Monitoring System for Electrical Measurements of Energy Distribution Stations

Marius-Constantin Popescu and Nikos E. Mastorakis

***Abstract*—** The system of measuring and recording electrical quantities presented in this paper is designed to achieve two goals. The first goal is to acquire specific electrical quantities to the operation of power stations (voltage, current, power, auxiliary contacts for switching elements), processing and transmission of these sizes to a higher level (dispatch, headquarters company, etc) through a support physical data transmission; the sizes taken are used to track continuously the operation of electrical distribution station. The second goal is to acquire synchronous over a specified period, a characteristic set of electrical quantities that appear in phase when the occurrence of damage in the monitored power station, the set of data saved during the deployment of the defect is then transmitted to a computer where data interpretation is made using a specialized program.

***Keywords*—** Data acquisition, Synchronous acquisition, Power station monitored

I. Introduction

The proposed system must provide the following basic requirements [16], [17], [18]:

a) *Opening* the collaboration is possible with other systems, such as the enterprise information system, system software design, control system distribution, system management, process modelling systems, system optimization, etc. and the possibility of extending the functionality. Opening must be present both in terms of hardware (different hardware platforms), software (different operating systems), communications (international standards) and in terms of data management (standards) and applications (possibly interface and provided support for other programs).

b) *Adaptability* which means that is the ability to configure specific components as required, even if these requirements change during the life of the system, the possibility to connect new equipments or software in the existing system.

c) *Providing the necessary data in time* is another important requirement by which appropriate measures can be taken in due time to remove any accidents or unforeseen circumstances.

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d) *Security and data security* is to prevent penetration of unwanted intruders in the system that can lead to disclosure of confidential business information. Also is necessary for the development an archiving system that recorded data can be accessed once and then stored for analysis. Thus, the data were archived can be deleted, this storage offering issued for the system.

e) *Acquired data is the necessary and as less possible*, that the system not be overloaded with unnecessary data. In the same time acquired data must reflect and be able to provide a more comprehensive overview of the system states and events.

f) *The possibility of rapid detection of faults* such as *their accurate* location is another requirement for monitoring system. Also, it should be able to provide all data on the possible elements involved in rectifying the fault.

g) *Simple and convenient interface* with users and the items with similar functions or that refer to similar things are grouped. To better understand the role and position of the system in the process is necessary to make a short presentation of a power station for electricity distribution scheme except that the scheme is hypothetical but the principle it can be applicate to any real state. In Fig.1 is presented a monofilar classical scheme of stations. The station is powered by two power supply lines (LEA1 and LEA2) and has 10 lines of departure for power consumers (LINE1 ... LINE10). The classical structure of electricity distribution station would be one where two power transformers are made at the medium voltage grid of 6 kV or 20 kV and for departures is used the voltage of 380 V. For each of the lines arriving and departing from the station are provided switching devices that provide input and output coupling of the station in accordance with consumer requirements. To supply consumers are provided for coupling two sections of their cells to the mains supply (C1 ... C7 and C10…C16). These sections are virtually identical and allow consumers coupling (a scratch) in two different ways: each set of cell functions independently and is powered to the arrival line properly (LEA1 and LEA2), and the two sets are linked together through cell C8 and C9 and in this case consumers are being supplied power from the Power of the Power LEA1 or LEA2 depending of power switching devices SI1, SI2, that IA1, IA2.

The significance of devices and symbols of monofilar scheme presented is as follows:

- TMUI1, TMUI2 are transformers voltage for input voltage value of the station on each power supply lines and SI1, SI2 are separators disconnect of power on that branch;

- IA1, IA2 are brakers for supply the electric cell section two starting. These devices operate in interdependence with related protective devices mounted on each of supply lines such that decoupling to ensure consumers as soon as possible if they occur from a fault (overload, short circuit, making the earth, etc.). TMCI1, TMCI2 are transformers supply current value of transformers TR1, TR2. Signals together with the value in the secondary supply voltage provided by TMUI1, TMUI2 protection systems are used for power transformers TR1, TR2 and to measure voltage and current value of food.

- TR1, TR2 - power transformers of the two sections of cells, are three phase high power transformers and ensure the adaptation of supply voltage electricity distribution network to consumers rated voltage work. The power of these transformers is a function of input power for consumers in each section. Usually their power is chosen such that more birth defects if a single power transformer can supply all consumers from two sections of beginning with energy for emergency situations. Maybe there was a second version in which each transformer can supply all customers, where the station will be working on only one processor changes on the second being made in an emergency. This applies in particular to supply industrial consumers with continuous fire which can not deprive the supply voltage.

- CI1, CI2, C1 ... C5, C10 ... C14 electric cells, for each of the power lines leaving from station coupling devices that provide consumers the power grid are placed physically in special enclosures that provide protection on the one hand and electrical equipment mounted on the other service personnel protection against electric shock.

- C7, C15 cells measuring for starting voltage by consumers for each section

- C8, C9 cells coupler that provides the coupling of the two sections of cells starting on a single power transformer when requested; C6, C15 cells downloads.

- TC1…TC14 - current transformers for protection from scratch each station and measure current on each of them.

- SP1 ... SP14 dividers making land that are linked whenever the cells are appropriate interventions (interventions, maintenance, service). For their coupling is interconditioning corresponding breaker status (e.g. not be coupled separator if the breaker is closed).

