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CONTRIBUTIONS TO DATA ACQUISITION AND CURRENTS AND VOLTAGES PROCESSING IN AN ENERGY MANAGEMENT SYSTEM

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CONTRIBUŢII PRIVIND ACHIZIȚIILE DE DATE CURENȚI ȘI TENSIUNI ȘI PRELUCRAREA ÎNTR-UN SISTEM DE MANAGEMENT ENERGETIC

Articolul prezintă un sistem de achiziţie şi de prelucrare pentru tensiuni şi curenţi de la o rețea electrică de joasă tensiune, o structură dezvoltată pentru a fi integrată într-un sistem complex de gestionare a energiei.
Pentru a asigura o flexibilitate sporită, sistemul este modular şi este complet personalizabil de software. Toate componentele sunt module compatibile, toate semnalele de intrare/ieşire sunt standardizate (0 .. 100V AC, 0 .. 5A AC şi 4 .. 20 mA - semnal unificat). Toate modulele sunt interschimbabile, tipul de configuraţie de intrare se introduce uşor prin aplicarea interfaței prietenoase.
Sistemul constă dintr-un set de semnal, un card de achiziţie de date şi un calculator personal. Toate conditionat au ieşire în semnal unificat, şi placa de achiziţie de date comunică cu computerul prin intermediul unui port serial (RS232 sau în cazul în care există un risc ridicat de interferenţă, RS485). Pe PC-ul se execută o aplicaţie cu interfaţă prietenoasă, responsabil de configurarea sistemului şi de stocare a datelor.

Cuvinte cheie: achiziții de date, de semnal unificat, de control a tensiunii
Keywords: data acquisition, unified signal, voltage monitoring

1. Introduction

The conception of a modern energy system, appropriate for the 21st century could contribute to re-establishing a balance between energy, human wellbeing and environment. This article presents an acquisition and processing system for voltages and currents from a low voltage electrical network, a structure developed to be integrated into a comprehensive energy management system [1]. The ultimate goal is the design of a power system which can efficiently use available energy sources (both classical and renewable) in powering the consumers without blackouts.

2. Problem description

Any energetic management system must include a component for monitoring the electrical parameters, with a high enough precision. Also, these parameters must be converted to the digital format, in order to be used for making decisions in the process of energy management.

3. Suggested solution

The system is based on acquisition equipment developed around a RISC microcontroller (PIC18F8722) [2]. The acquisition equipment has the following features:

- 16 galvanically isolated digital inputs with LED status indicator;
- 16 digital outputs for relay with LED status indicator;
- Alphanumeric LCD display;
- FRAM type memory for nonvolatile storage of data;
- 8 differential current analog inputs, with the accepted input domain 0 .. 20 mA.

Analogue inputs are such designed that signals acquired with the acquisition equipment can be applied at the same time, through series, to other devices with analog current inputs, provided that the total resistance of the analog inputs does not exceed 500 Ω. On the 8 analog inputs can be connected in any configuration the signal conditioning modules, that have as main function the transformation of current or voltage signal in unified signal, with the variation range of 4 .. 20 mA.

The current signals, after adapting through functional blocks of the acquisition equipment, are acquired by the microcontroller via the analog inputs and send as serial data packets with a fixed format to a computer that is responsible for monitoring and storage of data in order to generate reports. In other words, the system is built on 3 levels (figure 1):

- level 0 consists of signal conditioning blocks;

- level 1 is responsible for data acquisition and primary processing, and consists of acquisition equipment and the associated firmware;
- level 2 consists of a computer and the software for monitoring data storage and may contain a printer for printing occasional or periodic reports.

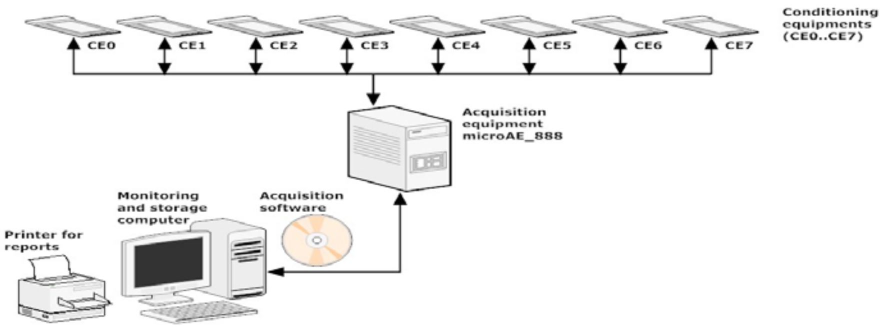


Fig. 1 Structure of the acquisition system

4. Signal adapting blocks

Adapting blocks turn standard AC signals (0 .. 100 V AC in voltage and 0 .. 5 A AC for current respectively) in unified current signals [3] in the domain 4 .. 20 mA. Such a signal conditioning block is composed of the following blocks (figure 2):

- Current or voltage transducer (T);
- Amplifier Block (A1);
- RMS value converter block in current value (C1);
    - Amplifier Block (A2);
    - Converter voltage/current (C2).

