Intelligent Building Security with Alternate Communication Path

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Abstract

Living and working spaces are becoming more and more intelligent with ever increasing integration of electronic equipment. One major concern of these intelligent buildings is the security of the building and its inhabitants including access control and a warning system for any imminent danger. In this work we present a security system composed of an access control system based on fingerprint recognition, a CO level detection system, a flammable gas detection system, and a radon level detection systems. All these systems are connected together to generate warning signals in any danger situation. Also these systems have a secondary communication path to avoid situations when warning signals are not observed in time by the inhabitants. This secondary communication path is based on a GPRS / phone modem connecting the system to a remote security center.

1. Introduction

Intelligent buildings include many sensor systems of which a great number deal with security and safety issues. Such issues are controlling access to the building by allowing only rightful persons to enter and alerting at intruder attempts; and also monitoring the environment to anything that can pose a threat to the health of the inhabitants and alerting in case of imminent danger [1],[2],[3].

There are monitoring systems for smoke or open flames for detecting fires. These systems are usually interconnected into a network with direct connection to the fire department for alerting them in case of fire.

There are other monitoring systems however which are not interconnected, just giving alert to the immediate vicinity of the sensor. Such systems include CO level detection, flammable gas detection, radon level detection, etc.

These systems usually employ the sensor and some display of the measured data, and maybe some acoustic warning for danger situations. However the alert of this systems may go unnoticed mostly because nobody is paying attention to these sensors.

We propose an interconnection system which collects data from these sensors and reports them to a remote location where trained personnel are watching constantly over them, so in a danger situation everybody can be alerted and evacuated.

2. Sensor systems

For the proposed system we used the following sensors: capacitive fingerprint sensor, radon detector based on ionization chamber, CO and flammable gas detector based on SnO_2 semiconductor sensor [4].

All sensors were available in independent commercial kits with visual and acoustic warning systems, but no interconnectable interface.

2.1. Fingerprint sensor

For fingerprint recognition a MDFP200 kit is used employing a MBF200 capacitive fingerprint sensor (figure 1) [5].

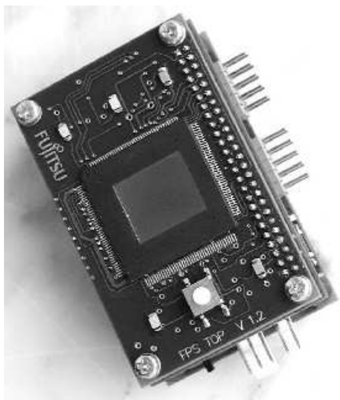

Fig. 1. MDFP200 fingerprint reader

This module contains besides the fingerprint sensor a MB91F302 microcontroller, 8MB SDRAM, 2MB flash memory and 2 UART interfaces.

The microcontroller is preprogrammed with fingerprint recognition software. This software acts as a library containing 3 functions for fingerprint acquisition, enrollment and matching. The use of this function is left on the designer's choice. The easiest way is assigning the acquisition function to the external interrupt coming from the sensor (which is generated when a fingertip is detected on its surface), and calling the enrollment and matching functions from a separate task started by the interrupt function, but managed by an operating system.

This way the remaining processor time can be used for other functionality. The recognition process is computationally intensive, so no processing time is left when the recognition is running, but this happens only when someone touches the sensor (can be considered very rarely) and takes only less than a second to complete.

The remaining time can be effectively used to monitor other parameters regarding building security.

2.2. Radon detector

Radon is a radioactive gas with half-period of 4 days, emitting alpha particles on its decay. Radon is dangerous because being a gas it can be inhaled and the alpha particles emitted on decay can cause lung cancer.

Radon is measured by detecting the alpha particles emitted on its decay. Detecting alpha particles is most often realized with an ionization chamber which also offers information about the energy of the alpha particle. The energy of an alpha particle emitted by radon decay is around 6-7.7Me. By numbering alpha particles having this energy the concentration of radon can be estimated.

In our security system we used a SafetySirenPro3 radon detector (figure 2).

Fig. 2. Radon detector

This detector employs an ionization chamber and a pulse formatting circuit converting the pulse generated by alpha particles into digital pulses. For detecting the type of alpha particles 2 digital lines are used, if the alpha particle is emitted by radon decay than a single pulse of 80µs is generated on line 1 and no pulses on line 2. Any other configuration as pulse on both lines, or multiple pulses means other types of alpha particles.

