FRI-10.326-1-EEEA-06

ELECTRONIC SYSTEM FOR HOME AUTOMATION

PhD student eng. Iordan Stoev
Department of Electronics,
Faculty of Electrical Engineering, Electronics and Automation,
"Angel Kanchev" University of Ruse
Phone +359 876 621 196
E-mail: istoev@uni-ruse.bg

Abstract: *This paper introduces the provision of the necessary comfort in the living space through the introduction of high-efficiency technologies and the use of certain energy resources, taking into account the high price, mainly of electricity for household purposes and, in some cases, gas for heating. Problem solving can be achieved by using modern microprocessor circuits with appropriate sensors for microclimatic parameters and actuators.The designed Home Automation System is presented as prototype.*

Keywords: *Home Automation, Sensors.*

INTRODUCTION

Home automation is a subdivision of the Building Management System (BMS). When talking about Building Automation is meant a distributed system, most commonly computer connected electronic devices that serve to monitor and control mechanical systems, security systems, fire and flood protection, humidity control over the entire building. Home automation can include centralized lighting control, heating, ventilation and air conditioning, door locks and other systems to provide comfort, energy efficiency and security. (ElShafee, A. & Hamed, K. A., 2012)

EXPOSITION

Basic elements of the system for home automation

The components of a home automation system can be broken down into several categories (Alam, M. R., M. R., Reaz, M. B. I. & Mohd Ali , M. A. A, 2012):

- sensors (such as temperature, daylight or motion detection);
- controllers (such as a normal computer or a dedicated automation controller);
- actuators (such as motorized valves, switches and motors);
- methods for connection (wired or wireless);
- interfaces (man-machine and/or machine-machine).

The tasks of the Home Automation System include (Bhatia, S., Bajaj, J. & Roja, M. M., 2014), (Purohit, D. & Ghosh, M., 2017):

- Climate control - heating, ventilation and air conditioning systems can include temperature and humidity control, including heating and natural cooling;
- Lighting. Lighting management systems can be used to control the electric lights in the household;
- Audio-visual. This category includes audio and video switching and distribution. Multiple audio and video sources can be selected and allocated in one or more rooms. This system can be connected to window blinds and lighting to provide a good mood for home entertainment;
- Shading. Automatic control of blinds and curtains can be used to simulate the presence of the occupant, privacy, temperature control, brightness control;
- Security and Access Control. A home security system integrated with Home Automation can provide additional services such as remote monitoring of security cameras via the Internet or central locking of all doors and windows. Through the Home Automation, the user can choose and

view live cameras over the Internet at their home or business office. Security systems may include motion detectors that detect any kind of unauthorized traffic and notify the user through the security system or via a mobile phone;

- Intercom. Intercom system allows communication via microphone and speaker between several rooms. Integration of the intercom, the phone or the video surveillance system with the TV allows residents to see the door camera automatically;
- Other systems. Using special hardware, almost every household electrical appliance can be monitored and controlled automatically or remotely, including cooking appliances, a swimming pool management system and many more.

Realization in the prototype of the Home Automation system

The designed Home Automation system includes the following functionalities:

- Lighting;
- Temperature control;
- Shading;
- Access control.

