# REMOTE MONITORING SYSTEM OF THE TEMPERATURE OF DETACHABLE CONTACTS FROM ELECTRIC CELLS

***Laurențiu ALBOTEANU, **Florin OCOLEANU, ***Alexandru NOVAC, *Gheorghe MANOLEA**

**Faculty for Electromechanical, Environment and Industrial Informatics Engineering, University of Craiova, **Faculty of Electrotechnics, University of Craiova,***SC PROMAT SA; e-mail lalboteanu@em.ucv.ro; focoleanu@elth.ucv.ro; alexandru_novac@yahoo.com; ghmanolea@gmail.com*

***Abstract*** **– This paper refers to a remote monitoring system of electric contacts with intense currents for eliminating the malfunctions due to imperfect contact and for increasing the security in electrical supply.**
**Most electrical station have been modernized and equipped with modern monitoring equipment and automation.**
**Still at the design stage was envisaged first as automaton for monitoring the temperature on the bars, to can meet operational requirements imposed, on the other hand, to can communicate with other modern automation equipment and monitoring.**
**The comunication of monitoring system with other equipment is accomplished through a MODBUS communication protocol type.**
**Monitoring system can display values of local temperature on the equipement screen, and remote, on the computer screen.**
**Remote transmission of information from local equipement to computer is performed on a serial RS232-485 communication network.**
**The advantage of this system is that local equipment through key can set an allowable limit value of temperature on the bar and to achieve that value of sound or acoustic warning system.**
**The experimental results were obtained in real conditions of operation and showed good functioning of The remote monitoring system of the temperature of detachable contacts from electric cells will be implemented on electric cells manufactured in Romania by SC Automatica SA Bucharest.**

***Keywords: monitoring system, temperature,*** **automation, microcontroller, modbus protocol.**

## 1. INTRODUCTION

The heating of the detachable contacts by intensive currents (1250 – 6300) A from the 0,4 kV screened panels, for inside use and for the distribution of electricity, has become a very important problem [1],[2].
The remote monitoring system will signal acoustically the overheating of the contact according to SREN 60529-1995.
In this remote monitoring system, a sensor will measure the temperature in the bus contact, and another common sensor will measure the ambient temperature. When the difference between the temperature of the bus contact and the ambient temperature is over 70°C imposed by SREN 60439-1, the central unit will issue an acoustic signal which will not be supplied any more after the decrease of the temperature to normal values of the sensor or by interrupting the auxiliary supply of 220 V/5OHz.
The remote monitoring system is made up of sensors that are attached to every contact, (as well as a common sensor for the ambient), system with a microcontroller for each functional unit from the electrical assembly and with a central unit placed in the command area which is linked through serial system to the microcontroller system and to the interface through the distribution station 0,4 kV.

## 2. SYSTEM PRESENTATION

The system designed for a remote monitoring of the temperature is a module system made by the Center of Innovation and Technological Transfer C.I.T.T. Craiova, [2], [3], [4], [5]. The automaton can measure six values of temperature in different points (fig. no.1). There are available values of temperature and humidity inside it, which are almost equal with the values around it.

Figure 1: Automaton for monitoring the temperature

There are presented the temperatures T1… T6 from the electrical cell. T7 and U it represents the temperature and the humidity from the vicinity of the equipment (the sensor is placed inside the equipment).
The temperature values are between –50 +125 Celsius. If the information is not correct, then the

