distributed system, the data post-processing module processes data from the SQL database using Microsoft Internet Explorer. The Internet post-processing is based on ASP pages using ActiveX graphical elements from NI Measurement Studio. Both post-processing modules are providing various data analyzing, data comparing, and data reporting. Power analyzers in the distributed system can be centrally online monitored via a supervising application developed in LabVIEW.

Computer-Based Power Analyzer
The faculty members of the Department of Electrical Measurements have been researching and developing electrical power quality for more than 11 years. During this period, the power quality analyzer has been developed jointly with the company ELCOM, a.s. The basis of the solution is the software application designed and developed within LabVIEW. From the very beginning, the application structure has been designed in such way to provide the open framework into which we can easily implement new software modules. After having the solution for the field instrument, we designed and implemented the distributed system concept using a SQL database for data storage and Microsoft Internet Explorer for Internet-based post-processing. For online remote supervising of distributed power analyzers, we designed and implemented the remote commands tree according to SCIPI. All of these significant extensions were done with minor changes in former LabVIEW code of BK500 power analyzer.

Instruments Implemented in the Analyzer
For all instruments the user can observe data on the instrument display and store them into the data files or SQL database. The most important instruments are described in more detail bellow.

FFT Analyzer – The first instrument from the virtual analyzers set is the fast Fourier transform (FFT) analyzer of harmonics and interharmonics. The instrument can display the signal either in time domain or in frequency domain. For each measured signal (voltage and current of the power network line) the amplitude

and phase spectrum is measured, and the FFT analyzer indicates the direction of the power flow for each particular harmonic. The user can see on the FFT analyzer display the amplitudes of the selected spectral lines.

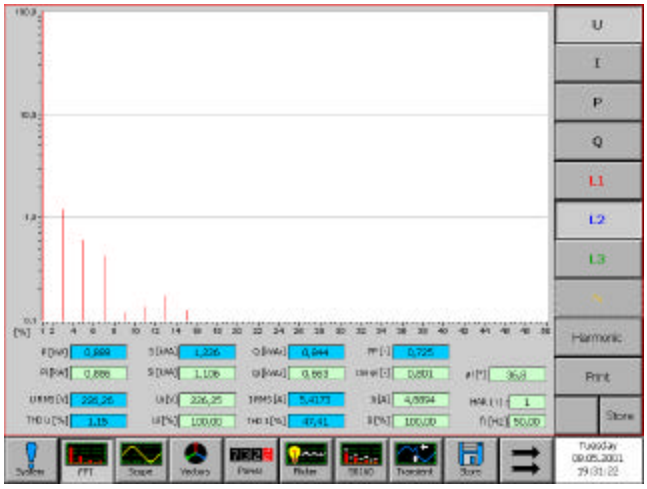

Fig. 1. FFT Analyzer Front Panel

Power and Energy Monitor – With this instrument. the user can evaluate the main power and energy quantities calculated from the instantaneous values of the voltage and current signals. The software implementation is designed in such way to allow the compensation of the errors caused by the non-linearity and frequency dependent characteristics of the used transducers, if these characteristics are known for the particular transducer(s) used for the measurement. These corrections allow compensating for phase errors of power clamps that are very frequently used for current measurements in the power networks. The analyzer provides to the user the possibility of observing the phase conditions on the vector diagram continuously updated in real time.

