SYSTEM FOR MONITORING AND VISUALIZATION OF ELECTRICAL POWER QUALITY

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For controlling the quality of the electricity supplied to the customer, it is needed to be measured many parameters of the electrical signal. Since 2003, in Bulgaria was admitted a new standard equal to EN50160-1999, valid for European Unions' countries. In this standard are described the basic definitions and the requirements for the electrical voltage parameters, which define the Electrical Power Quality.

1. BASIC FEATURES OF THE ELECTRICAL POWER QUALITY

Electrical Power Quality is defined by the electricity parameters given in a standard admitted for every country. This project is focused on low voltage supplies. This means that the nominal rms value of the supply voltage is up to 1kV. The EN 50160 standard defines the following low-voltage supply characteristics:

1. **Power frequency** – repetition rate of the fundamental wave of the supply voltage measured over a given interval of time.

2. **Magnitude of the supply voltage** – current value of the supply voltage.

3. **Supply voltage variations** – an increase or decreise of voltage normally due to variation of the total load of a distribution system or a part of it.

4. **Magnitude of rapid voltage changes** - a single rapid variation of the rms value of a voltage between two consecutive levels which are sustained for definite but unspecified durations

5. **Flicker severity** - intensity of flicker annoyance defined by the UIE-IEC flicker measuring method and evauetaed by the following quantities

- short term severity (P_{st}) measured over a period of ten minutes
- long term severity (P_{it}) calculated from a sequence of 12 P_{st}-values over a two hour interval, according to the following expression: $P_{it} = \sqrt[3]{\sum_{i=1}^{12} \frac{P_{sti}^3}{12}}$

6. **Supply voltage dips** – a sudden reduction of the supply voltage to a value between 90% and 1% of the declared voltage Uc (in this case Uc is equal to the nominal voltage Un), followed by a voltage recovery after a short period of time.

Conventionally the duration of a voltage dip is between 10ms and 1 minute. The depth of a voltage dip is defined as the difference between the minimum rms voltage during the voltage dip and the declared voltage. Voltage changes which do not reduce the supply voltage to less than 90% of the declared voltage Uc are not considered to be dips.

7. **Short and Long interruption of the supply voltage**
- long interruption – longer than three minutes caused by a permanent fault
- short interruption – up to three minutes caused by a transient fault

8. **Transient overvoltages between live conductors and earth** – a short duration oscillatory or non-oscillatory overvoltage usually highly damped and with a duration of a fiew milliseconds or less.

9. **Supply voltage unbalance** – in a three-phase system, a condition in which the rms values of the phase voltages or the phase angles between consecutive phases are not equal.

10. **Harmonic voltage** – a sinusoidal voltage with a frequency equal to an integer multiple of the fundamental frequency of the supply voltage.

11. **Interharmonic voltage** – a sinusoidal voltage with a frequency between the harmonics, i.e. the frequency is not an integer multiple of the fundamental.

Every characteristic is defined with nominal values and tolerances. For monitoring the Electrical Power Quality it is needed to be measured very precisely every parameter of the low voltage supply.

2. BASIC FEATURES OF THE SYSTEM FOR MONITORING OF THE ELECTRICAL POWER QUALITY

The main target of the project is to be designed hardware and also the additional software system for measuring, monitoring and visualizing the electricity parameters in agreement with EN50160 standard. This system has to have a powerful measuring and computation module for fast and precision determination of the electrical power parameters. For additional computation, there will be a possibility for Ethernet communication between the intelligent modules and personal computer. Except the digital data, there will be an analog interface, which will transfer the analog data for P, Q, U and f values of the electrical voltage.

A. HARDWARE DESIGN

The hardware system has to collect the basic data information, to make fast and precise computations and all of the processed data will be stored in the RAM and/or the additional EEPROM data memory. To make all this possible in the system has to be integrated input converters for the values of the electrical voltages and currents.

The standard decision is to be used three voltage resistive dividers for the voltages of every phase, and three transformers for normalizing the three currents of every phase. When these six values are normalized they have to be converted from analog values into digital values for computation. The A/D converter has to be more precise than fast. It is needed a six channel A/D converter with minimum 10bit resolution and conversion rate, not slower than 50KSPS. The EEPROM data memory is needed in two directions – first, there is constant data, which has to be stored, i.e. destination and source MAC and IP addresses for Ethernet communication; second, when the main power supply goes down, the current data from measurement has to be stored also. For better performance, it is good to have a DSP engine except the conventional ALU, because for some of the characteristics it is needed complicated computations, which can be made by the DSP, and the other can be made from the ALU integrated in the microcontroller. In case of missing power supply, a Supervisor circuit has to supply the MCU, and the system will go in power save mode.

