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Embedded system for remote temperature sensor's net

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Abstract – This paper describe solution of remote temperature measurement problem in two areas. First area is remote temperature measurement in prospecting holes on mine dumps to prevent risk of fire. Second area is remote temperature measurement in heat pump to prevent freeze of earth. The measuring system is using battery powered embedded system ensuring service time up to 12 months. Due good covering by signal in normal and demanding terrain the GSM communication system is used. The system has three options of sensor depending on temperature range and depth of boreholes.

Keywords: sensor's net, control technology, microprocessor control, remote control, monitoring

I. INTRODUCTION

This time requirements of security and cost reducing involve observing some parameters of earth. The measurement has to be done on different places without power net. Each station has to be equipped with own power source. In case of battery using service time should more than one year. In this reason good power management should be used. In such large distributed measurement systems the wireless communication with remote objects which are the integral part of these systems should be used. In the large systems we can utilize, with advantage, the communication which will be provided by the GSM technique. Good covering by signal in case of GSM enables the building up of measuring and control systems where the communication can run also in the demanding terrain. For wireless data transmission the whole series of producers offer the sets of radio-modems enabling the wireless data transmission in mobile telephone networks which, in addition, enable the interconnection with Internet. In these networks the short message service SMS can be used where the short message contains the data being measured or the data service GPRS. The data transmission in the GPRS networks is paid according to the data volume transmitted and not according to the number or time of connection what is suitable especially for applications of remote distributed measurements or safety systems, in both cases in connection with the central dispatching. In case of the whole series of systems the often transmission of small data volumes is required.

Compared with the usual communication technologies this technology has the following advantages:

- The costs for the data transmission in the GPRS network or SMS are very low.
- Time for transmission of 500 Bytes including setting the connection makes 2 sec.
- Mobility, possibility to realize the application anywhere in the sphere covered by the GSM signal.

II. SENSOR'S NET

The measurement data has to be collected from different places on the world or given area. Measurement places are often without any power source and with close or far distance from data destination. We can obtain large net of sensors – SENSOR'S NET. The sensor's net is configured from 1 to several measurement station (MS1… MSx) and one base station BS1. Each station is equipped with GSM modem. Maximal number of measurement station is limited by given GSM operator only.

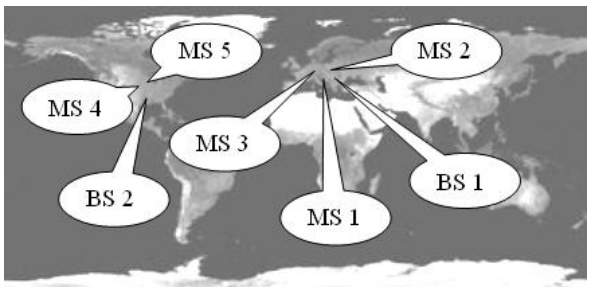

Fig. 1. Example of two sensor's nets

II. MEASURING SYSTEM

The embedded measuring system is composed of two main parts. The first part is the control one which is universal and, at the same time, it includes the power supply. The second part is the measuring one which depends on the application. This part can be changed in dependence on each application. At this time are developed three different measurement parts. Each variant differs with temperature range, distance from

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control part and maximum number of measuring points. For application "Measuring of temperatures in the prospecting holes" two different variants were developed, given in the flow sheet. Third variant was developed for the application "Temperature measurement in heat pump". Realized electronic control board supports all variants of measuring. The simple configuration of the embedded measuring system consists of the group of the temperature sensors, micro-controller, feeding part, GSM module and antenna as illustrated in the flow-sheet in the Figure 2.

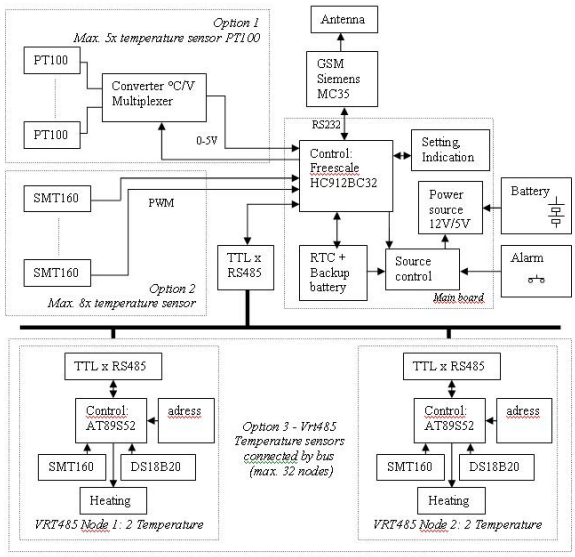

Fig. 2. Flow-sheet of embedded measuring system with three types of sensing option