message « ---« appears on the screen. The values for humidity are between 0…100 %.
If the information for humidity is not available then the message « ---« appears on the screen.
The equipment, which can be purchased in eight different sizes, allows the setting of several important parameters. As a result there can be set:
- XY device address where X,Y∈ {0, 1, 2,…, 9, A, B, C, D, E, F};
- start address of the XYZW data where X, Y, Z, W∈ {0, 1, 2,…, 9, A, B, C, D, E, F}. It is recommended not to use an address placed near FFFF in order to avoid the overstepping of the presentation format. The data is represented by the succession of T1, T2, T3, T4, T5, T6, T7, U. The start address of the data is the address of the T1 temperature;
- the speed of the serial: 4 800, 9 600, 19 200 bits/s ;
- the parity ODD, EVEN or NONE ;
- the highest temperature that activate the signaling – it belongs to a range between 0…+125 grade C;
- the lowest temperature that deactivate the signaling – it belongs to a range between 0…+125 grade C.
The interface for the user is assured through an alphanumeric display and a three button keyboard.
The interface for the process is made through a four connectors placed on the low area and another connector placed on the right area.
The automaton is made up of two modules:
- the slave module that scans the seven temperature values and one humidity value;
- the master module receives the data from the slave module, displays them on an alphanumeric display and carries out a MODBUS communication with other numeric systems (automate).

### 2.1. SLAVE MODULE

The SLAVE module has a central element, the ATMEGA8 microcontroller [6] (fig. no. 2), U3. Its reset is carried out by the Q1 circuit, type MCP120. Because the slave microcontroller sends the data to the master microcontroller through the serial port, we have chosen to use one external quartz, Y1, instead of the internal RC oscillator which is much less stable.

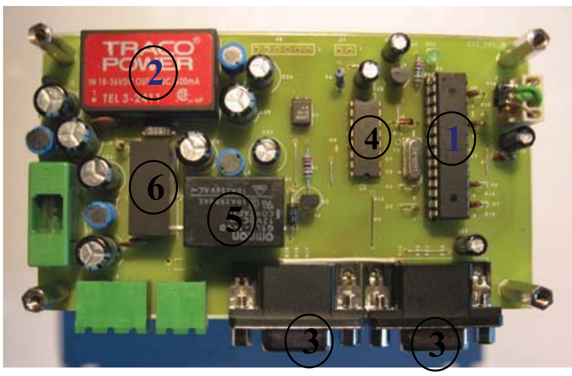


Figure 2: Board with components for slave mode

The scan of the temperature transducer is carried out with some blocks that contain a diode and two resistors. Thus, the microcontroller works with two electrical signals associated to an acquisition channel, even if the temperature transducer has only one data bidirectional.
The seven signals are available at the level of the couple 3. The supply of the slave module is carried out through two DC sources 2 and 6, with galvanic separation (fig. no. 2). The source 6, through the signal ON, can be activated by the master module. Thus, if the master module considers the data coming from the slave module is wrong, then it can command its reset by canceling the supply for a short period of time.
The slave module also contains, among other things, the command block of the relay 5 and an optocouple used of resetting the supply of the slave module.

### 2.2. MASTER Module

MASTER Module has been developed with ATMEGA128 microcontroller[ 7] (fig. 3). An efficient reset is carried out by the circuit no.2 (MCP120). As the microcontroller is SMD type (directly glued to the rear plate), for activating the programming function it is necessary to use the connector J4. The optocouple 3 assures the data serial transfer from the slave module to the master module. Having a code memory of 128 Koctets, a RAM memory of 4 Koctets, an EEPROM memory of 4 Koctets, two serial ports, 53 signals of input/output, up to 100 000 re-programmings and a very good work speed (up to 16 MIPS) carried out by a 16 MHz quartz, ATMEGA128 microcontroller represents an excellent solution.

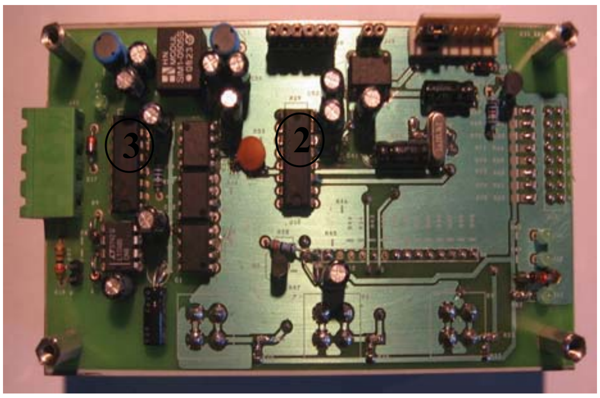


Figure 3: Cabling of master module - the part with components

The interface with the user is carried out through a three button keyboard and through an alphanumeric display with two rows with 16 characters each (fig. no.4).