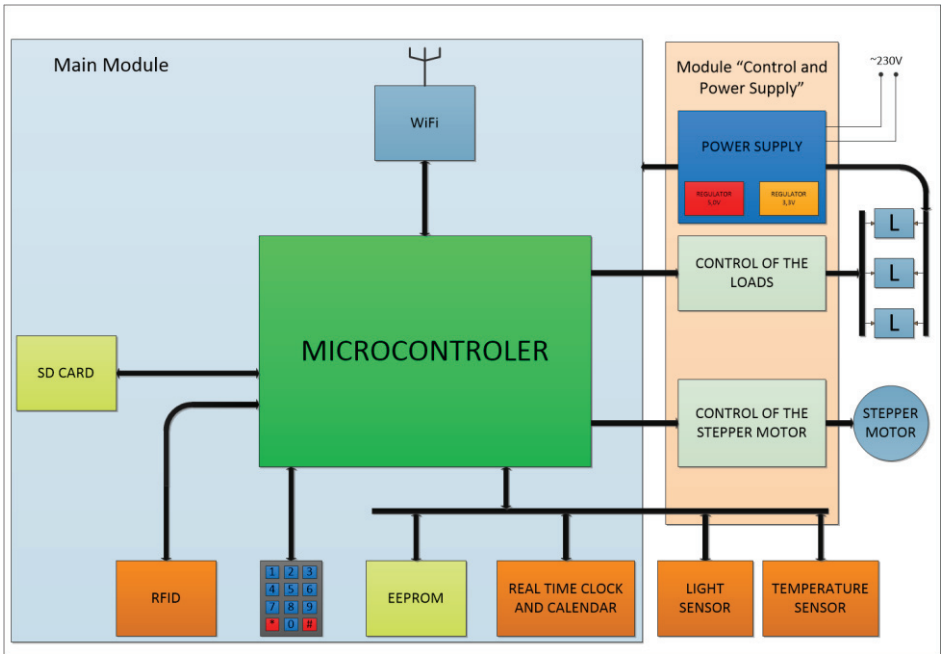

Fig. 1. Block diagram of the electronic system for Home Automation.

When designing a single network device, it is imperative to decide how it will be to connect to the LAN. There are devices that use only a wired communication. Others use wired and wireless. Others use wireless only. The cheapest and easiest option is the third option, emphasizing the lack of special and expensive RJ-45 connectors and integrated circuits that implement the physical layer between the network and the microcontroller.

The Electronic System for Home Automation is divided into two circuits – "Main module" and module "Control and power supply". The main module includes microcontroller, WiFi, Real Time Clock and Calendar, temperature sensor, keypad, RFID, SD card. The control and power supply module includes the control circuit for the actuators and the power supply for the whole system.

Different types of programs have been developed for the needs of the developed system - temperature monitoring, access control, stepper motor control, real-time clock, HTTP server, which will ensure the storage of several websites that will visualize the operation of the system,

NTP Network Time Protocol - a program that will synchronize the system to the Coordinated Universal Time (UTC) from a predefined server.

A. Real Time Clock and Calendar

In a Home Automation System, it is important to have a real-time clock and calendar. On the one hand, the TCP / IP stack itself has a SNTP module to obtain the exact time by querying an Internet server that has the ability to deliver Coordinated Universal Time (UTC) from a predefined NTP server (Mills, D., 1991). This time is the basic standard in which the whole world regulates time and adjusts the clocks. On the other hand, the system cannot rely on the fact that there is a constant presence of Internet service to the system itself. This requires the use of a local real-time clock and calendar. The microcontroller has a real-time clock and calendar, but it needs a battery, which further complicates the management of the energy states. Therefore, it is usually approached by setting an external real-time clock and calendar in an integral circuit implementation, with the microcontroller making a request to a predefined NTP server for universal time or relying on time from the local external real time clock.

B. Stepper motor

Another important feature of the home automation system is the "shading". There are different types of window blinds, some are hand manipulated, some are with an electric motor. In order for the system to manage a type of window blinds, it must drive an electric motor. There are different types of motors - synchronous, asynchronous and stepper. Synchronous and asynchronous are characterized by simple control, but have inertia and would require feedback on the position of the drive mechanism. In contrast, stepper motors offer high precision and have a number of advantages. The name "stepper motor" derives from the fact that under the influence of a magnetic field, the rotor of the motor can be moved in one step which is called a rotation angle. (Virgala, I., Kelemen, M., Gmiterko, A. & Lipták, T, 2015)

C. Communications interface to connect to a LAN

A wireless connection is used for communication interface of the Home Automation System. There are many WiFi modules from different manufacturers. Microchip has provided complete support in their TCP / IP stack for the modules they supply, and in particular for the MRF24WB0 and MRF24WG0 series. The two sets of modules differ only in the WiFi protocol. While the MRF24WB0 only works in the 802.11 / b standard, the MRF24WG0 works at 802.11 / b / g but is more expensive and unnecessarily fast for the system being developed. Operating frequencies range from 2412 MHz (1 channel) to 2472 MHz (14 channels). The two series modules are interchangeable with minimal changes in communication at the software layer.

D. Temperature sensor

A home automation system can control heating, and based on this, a temperature sensor is selected to measure room temperature. Thus, a thermostat can be built and room temperature controlled by temperature profiles.

E. Light sensor

For the same reasons, the system also needs a daylight sensor. One of the criteria for selecting a light sensor is the ability to detect light with a wavelength visible to the human eye - the range 380-780 nm.