III. CONTROL PART

The core of the control part is the 16-bits micro-controller Freescale HC12 (Kotzian and Srovnal, 2002a) which controls the GSM modem Siemens MC 35 with the help of the AT commands. The communication runs on the serial line RS 232. The specially adjusted antenna for horizontal location on the probe surface is connected to the GSM module. For ensuring of the universal character of the measuring system utilization anywhere in terrain the supply from 12 V accumulator of the type WP26-12 (12V/26Ah) was selected. For ensuring of low electrical power consumption and so the long-term service life of measuring system the following system of the feeding control was proposed. The system contains the back-up lithium battery which feeds the control of the source being connected and the RTC circuit for generation of the real time and alarms. The micro-controller controls the RTC circuit through the bus I2C. After programming of the next starting up of the embedded system, the micro-controller will interrupt supply of measuring part, GSM modem and itself. On this interrupt is cooperating the of the switched power supply control circuit. Herewith, the consumption of the whole system will be significantly reduced to several micro-amperes. The control part contains also the safety input which monitors the unauthorized handling with the probe, e.g. by opening the lid of the probe covering. The safety input is also bound on the circuit of the supply control enabling the immediate transition from the mode of the reduced supply.

Algorithm of the control part behaviour ensures the following functions:

- The regular activation of the microprocessor and GSM module in the selected measuring intervals and services.
- The measuring itself with the data transmission through GSM.
- Reception of control and configuration data from the dispatcher's working place.
- Immediate reporting of the alarm input.
- Immediate reporting of the decrease of the accumulator capacity and the back-up battery under the limit selected.

The programming of the embedded system for measuring and transmission of the data measured can be carried out either by the SMS service or GPRS. The microcontroller is programmed using CodeWarrior for Embedded Systems environment from Metrowerks. (Kotzian and Srovnal, 2002c)

The whole control system was proposed universally in such a way so that it with connection to microcontroller could be possible to utilize it also for other applications than the temperatures measuring in the application selected.

IV. MEASURING PART

The electronics measuring station has three possible solutions. The solutions differ by the limit of the maximally achieved operating temperature which is influenced by technological principle of sensing elements.

A. *Variant 1. Semiconductor sensor*

This variant respects the economic requirements. The low cost variant of the prospecting holes using semiconductor sensor SMT 160-30. The limit working range is up to 175ºC (optimum limit of the working temperature makes 135ºC). The financial saving is reflected in simplifying of the circuit solution of circuits for processing of the signal linked up on the implemented microcontroller Freescale HC12.

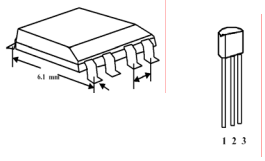

Fig. 3. Semiconductor sensor SMT 160-30

Thanks to the selection of intelligent (programmable) sensors with the output with the coded measuring values into the width modulation of the outgoing voltage signal this version is simplified by the circuits of the signal adjustment – filters, amplifiers, multiplexers, current sources. The outputs of single sensors are led directly on the digital inputs of microcontroller and the value of single sensors, thanks to the internal counters and program means of the microcontroller, is converted on the digit and, subsequently together with other data according to the selected program of values distribution, sent by the SMS service or GPRS for processing in the dispatching working place.

B. *Variant 2. PT1000 sensor*

The more economically demanding variant of measuring part, fully meeting the required range of temperatures measured, works with the sensors Pt1000 "Fig.4." The sensors are executed in the encasing in stainless steel tanks and silicon insulation line. This configuration resists the increased temperatures for a long time and respectively also the aggressive environment. The outputs of single sensors are led to the analogue multiplexer. The connection of multiplexer measuring channels is controlled by digital outputs of the micro-controller Freescale HC12. The single sensors are supplied by the current source. Thanks to the implemented circuit connection the affects of lines and connected circuits on measuring accuracy are removed. The signal from the multiplexer is amplified by the operating amplifier and connected to the internal A/D converter of the micro-controller. The program will convert the analogue value on digit and, subsequently together with other data according to the selected program of the value distribution, is sent by the SMS service or GPRS for processing into the dispatching working place.

Fig. 4. PT1000 Sensor

C. *Variant 3. Distributed sensors VRT485*

This variant is suitable for temperature measurement in deep boreholes. Variant A and B are suitable for distance more than several meters or hundreds of meters. For measuring temperatures in deeps more than hundreds of meters it is necessary to process sensors data locally. Processed data are sending to control part using industrial bus. Variant 3 is collection of nodes connected to industrial bus standard RS485. Each node is equipped with two different semiconductor temperature sensors, heating resistor for temperature jump, microcontroller, communication interface, and power supply monitor. Maximal number of nodes is 32. Node is programmed using ISP (In system programming) connector. Block diagram is shown of figure 5.