A microcontroller counts these pulses and displays the result on a 7 segment display in pCi/l. The pulses are averaged for 7 days to give a more accurate result.

2.3. CO and flammable gas detector

In this system we used a SafetySiren Carbon Monoxide and Combustible Gas detector (figure 3).

Fig. 3. CO and flammable gas detector

This detector uses SnO_2 based solid state sensors for detecting carbon monoxide concentration and methane/propane concentration.

The measurements are effected by a microcontroller giving alarm conditions when a critical level of CO or flammable gas concentration is reached as follows:

- red LED and continuous buzzing when CO levels critical
- red LED and intermittent buzzing when methane or propane levels critical

3. Interconnecting system

As it has been seen none of this sensor features any kind of interface besides a local display.

To connect these sensors together a microcontroller is used to collect independent data from the sensors and to present the collected data in a compact form to a remote monitoring system.

The block diagram of this system is presented on figure 4.

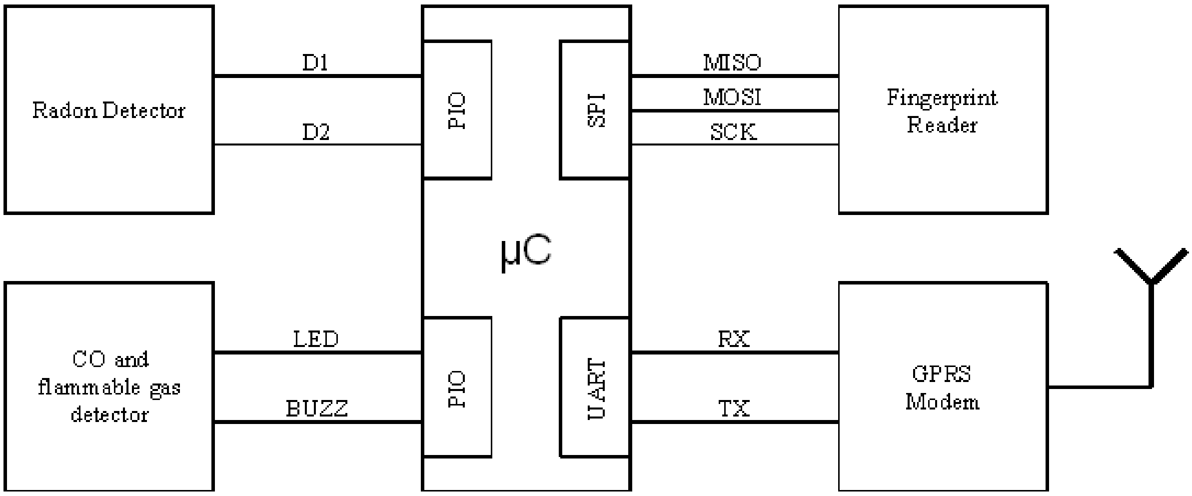

Fig. 4. Block diagram of the proposed system

For the central microcontroller an Atmega16 is used. There is also an optional local display by the means of graphic LCD for displaying all the alarm conditions.

The radon detector and the CO and flammable gas detector are connected to the parallel IO pins of the microcontroller (with interrupt on change capability), while the fingerprint reader is connected through the SPI interface. The UART is used for communication with the GPRS modem.

There are two methods to read the radon detector:

- reading values directly from the 7 segment display
- counting the digital pulses on the 2 signal lines from the analog block of the sensor

The first method assumes using 8 + 4 PIO lines for reading the 8 data lines (7 segments + the dot pitch) and the 4 mux lines of the display. This means a lot of pins of the microcontroller must be used and connecting the detector to the system is done by a parallel interface extremely sensitive to noise. Also the reading is very time consuming as constant monitoring of the data and mux lines is necessary.

The second method assumes only 2 PIO lines, but the computation of the radon concentration has to be done again in the central microcontroller. However this computation can be softened up by the fact that only alarm condition is needed for high concentration of radon.

For counting the correct pulses (those caused by radon decay) the following conditions must be met: there is a single pulse on D1 and no pulses on D2.