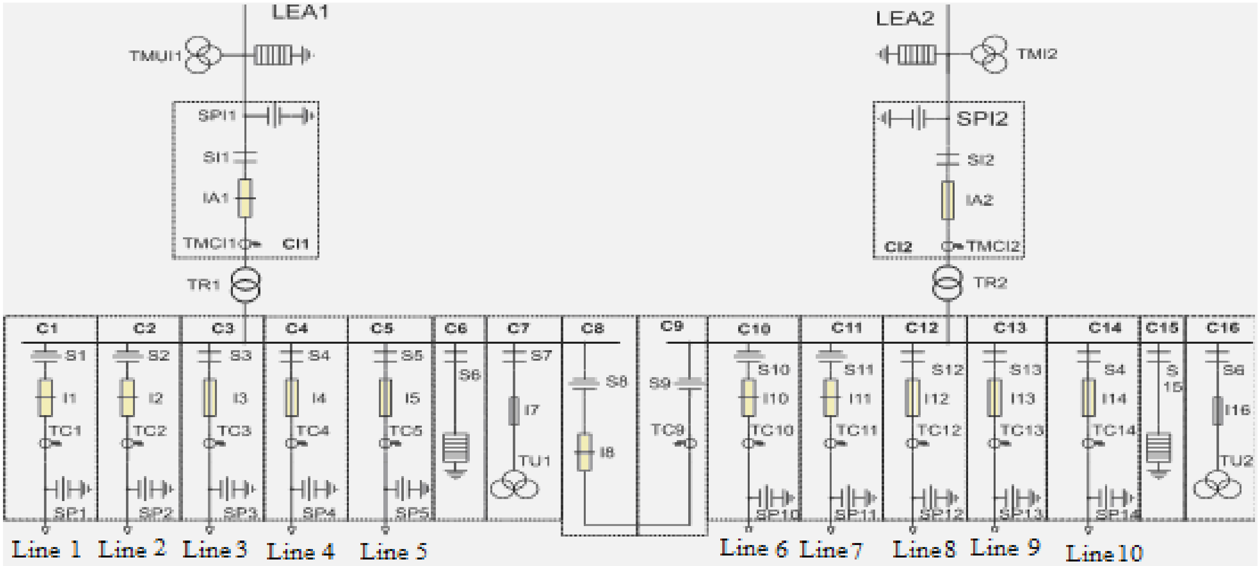

Fig 1: Monofiber schedule for power transformer station.

II. System Description

To achieve two goals at the beginning to design a complex system of procurement, transmission and processing data whose block diagram is shown in Fig. 2. As noted in block diagram analysis of this system consists of the following subsystem: subsystem processing, storage and display data, data communications subsystem, subsystem synchronization of local data acquisition equipment and local data acquisition stations.

Processing subsystem, storage and display data consists of an IBM compatible PC - PC and related software that allows storing, processing, displaying and printing data from a maximum of 247 local acquisition stations in the process. That PC can be integrated into the LAN from the dispatcher, allowing the access of data to authorized users [10], [11], [12].

The subsystem of data communications is made by a equipment to support fibre coupling (an equipment dispatcher and one at each of the cells electrical equipment from the perimeter station supervisor) that ensure communication and safer speed of data processing subsystem and local data acquisition stations. The proposed subsystem is immune to electromagnetic disturbances and provides galvanic isolation of the equipment purchase and equipment of the dispatcher.

The subsystem synchronization of local data acquisition equipment consists of specialized equipment in each power cell and ensure synchronization of all local data acquisition equipment in that house after the universal time taken by the local antenna and GPS modules from satellites. By mounting such equipment shall ensure synchronous data acquisition in each cell of the electrical home and at power station. This thing is extremely useful for analysis of data acquired, allowing the user to follow the propagation of a defect at both station and distribution system-level power.

Local data acquisition stations are specialized equipment synchronous data acquisition of process installed in each cell (two cells power transformers CI1, CI2 and 10 starting cells C1 ... C5, C10 .... C14) of power station supervised. This equipment will be designed such that the data acquisition process to ensure the safe and can achieve the following core functions:

- The measuring function of the following parameters: measuring current (RMS value for the currents on each of 3 phases and neutral current, peak current on each of 3 phases), measuring voltages (phase-zero voltages V1, V2, V3 and phase-phase voltages: U21, U32, U13) measuring frequency and power measurements (active power, reactive power, apparent power and power factor).
- Storing and diagnosis functions. Values stored in the event of a defect must be saved at least the following amounts for the last 3 malfunction: saving the 3 phase currents and neutral current a failure occurs for defect analysis, store sizes: U21, U32, U13, F, P and Q; save sizes taken from digital switching equipment in each cell separately.
- Recording function defects in each cell. For recording function values of the quantities sampled analog and logic states the user can set the following parameters: the event which can trigger recording (either current or any numerical size), registration period before the defect and the number and duration of records (number of records: adjustable between 1 and 3, the total duration of a record: adjustable between 1 s and 20 s - the total of all records must not exceed 20 s , triggering automatic registration, off a record (automatically to achieve maximum time available, on demand by switching digital input prior to any set of user sampling frequency: variable (0.5 ... 2 ms), duration of registration before the defect: selectable from 0 to 99 period, data registered: 4 currents, voltages 4, 16 digital inputs)

Diagnosis functions for breaker. The device saves the following additional parameters: the trigger current cumulative, number of operations and operating time.