F. Access control

The access control process starts when the user presents the credential (typically an employee badge or ID card) to the reader, which is usually mounted next to a door. The reader reads data from the card, processes it, and sends it to the control module. The control module

validates the reader and accepts the data. Depending on the overall system design, the control module may next send the data to the host computer or may have enough local intelligence to determine the user's rights and make the final access authorization. (Smart Card Alliance. Contactless Technology for Secure Physical Access: Technology and Standards Choices).

When designing the system, contactless RFID mechanism was implemented. The following card validation method has been incorporated into the developed system: the serial number from each card is read and it is checked whether the card is registered in the system. After verification, access to the home can be granted. Every family member has a reprogrammed access card.

In addition to the selected RFID Access Control Interface, a keyboard is also provided that allows the user to confirm their identity by dialing a user code and a PIN. The use of the keyboard is minimized, and it is only used in emergency situations on the main reader. The keyboard is a matrix with digits 0-9 plus "*" and "#" characters. The buttons are matrix-connected 3x4. When developing the system software, it is decided that the user will key in the four digits user code followed by the PIN and "#" at the end. The algorithm of the access module is show on Fig. 2.

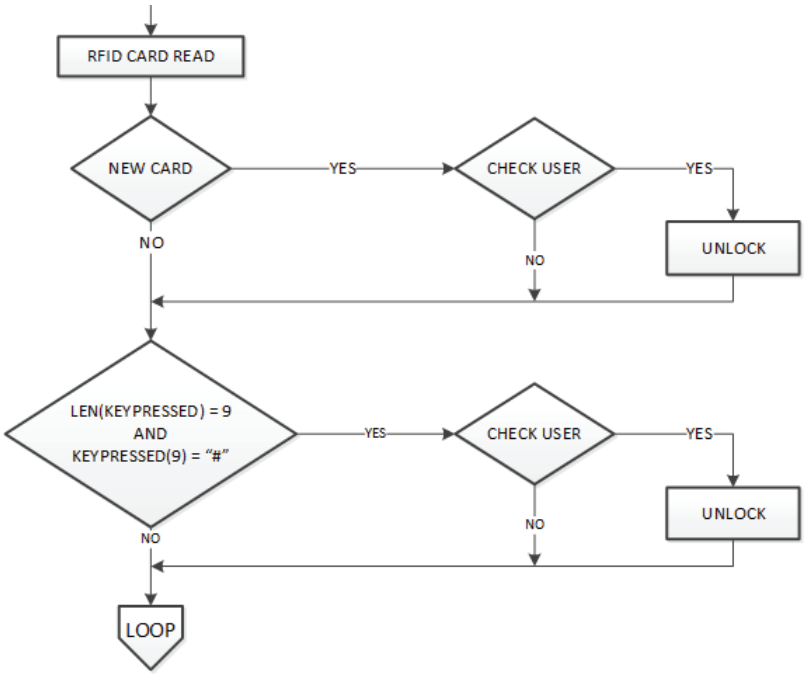

Fig. 2. Algorithm of the Access Control Module

G. Outputs for control of different loads

In order to test the performance of the prototype, there are three incandescent lamps imitating real consumers.

H. SD Card

The system has the ability to record all events on a standard SD card. The system records microclimate data in the home, and based on this data, further analyzes can be made.

Microcontroller from the PIC32MX series is used in the developed system. The choice is dictated by the free software supplied by Microchip - the Integrated Development Environment, the compiler for the program, and the ability to integrate the TCP / IP stack. (Peters, C. E. & Power, M. A., 2014)

The schematic of the main module is shown in Fig. 3. Fig. 4 shows an appearance of the prototype of the realized prototype of the Home Automation system.