To achieve this condition D1 and D2 is connected to interrupt on change pins, which generate an interrupt when the positive edge of the pulse is detected. When a pulse on D1 is detected a timer is started with a timeout period of 320µs. During this period any other interrupt on these pins disables the counting for this pulse. If no such condition exists after the timeout the pulse counter is incremented.

Every hour the current count is stored in memory and the last 128 hourly counts are averaged. This average value gives the radon level which is transmitted to the remote location.

Reading the CO and flammable gas detector is done through its local warning interface consisting of a LED and a buzzer. The LED is lit in case of alarm conditions and the buzzer is modulated according to the cause of the alarm condition.

The LED is connected to an interrupt on change pin to detect when an alarm condition is active. In the interrupt routine for this pin the PIO pin connected to the buzzer is inspected for 1s. If the buzzer is continuously on then the alarm flag for CO is set, otherwise the alarm flag for flammable gas is set.

This two flags are also transmitted to the remote location.

The fingerprint reader as presented above has its own microcontroller which can be programmed by the user to use the built-in libraries for fingerprint recognition but also other user defined programs.

In this user defined part a monitor program is located which monitors a movement detector on the entrance where the fingerprint module is located. When someone enters the building without authenticating an intruder alarm is generated.

Both the intruder alarm and the successful recognition of an authorized person is signaled to the system by sending a message through the SPI port.

The central microcontroller is connected to this SPI port listening to messages from the fingerprint reader. The incoming messages will be passed toward the remote location.

For communicating to the remote location a GPRS modem is used connected to the UART interface of the microcontroller. The microcontroller generates AT commands to open a connection to a remote server and passes alarm conditions to this server.

The GPRS modem is an EZ10 modem employing EasyGPRS protocol. It uses a standard RS232 interface (needing a level converter at the central microcontroller) and is commanded through standard AT commands.

The microcontroller sets up a connection to a server by a predefined IP and port address. If no special event happens the connection is established every hour and the current status of the system is sent in a single TCP/IP packet. After the acknowledgment is received the connection is closed.

Whenever a critical event occurs such as dangerously high levels of radon, CO or flammable gas concentration or an unauthorized access a connection is opened immediately transmitting an alarm packet containing the source of the alarm.

The prototype system of this application is presented on figure 5. This includes the central microcontroller unit, as well as the presented sensor modules and the EZ10 GPRS modem. The central microcontroller unit includes a power supply also powering the sensor modules and a graphical display for local information about the measured values. The front panel with the display is presented on figure 6.

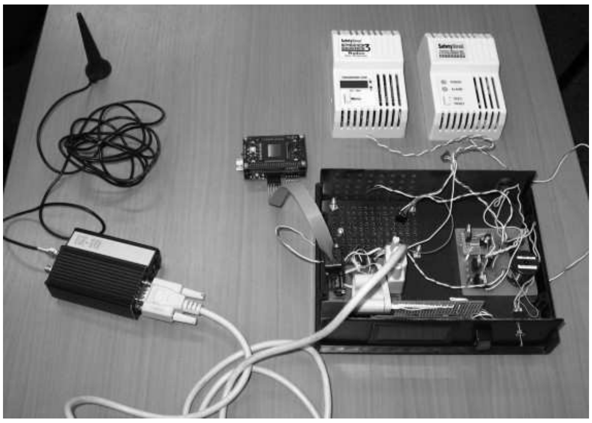

Fig. 5. Prototype assembly

Fig. 6. Front view with local display

At the remote monitoring location a PC is used acting as a server listening to incoming connections. Incoming packets containing the measurement values are saved into a database together with the packet identifier which uniquely identifies the exact location of the measurements. This identifier can be fixed on a map for easy determination of the location of the danger and correct dispatching of emergency units.

4. Conclusions

The system proposed in this work manages to connect together several safety and security related products which originally were designed to work independently.

With the interconnection of these modules we can achieve greater security of the buildings as all the collected data is transmitted to a remote location where is can be constantly monitored by trained personnel. This way problems arisen from not observing the local warnings can be avoided.

This system presents the same performances of a system designed directly for interconnection and remote operation, but has the advantage of using already existing security modules, allowing an easy upgrade of an intelligent building to remotely monitored intelligent building.

Acknowledgments

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