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Temperature Monitoring System with Integrated Sensors

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Abstract

The paper describes a solution for a temperature monitoring system. The final objective was the hardware and software implementation for this system using the semiconductors devices like sensors and the TCP/IP protocols for communications. The local equipments will be connected through the network cables. The communication system will permit the online supervision.

Key words: *monitoring, integrated sensor, data transfer protocol.*

Introduction

This project describes the implementation of local measuring equipments for internal and external temperature of a close space and connection of those in a flexible and modern system, using an advanced hardware and software technology.

The local equipment for monitored parameter, temperature, will be connected by network cables with a large numbers of computers, where the operator can supervise the internal and external temperature.

Integrated temperature sensor with semiconductors devices

The functionality of these sensors category is based on law between temperature and direct voltage – in case of semiconductor diode – or base - emitter voltage in case of transistor, when they are penetrated by a constant current. Based on the semiconductor devices properties, there are implemented integrated circuits like Zener diode or power source, where the output signal is proportional with absolute temperature [2].

The bipolar transistor can be used like temperature sensor knowing that the law between collector current I_C and base – emitter voltage U_{BE}, in condition of collector – emitter voltage is very large and $U_{BE} \gg \frac{kT}{q}$, is:

$$I_C = \propto \cdot I_{es} \cdot e^{q \cdot \frac{U_{BE}}{k \cdot T}}, \tag{1}$$

where α is amplifier factor in direct current, I_{es} – the saturation current of diode emitter – base measured with short-circuit to base.

From relation (1) we can obtain:

$$U_{BE} = k \cdot \frac{T}{q} \cdot ln\left(\frac{I_C}{\propto \cdot I_{es}}\right), \quad (2)$$

which means a linear dependence between U_{BE} and T, considering I_C=const. and without the residual factor effect.

The temperature integrated sensors use transistors, running for different density of collector current, so the difference between bases – emitter voltages for two transistors is direct proportional with absolute temperature.

For obtaining the difference like:

$$U_{BE}[mV] = k \cdot T^2[K], \quad (3)$$

we can work with dual transistors running for different collector current, or with different transistors running for identical collector current. Another most recent method uses a single multi-emitter transistor alternatively operating two different levels of collector current, obtaining an U_{BE} voltage proportionally with absolute temperature [2].

DS1621 integrated temperature sensor

DS1621 integrated sensor have the next characteristics: temperature measurements require no external components; measure temperature from -55°C to +12 in 0.5°C increments; Fahrenheit temperature equivalent -67 F to 257 F in 0.9 F increments; temperature is read as a 9-bit value (2-by transfer); wide power supply range (2.7V to 5.5V); converts temperature to digital word in 1 second; thermostatic settings are user definable; data is read from/written via a 2-wire series interface (open drain I/O lines); applications include thermostatic controls, industrial systems, consumer products, thermometers, or any thermal sensitive; system 8-pin DIP or SO package [4].

The figure 1 presents the DS1621 PIN assignments: SDA- 2-Wire Serial Data Input/Output, SCL- 2-Wire Serial Clock, GND- Ground - Thermostat Output Signal T_{OUT}, A0- Chip Address Input, A1- Chip Address Input, A2- Chip Address Input, V_{DD} - Power Supply Voltage.

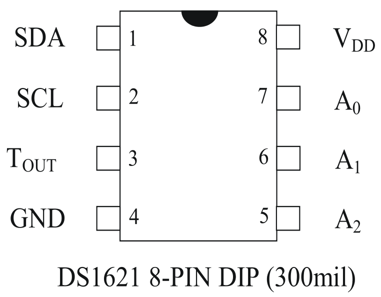

Fig.1. DS1621 PIN assignments [4].

The DS1621 Digital Thermometer and Thermostat provides 9-bit temperature readings, which indicate the temperature of the device. The thermal alarm output, T, is active when the temperature of the OUT device exceeds a user-defined temperature TH. The output remains active until the temperature drops below user defined temperature TL, allowing for any hysteresis necessary. User-defined temperature settings are stored in nonvolatile memory so parts may be programmed prior to insertion in a system. Temperature settings and temperature readings are all communicated to/from the DS1621 over a simple 2-wire serial interface.

A block diagram of the DS1621 is shown in figure 2. The DS1621 measures temperatures through the use of an onboard proprietary temperature measurement technique [4].

