Temperature Measurement in Distributed System for Building Management

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***Abstract*-**The paper present a system for management building based a compatible PC computer that communicates through a RS-485 serial protocol with the development board with microcontroller. The development boards are placed on the level of each building floor. These development boards take the signal from sensors placed on the level of each room and achieve the command function based on an independent algorithm, commanding by case the corresponding central heating or cooling plant.

I. Introduction

The building management systems allow to the rooms to adapt oneselves to human necessities as agreeable is possible. The offered environment by certain illumination and temperature conditions and by sound environs is a part of life quality of each of us. The building management systems allow the individual choosing of the illumination and of the temperature with purpose of harmonizing in particular situations but also offer the building security against the breach of close and calamities, from the exterior building illumination to the individual adjustment. Due to the breakers and intensity regulator, it is allowed the harmonious achievement of any kind of combination in temperature or illumination control. The building management systems allow thus the implementation of some different functions into a perfect harmony with the individual habits of one building's lodgers. Moreover, to the individual heater profiles or lightings settings it could be added the activation of predefined operations of remote control.
The sensors and driving, as room thermostats, windows contacts s.o., are connected systematically to work economically. Different states and signals can be logical interconnected (for example if a window from a certain room is opened, the heating will be automatically closed from economical reasons). This kind of control circuit can take into account the available natural lighting level, beside the exterior temperature. In this way, the journal and the using profiles can be taken as base in aim to assure the individual heating of each room following an optimal efficiency/cost ratio, at the same time being offered an increased comfort degree.
In the office buildings, the intelligent control of window blinds is very important. This must work automatically and take into account the hour, solar lighting/heating, climatically conditions as wind and rain. At the bringing down of blinds is required a room lighting or only its adjustment depending on the available natural lighting.

II. The integrated temperature sensor DS1820 [6]

The DS18S20 Digital Thermometer provides 9–bit centigrade temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18S20 communicates over a 1-wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. It has an operating temperature range of –55°C to 125°C and is accurate to 0.5ºC over the range of –10°C to +85°C. In addition, the DS18S20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply. Each DS18S20 has a unique 64-bit serial code, which allows multiple DS18S20s to function on the same 1–wire bus; thus, it is simple to use one microprocessor to control many DS18S20s distributed over a large area.
The inside scratchpad memory contains the 2-byte temperature register that stores the digital output from the temperature sensor. In addition, the scratchpad provides access to the 1-byte upper and lower alarm trigger registers (TH and TL). The TH and TL registers are nonvolatile (EEPROM), so they will retain data when the device is powered down.

The DS18S20 uses Dallas' exclusive 1-wire bus protocol that implements bus communication using one control signal. The control line requires a weak pull-up resistor since all devices are linked to the bus via a 3-state or open-drain port (the DQ pin in the case of the DS18S20). In this bus system, the microprocessor (the master device) identifies and addresses devices on the bus using each device's unique 64-bit code. Because each device has a unique code, the number of devices that can be addressed on one bus is virtually unlimited.
The DS18S20 can be powered by an external supply on the V_{DD} pin, or it can operate in "parasite power" mode, which allows the DS18S20 to function without a local external supply. Parasite power is very useful for applications that require remote temperature sensing or that is very space constrained. The stolen charge powers the DS18S20 while the bus is high, and some of the charge is stored on the parasite power capacitor (C_{PP}) to provide power when the bus is low. When the DS18S20 is used in parasite power mode, the V_{DD} pin must be connected to ground. In parasite power mode, the 1-wire bus and power capacitor can provide sufficient current to the DS18S20 for most operations as long as the specified timing and voltage requirements are met. However, when the DS18S20 is performing temperature conversions or copying data from the scratchpad memory to EEPROM, the operating current can be as high as 1.5 mA. This current can cause an unacceptable voltage drop across the weak 1-wire pull-up resistor and is more current than can be supplied by C_{PP}. To assure that the DS18S20 has sufficient supply current, it is necessary to provide a strong pull-up on the 1-wire bus whenever temperature conversions are taking place or data is being copied from the scratchpad to EEPROM. This can be accomplished by using a MOSFET to pull the bus directly to the rail.
Each DS18S20 contains a unique 64–bit code stored in ROM. The least significant 8 bits of the ROM code contain the DS18S20's 1–wire family code. The next 48 bits contain a unique serial number. The most significant 8 bits contain a cyclic redundancy check (CRC) byte that is calculated from the first 56 bits of the ROM code. A detailed explanation of the CRC bits is provided in the CRC GENERATION section. The 64–bit ROM code and associated ROM function control logic allow the DS18S20 to operate as a 1–wire device using the protocol.
The 1-wire bus system uses a single bus master to control one or more slave devices. The DS18S20 is always a slave. When there is only one slave on the bus, the system is referred to as a "single-drop" system; the system is "multi-drop" if there are multiple slaves on the bus. All data and commands are transmitted least significant bit first over the 1-wire bus. The following discussion of the 1-wire bus system is broken down into three topics: hardware configuration, transaction sequence, and 1-wire signaling (signal types and timing).