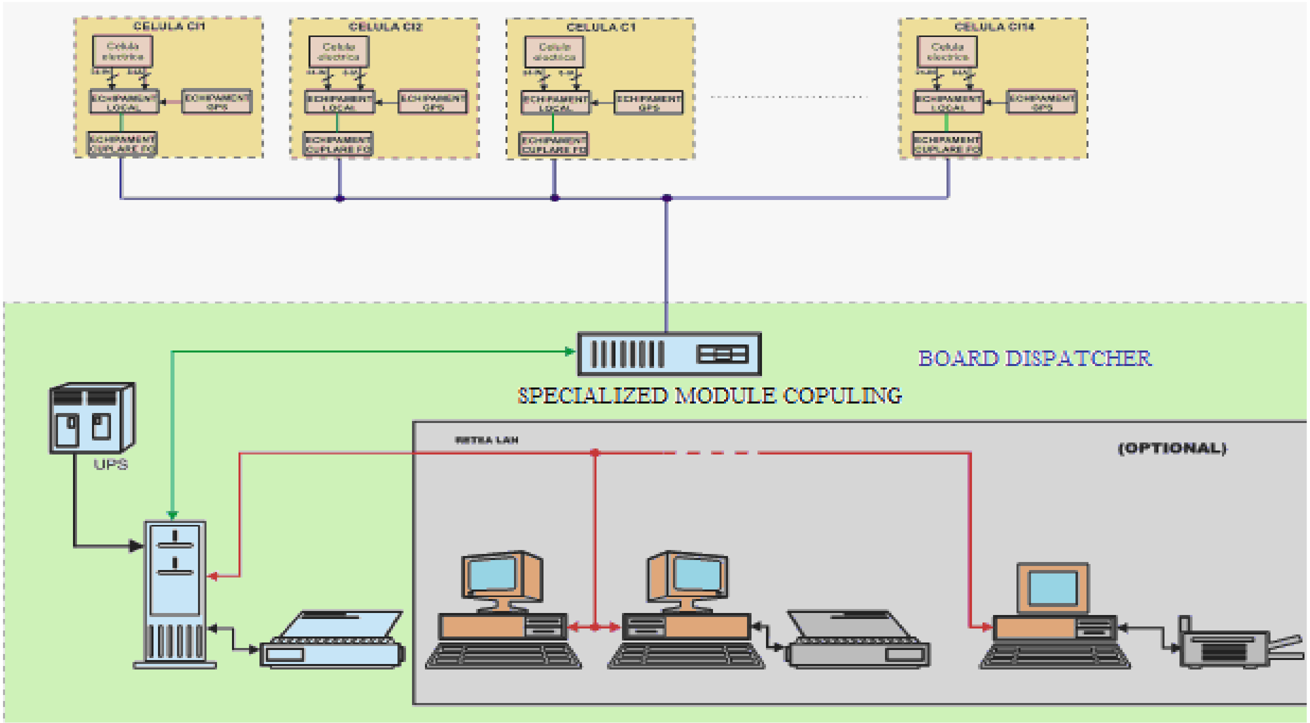

Fig. 2: Block diagram: recording system energy quantities of electric power stations.

Achieving an efficient system of measuring and recording electrical quantities in a gas station, a line of design and technology is subject to completion of equipment performance data acquisition process that can perform all the functions proposed. For the other components of the system (data communication, GPS synchronization equipment computer equipment) there are technical solutions that enable these components to high level. The only problem remains sensitive to the creation of a powerful software subsystem processing, storage and display data must do the following main functions:

- view at all times and real-time power station operation characteristic quantities (currents, voltages, powers, energies, power factors, auxiliary contacts);
- visual and audible alarm if exceeded predetermined threshold for any of the monitored quantities;
- visual and audible alarm in case of equipment defects (failure of communication lines, crash data collection equipment, etc);
- recording information in a database (dispatcher), providing the possibility of data processing computer network server or any workstation connected to network;
- the display in graphical form the quantities taken from the process, the user-defined time period;

- printing charts and graphs consumer specific user-defined time period to a colour printer;
- interconnect in a computer network and transmitting data at a higher level.

III. Acquisition of Signals from Process

A. Signals taken

Monitoring the parameters of the system requires the purchase of a large number of sizes, electric and nonelectric parameters can be monitored using software powerful dedicated monitoring [9]. To can monitoring the operation of power stations, it is necessary to take the largest possible number of signals that describe the state in which the switching elements in cells supervised at a time. The signals taken can be digitals (contact type relay) which describe the state in which the breakers, separators, control buttons, etc. Electrical analogue of the cell taken through the transducer and signal conditioning circuits, points of interest. Signals collected from each cell in the electric station is digital signals (relay contact type) in number 24 and number 8 analog signals.

B. Transducers used

For taking tension transducers it used for measuring voltage transformer type existing in cells measuring voltage at power station circuits on both arrival and departure sections of the station cells. Voltage transformers are of special construction providing galvanic isolation between input and output circuit in less than 1% accuracy class, type UN/100Vef, where UN is the nominal voltage of the primary.

For the acquisition of currents are used current transformer type transducers mounted on the power circuit of transformers TR1, TR2 and the output of each cell lines in part LINE1 ... LINE10.

These current transformers are of special construction providing galvanic isolation between input and output circuit in less than 1% accuracy class, the type IN/5Aef or by type IN / 1Aef, where IN is the primary nominal current. The measuring transformers are mounted on bars of power consumer after the breaker which coupling the consumer to the mains supply voltage [4], [5], [6], [7].

IV. Local Data Acquisition Equipment

The block diagram of data acquisition local equipment that can perform all the functions proposed is shown in Fig. 3. Electrical signals collected from each of the cells constituting the electric power station are two categories [11], [12]:

- analog signals: 4 current signals directly taken from the measure transformers on the departure of the cell line (depending on the type substations these signals are received at the entrance station In/5Aef type or type In/1Aef, where In is nominal current on the going line of the cell line) and 4 voltage signals talked directly from the voltage converters measuring line (type Un / 100Vef).
- digital signal type relay contact and describe the position of each electrical equipment installed in the cell (protection, switches, load separators, separators for making the earth).

