JIEE Časopispriemyselnejelektrotechniky
Journal of Industrial Electrical Engineering
ISSN 2454-0900
www.jiee.eu

Design of the security system based on ESP32

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***Abstract* — This paper deals with design of a security system model. The article is focused to the individual components. It provides information about what sensors and components are used in the creation of this security system and about how the software part for security system management is designed. At the end is presented result of the implemented designed security system.**

***Keywords* — ESP32, security, security system, Wi-Fi**

I. Introduction

Security systems are used at almost every step and there are many industries where they can be used. Under the security system, we can imagine a group of sensors and components that are used to detect some undesirable conditions, which can cause, for example, fire, personal injury, theft of property, and many other undesirable problems. The security system tries to prevent possible threats and solves timely notification of the problem, whether through an alarm, website, mobile application, SMS message, or other available means. A wired security system is used in this paper. There is installed in simple model of a house. The reason for using a wired security system is that it is not prone to the EMC problems and the individual components are cheaper compared to the wireless system. In this security system, the mantle, spatial and other protection of the building is used, which is described in the previous article.

II. Design of the system components locations

First design of the sensors locations is presented. The floor plan of the house with the sensors locations are shown in Fig. *1*. Window sensors, where magnetic switching contacts are used, are marked in green. These window sensors are connected in series with each other. If the safety system is activated and window detection is enabled, the electrical circuit is interrupted when the window is opened, and the control unit immediately triggers the alarm device.

The yellow color shows a buzzer, which is an alarm device to generate an acoustic signal. The alarm device is activated by the control unit if the safety system is activated and one of the sensors detects an intruder or CO gas leak.

The location of the control unit, which oversees the functionality of the entire safety system, is shown in black. The CO gas sensor is in the kitchen because the most likely place of fire is the kitchen. It is marked in dark blue. If the safety system is activated and gas detection is enabled at the same time, the control unit will immediately trigger the alarm system in the event of a fire or gas leak.

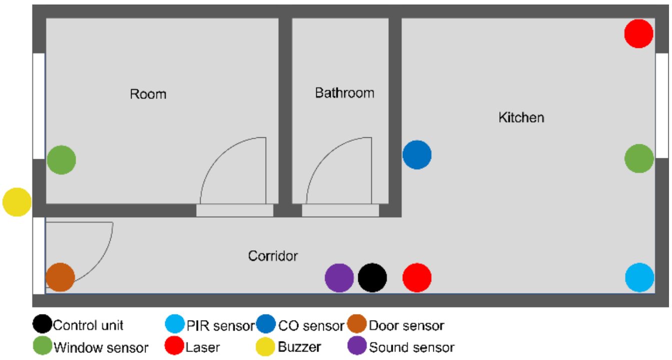

Fig. 1 House floor plan with the system component locations

The laser sensor is marked in red. The transmitter module that emits the laser beam is located close to the control unit. The laser beam receiver module is in the corner of the kitchen near the window. The laser beam is guided through the mirrors from the transmitter to the receiver so that it covers the entire room. If the safety system is activated and the detection of the laser sensor is enabled, then the control unit immediately triggers the alarm device when the laser beam is interrupted.

For other sensors used, the alarm device is triggered with a time delay of twenty seconds. This delay is set due to the possibility of manual deactivation of the security system via the keypad.

The location of the door sensor is marked in brown, where a magnetic switching contact is used. This color coding is not marked in green as with window sensors because this magnetic switch is not in series with other magnetic switching contacts. If the safety system is activated and door detection is enabled, then when the switch is opened, the control unit will not trigger the alarm until a time delay has elapsed.

The sound sensor is marked in purple, where a microphone is used to detect excessive noise. This sound sensor is used to detect breaking doors or windows. With this type of object disturbance, it can happen that the magnetic switch remains intact and thus the alarm device would not be triggered by the control unit. This sensor detects an intrusion only if the security system is activated and sound detection is enabled.

The light blue color shows the PIR sensor, which secures the hallway and the kitchen. This sensor also uses a time delay to trigger the alarm device due to the manual deactivation of the safety system. The PIR sensor detects movement only if the safety system is activated and PIR sensor detection is enabled.

III. Security System Components Description

The main component in this security system is the NodeMCU ESP32 development board itself. The storage location of the control unit should be as far away from the xxx The main security system controller is a development board NodeMCU Esp32 DevKit v1 shown in Fig. 2.

