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ZigBee Based Home Security Alert System: An Integrated Approach

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ABSTRACT

In remote home monitoring security system, embedded devices play a vital role. In this study, GSM, ARM and ZigBee are used to establish a security for smart home. In this study, LPC2148 is used as Microcontroller Unit (MCU), Resistance Temperature Detectors (RTD) to observe temperature, smoke sensor to detect the presence of smoke and vibration sensor over doors and windows to detect forced entry, overall system safeguard the home from burglary. On entering the correct password, MCU disarms the security feature else it activates the alarms and sends image of the burglar to amenable persons through ZigBee and whenever there is smoke or fire MCU sends SMS to owner as well it automatically activates safety measures like, opening window turns on the exhaust fan and sprinkler.

Key words: LPC2148, ZigBee, GSM, sensors

INTRODUCTION

As there are lots of burglaries happening in and around our place, people are more concerned about the safety of their valuables. To tackle this we have a distant monitoring and control system which is having temperature, smoke and vibration sensors to keep the house safe (Li and Cai, 2010). Whenever there is trespassing, the MCU directs the camera to take photos and send the photos to security office and send SMS to the owner as well as security office in that apartment (Huang *et al.*, 2010). Traditionally, the monitoring system has only buzzer or CCTV where CCTV records each and every minute of the day which is not required and is a waste of resource. The existing system also fails to deliver the response of smoke sensor.

But, this security system effectively utilizes the camera when someone who doesn't know the password tries to enter in to the house. The keypad has UART interface, LPC2148 comprises of internal transmission protocol (Ramamurthy *et al.*, 2010). And, whenever there is a smoke in the room and the MCU alerts the owner through SMS and turns on the exhaust fan. This control system can be used in the houses and as well as shops.

The existing system consists of GSM based home monitoring system (Sujana *et al.*, 2011), which sends SMS and MMS on occurrence of interrupt. For sending MMS, GPRS connection is essential. While this feature is not supported by low-end mobiles and cost is also comparatively high for sending MMS. Also sending culprit's picture to owner at distant place is unnecessary. Thus in proposed paper ZigBee is used, through which the picture is transmitted to security center located within a residency. Even though ZigBee has low coverage on comparing with GSM, its range is feasible to communicate between home and security center.

FUNCTIONAL BLOCK DIAGRAM AND DESCRIPTION

The overall block diagram of the entire system is shown in the Fig. 1. The major components and their connections are shown. The block diagram comprises of LPC2148 which is an ARM based microcontroller and the tracking components are Gas sensors to detect LPG and smoke, Resistance Temperature Detectors (RTD) to measure temperature and based on the output of RTD and gas sensor, the fire alarm will be activated and SMS is send with an accident message to the owner through GSM (Li and Cai, 2010), vibration sensor module will detect unauthenticated entry with password security system at door. The detailed descriptions of each module used in the system are explained below.

ARM7TDMI core: The monitoring system is effectuated by LPC2148 (Tang *et al.*, 2011). The LPC2148 is 16/32 bit ARM7TDMI-S. Emulation in real time and embedded trace (i.e., combines controller and high speed flash memory) are supported. Low power consumption and its small size make it suitable for access control applications.

It has high processing power which makes it suitable for low end imaging. It comprises of 45 GPIO lines, 32-bit timers, 10 channel 10-bit ADC and DAC.

Sensors: A sensor is a device, which responds to change in physical parameters. It's actually a converter that measures physical quantity and converts it in to an electrical signal which can be understood by an electronic instrument. In this study we are using RTD and MQ7.

Resistance temperature detectors: Here, PT100-TF101N platinum based resistance temperature detectors are used. Its precision is up to 0.1 degrees. They give stable output for long period of time; calibration is easy and accurate readings. They are immune to the electrical noise and is well suited to work in different environment conditions. They can measure from -50 to 550°C which is very much needed for detecting fire.

Gas sensor (MQ-series): Its sensitive material is SnO₂, which has lower conductivity in air and has an Electro-circuit that changes conductivity to matching gas concentration. When the gas