Analog and digital signals from the measuring transformers are applied to the inputs of each local station data acquisition through specialized adaptation blocks.

To ensure accuracy for analog signals taken from the process they are applied to the entry in your local data acquisition in two distinct ways: to the entry of energy metering quantities and to the block entry adapting analog signals. This think is necessary because at the time of occurrence of a defect (e.g. a cage on the outlet of a cell) the pack instant for current and voltage can reach very high values which must be measured to achieve an accurate analysis of defect. Because these sizes can have up to 30 ... 40 times then face value of such size is necessary to provide a separate block adjusting input signals that can retrieve these values. Accuracy of measurement in these cases is not large, but significant flaws in the analysis is to reproduce as accurately waveform signals from entering the station less important is the precision with which we take these quantities. For these practical considerations in the local station data acquisition system is implemented two energy value applied measure systems applied to input quantities. An accurate measurement of large-format sizes metering energy

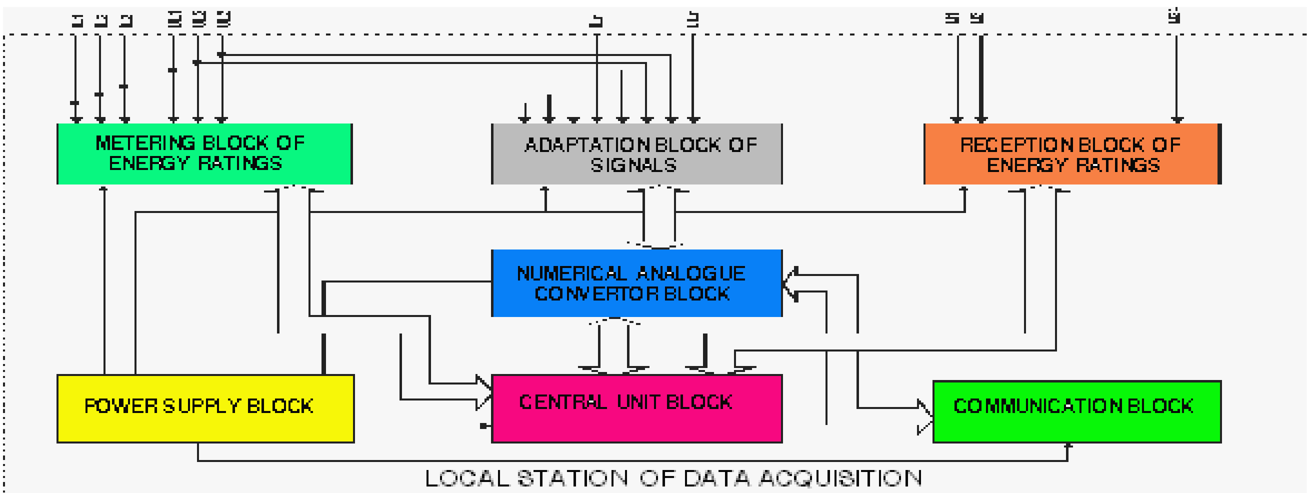

Fig. 3: The block diagram of data acquisition local equipment.

central mode that provides energy for the cases of sizes taking normal operation and a measure of energy quantities for emergency situations comprising adjusting block analog signals, Block Converter analog digital, central block. The two measure systems operate in parallel and the central unit extracts data from one of them according to actual situation (normal operation or fault).

The block sizes as energy is a complex block which ensures the acquisition of the current energy (3 current and 3 voltage) during the operation without damage of electrical cell supervised. Block provides a more accurate measure, accept at the input signals in 0 ...1,2 In and 0...1,2Un and is able to perform the following functions: electrical isolation of the analog input to your local procurement process, adjustment signals received at the entrance with the entrance into account the current energy blocks in an area of 0 ... 1.2 In (for the currents) and 0 ... 1.2 Un (for tension), filtering input signals, continuously calculating actual values for pack applied to the input, continuously calculating the quantities of direct quantities (active power, reactive power, power factor), always calculating the derived quantities (active power, reactive power, voltage line , line current, maximum values of measured and derived quantities for a preset time), sending the processed data to the central unit module whenever it is requested. Time of acquisition in this case is large, important being accuracy of data acquisition.

Adaptation block analog signals received at input the same information as the block size as energy, but provides for a range of input signals as much (for 0 ... 40In currents and for voltages 0 ... 2.2 Un) and provides the following functions: electrical isolation of the analog input to your local procurement process, adjustment to input signals received by the entry in block digital analog converter in a range of 0 ... 40 In (for current) and for 0...2.2Un (for tension). Time of acquisition in this case is very small, important being taking a large number of samples for each the size of entry during damage.

Digital signal adaptation block provides the following functions: electrical isolation of the digital input to your local procurement process, adjustment the input signals received by the input of the module unit and filter input signals. Analog digital converter is made by a 8 to 14 bit digital analogue high speed. Acquisition of data from order entry module is synchronous to UC so that subsequent analysis of data acquired can allow recovery of as a precision waveform signal applied to the entry block converter. For analysis of finesse is absolutely mandatory simultaneous acquisition of data from the 8 block entry of numerical analog conversion. Block contains in addition to the specific modules of 8 converters and signal conditioning modules, input and numerical data transfer to UC module.