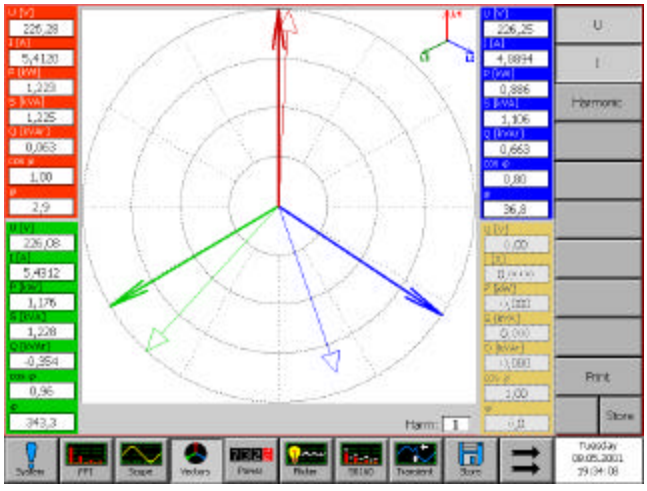

Fig. 2. Vector Diagram Panel

Flickermeter – This instrument is designed for measuring the flicker effects of voltage signals according to IEC 868 recommendations. From the time domain of the voltage signals , the 10 min and 2 hours flicker is being evaluated. Both evaluations are done each minute, minimizing the dependence between the instrument measurement start time and the particular time when the event affecting the level of the flicker occurs. Data are displayed on the display and can be also stored into the data files. Currently the research and

development effort is focused into the modification of used algorithm in such way to allow measuring also the flicker caused by interharmonics or evaluate the flicker caused by the light source, 60 W electric bulbs.

Voltage Monitor – This instrument analyzes the quality of the electrical energy according with EN 50160 standard. The user gets the complex overview of all quality parameters measured according with this standard. The user can individually set the levels for catching the voltage drops events. If the voltage drop occurs, the signal in time domain before and after the event is stored as well.

Fig. 3. Voltage Monitor Front Panel

Transient Recorder – This instrument allows storing the voltage and/or current signals if the set trigger condition(s) is/are met. The user has a wide range of possibilities in how to set the trigger conditions for each particular power network line and combine them with logical AND and/or OR. There is also the possibility for setting the pre and post trigger length within the time window. The length of stored data is 64 kS. Subsequently on the stored time window the instrument user can perform the of-line analysis.

Measured Data Analysis

Directly within the analyzer, thanks to the virtual instrumentation concept, the instrument user can perform all of-line analysis. With the developed post processing software module, users can process the measured data from any of BK550i instrument and print the protocols form the measurements. Also it is possible to export the measured data into ASCII files. Then it is possible to do any data processing within standard spreadsheet processors.

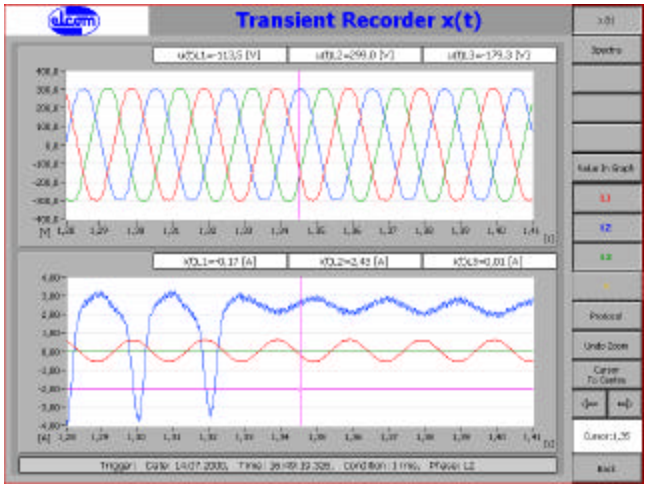

Fig. 4. Transient Recorder Post-Processing Panel

For the distributed system, we implemented the new revolutionary post-processing using Microsoft Internet Explorer and ActiveX graphical elements from NI Measurement Studio. With Internet Explorer and the ActiveX graphical elements from Measurement Studio, we easily performed data analysis from anywhere on the Internet. We could even compare data from different analyzers placed in different locations.