Fig. 2 NodeMCU Esp32 DevKit v1

The development board has a 32-bit Tensilica Xtensa LX6 dual-core processor, which operates at speeds of 160 to 240 MHz and power of up to 600 DMIPS. It also has a built-in antenna for Wi-Fi and Bluetooth connectivity. There are 30 GPIO pins on the board (some of them support UART, I2C, and SPI interfaces) as well as two buttons and a micro USB connector for serial communication and ESP32 power supply at the same time. This board has FLASH memory of 16 MB mapped to the CPU code space and also integrated SRAM memory of 512 kB. The ESP32-WROOM chip is equipped with a Wi-Fi receiver and transmitter operating in the 2.4 GHz band with Wi-Fi protection (WPA / WPA2 / WPA2-Enterprise / Wi-Fi Protected Setup (WPS)). The chip is equipped with Bluetooth connectivity (v4.2 BR / EDR and BLE) with normal and low power consumption. Operating voltage is 2.2 to 3.6 V [1][2].

As already mentioned, the NodeMCU ESP32 development board does not have the required number of GPIO pins, so the Arduino UNO board is connected to the ESP32, with which we obtain additional GPIO pins. The Arduino UNO board is shown in Fig. 3.

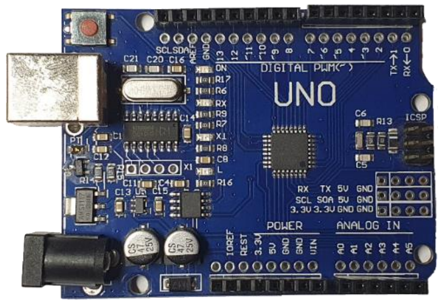

Fig. 3 Arduino UNO board

The board has an 8-bit ATMega328P processor, which works at an optimal speed of 16 MHz but can also work at a speed of 20 MHz. There are fourteen digital and six analog pins on the development board (some of which support USART, I2C, and SPI interfaces) as well as a reset button, a USB B connector, and a 2.1x5.5 mm connector to power the 9 to 12 V. Microcontroller has FLASH memory of 32 kB and 2 kB SRAM memory. This microcontroller contains two 8-bit timers, one 16-bit timer, and one analog comparator with scalable reference input. Of the fourteen digital pins, six can be used to generate a PWM signal. The operating voltage of the board is 2.7 to 5.5 V [3].

A 20x4 LCD display with an I2C module is used to display individual steps and information, which provides communication via two cables and uses liquid crystal technology. The display is shown in Fig. 4.

Fig. 4 LCD display 20x4

The LCD display has 16 pins. The Vcc (+ 5V) and Vss (GND) pins are used to power the LCD display. A potentiometer is connected to the pin marked V0, which adjusts the contrast for better reading of characters from the screen. RS (Register Select), R / W (Read / Write), and E (Enable) pins are used to control the LCD display. The R / W pin is used for writing and reading from the LCD display. If a logic zero (0 V) is applied to this pin, it means that we want to write data to the display. If a logic unit (+5 V) is applied, it means that reading data from the LCD display is selected. The pin marked E is used if we want to allow writing or reading data. There is a I2C module located on the bottom of the LCD display. It provides interface between the ESP32 and the LCD display and allow to control the LCD using 2 wires only.

The security system uses an electret microphone with a MAX9814 amplifier, which has automatic signal sensitivity compensation. It also includes a low-noise microphone bias. The electret microphone works on a similar principle as the condenser microphone. Instead of the need for an external voltage source to charge the diaphragm, as in the case of condenser microphones, an electret microphone uses a permanently charged plastic element placed parallel to a conductive metal plate. The operating voltage of the module is 2.7 to 5.5 V. The module also offers a change in sensitivity. In the basic state, the sensitivity is set to 60 db. This can be changed via a pin labeled Gain. If we connect the gain to the ground, the sensitivity will be set to 40 dB. If we connect a voltage from 2.7 to 5.5 V to the gain, the sensitivity of the amplifier will be set to 50 dB [6][7]. The microphone is shown in Fig. 5.

Fig. 5 Microphone MAX9814

The DHT11 module is used in the security system to measure the temperature in the house. The module can be powered from 3.3 to 5.5 V. The measured temperature range is from 0 to 50 °C with a possible deviation of ± 2 °C. In addition to temperature, humidity in the range of 20% to 90% can be measured [8]. The reason for using this sensor is that it measures the temperature in the range from 0 to 50 degrees, which is quite sufficient for the proposed house model. The DHT11 module is shown in Fig. 6.

Fig. 6 Microphone MAX9814

The keyboard shown in Fig. 7 is used in the project for manual control of the security system. A specific type of keyboard is used in the security system because it has enough keys and uses 8 digital pins for sending data.

Fig. 7 Keyboard 4x4

The laser receiver and transmitter module used in the proposed security system are shown in Fig. 10. The reason for using these modules is that they are implemented in a simple design and are dimensionally ideal for the project. The laser transmitter must be powered by a 5 V DC voltage and its luminosity wavelength is 650 nm. The NPN transistor BC547B is used to switch the laser because the laser needs to supply 5 V and the digital pin output of the NodeMCU ESP32 development board is 3.3 V. This voltage is not sufficient for the laser to emit a strong beam. Therefore, the NPN transistor solves the switching of the laser, which is powered by 5 V. The laser receiver module must be supplied with 5 V and the output of this module is 0 or 5 V. If the output voltage is 5 V, it means that the laser is interrupted. If the output is 0 V, it means that the laser is not interrupted [9].