The central unit module ensures the proper functioning of the local station data acquisition. The module is built around a powerful 32-bit processor from Motorola 8086 family and provides the following main functions:

- purchase order synchronous data taken from the process when an event occurs (a certain number entry or a value greater than the amount prescribed for a pack of analog input);
- store acquired data in its memory work (its maximum capacity is 16 MB) and transmission to the dispatcher computer system in the shortest possible time (normally within 30 sec.) recorded data such that state to be prepared to answer a new event
- transmission to the dispatcher computer system, any timing errors Station after time over the subsystem Universal GPS (Global Position System) devices to synchronize local data [11].
- processing, under normal working (missing events) energy information specific to the cell supervised and their transmission to the dispatcher to track the on-line activity energy

The communication block is a specialized module that ensures information transmitting from and to the dispatcher in minimum time with maximum safety and maximum protection from electromagnetic disturbances. The block ensures the identification of a maximum of 255 local data acquisition stations that can be mounted simultaneously in a power distribution station electrical. The speed of transmitting

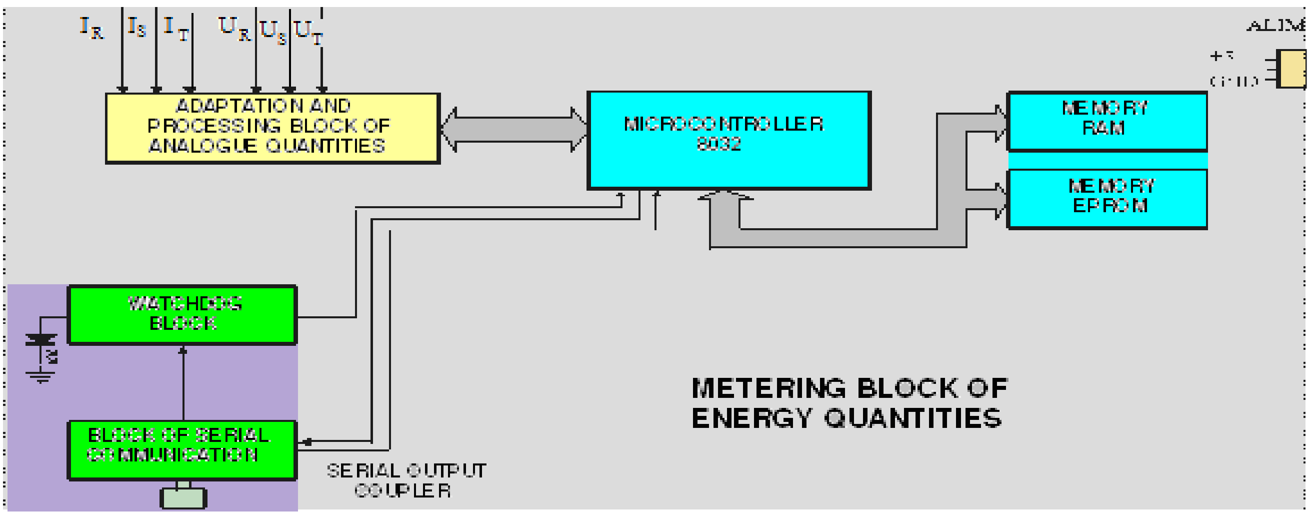

Fig. 4: Block sizes measuring energy.

information on optical medium that provides the link between local stations and purchase computer equipment from the dispatcher, is 10 .. 100Mbps.

Proper functioning of the station is ensured by a power source that provides the necessary supply voltages system of each building blocks station. The source is the special construction equipment operating in industrial environments with greater tolerance to electrical and electromagnetic disturbances.

V. The Measure Energy Quantities

Energy metering size is designed for taking specific electrical quantities of electrical distribution stations being used for their monitoring and energy measurement**.** The measurement block performed the following main functions [1], [2], [3]:

- takeover a number of 6 sizes from transducers mounted analogue stations supervised electrical (voltage, current), primary processing of quantities purchased and working memory storage period of time, in accordance with an own algorithm included in the program memory of the equipment (typical values during storage and processing results is that between two successive data transmissions to the dispatcher), and values of type sizes to save energy for a period of time much greater;
- transmitting acquired and stored data in central module of the station local data acquisition through a high-speed serial links.

Diagram of this component of the local station data acquisition is shown in Fig.4. The block operation is ensured by a 8032-type microcontroller, around which are located a number of other electronic circuits which function module properly and all equipment.

The program is part of EPROM memory with a capacity of 32 kB and is given by a single integrated circuit and data memory RAM module 32 also has the ability kB and ensures an integrated circuit, which is used to maintain the values acquired the process during the second data to the central unit of the local stations. Communication with the central unit is done through the serial communication block. It provides data communication between the two components of the station at high speed so that when the central unit is busy taking data from metering is minimal. A essential block for the proper functioning of the block is WATCHDOG module) which is to issue a RESET signal to the microcontroller when a step included in the program EPROM memory is not running a certain time frame, and automatically reinstituted its implementation the end. The module is extremely useful especially for data acquisition equipment working in environment with high levels of disturbance on power circuits which can penetrate the food source, disturbing the operation of equipment.