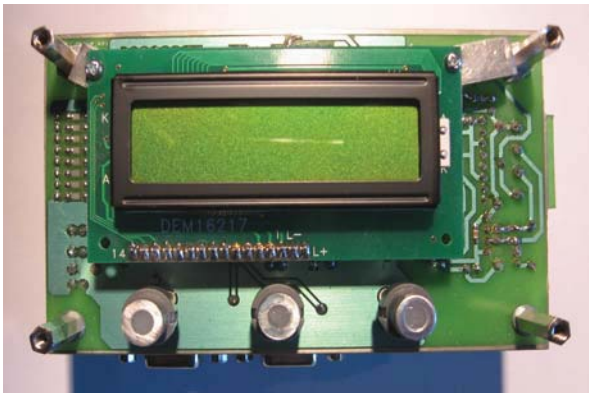

Figure 4: Cabling of master module – the part with junctions

### 2.3 RS485-RS232 adaptor module

The automaton can function also independently from a network by connecting it to a computer through a RS485-RS232 adaptor module. Such a module contains a TTL-RS232 driver (3), a TTL-RS485 driver (2) and a monostable circuit (4) (fig. 5).
The presence of data fluxes is highlighted by the LED-s D3 and D4. The LED D2 shows that the supply is on. The design structure has galvanic separation and it can function with a transfer rate up to 115 kbits/s.

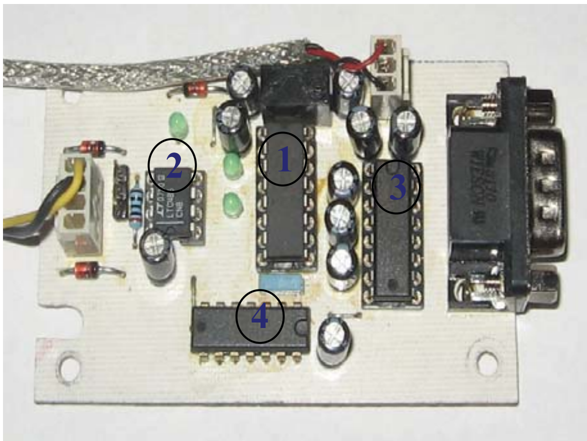


Figure 5: RS485-RS232 adaptor module

The supply of the module is made through the USB port of the computer. The result is a portable small product.

### 2.4 Temperature Sensor

DS18B20 temperature sensor is made by Dallas Semiconductors company[8] and it needs no other parts for producing the signal and it can measure temperatures between -55 °C and +125°C with a precision of ± 0.5% in a temperature range of -10°C … + 85°C.

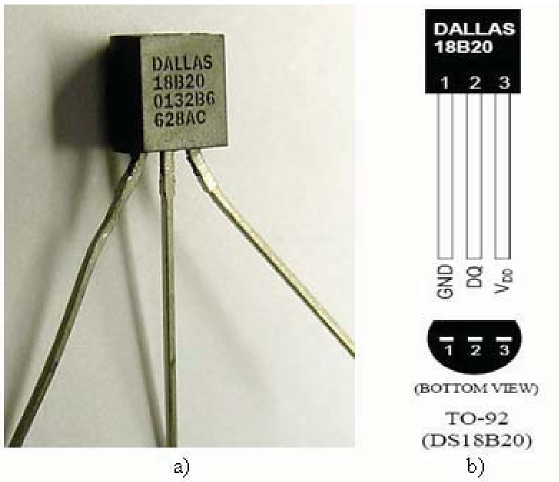


Figure 6: The used temperature sensor: a) overall view; b) the configuration of the pins

The Description of the pins:
GND - mass
DQ - Input/Output Data
VDD - supply
The sensor resolution can be set to a value between 9 and 12 bits. The temperature conversion at 12 bits is carried out in a maximum period of time of 750 ms.
The sensor contains two registers of 8 bits each for stocking the minim and the maxim alarm levels ($T_H$ şi $T_L$) and another register through which the user can set the temperature conversion in digital format of 9, 10, 11 or 12 bits. This is the fact that sets the incrementation pace of the measured values: 0.5, 0.25, 0.125 and 0.0625°C.
The implicit resolution is of 12 bits.