The hardware system will support two interfaces: Analog and Digital. The analog interface is ±5mA current interface, which gives the analog information for *P*, *Q*, *U* and *f* parameters of the electricity voltage. The digital data is for Ethernet network communication between the hardware system and a Personal Computer. This connection is very important, because it is very convenient to be used for additional computations, fast and precision control and for very good. The Ethernet communication, will be based on TCP/IP and UDP protocols. It is needed to be used an Ethernet controller for realization of such kind of network communication.

Correspondent to decisions made above, it can be shown the following block diagram:

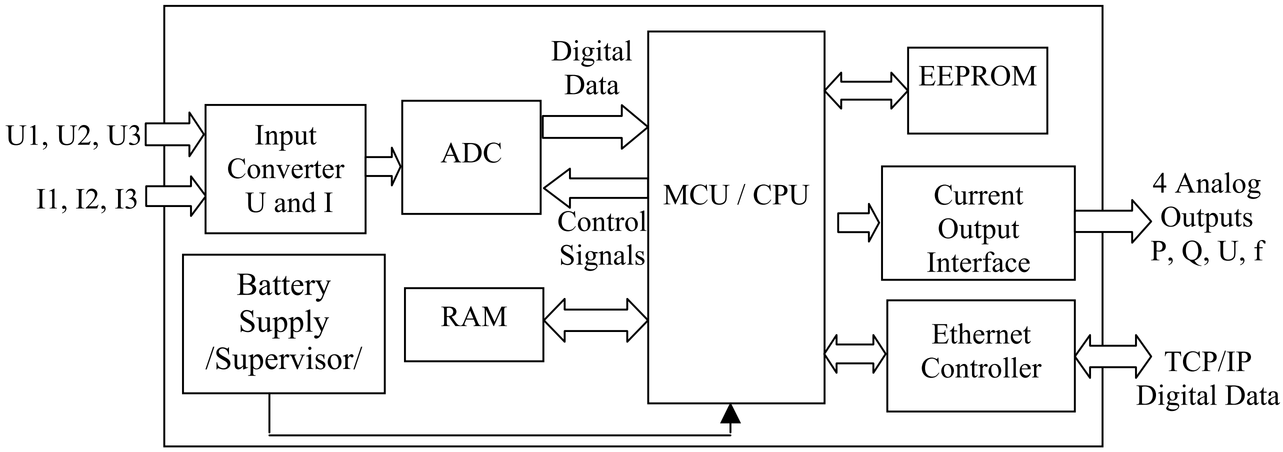

Fig. 1 Block diagram of the hardware system device

In this diagram are shown the main modules of the hardware system. The RAM, ADC, EEPROM and CPU/MCU modules can be integrated in one package. The Microchip Company produces so-called Digital Signal Controllers (DSC) – dsPIC30F family. These controllers combine the characteristics of the conventional microcontrollers with the DSP functionality. The biggest controller from dsPIC30F family at the moment is dsPIC30F6014. This device is situated in 80-pin package, with integrated 16-channel 10-bit/100KSPS A/D Converter, 48K Instructions program FLASH memory, 4 kBytes EEPROM and 8 kBytes RAM data memories, UART, SPI, I2C and CAN interfaces, Selectable Power Management Modes – Sleep, Idle and Alternate Clock Modes and also powerful DSP engine.

All these basic features of the dsPIC30F6014 are making it appropriate for development of the hardware system for monitoring the electrical power quality.

B. SOFTWARE DESIGN

- Low level Software design – this design is pointed to programming the digital signal controller. Because of the complicated device as functionality, the controller has to be programmed by using not only Assembly but also C programming languages. The hardware system has to support ICMP, TCP/IP and UDP protocols of the so-called Transport Layer. ICMP – Internet Control Message Protocol is needed for making PING function. This function is very useful because if there is a problem and some device of the network is not working, the user can check every device in the network if it corresponds with PC. TCP and UDP protocols are for controlling the data transfer between the PC and the hardware monitoring systems in the Ethernet network.