Adaptation and processing block is a block size analog complex electrical quantities witch measured and calculated all of the network of cell-phase electric power station which is connected (Fig. 5). The block is built around the integrated circuit ADE 7758 (ANALOG DEVICES), which is a complex circuit able to calculate all sizes specific power three phase network. Analog input signals are applied to enter the circuit through signal adapter. Three-phase currents are applied by means of current transformers which are adapting to the 5A level signal to 500mV. Output voltage signal from current transformers is applied to the inputs of three amplifiers PGA1 are variable gain amplifiers with differential input. Amplifiers accept to the input differential signal with maximum amplitude of 500 mV. Range of amplification for these amplifiers is 1.2 or 4. Amplifier output is applied to the 3 analogue inputs 24 bit synchronous digital sign which differential input can be set to turn in three areas (+0.5, +0.25 V or 0125 V) in accordance with the gain set for amplifiers Entry PGA1. Change fields for entering the converters are achieved by changing the voltage reference to the converter. Voltage signals are applied through resistive dividers at the entrances of three amplifiers PGA2 which are variable gain amplifiers with differential input.

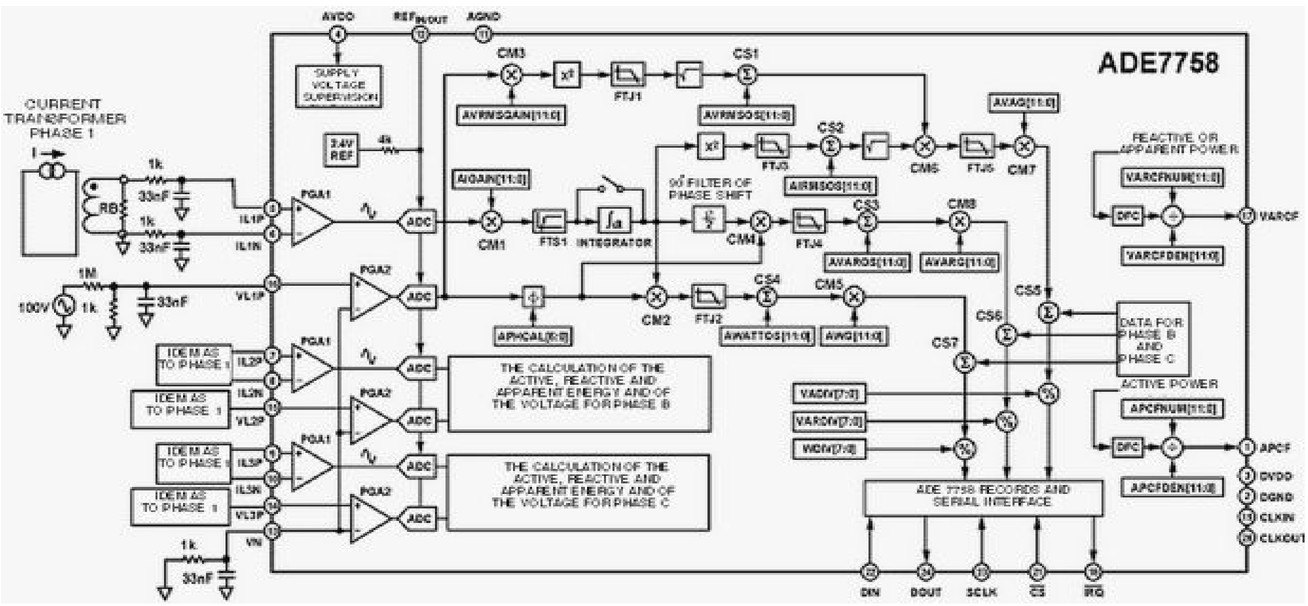

Fig. 5: Block diagram of the module to adapt and processing analog magnitudes.

Amplifiers accept to the input differential signal with maximum amplitude of 500 mV. Range of amplification for these amplifiers is 1.2 or 4. Amplifier output is applied to the 3 analogue inputs 24 bit synchronous digital sign which differential input can be set to turn in three areas (+0.5, +0.25 V or 0125 V) in accordance with the gain set for amplifiers entry PGA2.

At the analog outputs of the 6 synchronous digital converters we obtain the numerical value at any time with mark of applied voltages and currents from entering the circuit. The numeric value at the out converters may vary between 0xd7AE14 (HEX) (-2,642,412) and 0x2851EC (HEX) (2,642,412). As of now all calculations which are made for obtaining energy parameters are numerical. To can perform these calculations in time as small, the circuit is constructive with a DSP processor inside. At the each out of the 6 CAN it obtain samples of the quantities entering the circuit with variable sampling rates. Are possible, depending on subsequent calculations required, use one of the following sampling rates: 26 KSPS, 13 KSPS, 6.5 KSPS and 3.3 KSPS.

Current channels. Sampled signal is obtained in three different sizes used for subsequent calculations: a size which is used to calculate the RMS value of current on each phase, one size to save in a special register containing the current waveform and a magnitude that later use in calculating active and reactive power. Each of these sizes is scaled by multiplier CM1 with a value contained in register AIGAIN following relationship:

$$\text{Current waveform} = ADCout \times \left(1 + \frac{AIGAIN}{2^{12}}\right) \quad (1)$$

This applies to all three current inputs. The value scale is applied as a filter entry number goes up FTS to eliminate DC offset, and leaving it to the entry of an integrator.

Voltage channels. Appropriate signals for each channel voltage input channels are applied in two directions: for active and reactive power measurement, the signal from the ADC output goes directly into two multipliers CM2 and CM4, the signal is applied to enter the circuit for calculating the RMS voltage (CM3 multiplier entry). The circuit is equipped with detectors applied to the input signal crossing zero. This is used for calculating the phase angle between voltage and current in each phase and it's still effectively used to calculate active and reactive powers. Also, zero crossing detection signal input is used to calculate the frequency of signals applied to input. For each of the signals applied to the input (current and voltage) circuit is able to detect and save the maximum amount of signal on a defined number of times each of the three phases. Signals using zero crossing detection signal circuit are able to detect the correct sequence of phases and transmit it to subsequent processing.