III. The development microsystem BigPic4 [3]

The BigPIC4 development system is a full-featured development board for Microchip PIC microcontrollers. It has been designed to allow engineers to easy explore and used the capabilities of PIC microcontrollers. It allows PIC microcontrollers to be interfaced with external circuits and a broad range of peripheral devices, allowing the user to concentrate on software development.
All ports have direct connections to Direct Port Access connectors. Such connectors are tipically used for connecting external peripherials to the board, or for providing useful points for connecting digital logic probes. The microcontroller's pins are routed to various peripherials and illustrated in figure 1. All ports are connected to LEDs, push-button switches and pull-up / pull-down resistors, allowing easy digital pin state monitoring and testing. Some of the pins are connected to other peripherials such as the DS1820 temperature sensor, RS-485 communications, LCD, etc. The BigPIC4 has 46 push buttons witch can be used to provide digital inputs to microcontroller's ports. There is also one push button that acts as a Reset.
All microcontroller input/output pins can be accessed via connectors placed along the right side of the board. For each of PORTA, PORTB, PORTC, PORTD, PORTE, PORTF and PORG there in some 10 pin connector providing V_{CC}, GND an dup or eight port pins.
The connectors can be used for system expansion with external boards such as Serial Ethernet, Compact Flash, MMC/SD, ADC, DAC, CAN, RTC, RS-485, etc. Ensure that the on-board peripherals are disconnected from microcontroller by setting the appropriate jumpers, while external peripherals are using the same pins. The connectors can also be used for attaching logic probes or other test equipment.
For this board is no need for the use of external equipment during programming because development system has its own on-board USB 2.0 programmer. Load the program into the microcontroller via the PICflash programming software, with is supplied with the board.
A graphic LCD (GLCD) allows advanced visual messages to the displayed. While a character LCD can display only alphanumeric characters, a GLCD can be used to display messages in the form of

drawings and bitmaps. The most commonly used graphic LCD has the screen resolution of 128 x 64 pixels. The GLCD's contrast can be adjusted using the potentiometer.
RS-232 communication enables point-to-point data transfer. It is commonly used in data acquisition applications, for the transfer of data between the microcontroller and a PC. Since the voltage levels of the microcontroller and PC are not directly compatible with each other, a level transition buffer such as the MAX232 must be used.
The PS/2 connector allows direct connection between the board and devices that use PS/2 communication, such as PC, keyboard or mouse. For example the microcontroller can be connected to a keyboard to capture pressed keys or it can be connected to a PC to act as a keyboard in testing process. CLK and DATA lines are used for data transfer. In this case they are connected top in RC1 and RCO respectively.
MMC card is used as storage media for a portable device, in a form that can easily be removed for access by a PC. With an MMC reader can easily transfer data from MMC card to computer. Microcontroller on board communicates with multimedia card via SPI communication.