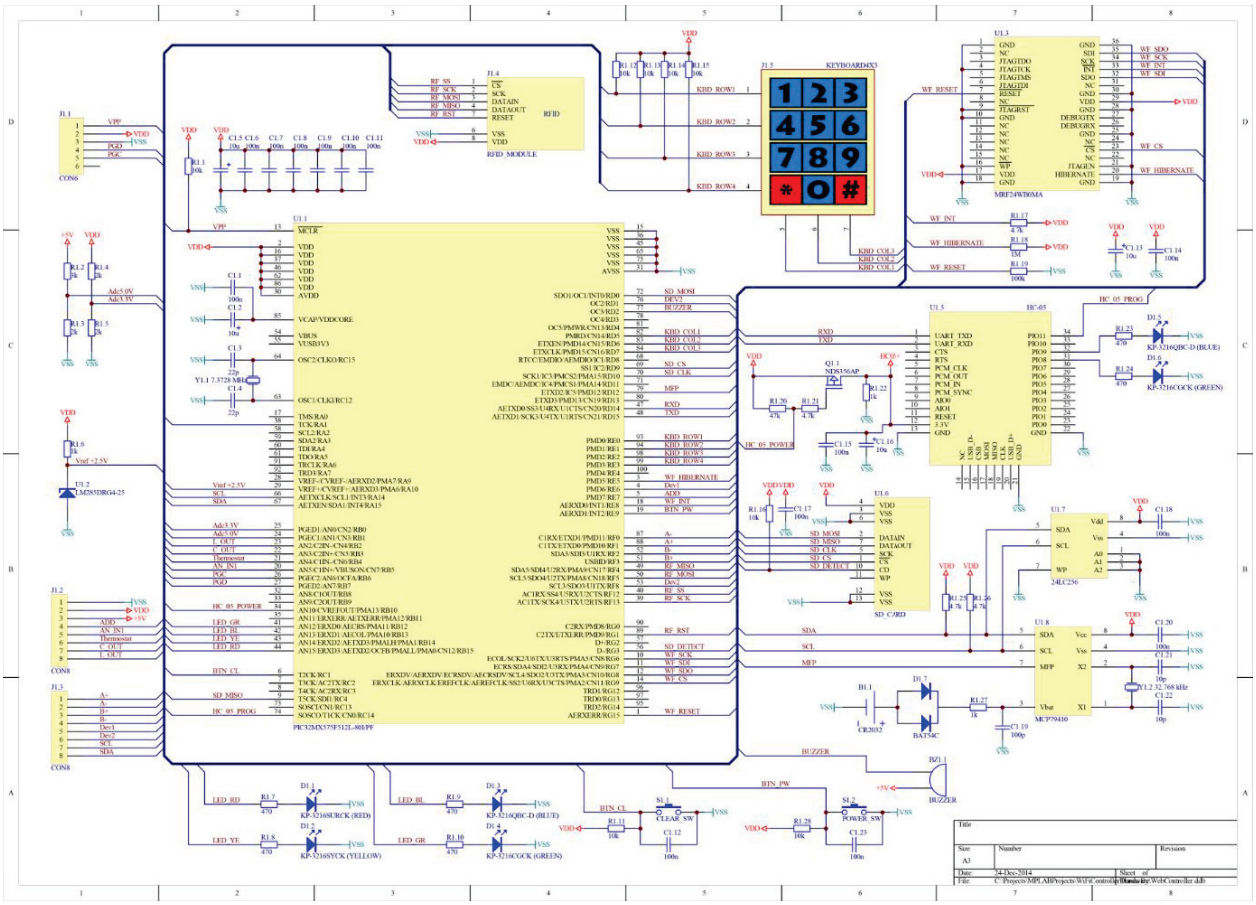

Fig. 3. Circuit diagram

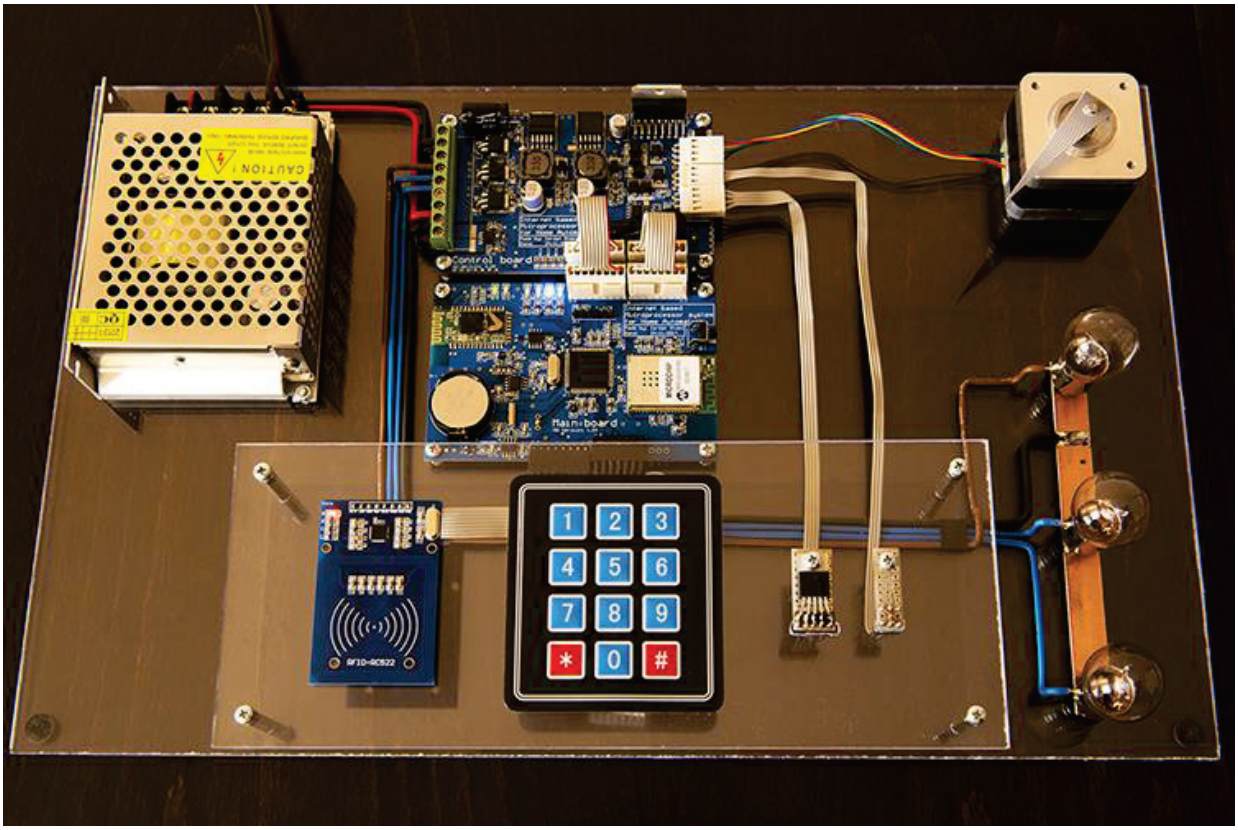

Fig 4. Prototype of the system

CONCLUSION

The prototype of the Home Automation system covers only four basic functionalities, in order to satisfy the minimum requirements for Home Automation System. Work on expanding of the capabilities of the system by adding a large number of sensors and outputs to actuators, managing the home equipment, providing the necessary comfort with minimal power consumption, is to be explored. Reduced energy consumption can be achieved by preparing the microclimate before returning from work or before waking up.

Ensuring the necessary comfort in a living space requires the introduction of high efficiency technologies and the use of certain energy resources. Considering the high cost, mainly electric energy for household purposes, in some cases also for heating gas, it is of particular importance to manage the energy flows by power and time.

REFERENCES

Alam, M. R., M. R., Reaz, M. B. I. & Mohd Ali , M. A. A (2012). *Review of Smart Homes– Past, Present, and Future.* Paper presented at the IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews) (Volume: 42, Issue: 6, Nov. 2012)

Bhatia, S., Bajaj, J. & Roja, M. M. (2014). *Technology, Systems and Implementation of a Smart Home Automation System: A Review.* Paper presented at the IJCTA-Volume 5 Issue 5/ September-October 2014