The calculation of RMS values of input quantities. RMS value of a continuous signal is calculated by the relationship:

$$FRMS = \sqrt{\frac{1}{T}\int_0^T f^2(t)dt} \quad (2)$$

For signals sampled in time, the calculation involves raising squared RMS value of the samples, obtaining their environment and then extracting the square root.

$$FRMS = \sqrt{\frac{1}{N}\sum_{n=1}^{N} f^2(n)} \quad (3)$$

The method used for calculating the RMS value of signals applied to the ADE 7758 circuit entrance is passed through a low-pass filter (FTJ1, FTJ3) of the square input signal and then extracting the square root of the result.

If $i(t) = \sqrt{2} \times IRMSx\sin(\omega t)$ then

$$i^2(t) = IRMS^2 - IRMS^2\cos(\omega t) \quad (4)$$

RMS calculation is done simultaneously for all six input channels. Each result is saved in registry AIRMS, respectively AVRMS the current tension on phase 1, BIRMS, respectively BIRMS the current tension on phase 2, CIRMS, CVRMS for current voltage on phase 3 respectively. The circuit has the possibility to compensate the offset error for each of these values by the values contained in registers AIRMSOS, AVRMSOS for phase 1, BIRMSOS, BVRMSOS for phase 2 and CIRMSOS, CVRMSOS for phase 3.

Calculation of power and active energy. Electrical power is given by the product of the waveform of voltage and current. The resulting waveform is called the instantaneous value of power and is equal to the energy consumed per unit time. The following equations describe the instantaneous power signal expressions in an alternative system [8]:

$$v(t) = \sqrt{2} \times VRMS \times \sin(\omega t)$$
$$i(t) = \sqrt{2} \times IRMS \times \sin(\omega t) \quad (5)$$

where VRMS is the value of RMS voltage and IRMS is the value of RMS current.

$$p(t) = v(t) \times i(t) =$$
$$= IRMS \times VRMS - IRMS \times VRMS \times \cos(2\omega t) \quad (6)$$

power consumed by a number of n cycles is given by the equation:

$$P = \frac{1}{nT}\int_0^{nT} p(t)dt = VRMS \times IRMS \quad (7)$$

where, *t* is the time signal and *P* is defined as active power or real power.

Active power is equal to the DC component of instantaneous active power signal *p*(*t*), VRMS × IRMS. This is in fact the relationship with the circuit ADE7758 calculates active power for each of the three phases. DC component for each of the three phases is extracted using low-pass filters applied FTJ2 out multiplier CM2. Active power on each of the three phases is acquired in three registers AWATTHR, BWATTHR and

CWATTHR. If given that the circuit continuously accumulate registry AWATTHR, BWATTHR and active power CWATTHR samples then will write the relationship:

$$Energy = \int p(t)dt = \lim_{t \to 0} \left\{ \sum_{n=0}^{\infty} p(nT) \times T \right\} \quad (8)$$

where n is the number of samples and T is the distance between two samples.

Calculation of power and reactive power. The following equations give the instantaneous reactive power expression in alternative systems the current phase is shifted by 900.

$$\begin{aligned} v(t) &= \sqrt{2}V \sin(\omega t - \theta), \\ i(t) &= \sqrt{2}I \sin(\omega t), \\ i'(t) &= \sqrt{2}I \sin(\omega t + \frac{\pi}{2}) \end{aligned} \quad (9)$$

where: V is RMS value of voltage, I is the RMS value of current and θ is the phase shift caused by the reactive elements of the load.

Under these conditions the instantaneous reactive power $q(t)$ is given by the following equation:

$$q(t) = v(t) \times i'(t) \Rightarrow$$

$$q(t) = VI\cos(-\theta - \frac{\pi}{2}) - VI\cos(2\omega t - \theta - \frac{\pi}{2}) \quad (10)$$

or

$$q(t) = VI\sin(\theta) + VI\sin(2\omega t - \theta) \quad (11)$$

where i' is the current with phase shifted by 900.

The mean reactive power consumed by a number of cycles (n) is given by the following equation:

$$Q = \frac{1}{nT}\int_0^{nT} q(t)dt = V \times I \times \sin(\theta) \quad (12)$$

where T is the signal period alternately, and Q refers to the average reactive power.

The value of instantaneous reactive power $q(t)$ is generated by multiplier CM4 at which entry applies the signal voltage and current signal offset 900 for each of the stages of entry. DC component of the instantaneous reactive power signal is extracted by low-pass filter to obtain information FTJ4 the average reactive power on each of three phases. Reactive power on each phase is accumulated in some special registers (AVARHR for phase L1, L2 and BVARHR phase CVARHR phase L3). Data from these registers can be used for further processing. Reactive power is defined as the integral of reactive power. Similar to the calculation circuit ADE7758 active energy integral signal carried by accumulating reactive power reactive power signals in some special registers. This accumulation at discrete intervals of values of reactive power is equivalent to the signal integration time. Relationship describes this:

$$\text{Re}\,activeEner\ gy = \int q(t)dt = \lim_{T \to 0}\left\{\sum_{n=0}^{\infty} q(nT)xT\right\} \quad (13)$$

Calculation of power and apparent power. There are two ways to calculate the apparent power. The method uses mathematical product of voltage and current RMS values as shown in the following equation:

$$S = VRMS \times IRMS \quad (14)$$

where S is apparent power.