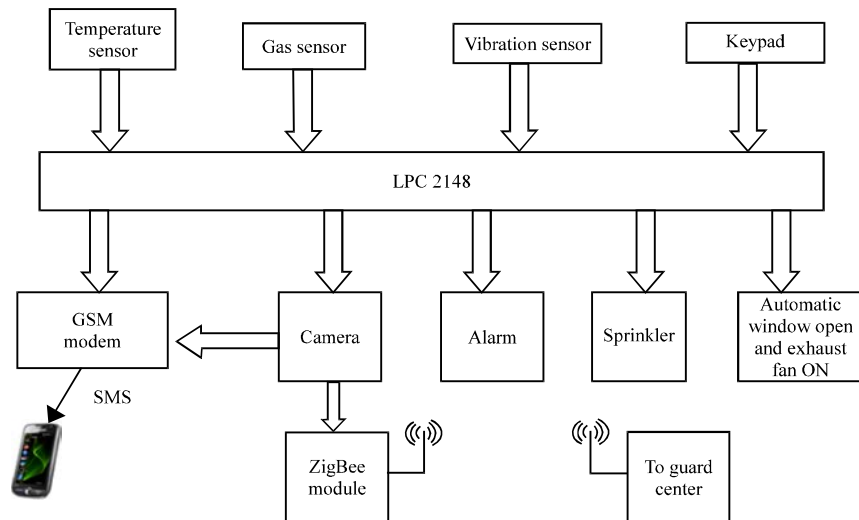


Fig. 1: System overview

concentration starts rising the sensor conductivity also rises. MQ-7 sensor is highly sensitive to Carbon Monoxide. This sensor can detect gases which are CO derivatives. MQ-5 gas sensor detects LPG leakages. Its low cost makes it suitable for different applications.

The features of MQ include:

- Domestic gas leakage detector
- Sensitive to both natural and combustible gas

Vibration sensor: The vibration sensors are placed on the door and windows and their configuration is such that whenever vibration exceed the level (specified in g's.), the mechanical arrangement breaks and stops the current flow in the circuit and thus raises an alarm. These vibration sensors can be tuned based on the requirement of the application. Low output sensors of 10 mV g^{-1} are used to measure high vibrational levels.

The features of vibration sensors include:

- High accuracy
- Good response time

GSM modem: It's a device which converts the digital signal to signals which will be used in GSM and converts back the GSM signal into digital signal. AT commands are used to interact with the GSM modem. AT commands are used for sending and receiving SMS.

This proposed system uses SIM 300. Its frequency range is between 900 and 1800 MHz. It's a triple band GSM/GPRS engine. Their small sizes make them suitable to be fit at any place based on the requirement. Sixty pins board to board connector are used to connect it to mobile interface. The power consumption of SIM 300 is very low which makes them an ideal GSM modem. It has built in TCP/IP protocol which can be added with AT commands for data transfer.

Mobile phone: A mobile phone is a device for making and receiving telephone calls over a wireless network at the same time can move through a wide geographical area. Today, Mobile phones are being used by almost all the people which makes them a suitable device capable of sending commands to the distant operator. This system uses mobile phone for sending SMS through SIM 300 GPRS modem.

ZigBee module: ZigBee follows wireless mesh network topology. It's low cost made this to be widely deployed in wireless control and monitoring application. It uses very low power and thus has a very long battery life. It uses unlicensed 2.4 GHz ISM band which is available worldwide. It has range between 10 m to 2 km; works well with networks such as Wi-Fi, Ethernet and GPRS and provides scalable networking solution which makes it suitable to be used in our application.

SYSTEM FLOW

The set up consists of two LPC2148 boards, two ZigBee module, one GSM module and one stepper motor. Proposed system comprises of three modules. The system flowchart is shown in Fig. 2.