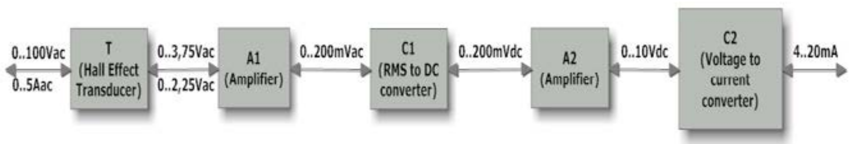


Fig. 2 The signal conditioning blocks

The transducers used are Hall effect sensors with high conversion precision (below 0.2 %). Amplifiers were made with lownoise operational amplifiers. Conversion from AC to DC is performed by a great accuracy converter (± 0.3 %).

To ensure greater flexibility of the system, the signal conditioning blocks were made modular, so each block is removable and is also completely galvanically isolated from the measurement line.

Signal adapting blocks power is unipolar in a large range: 18-36 V DC.

Mounting of signal conditioning blocks is standard on 35 mm DIN rail.

All components used for the entire assembly are designed for use in an extended temperature range (-40 ÷ 80 ºC).

Fig. 3 The current adapting block (0..5V AC - 4..20mA)

5. Data acquisition equipment

The data acquisition and initial processing equipment is done around the PIC18F8722 microcontroller (figure 4). The equipment was designed to use in maximum of the resources available to the microcontroller [4].

Considering that all component modules of the system are connected to an electrical network, which can be a powerful source of electromagnetic disturbances, all the building blocks of the system were galvanically isolated to each other. Isolation of signal conditioning block was performed at the voltage and current, transducers, respectively. It was also performed the galvanic isolation of the computer towards the acquisition equipment by using high-speed optocouplers on both serial ports of the microcontroller [5]. On one of the ports a driver was used to convert TTL signals in RS232 signals (figure 5), and on the second it was used a use RS485 driver [6] (figure 6).

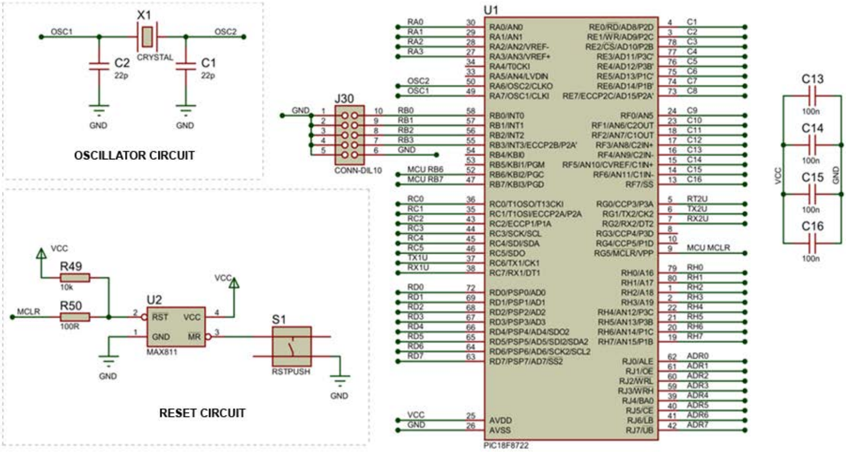


Fig. 4 The connection of RESET circuit and external oscillator to the microcontroller

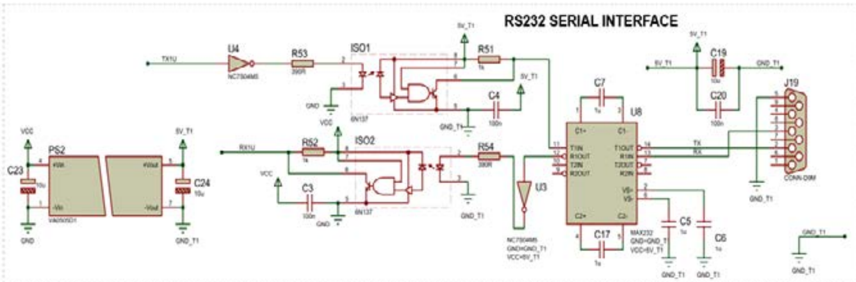


Fig. 5 Galvanically isolated RS232 port

6. Data monitoring and storage software

To monitor the acquired electrical parameters it was developed a wide-range Windows application for monitoring data and their storage, which can now handle up to 8 analog admeasurement and 63 logic states.