Vector method uses the square root of sum of squares extraction of active and reactive power:

$$S = \sqrt{P^2 + Q^2} \quad (15)$$

where, S is apparent power, P is active power and Q is reactive power.

If the system is purely sinusoidal two methods give the same result. The circuit (ADE7758) using the first method of calculation. Values for apparent power on each phase are accumulated in registers AVAHR phase L1, L2 and BVAHR phase CVAHR stage L3. Apparent power is defined as the integral of the apparent power. Similar to those shown in the active and reactive power calculation of this integral is the apparent power by accumulating values in special registers. Relationship describes this:

$$AparentEnergy = \int S(t)dt = \lim_{T \to 0}\left\{\sum_{n=0}^{\infty} S(nT)xT\right\} \quad (16)$$

VI. CONNECTING THE SYSTEM FOR MONITORING

The device takes electrical variables. The module is an electronic device with a microcontroller that communicates through a RS485 bus with the computer that controls the system. The device is connected for measuring the currents with current transformers, and the charging voltages are actually the three phases. On the measurement, supplying and also communication sides, the device is optical galvanic isolated or isolated through the transformer. The device has a unique address in the system which is hardware configured with jumper-e when is connected. The addresses are from 0 to 255 for this type of devices [19], [20].

Module is the most complex module; it monitors the electricity consumption, power pack and even waveforms which are provided by a network of devices. Each device has a different address and the application interrogates them asking for necessary information. The information which is received by a point of measurement is very well summarized by a screen which represents that point of measurement.

As we can observe, this screen shows momentary values currents, cos(φ), powers, voltages for each phase and the daily and monthly values (Fig. 7).

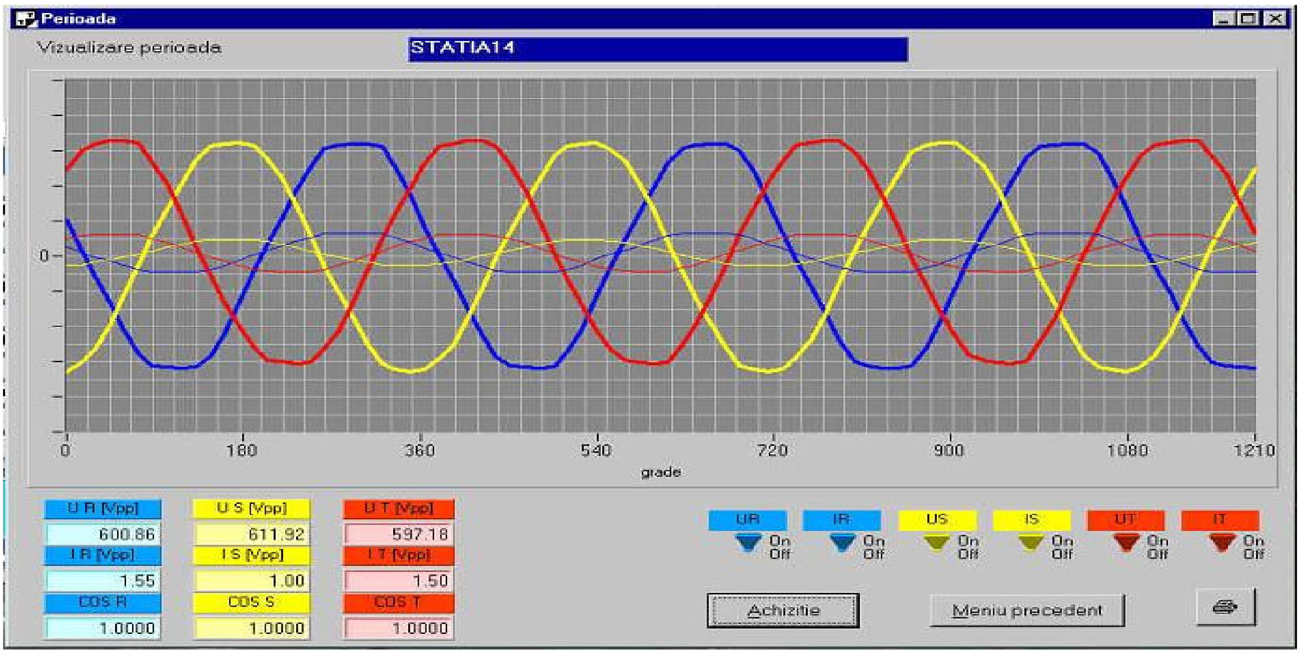

Fig. 7: Interface - records.

All these values are recorded daily in a file every quarter of an hour or if the system configuration is chosen for all records, then the information from each query of that point are saved. The information stored in a daily report file are: address, name, date and hour, minute, second of the point of measurement; active and reactive power cost of energy for the phases; active and reactive power at that time.

All these quantities are stored for each measurement point and for certain groups of points of measure or the whole system if the application was configured to do so. They will appear in relation to the assigned name of the configuration and virtual addresses that are not found in the domain addresses for points of measurement (for the system is used the 999 address and this may be baptized with the name of the enterprise "Company"). Besides the above measurement it can view the statistical curve for current day and current month. An interesting element is represented by the possibility of viewing waveform of voltage and current.

VII. Conclusion

In conclusion, according to the previously submitted work, the special registers of the circuit are at any time any information relating to voltage and current signals applied at the entrance to each of the three phases. At any time is available a set of numerical values which completely describe in terms of energy, which is coupled process of getting your local. The available data in various registers of the circuit can be used at any time for further processing. The system described in the paper maybe is flexible and can be adapted to monitor electrical quantities in most of the electricity distribution stations.

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