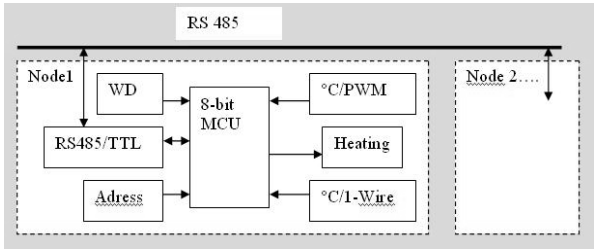

Fig. 5. VRT485 Node with Sensors and heating

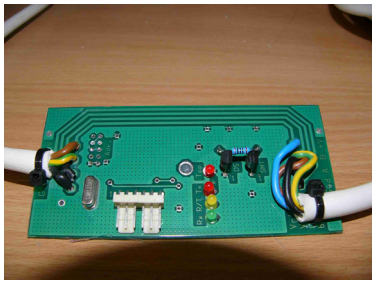

Fig. 6. Implementation of VRT485 Node

V. BASE STATION

The program equipment of the dispatching in the function of visualization working place was developed. The working place of dispatching is equipped with the computer PC and terminal Siemens MC35. The visualization application was carried out in the SCADA system Promotic. The majority of the GSM modules can communicate with the environment with the help of the RS232 interface. The module functions are controlled with the help of the AT commands, which can be entered directly in the text form, for instance with the help of HyperTerminal, which is an integral part of the accessories of the operating system Windows 95 and higher.

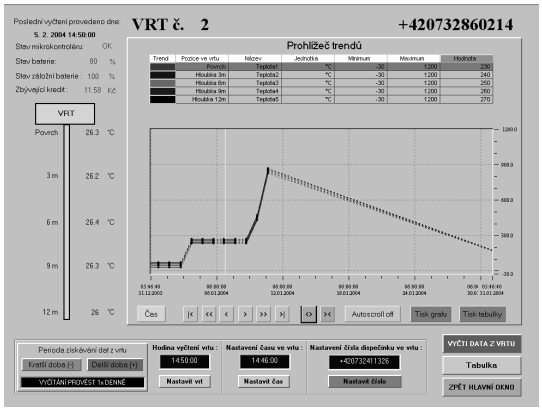

Fig. 7. User interface of Base station

VI. APPLICATIONS AND RESULTS

This project has two main utilizations. First area is remote temperature measurement in prospecting holes on mine dumps to prevent risk of fire. Two systems with semiconductor sensor silicon was created and delivered to the customer. The customer was installed them in Ostrava region. Second type was installed on VŠB-TU University. This application makes remote temperature measurement in heat pump o prevent freeze of earth of new university hall. The test station of this type is on the figure 8. Pictures from installation are on figures 9 and 10.

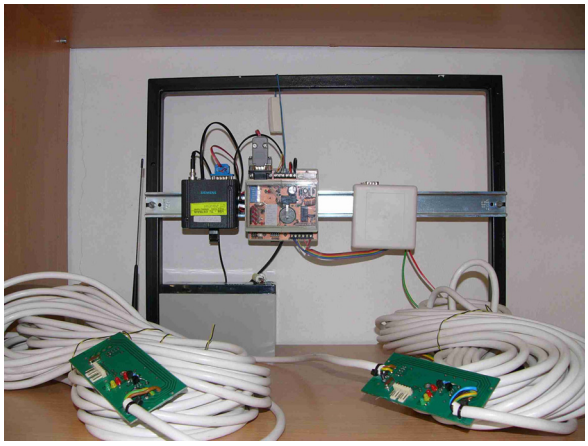

Fig. 8. Test setup of Measuring station.

Fig. 9. Real installation of VRT485 bus of sensor

Fig. 10. Real VRT485 placing

VIII. CONCLUSION

This project solves the problem of remote measurement with battery supply with long service time. Within the project the embedded system for measuring station was developed. Base station and three variant of measuring part are supported now. Variants differ by the operating temperatures and measuring distance. Developed system was realised with all three measuring variants. Two variants of measuring were practically applied. Two systems with VRT485 measuring nodes were tested on university and two systems with semiconductors sensors were used by personal company in the Czech Republic.

VII. AKNOWLEDGEMENT

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REFERENCES

[1] Kotzian J. and Srovnal V.(2002a): Methodology of Designing Embedded Control Systems. *In: Proceeding International IFAC Workshop PDS 2001. PERGAMON (Elsevier Science)* 2002,Great Britain, ISBN 0-08-044081 9, p.133-138

[2] Kotzian J.and SrovnalV.(2002b): Using Formal Methods for Designing Embedded Control Systems. *In: Proceeding International IEEE Workshop TC-ECBS and IFIP WG 10.1*(Lund, Sweden). University of Stirling 2002, Great Britain, ISBN 1-85769-169-5, p.77-84

[3] Kotzian J.and Srovnal V.(2002c): Software Tools for Embedded Control Systems. *In: Proceeding 6th World Multiconference SCI 2002.* Orlando, Florida, USA, ISBN 980-07-8150-1, p.321-325