## 3. FUNCTION IN MODBUS NETWORK

The automaton recognizes the MODBUS ASCII protocol [9], [10], [11]. It can answer to a call having the form:
« :010300FF000888 » namely
:= start marker, 01= device address, 03= function code, 00FF= the address that is requested by the necessary data, 0008= it is requested 8 data, 88=LRC, two end markers.
Automaton responds:
:01030800140014001400140014001400190025A5
namely:
:= start marker for serial, 01= device address, 03= function code, 08= number of data in the answer, 0014= temperature 1(+20 grades C),0014= temperature 2(+20 grades C),0014= temperature 3(+20 grades C), 0014= temperature 4(+20 grades C), 0014= temperature 5(+20 grades C),0014 temperature 6(+20 grades C), 0019 temperature 7(+25 grades C),0025= humidity (37%, A5= LRC, two characters at the end of the serial.

In the network the information about the temperature is available under the form of « unsigned char ». Thus, the value 125 means +125 grades C and this is the highest value that can be measured and displayed. The value 126 can not be reached in a normal operation. This is why it was chosen in order to mark a malfunction of the sensor – on the device display it is displayed the message « ---« .
A humidity value higher than 100 will create a problem to the sensor.
The automaton can be requested 1, 2, 3, 4 ,5, 6, 7 or all 8 sizes that he can purchase.

## 4. EXPERIMENTAL RESULTS

In order to test the remote monitoring system of temperature in real condition, we have made an experimental bank which is made up of a detachable contact between two copper bars with the same cross section as the bars from inside a 1250A cell.
The general view of the bank and of the remote monitoring system of temperature is shown in fig. no.7.