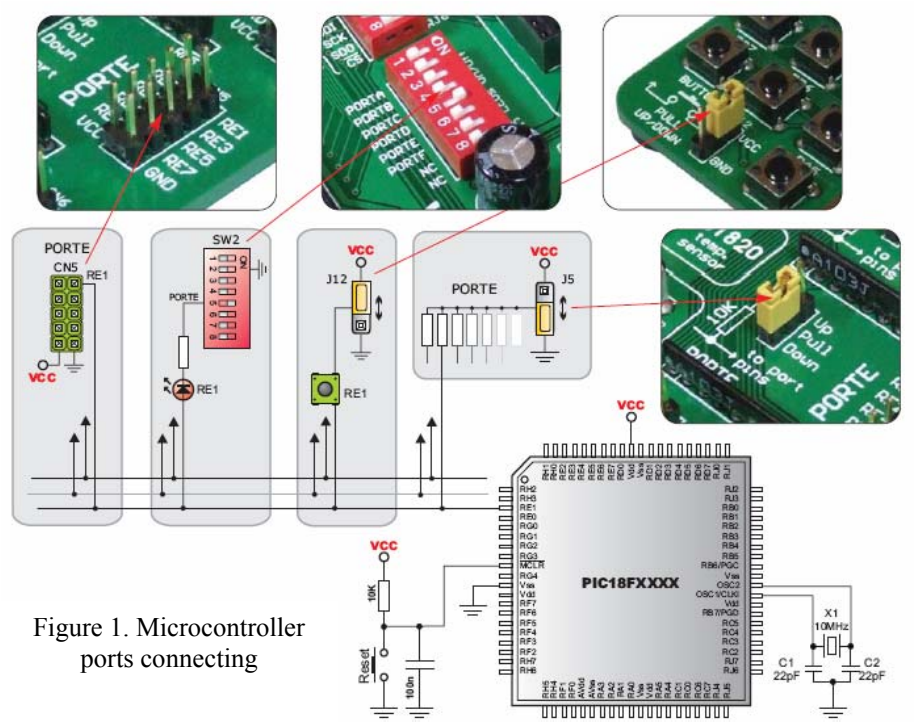

Figure 1. Microcontroller ports connecting

IV. The presentation of temperature management system

Inside the functional buildings, the management systems offer a variety of opportunities in energy consumption optimization meant for heating. Because the different control functions for buildings are able to communicate between them, it is possible to use energy optimally for heating. If is not detected a movement for a certain time period inside an office, then the heating is temporary stopped. The system saves the temperature recordings with very good time accuracy. A computer in aim to optimize the system can then evaluate these recordings.
The proposed system (figure 2) has on the base a compatible PC computer that communicates through a RS-485 serial protocol with the development board with microcontroller. This bus offers the required speed for data transferring has a low number of wires and allows the connecting of more boards on the same bus. The development boards are placed on the level of each building floor. The development of the network can be done usually through connecting of new boards on the existing RS-485 bus. These development boards take the signal from sensors placed on the level of each room and achieve the command function based on an independent algorithm, commanding by case the corresponding central heating or cooling plant.
The temperature sensors from the rooms of one floor are as DS1820 kind connected on the same 1-wire bus and supplied through that. The advantage of using of these sensors is that all sensors are connected to the digital system through only one bus consisting of two wires, the sensors supplying being made also through these two communication connections. The fact that on the same bus it can be connected a

number as much as higher is possible of sensors allows the easily extension of the system through adding new sensors.