Number of admeasurements that can be managed is currently limited by the format initially required for data package [7].

The admeasurements can be viewed in graphical form through specific Windows application objects (groups, buttons, scroll bars).

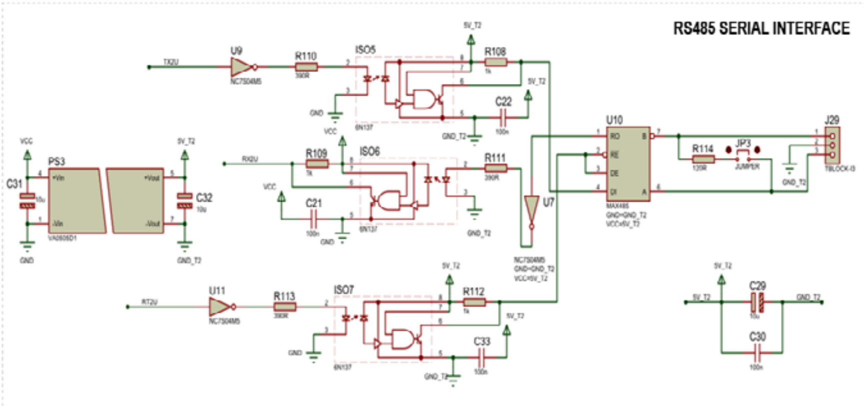


Fig. 6 Galvanically isolated RS485 port

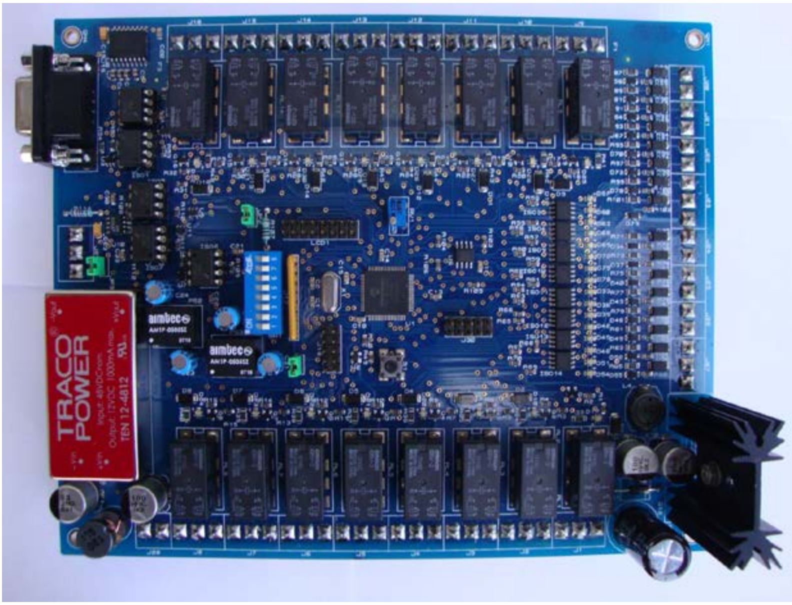


Fig. 7 Data acquisition equipment

The connection with acquisition equipment is serial via a COM port of the computer. If the computer is not equipped with this type of port, virtual ports specific to converters are supported (eg USB - RS232 converter, or Ethernet - RS232). Each data packet has a specific format that begins with 2 bytes that signify the beginning of the packet, followed by 7 data bits (most significant bit of each byte of data is zero) and finally the checksum (CRC) [8].

At the first execution of the application a configuration file is created which contains the serial port settings to use, but also contains the application's main labels, that can be edited at any time.

Besides monitoring by virtual instruments, the data can be also tracked through diagrams. Thus, the system can track simultaneously up to 16 channels (8 analog, with up to 6 digital channels).

The graphic object used to implement virtual oscilloscope has all the functionality of such an instrument and some additional features [9] (figure 8):

- acquisition can be started/stopped at any time by the operator;
- signal capture can be moved in any direction on any of the axes X and Y;
- all features of the “ZOOM” function (zoom in, zoom out, zoom all, zoom box);
- cursors can be used that show the values for any of the signals acquired;
- the graphic image can be copied to the clipboard;
- the picture (current screen) can be saved as a graphics file;
- the image (current screen) can be printed to a printer.