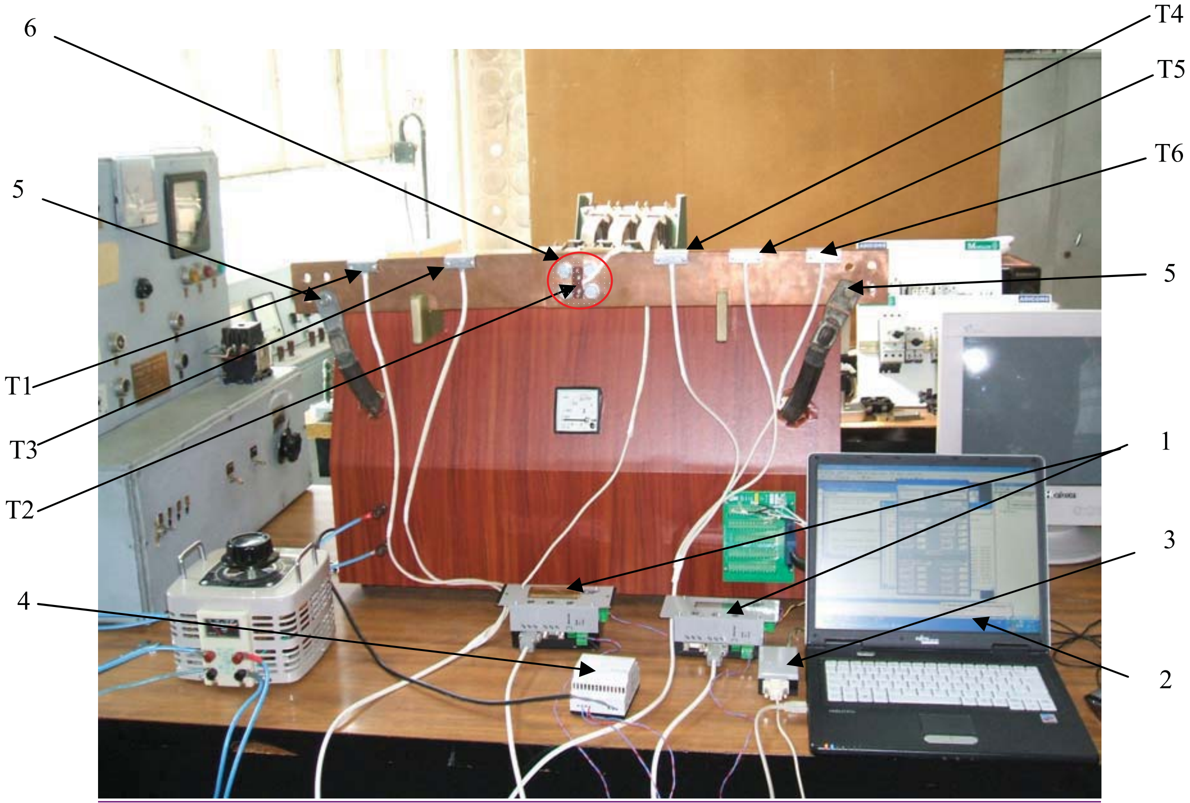


Figure 7: The Experiment of the monitoring system

The two copper bars connected with screws are supplied by a current transformer, having the possibility to vary the charging current of the bars.
According to figure 7, the six sensors where installed in this way:
T1 sensor – near to the bar and the supply cable from the end of the bar;
T2 sensor – at the connection of the two bars;
T6 sensor – at the contact between the bar and the supply cable from the end of the bar
T3 and T5 sensors – in the middle of the bar;
T4 sensor – near the connecting area.
The experimental checks were carried out by measuring the temperature on the bars in the above mentioned points, by charging the bars at a current of 910 A.
The specification of the elements from inside the monitoring system is the following:

1- Serial monitoring automaton in MODBUS protocol;
2- hierarchical computer;
3- RS232-RS485 serial adaptor;
4- 24 V DC supply;
5- The connecting contact of the bars with the supply cable;
6- the connecting area between the two bars.

The results of the measurements got at the lab checks are presented in the figures 8, 9 and 10.
In figure 8 are shown the results of measurements in case the area has the entire screws tight junction.
In figure 9 are shown the results of the experiments when the connecting area has a loose screw.
In figure 10 are shown the results of the experiments when the connecting area has two loose screws.

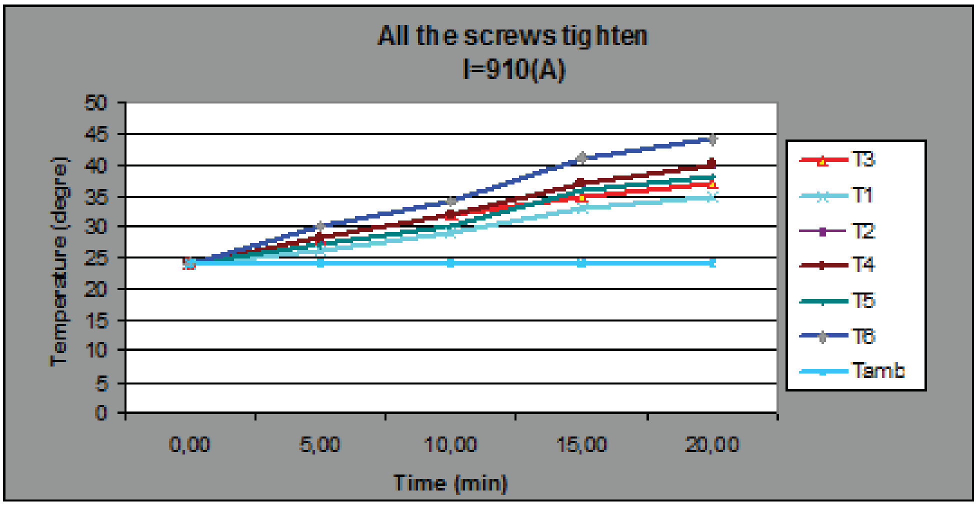


Fig. 8 The results of the experiments when the connecting area has all the screws tighten, I= 910A

