A New Approach To Online Power Quality Monitoring In Distribution Networks Over The Internet

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ARTICLE INFO
Article history:
Received 25 June 2014
Received in revised form 1 July 2014
Accepted 31 August 2014
Available online 15 September 2014

Abstract
In this paper, two new and important topics in power quality are discussed. First issue is the online monitoring of power quality by using Internet, and the latter is making an online monitoring system for power quality in distribution networks. Components used in this device, so we have selected may be available in the Iran market. One of the interesting parts of the device is a tablet with connecting to the GPRS network. The point is that our proposed system with respect to all similar models could be distinguished, because the tablet beside all necessary tools (such as GPS module, CPU, communication equipments for connecting to the Internet ...) has operating system, and there are special advantages in the operating system. After describing the system architecture, we have spoken about data collection and data analysis over the Internet. In addition, the software packages that can be used to analyze the online data and to implement the intelligent algorithms, have explained. For the case study, a 10-bus distribution system in the Simulink environment of MATLAB software has simulated. In addition to static loads, there are three dynamic loads and an SSSC in the network.

INTRODUCTION

In the power quality issue, fluctuations of voltage, current and frequency of the power system are investigated (BAYHAN, S., et al., 2013; Zacharis, E., et al., 2012; Chen, M., et al., 2011). Since today’s electrical equipments and instruments are more sensitive to the power system disturbances than before (either client side or on the side of the system), the term of power quality has become an important issue (Zhang, M., K. Li, 2009). The purpose of power quality studies is which of the parameters is going wrong and should be corrected (BAYHAN, S., et al., 2013). For identification and classification of disturbances, we require the appropriate standards such as IEEE 519-1995, IEC 61000 and EN 50160 (BAYHAN, S., et al., 2013; Francisco José Gómez, and etc. 2013; Zacharis, E., et al., 2012; Salim, F., et al., 2012; Duan, X., et al., 2012; Chen, M., et al., 2011; Zhang, M., K. Li, 2009; Chan, S., J. Teng, Y. SU., 2004; Cristaldi, L., and etc. 2003; MONTEIRO, M.E., and etc. 2003; Waclawiak, M., et al., 2001).

To evaluate the power quality in a distribution network, we must collect the necessary information by sampling of the electrical quantities in various positions and compared them with the references values to tracking the problem in the system. On the other hand, nowadays, Internet network is nationwide available. Therefore, we developed a device that can collect data from stations and save them on a server by the Internet. Then we can process the stored data, and the results will be available in all parts of the country. Such a system has many advantages, including cut costs, online and real-time monitoring, access to network information from all points, and etc.

System structure:
Distribution substations are the data acquisition locations. By sampling of instantaneous 3-phase voltages and currents, we can achieve to power quality parameters. Therefore, we should design a measurement and communication system with small size and reasonable price, and install it in the distribution substations. In Figure 1, the system required equipments that must be installed in the distribution substations, is shown. For sampling and convert the analog signal to digital, we can use of TI TMS320F28232 (ADC) chip (Texas Instruments, 2014).
Instruments, 2012). By using this chip, the maximum sampling frequency will be 125 kHz. Since the maximum I/O voltage of this chip is 3.3 V (Texas Instruments, 2012), we have to design a signal level conditioner to correct the signal level, then apply the corrected signal to the chip. A signal level conditioner has been shown in figure 2 (Jung, W., 2004). Of course, there are some commercial signal level conditioners.

![Signal level conditioner](image)

**Fig. 1:** the system structure

To send the digital signal over the Internet, we must use the microprocessor (BAYHAN, S., *et al.*, 2013; Francisco José Gómez, and etc. 2013; Salim, F., *et al.*, 2012; Duan, X., *et al.*, 2012; Chen, M., *et al.*, 2011; Zhang, M., K. Li, 2009; Chan, S., J. Teng, Y. SU., 2004). As can be seen in the papers, use a single CPU need to install the GPRS module and other communication equipments, install the GPS, keyboard and display installation, assembly programming, and the design of power sources. To solve all these problems and reduce costs, we recommend using the tablet.

![Data mining and analyzing over the Internet](image)

**Fig. 2:** Signal level conditioner

By using a tablet, we can access to all abovementioned equipments with mush better price and much smaller size. Furthermore, a tablet has an OS (Windows, Android, iOS or ...) result to programming convenience, and efficiency and the interface is much better. By using tablet, in addition to all these benefits, the power quality analysis can be carried out at each substation for it or at any substation check out the other stations by using the internet on the tablet. To connect the tablet to TI TMS320F28232, we must use an interface. With guidance from the Texas Instruments web site, we use TUSB341 for connection between tablet and ADC chip. The TUSB341 user manual completely described in reference (Alter, D.M., 2012).