The data viewed through virtual oscilloscope can also be stored in text files in CSV format, which allows both viewing in a normal text editor (figure 9) as well as importing the data into specialized spreadsheet programs that supports such a format - for example Microsoft Excel (figure 10).

Using such software, data can be processed very easily, both statistically and graphically.

7. Conclusion

The system successfully acquired electrical data from the sources during the tests, with a high level of precision. Due to user friendly computer interface, the system can be used both in industrial and household applications, and can be used by persons without special training.

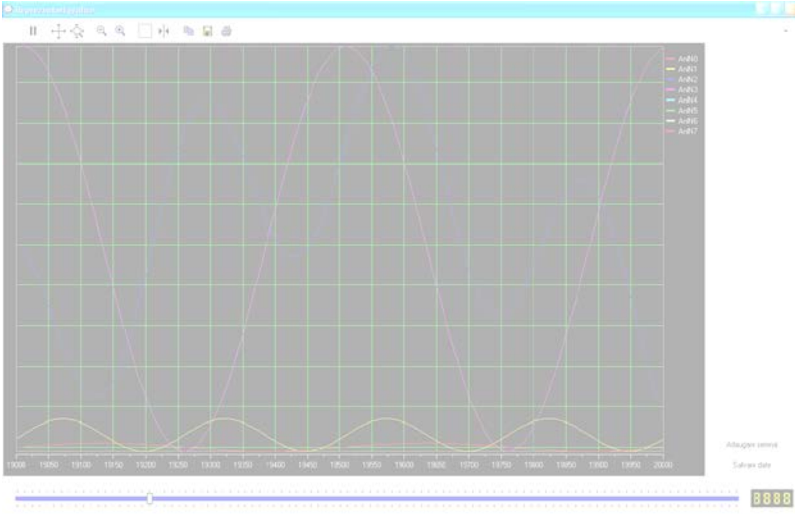
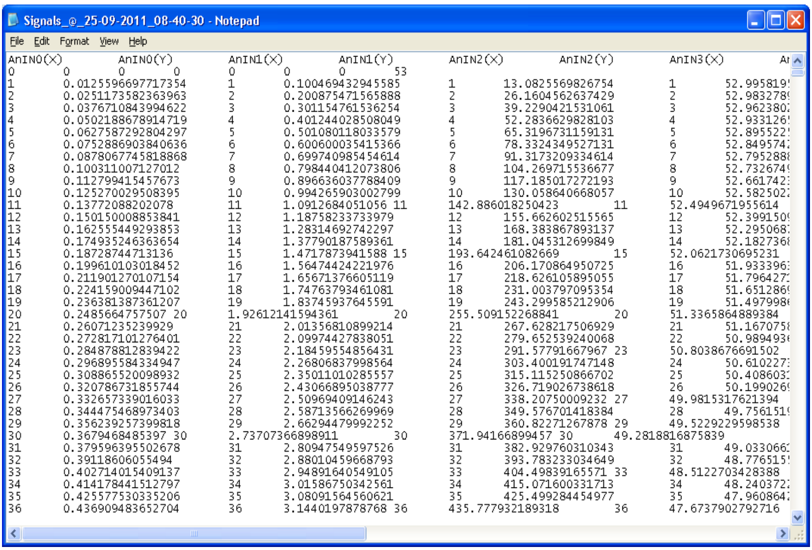