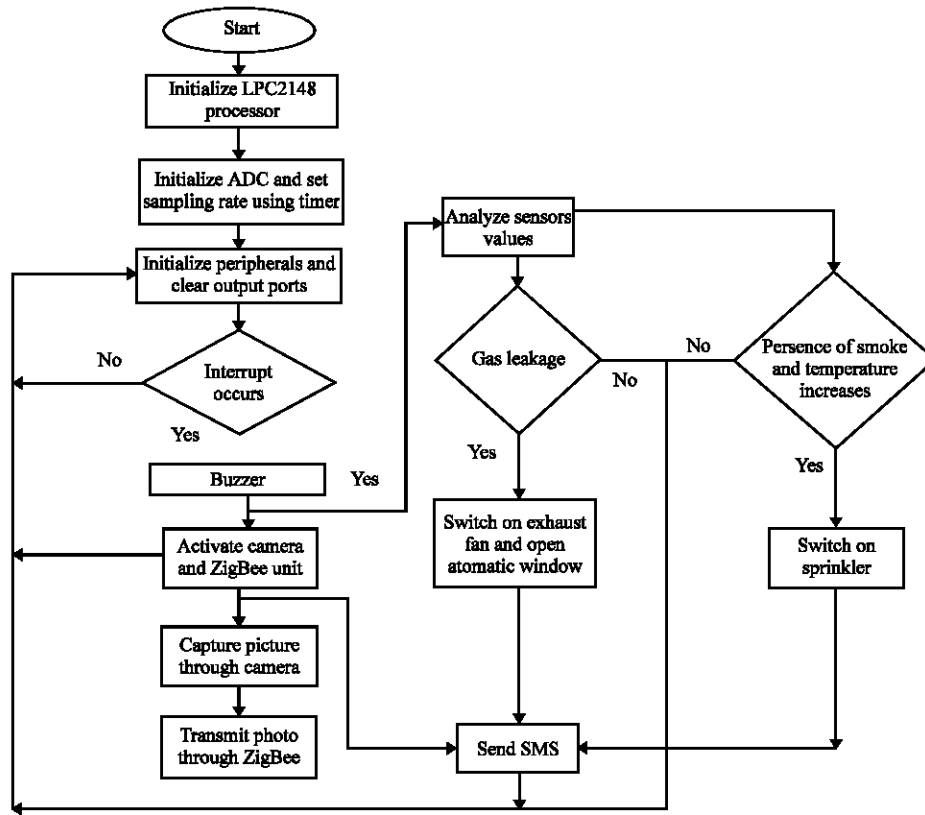


Fig. 2: System flowchart

The first module comprises of temperature and gas sensor (MQ-7) in which LPC2148 continuously monitors the temperature from RTD and also the output of smoke sensor through ADC. If the temperature value is above 50°C and concentration of CO is more than 200 ppm, then MCU will activate the alarm as well as relay which in turn will activate the sprinkler.

In second module Gas sensor (MQ-5) is used to detect LPG leakage. If MCU detects leakage exceeds 1000 ppm then it activates the security features. Here stepper motor rotation is used to indicate mechanical opening of window and relay 2 is activated to Switch ON exhaust Fan. At the same time LPC2148 will activate the alarm and GSM module to send an SMS to alert the owner.

The third module comprises of vibration sensor, ZigBee and camera modules, Whenever anyone tries to forcibly enter the house, the vibration sensors placed at doors and windows detects that exceeding vibration and activates MCU. Thus camera placed at the doorstep will get initiated and take the picture of the burglar and through ZigBee the picture will be sent to the security and an SMS will also be sent to owner. Here X-bee pro is used, it coverage of about 40 m-1.6 km. The hardware implementation is shown in Fig. 3.

RESULTS

Comparison between proposed and existing methods is shown in Table 1. So, based on the result we can see that whenever there is a forced entry into the house or there is any fire or smoke breakout, then the system will send SMS to the owner and through ZigBee module the image of the burglar will be sent to the security center. Here we trigger safety measures

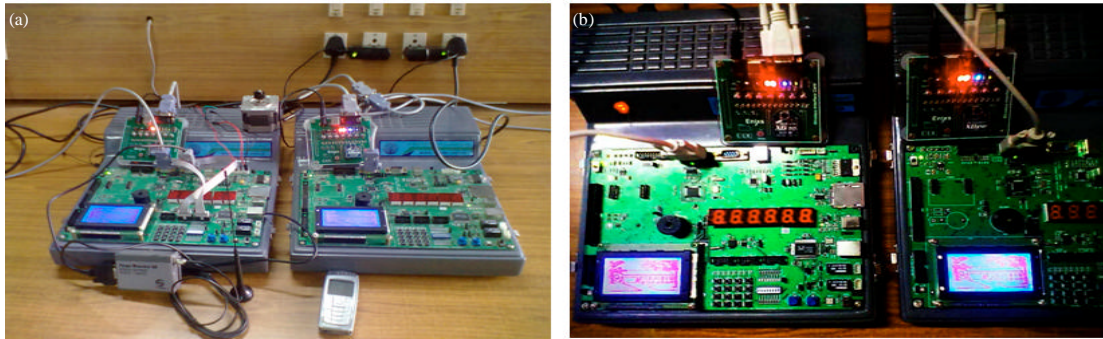


Fig. 3(a-b): Hardware implementation

Table 1: Comparison between proposed and existing methods

Proposed method	Existing methods
LPC2148 consumes very less power as it works on 3.3 V power. It has got internal ADC to convert the analog signals to digital	All other microcontrollers uses 5 V for operation and requires separate IC to convert the signal from analog to digital
ZigBee is used to send the captured image to security office, which is located within apartments	Existing method uses GPRS to send the captured image which is complex and costly, since data rates are applied
Vibration sensor is used which is used for detecting intrusion. These sensors convert the seismic vibrations to electrical signal which is than processed and has higher accuracy than magnetic sensor	Magnetic sensors fail to guard the house when there is an excessive movement in the door or window because it creates conditions for unreliable detection and will unnecessarily put false alarm
MQ-7 gas sensors are used to detect high levels of carbon monoxide and importantly it detects the leakage of LPG gas	Other paper suggests the use of smoke sensors but it fails to provide the proper solution for detection of LPG gas
Cameras are commanded to take photos only when there is an intrusion and then transfer those photos to the security controller	Other paper suggests the use of CCTV which is not best suited because it records each and every minute of the day which is a waste of resource
Automatic measures are activated, such as window.open, sprinkler, exhaust fan and alarm on critical situations	No such measures, only alarm is activated
Through GSM continuous message alert is send to owner on critical situation	No such alert system is supported

like window opening, sprinkler etc, same way many other measures can also be incorporated. Also, the proposed system is cheap, secured, can be easily implemented and has much scope of up gradation.

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