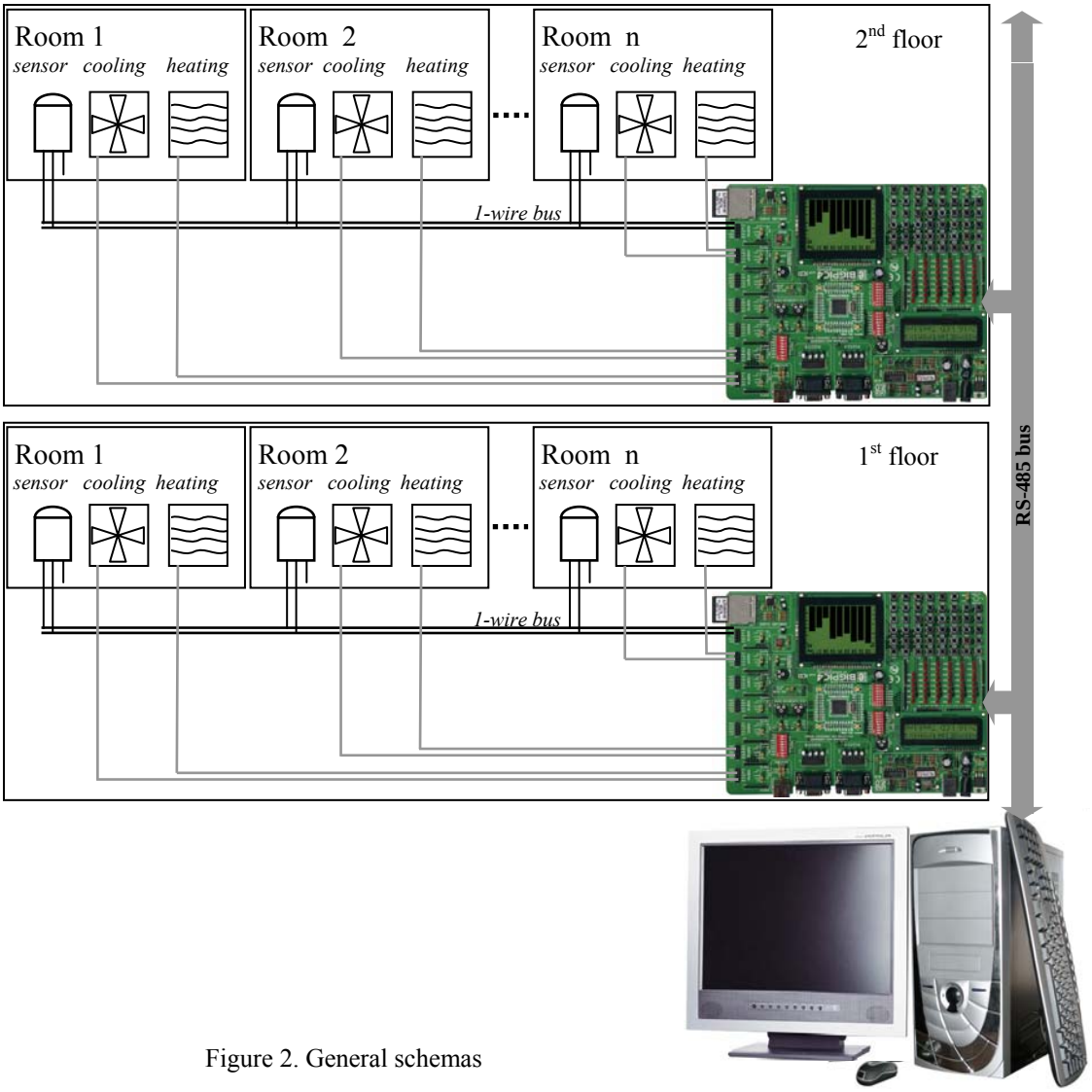

Figure 2. General schemas

The adjusting algorithm for each room is implemented on the development board with microcontroller. For each room we establish a minimum and a maximum admissible value of temperature. If the sensor approaches a temperature out of settled interval is started by case the climatizer. The temperature monitoring from the rooms of one floor can be done based on the digital system with microcontroller which can display locally the temperature value and the condition of climatizer for each room. To achieve a centralized control in the whole building the computer takes the temperature values for each room and allows changing the adjustment parameters for each of monitored room. In figure 3 is presented the virtual instrument panel that allows the centralized data displaying and the command of the adjustment regime unitary or individually on rooms.