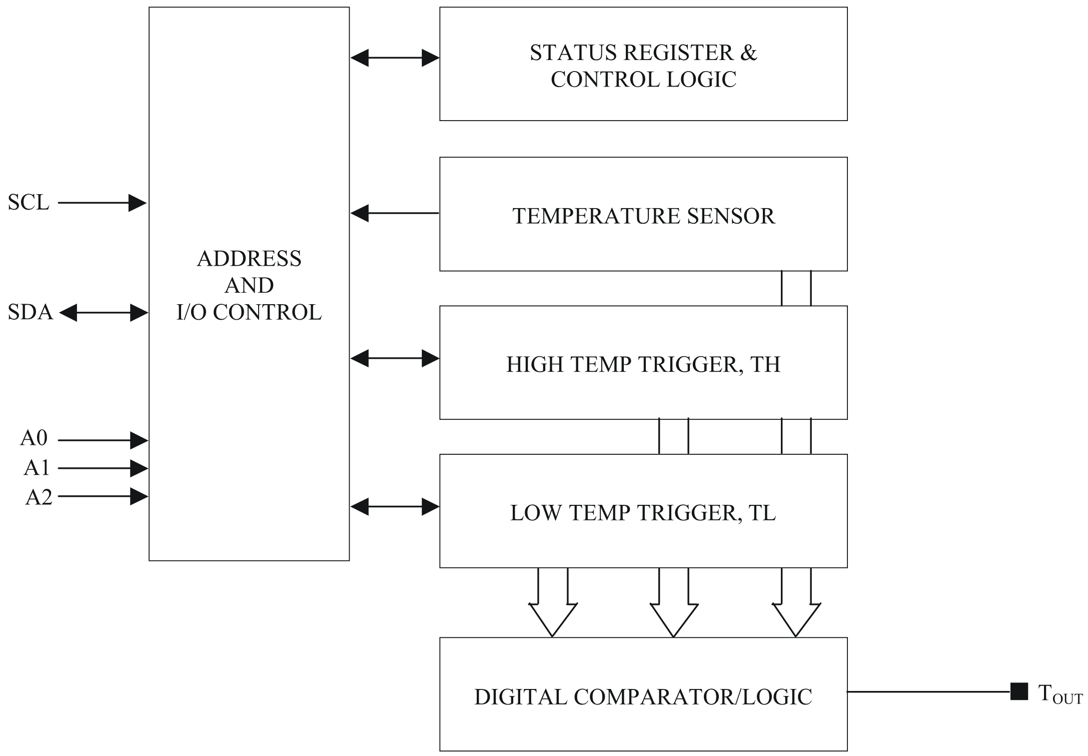

Fig.2. DS1621 functional block diagram [4].

Since data is transmitted over the 2-wire bus MSB first, temperature data may be written to/read from the DS1621 as either a single byte (with temperature resolution of 1C) or as two bytes. The second byte would contain the value of the least significant (0.5C) bit of the temperature reading.

Temperature is represented in the DS1621 in terms of a ½C LSB, yielding the following 9-bit format: that the remaining 7 bits of this byte are set to all "0"s.

MSB									**LSB**							
1	**1**	**1**	**0**	**0**	**1**	**1**	**1**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

The higher resolutions may be obtained by reading the temperature and truncating the 0.5C bit (the LSB) from the read value. This value is TEMP_READ. The value left in the counter may then be read by issuing a READ COUNTER command. This value is the count remaining (COUNT_REMAIN) after the gate period has ceased. By loading the value of the slope accumulator into the counter register (using the READ SLOPE command), this value may then be read, yielding the number of counts per degree C (COUNT_PER_C) at that temperature. The actual temperature may be then be calculated by the user using the following relation [4]:

$$TEMP.=TEMP\_READ - 0.25 + (COUNT\_PER\_C - COUNT\_REMAIN) / COUNT\_PER\_C$$

System configuration

The configuration of temperature monitoring system is presented in figure 3, where S_1 is sensor for internal temperature of close space, S_2 - sensor for external temperature, MB – measurement block.