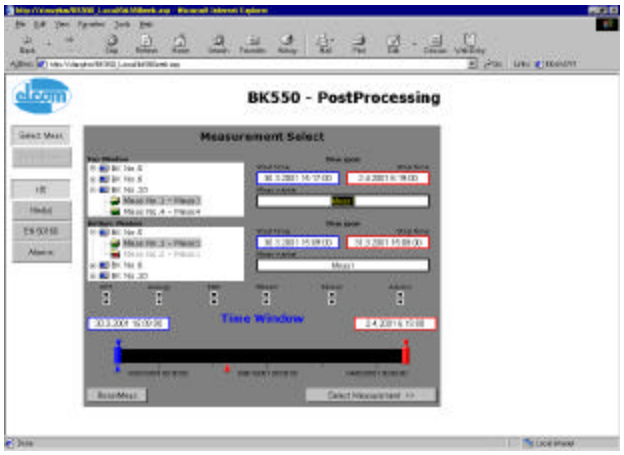

Fig. 5. Web-Based Post-Processing Instrument Selection Panel

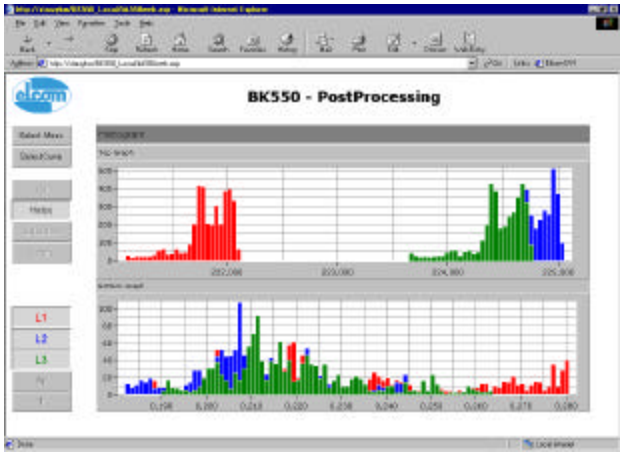

Fig. 6. Web-Based Post-Processing Data Histogram

Supervising Module

For remote set-up and on-line monitoring of the distributed system, the supervising software was designed and developed as a stand-alone application. With the supervising module, we set-up ranges, constants, configure storing intervals. We could monitor on-line up to four BK550i at the same time and display the most important screens.

Hardware Platforms for the Virtual Analyzer

Currently, the analyzer is implemented on two hardware platforms. A portable industrial computer represents the first one. The computer is equipped with a plug-in data acquisition (DAQ) board, touch screen, and plug-in modules for signal conditioning. From the very beginning of the development process, we used the high-quality DAQ plug-in boards from National Instruments. Currently, the PCI 6035 or PCI 6023E is part of the analyzer. Both boards provide 16 analogue channels and the maximum sampling rate is 200 kS/s. The DAQ process of instrument software uses sampling frequency 12,8 kS/s per each channel. Plug in modules for signal conditioning are programmable via RS 485 and are equipped with amplifiers/attenuators, galvanic

isolation, anti-aliasing filters and have very good linearity. Thanks to the touch screen as a standard part of this hardware configuration and software design, the user can operate the instrument without keyboard or mouse.

The second platform is a PC furnished with two USB ports that connect the variety of peripherals (keyboard, mouse, network etc.) as the hot plug-ins. Another component of the hardware is also the modules for signal conditioning and DAQ board. Also this configuration contains the touch screen as the standard way for operating the instrument. Using the keyboard or mouse is not intended in a case of standard usage.

We also developed the application for use on other platforms, where the basis is the personal computer, DAQ board, and signal conditioning board. For this purpose, the signal conditioning plug-in board for a standard PC could be used.

Advantages of the Virtual Analyzer

The main advantage of the described solution is its flexibility. Using an all-purpose PC with hardware and software interfaces, plug-in DAQ board and signal conditioning is possible, implementing the powerful and user-friendly power quality analyzer. Using the development environment of graphical programming, dramatically simplifies the software maintenance and further development.

With the application structure, we subsequently implemented further software modules, realizing new instruments without impact on the current solution. We continue to use the power and performance of the PC technology and NI products to implement more time-demanding advanced signal processing algorithms.

Future Vision

In addition to further extensions of the set of available instruments, we focus our R&D effort on the innovation of the distributed system for monitoring of the electrical quality parameters base on the described analyzers. We use Microsoft Internet Explorer as the only tool for full remote servicing of distributed power quality analyzers BK550i.

With the development of the hardware platform of real-time DAQ components of National Instruments and their compatibility with the graphical development environment of LabVIEW, we plan to run the DAQ core on the independent hardware with a real-time operating system (OS) and let only the time non-critical visualization run on the standard PC, while still using all the advantages of the graphical Windows OS features.

Note

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