Indoor Environmental Parameters Monitoring for Building Automation Systems

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Abstract – This article presents the implementation of a novel architecture of a specialized measurement and control system that is intended to be integrated in a complex automation system for buildings. The proposed design is realized around Atmega 328 microcontroller embedded on Arduino Uno development board. For indoor environmental monitoring are used different sensors associated with various physical quantities. In our approach were used three types of sensors: a combined temperature-humidity sensor (AM2302/DHT 22) characterized by a high precision and having digital output and digital pressure sensor (BMP 180) together with a light depended resistor (LDR) for light intensity measurements. The system is extendable and in the proposed configuration is capable to control multiple loads, including pulse width modulation (PWM) based proportional control. The correct operation and the reliability of the monitoring and control system were evaluated through simulations and practical test with implemented module. Compared with other implementations, the proposed design has the advantage of a flexible and versatile implementation, based on reconfigurable concepts specific to the high performance programmable microcontrollers, combined with a simple user interface for equipment control.

Keywords - environmental parameters, building automation, sensor

I. INTRODUCTION

The distributed control of complex house’s systems, including fire safety, surveillance and security, heating, lighting, air conditioning and ventilation has evolved in an accelerate manner due to the increased demands regarding the living comfort and functionality but also due to necessity to integrate in the building’s systems the latest developments realized in the green energy domain. Also, the development of powerful microcontrollers and IT systems combined with efficient communication protocols and long distance communication networks that are capable to realize secured data transmissions has lead to further development of building automation systems and intelligent house concepts. The acceptance of such kind of systems is relatively reduced because of increased implementation costs and high complexity but also due to the concerns related to the security that can be compromise by unauthorized access to critical control components of the building automation system. The building automation systems (BAS) are based on complex distributed measurement and control architectures. The main purpose of such kind of systems is to maximize the comfort and functionality of buildings [1], [2].
The practical implementation of building automation systems requires the integration of multiple types of technologies including data acquisition, sensors, transmission protocols, communication networks and interfaces, control algorithms and data processing algorithms operated on high speed microcontrollers. The general architecture of building automation systems can be divided in three main sections: management, automation, and field level. At the management level of the system are defined the control strategies while automation level contains the advanced controllers that regulates the operation of the devices situated at the field level. In this context, in this paper we present a reliable and cost effective implementation of an important part of building automation system, namely the indoor environmental parameters monitoring, which represents the direct interface with the actuation and control components of such systems [3].

II. THE STRUCTURE OF THE SYSTEM

The monitoring system for indoor environmental parameters is organized having as central unit a Arduino Uno development board based on Atmega 328 microcontroller (Fig. 2). The programming and the control of the development board is realized through an USB-FTDI interface circuit that ensures the communication with a PC. This interface circuit ensures the conversion from USB to TTL serial UART of the data transferred between the Atmega 328 microcontroller and PC. In the proposed system a set of digital and analog sensors were used for monitoring the basic indoor physical quantities. The measurement of temperature and humidity in the interior space of buildings was realized with AM2302 digital sensor. This device was selected due to its simplified connection interface based on only one wire bus correlated also with good accuracy and low power consumption. The light intensity measurement is realized with a light depended resistor (LDR) connected to one analog port of the Arduino board. The signal generated by the LDR is conditioned and then transformed in digital format with 10 bits resolution by the internal analog-to-digital converter (ADC). For pressure monitoring in the indoor environment a BMP180 digital sensor was used. The pressure sensing is ensured by a piezo-resistive element which leads to an improved sensibility and robustness of the device. Also, the BMP180 sensor contains all required signal processing stages necessary to obtain the measured signal n digital format. This allows direct connect between the sensor and Atmega 328 microcontroller using the inter-integrated circuit interface (I2C). By its multiple output ports the system is capable to control multiple loads and execution elements, including heating, ventilating and air conditioning equipments (HVAC) that requires pulse width modulation (PWM) based proportional control [4].

III. THE SOFTWARE APPLICATION

The software application used for controlling the operation of the indoor monitoring system was realized in Arduino’s specific programming environment. A sample capture presenting the initialization routines for Atmega 328 microcontroller is presented in Fig. 3. Also, in the Fig. 4 is illustrated the simplified state diagram of the software application. As can be remarked, after the initialization of the Atmega 328 microcontroller the sensors are periodically read and if the acquired values for one of the monitored parameters are not in the required range then are activated the corresponding correction subsystems. These subsystems operate until the values for the monitored parameters are in the desired ranges established by the user. At every cycle, after a configurable delay, the output values of the sensors are also displayed on local LCD.

![Figure 2. The simplified block diagram of the module used for indoor environmental parameters monitoring.](image)

![Figure 3. The initialization routine of the software application used for controlling the operation of the indoor monitoring system.](image)
IV. THE HARDWARE IMPLEMENTATION AND RESULTS

As was mentioned before, the monitoring and control system presented in this paper was implemented around an Arduino Uno development board having as main processing device a versatile Atmega 328 microcontroller with 23 programmable digital inputs/outputs lines, internal analog-to-digital converter with 10-bit resolution and 8 input channels multiplexer, 6 pulse width modulated outputs and one configurable 16 bit timer and counter. The maximum operation speed of this device is achieved at a frequency of 20 MHz which is sufficient for the requirements of the designed system [5].

The Atmega 328 microcontroller communicates with the external PC using a programmable serial interface (USART). The conversion between the USART and the USB interface of the PC is realized with a specialized USB to TTL serial UART converter produced by FTDI (Future Technology Devices International). Also, the initial programming of the Atmega 328 microcontroller was realized through this interface and using a bootloader previously stored in the device’s memory.

For testing the performances of the proposed monitoring system, some experimental boards presented in Fig. 5 and Fig. 6 was implemented. The DHT22 and its wired version AM2302 are the digital sensors used for reading the temperature and humidity in the indoor environment. This sensor is characterized by a 0.5 Hz sampling rate, having a maximum of 2% accuracy for a range of 0-100% humidity readings. For temperature readings in -40 to 125 °C domain, the accuracy of the sensor is ±0.5 °C. During long term testing it was found a degradation of the repeatability of values read with this sensor on both domains so for improved performance of the monitoring system it is desirable to replace him with a more performing device.

The BMP 180 sensor has a minimum conversion time of 4.5 ms, 0.06 hPa resolution and the measurement domain is 300-1100 hPa which impose also the measurement domain of the proposed monitored system. Due to its internal EPROM memory that store individual calibration data, the BMP 180 pressure sensor allows implementation of more simple and accurate calibration procedure.
Figure 6. The prototype board used for initial testing of the hardware and software components that compose the indoor environmental parameters monitoring module.

Figure 7. An implementation example, showing the operation of the module used for indoor parameters monitoring.

V. CONCLUSIONS

The demands for improved functionality and higher living comfort have increased constantly, reflecting in the development of more complex automation systems for buildings.

The monitoring and control system for indoor environmental parameters, presented in this paper, achieve good accuracy and reliability that makes them suitable for integration within more complex automation systems for buildings, especially those based on green energy.

The proposed system can be further improved by attaching a wireless communication module that creates the possibility to implement a sensor network for extended monitoring areas. Also, by connecting the designed system to the Internet or GSM communication network, the operation range of the system is practically unlimited because of the global availability of these data transmission systems.

REFERENCES