The security system is using the HC-SR501 PIR (Fig. 8) module for motion detection. It does not take up much space and can be powered by 5V DC. The module can detect movement up to seven meters. The detection angle is 110 degrees. The module can be powered by a DC voltage from 5 to 20 V.

The output is a voltage of 3.3 V if the sensor has detected movement, otherwise it is 0 V [10].

Fig. 8 MQ-7 CO sensor

The system is using also MQ-7 CO sensor module (Fig. 8). It belongs to the group of electrochemical sensors. The module of the given type is used for the detection of carbon monoxide in a confined space, which is suitable for use in the proposed house model. The module can be supplied with 5V DC. The component has two outputs: one digital and one analog.

Fig. 9 Active buzzer

The active buzzer (Fig. 9 in security system is used to generate an acoustic signal. The component can be supplied with 2.5 to 3.5 V DC. When the buzzer is powered, it generates an acoustic signal with a frequency of 2300 Hz [11].

Fig. 10 Magnetic switch

Door or window opening detection is realized by the magnetic switch (Fig. 10). Alternative way of communication with the user – state of the security system is performed by the RGB led. The LED module is shown in Fig. 11. The module contains an RGB LED with a common cathode and three 150 Ω resistors.

Fig. 11 RGB LED module

IV. Security system control unit

The main component in this security system is the NodeMCU ESP32 development board itself. The storage location of the control unit should be as far away from the front door as possible. Therefore, we decided to place the control unit on the wall at the end of the hall, where the sound sensor is also stored. The control unit contains the NodeMCU ESP32 development board itself, an LCD display, a control keyboard, and a module for a micro SD card for storing and logging the necessary data. Since many sensors are used and the NodeMCU ESP32 development board does not have the required number of GPIO pins, we decided to connect another Arduino Uno development board to the given development board using I2C communication. A smoke detector, temperature sensor, and keypad are connected to the Arduino. The other sensors are connected to the NodeMCU ESP32 development board. The control unit also includes a temperature sensor and an RGB LED, which is used to display the individual states of the security system. Block diagram of the security system is shown in Fig. 12.

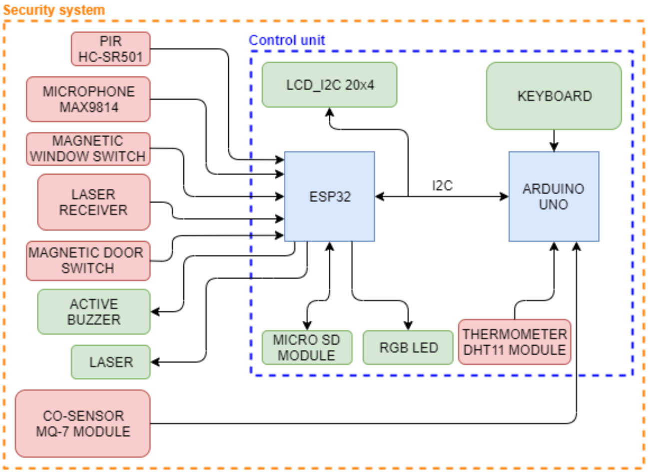

Fig. 12 Block diagram of the security system connection

The PCB with mounted components is placed in a plastic box, into which holes were cut for the Arduino UNO power connector with a DC voltage from 9 to 12 V, and connectors for the possibility of programming both development boards were also taken out. The temperature sensor DHT11 is located at the top of the box. The control unit box is shown in Fig. 13

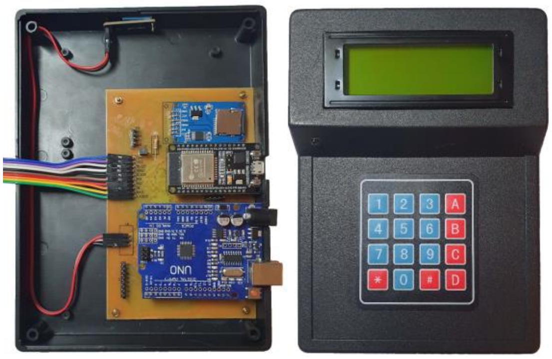

Fig. 13 Control unit box.

V. Conclusion

The article contains information about which security system we designed, and also which components and sensors are used in a given security system design. The article also shows the floor plan of the house model and the implemented control unit, which contains the development board NodeMCU ESP32 and Arduino UNO. The Arduino UNO development board was used due to the lack of GPIO pins on the NodeMCU ESP32 board. The communication of both development boards is solved through I2C communication.

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