- High level Software design – this is the software installed on the PC which will be a main station (server) for the Ethernet network. One example for Ethernet network realization can be:

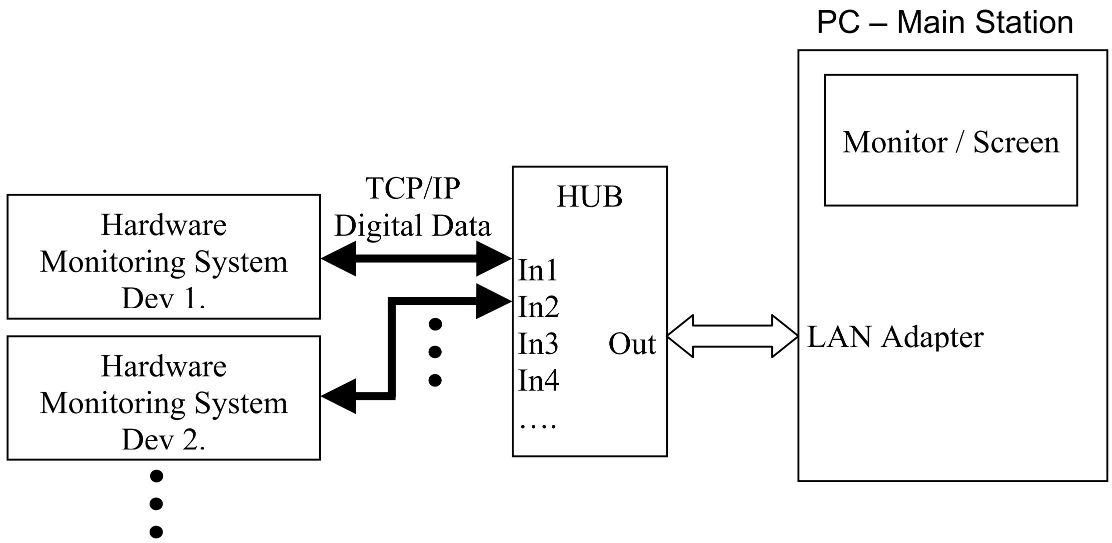

Fig. 2 Ethernet network communication between the intelligent modules and PC

The software installed on the personal computer has to perform two modes – test and basic. The test mode is for calibration of the hardware modules. This mode can be used only from the person who supports technically the hardware system. Working mode is for the customer/user. The PC will collect the data from the monitoring system devices connected in the network. The software will automatically scan every device in the network, but also it will be possible to be choused from user which device not to be scanned or only to be scanned. After the investigation it will be decided what exactly to be done for best and easiest way of operation. At the moment the decision is:

- to visualize the current values of the electrical parameters on the PC screen, as graphic and/or as table text format;
- software has to archive (store) the data on every 1, 2, 5, 10, 15 or 20 minutes
- automatic scan of every device connected in the network on every 30 seconds
- this software will be compatible with Windows operating systems

The two levels of the software have to be harmonized according to which ports is transmitted and received the data. It means that the software installed on the PC has to be programmed to expect the information on exact port. For easy realization it is better every device in the network to transmit the data on one and the same port. This means that it is forbidden two of the devices to send data in one and the same time to the PC. That is easy for design, because the network will be organized on principle master and slave. The data will be transmitted from the hardware systems to the PC when there is a request from it. On other side the hardware systems will be programmed to receive the data from the network on exact and the same port. This synchronization is needed because of the organization of the protocols – UDP and TCP/IP from the so-called Transport Layer.

There are many types of languages for developing the high level software, but the most appropriate are Visual Basic and Visual C++. They offer easy to use tools for the programmer and give him many opportunities for choosing the interface and very useful designed libraries.

3. CONCLUSIONS

The system for monitoring and visualization of electrical power quality is very complicated as a software and hardware design. But this system has many advantages as interfaces – analog and digital, network communication possibility and complex parameter measuring and monitoring. Together with the high level software for the personal computer, the user can have not only an electrical power meter, but also registration device which can store a big amount of data. For sure this system is appropriate for big industrial companies, which needs to monitor the electrical power quality during the industrial process. The Ethernet network for communication is standard and it is cheap and easy to be realized.

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