ElShafee, A. & Hamed, K. A. (2012). *Design and Implementation of a WiFi Based Home Automation System*. Paper presented at the World Academy of Science, Engineering and Technology - International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol:6, No:8

Mills, D. (1991). *Internet time synchronization: the network time protocol.* Paper presented at the IEEE Transactions on Communications (Volume: 39, Issue: 10, Oct. 1991)

Peters, C. E. & Power, M. A. (2014). *Tcp/Ip Control System Interface Development Using Microchip Brand Microcontrollers.* Paper presented at the 10th International Workshop on Personal Computers and Particle Accelerator Controls at Karlsruhe Institute of Technology, 14th -17th October 2014, Karlsruhe.

Purohit, D. & Ghosh, M (2017). *Challenges and Types of Home Automation Systems*. Paper presented at the International Journal of Computer Science and Mobile Computing Vol. 6, Issue. 4, April 2017

Smart Card Alliance. Contactless Technology for Secure Physical Access: Technology and Standards Choices. URL:

https://www.securetechalliance.org/secure/reports/Contactless_Technology_Report.pdf

Virgala, I., Kelemen, M., Gmiterko, A. & Lipták, T (2015). *Control of Stepper Motor by Microcontroller.* Journal of Automation and Control, 2015, Vol. 3, No. 3, 131-134