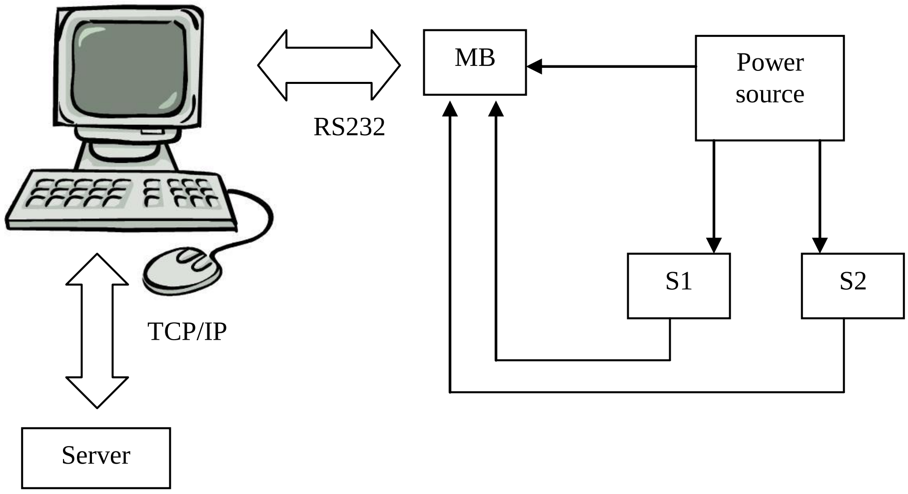

Fig.3. The configuration of temperature monitoring system.

The local equipment is designed to work independent or connected with a server through Internet Network. According to specified conditions, the connection to the system will be made by using RS232 – Ethernet convertors. An IP address can be assigned to this equipment for connection to the computer.

The electrical scheme for this system is presented in figure 4. There were used LM7805C stabilized power source, DS1621 integrated sensors, RC passive components, circuit active elements, DB9 adapter RS232 cable.

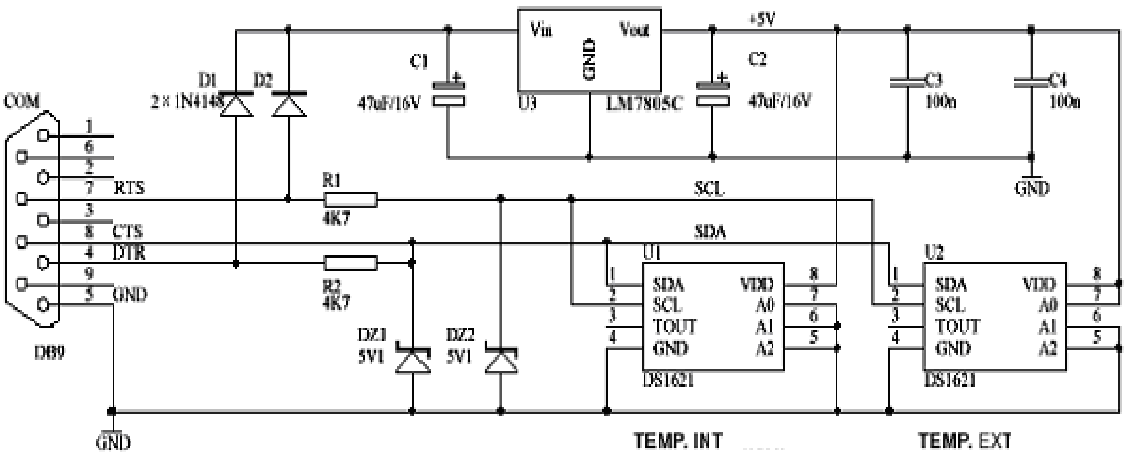

Fig.4. Electrical scheme of local system.

The direct circuit connected to the serial port of the computer, which allows the connection between the two sensors and the system and also the supply power for sensors, has the following layers structure, presented in figure 5.

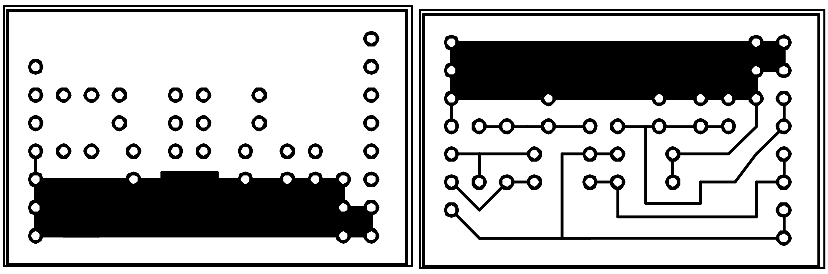

Fig.5. The printed cabling layer of circuit connected to the computer: front and back.

The temperature sensors printed cabling layer is shown in figure 6. They are assembled in metallic capsules which do not allow them to be destroyed by mechanical shocks and other factors. The thermal transfer between capsule and chip is assured by a special substance named Artic Silver.

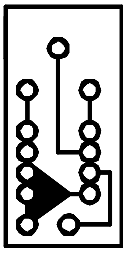

Fig.6. The printed cabling layer of temperature sensors.