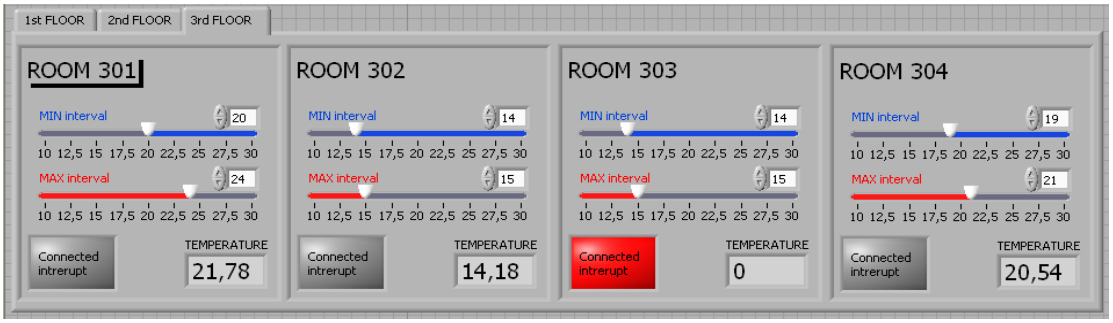

Figure 3. Virtual instrument for distributed building management system

The system functions placed at disposal by the LabVIEW programming language are diversified and powerful, centered on domains very useful for developing of environmental processes monitoring systems. The data transmission control is made through some specific command and control functions of computer port (RS-232) or of RS-485, GPIB and VXL devices. The data changing with other applications or other computing systems is facilitated by the included network or interapplications communication functions.
On data analyzing domain (statistical evaluations, linear algebra elements, time and frequency computing functions, digital filters, s.o.) the advance processing modules of data acquired directly or being in databases allow the real time displaying of the monitored parameters into a suggestive format or can constitute a database that can be processed ulterior.
This system can be used for industrial units where the thermal condition can be selected depending on the activities which take place in each of these and where after the program ending we can choose for temperature out of human comfort interval. Another using is represented by hotels where the rooms can be thermal monitored optimally and those non-lived can have temperatures out of comfort interval for energy economy.
The damage indicator that operates for one room in case in that from here temperature changes rapidly into a large domain represents another facility of the system. It is the case of fires, some open windows during the cold season, some climatizer out of working, all these leading to temperature variation more out of the prescribed interval. The same indicators will action also in case of the data transfer interrupting on the measurement chain either in case of sensors connections with the microcontroller board or in case of connection of the boards with the computer. The phenomenon is detected easily starting the damage signal at one whole section.

V. Conclusions

The advantages of management system:
- possibility to adjust the temperature domain for each room
- ensuring, besides a rapid and précis adjustment, of one monitoring with saving of the read temperature values and simultaneous implementation of one damage warning system
- a great degree of flexibility through decentralized setting of the components
- additional functions and the system extension can be implemented ulterior
- appropriate planning.

The device is able to switch more independent consumers as lighting, ventilation or heating. The switching function is executed by the relay contacts configurable depending on the needs. Depending on the application, the device can be used for different functions, as the logical or those for temporization.
The using of the virtual instrumentation on process and environmental factors monitoring offers more advantages regarding the achieving of some more special applications, spectacular, easy tested and repaired, perfect adapted to the imposed requirements by systems.
The LabVIEW programming language put to the disposal of the user and designer of such systems the significant advantages of graphical programming, being accessible to some specialists less familiarized with the classical programming (code lines) into high level language and more specialized on environmental problems.
The connection with one computer allows remote controlling using a modem. For example, service personnel can achieve a direct connection with the system from building. In this way the errors can be analyzed in real time and without traveling costs.
The system can be developed through changing of the temperature controls for each room with a menu that contains adjustment templets for different real cases or through automatic switching between different adjustments algorithms in various horary intervals.

References

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