Fig. 8 The virtual oscilloscope used in the monitoring application

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AnIN0(X)  AnIN0(Y)            AnIN1(X)  AnIN1(Y)            AnIN2(X)  AnIN2(Y)            AnIN3(X)  An
0         0         0         0         0         0         0         53
1         0.0125596697717354  1         0.100469432945585   1         13.0825569826754    1         52.995819
2         0.0251173582363963  2         0.200875471565888   2         26.1604562637429    2         52.983278
3         0.0376710843994622  3         0.301154761536254   3         39.2290421531061    3         52.962380
4         0.0502188678914719  4         0.401244028508049   4         52.2836629828103    4         52.933126
5         0.0627587292804297  5         0.501080118033579   5         65.3196731159131    5         52.895522
6         0.0752886903840636  6         0.600600035415366   6         78.3324349527131    6         52.849574
7         0.0878067745818868  7         0.699740985454614   7         91.3173209334614    7         52.795288
8         0.100311007127012   8         0.798440412073806   8         104.269715536677    8         52.732674
9         0.112799415457673   9         0.896636037788409   9         117.185017272193    9         52.661742
10        0.125270029508395   10        0.994265903002799   10        130.058640668057    10        52.582502
11        0.13772088202078    11        1.0912684051056 11  142.886018250423    11        52.4949671955614
12        0.150150008853841   12        1.18758233733979    12        155.662602515565    12        52.399150
13        0.162555449293853   13        1.28314692742297    13        168.383867893137    13        52.295068
14        0.174935246363654   14        1.37790187589361    14        181.045312699849    14        52.182736
15        0.18728744713136    15        1.4717873941588 15  193.642461082669    15        52.0621730695231
16        0.199610103018452   16        1.5647442422197 6   16        206.170864950725    16        51.933396
17        0.211901270107154   17        1.65671376605119    17        218.626105895055    17        51.796427
18        0.224159009447102   18        1.74763793461081    18        231.003797095354    18        51.651286
19        0.236381387361207   19        1.83745937645591    19        243.299585212906    19        51.497998
20        0.2485664757507 20  1.92612141594361    20        255.509152268841    20        51.3365864889384
21        0.26071235239929    21        2.01356810899214    21        267.628217506929    21        51.167075
22        0.272817101276401   22        2.09974427838051    22        279.652539240068    22        50.989493
23        0.284878812839422   23        2.18459554856431    23        291.57791667967 23  50.8038676691502
24        0.296895584334947   24        2.26806837998564    24        303.400191747148    24        50.610227
25        0.308865520098932   25        2.35011010285557    25        315.115250866702    25        50.408603
26        0.320786731855744   26        2.43066895038777    26        326.719026738618    26        50.199026
27        0.332657339016033   27        2.50969409146243    27        338.20750009232 27  49.9815317621394
28        0.344475468973403   28        2.58713566269969    28        349.576701418384    28        49.756151
29        0.356239257399818   29        2.66294479992252    29        360.82271267878 29  49.5229229598538
30        0.3679468485397 30  2.73707366898911    30        371.9416689945 7 30 49.2818816875839
31        0.379596395502678   31        2.80947549597526    31        382.929760310343    31        49.033066
32        0.39118606055494    32        2.88010459668793    32        393.783233034649    32        48.776515
33        0.402714015409137   33        2.94891640549105    33        404.49839165571 33  48.5122703428388
34        0.414178441512797   34        3.01586750342561    34        415.071600331713    34        48.240372
35        0.425577530335206   35        3.08091564560621    35        425.499284454977    35        47.960864
36        0.436909483652704   36        3.1440197878768 36  435.777932189318    36        47.6737902792716
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Fig. 9 Visualisation of the stored data in NOTEPAD

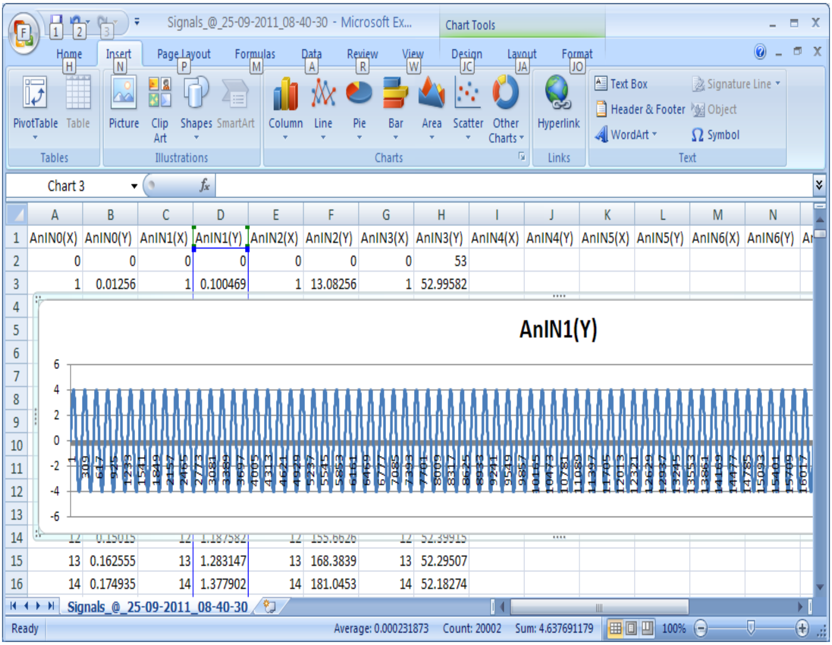

Fig. 10 Visualisation and processing of the data in Microsoft Excel

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