According to Figure 3, the data collected from the various substations will be sent via the Internet to a Server. Server processes the information and makes them available to users via the Internet. Data collected from various positions must be synchronized with the time and it is done with the help of GPS module in the tablet or Internet Time (Chen, M., *et al.*, 2011; Zhang, M., K. Li, 2009; Chan, S., J. Teng, Y. SU., 2004).

![Data mining and analyzing over the Internet](image)

**Fig. 3:** Data mining and analyzing over the Internet
After data collection in a server, the data must be analyzed by proper software. We can program it or use commercial software like MATLAB, LabView, or etc. LabView has a specific area to analyze power quality (BAYHAN, S., et al., 2013). By MATLAB, we can implement artificial intelligent algorithms (سیستمهای، سیستمهای، 1391).

**Challenges and Opportunities:**

In the power quality studies, usually these parameters have been analyzed: power frequency, magnitude of the supply voltage, flicker, supply voltage dips and swells, voltage interruptions, supply voltage unbalance, voltage harmonics, rapid voltage changes (RVC), power measurement, energy measurement, aggregation (demand).

Hence a power quality meter should have these equipments: vector scope, oscilloscope, Power and energy monitor, flicker meter, symmetrical components analyzer of 3-phase system, network impedance analyzer, half-period RMS monitor, transient recorder and fault recorder, FFT analyzer (BAYHAN, S., et al., 2013; Francisco José Gómez, and etc. 2013; Zacharis, E., et al., 2011; Salim, F., et al., 2012; Duan, X., et al., 2012; Chen, M., et al., 2011; Zhang, M., K. Li, 2009; Chan, S., J. Teng, Y. SU., 2004; Cristaldi, L., and etc. 2003; MONTEIRO, M.E., and etc. 2003; Waclawiak, M., et al., 2001). By this suggested method, in addition to above facilities, we achieve the other opportunities such as:

- Network monitoring from anywhere
- Cut costs, fast performance and instantaneous monitoring
- Instantaneous power flow of distribution networks
- Positioning of effective loads
- Substation demand comparison
- Help to evaluate the reliability
- Positioning of harmonics generating loads
- Impedance and voltage loss measurement of all lines
- Sending control signals to network controllers

According to the costs that are paid for power quality monitoring and limitations of current systems, there are no important challenge for our project. However, we can say that the most important challenge is include of initial cost for installing, Server, the fee for the use of Internet, the maintenance and updates. However, the writer comments that this project makes the new opportunities available for the power companies, and finally the return costs will be the beneficiary of the power companies.

**Diagnosis and classification of disturbances:**

For data mining and disturbances classification, various algorithms can be used. With according to the reference (سیستمهای، 1391), the best algorithm for online classification is the MSFS-KNN multifactorial algorithm. This algorithm can classify the data with a precision about 99.77 percent.

![Fig. 4: 10-bus distribution network with SSSC and dynamic loads](image)

**Simulation:**

Here we simulate a 10-bus distribution system. In this 20kV system, there are three dynamic loads and a SSSC, as shown in figure 4. We simulate this system with applying a 3-phase fault to bus 5, and results have shown when the SSSC is present and when it is not. The RMS voltages are shown in figure 5 (without SSSC), and are shown in figure 6 after compensation.
Fig. 5: RMS Voltages before compensation

Fig. 6: RMS Voltages after compensation

Fig. 7: 3-phase Voltages of bus 4 before compensation

Fig. 8: 3-phase Voltages of bus 4 after compensation
For a sample, we have shown the voltage waveform of bus 4 in figures 7 and 8, before and after compensation, respectively. In the figures 9 and 10, the voltage angle of bus 4 is shown, before and after compensation, respectively. The dynamic loads also affect the bus voltage angles. For example, the effects of dynamic loads on the bus 7 voltage angle have shown in the figure 11.

Conclusion:

In this paper, a new and updated method for power quality monitoring was reviewed, and a new system was introduced for the data acquisition and sending them. Various papers introduced diverse data acquisition devices that each of whom had special limitations. Most of them used of old signal processing chips, but we used of a new one, called TI TMS320F28232. In addition to higher and better features, this chip can be connected to a USB port by using TUSB341 (The key of using tablet). By using tablet, we leave behind the problems such as using individual devices for GPS, GPRS, memory, display and etc, and achieve the benefits such as better interface, programming facilities, smaller size, low price and etc. At last a 10 bus distribution system is simulated in the Simulink area of MATLAB.

REFERENCES


Francisco José Gómez, and etc. 2013. “Web Services Framework for Power Quality Monitoring”, Smart SysTech, June 11-12, 2013 in Erlangen/Nuremberg, Germany