Monitoring program

The temperature monitoring program is developed in VC++ and has the following functions: receiving data from local equipment, operator interfacing, saving data. The operator interface is presented in figure 7.

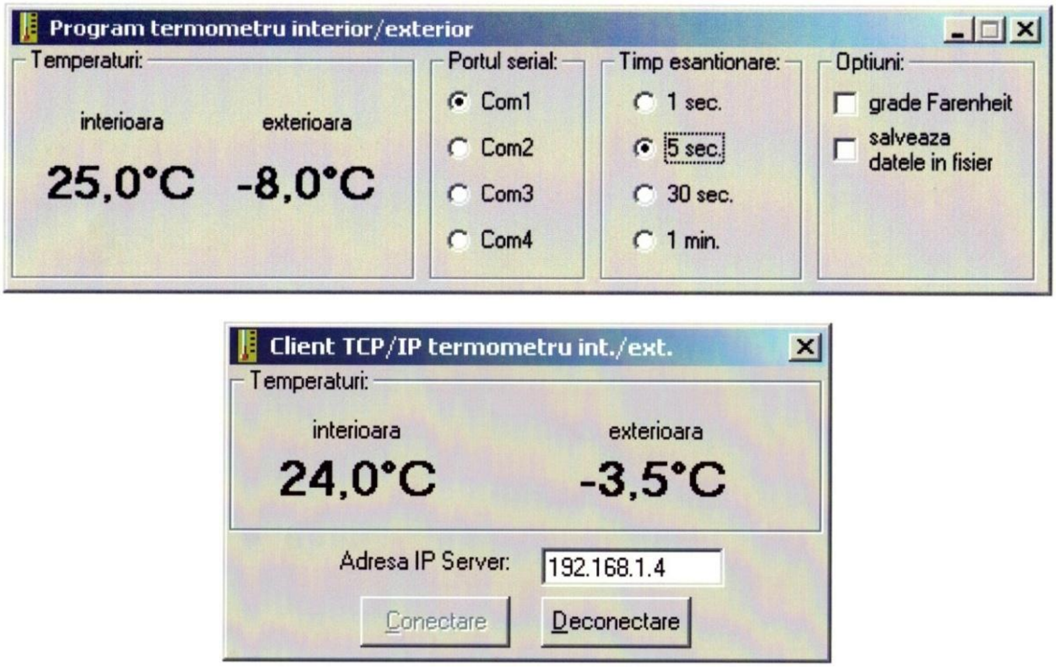

Fig.7. Operator interface.

An example for monitored parameter history has the following form:

01-25-2006	22:10:34	-11,0°C	25,0°C
01-25-2006	22:10:35	-11,0°C	25,0°C
01-25-2006	22:10:36	-11,0°C	25,0°C
01-25-2006	22:29:44	-11,0°C	25,0°C
01-25-2006	22:29:45	-11,0°C	25,0°C
01-25-2006	22:29:47	-11,0°C	25,0°C
01-26-2006	18:09:33	-00,5°C	25,0°C
01-26-2006	18:09:34	00,0°C	25,0°C
01-26-2006	18:09:35	00,0°C	25,0°C
01-26-2006	18:09:36	00,5°C	25,0°C
01-26-2006	18:09:37	00,5°C	25,0°C
01-26-2006	18:09:38	00,5°C	25,0°C
01-26-2006	18:09:39	01,0°C	25,0°C
01-26-2006	18:09:40	01,0°C	25,0°C
01-26-2006	18:09:41	01,5°C	25,0°C
01-26-2006	18:09:42	01,5°C	25,0°C

Conclusions

This system offers facilities and functions designed to improve the equipment performances and optimize the activity such as: real time information about temperature values; reduction of surveillance and maintenance costs.

Using the Internet facilities we can obtain an efficient supervision, without distance limitations. We can easily realize these equipments and have a lot of applications in different fields of activity.

References

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4. * * * – *www.maxim-ic.com – DS 1621 Digital Thermometer and Thermostat*.

Sistem de monitorizare a temperaturii utilizând senzori integraţi

Rezumat

Lucrarea prezintă o soluţie privind realizarea unui sistem de monitorizare a temperaturii interioare şi exterioare pentru o incintă. Obiectivul final a fost implementarea hardware şi software a sistemului utilizând dispozitive semiconductoare ca şi traductoare de temperatură şi utilizând facilităţile protocolului TCP/IP pentru comunicaţii. Echipamentul local de măsurare a temperaturii este proiectat să lucreze independent sau conectat la un server printr-o reţea intranet.