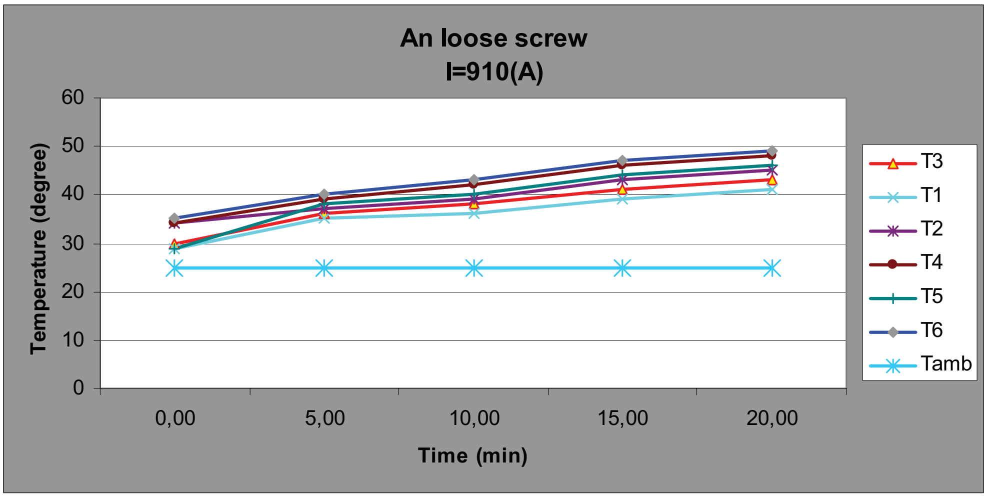


Fig. 9 The results of the experiments when the connecting area has a loose screw, I= 910A

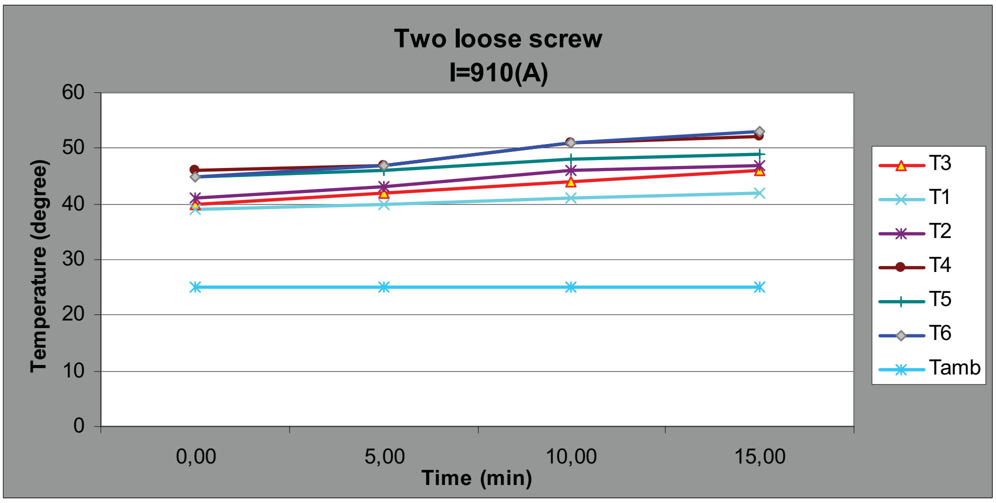


Fig. 10 The results of the experiments when the connecting area has two loose screws, I= 910A

## 4. CONCLUSIONS

The results of the experiments carried out of the remote monitoring system of the temperature in lab conditions have emphasized the functionality of all elements and of the overall system.
In order to check the precision of the monitoring system the temperature of the contact between the two bars was measured with standard reference equipment.

### Acknowledgment

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