A Wireless Warning System using a Programmable Intelligent Computer

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Abstract. The problem of preventing unauthorised persons from accessing specific places has become an interesting research field. This study proposes a warning system to alarm the owner about any unauthorised attempt to access a secure gate. In the proposed system, the classic alarm circuits that use 555 timers or operational amplifiers are replaced with a simpler and more reliable electronic circuit that includes a small microcontroller chip known as a Programmable Intelligent Computer (PIC). The PIC is programmed to perform sense any touch and produce an alarm signal (buzzer sound), or to send a text message and/or phone call. Implementation of the system demonstrates the superiority of PIC-based circuit over rudimentary electronic circuits in terms of cost, size, complexity, reliability, and system updates.

1. Introduction

Many people are becoming increasingly disturbed by news of the spread of crime that appears to threaten their security. Crime rates are still growing in many areas in spite of attempts to develop resources to avoid or limit criminal activity. Studying ways to modify warning systems that use traditional devices to accommodate the new challenges of detecting criminals is thus a useful step, and with the use of modern warning systems, crime can be reduced to a large extent; however, problems related to the issue of incorrect warnings have also become a topic of increasing concern [1]. Modern electronics can be used to reduce the chances of such false alarms and increase the effectiveness of these warning systems, however, and the use of a touch-based alarm system is more effective because it ensures that the alarm occurs only when a knob, key-hole, or other specified portion of a thing is touched.

The application of modern electronic technologies makes personal security simpler and more reliable. One application of such electronic devices is in alarm systems, which may prevent criminals from accessing private locations. Such alarms can be used to avoid or reduce the effect of crimes where alerts are sent immediately and correctly so that they are received in time for preventative action to be taken. Security systems of this type must, however, also offer a high degree of accuracy to avoid false warning signals that cause confusion and disturbances.

A basic security system can be implemented using a camera connected to a monitor screen such that an observer can detect any abnormalities in a scene. The difficulties with such systems include the requirement to continuously monitor the area of concern. Face recognition techniques [2][3] can be used to overcome this difficulty by identifying human faces and determining whether these are “known”. In addition, ultrasonic sensors [4], passive infrared (PIR) sensors [5], and infrared cameras [6] can be used to detect human action in the surrounding area. Failures by sensors include detecting inhuman things such as animals and vehicles; the best solution to these problems is thus the use of a
touch sensor that produces a signal when someone touches any conducting part of a selected item that is connected to the sensing terminal.

2. Related work

In the literature, several approaches have been presented to overcome security problems using different technologies. An alarm system based on touch sensing was introduced in [1] using 555 timers and a loudspeaker. The researchers faced an essential problem with regard to the sensitivity of the triggering circuit, which sometimes produced an alarm sound without any touch on the sensor terminal, however. This problem was solved by reducing the resistance related to the sensor terminal and the triggering pin of the 555 timer. The authors in [7] analysed various attacks that might occur on the security systems of vehicles that depend on keyless entry. They also made a comparison between attack types in terms of system vulnerability, attack difficulty, and attack tools. The authors then suggested some ideas to help vehicle designers to design security systems with a higher degree of robustness against such possible attacks. In [8], a wireless security system was proposed using Global System for Mobiles (GSM)/General Packet Radio Service (GPRS) techniques and various sensors such as PIR, magnetic, and fire sensors. A similar system was proposed in [5] using PIR sensors and GSM/GPRS techniques that allowed monitoring of a secure place via mobile communications. In [4], a surveillance system was designed using multiple ultrasonic sensors, and a web camera was used to send captured images to the owner’s page on the internet. The aim of using multiple ultrasonic sensors was to increase the accuracy of the system against false intruder detection. The authors in [9] similarly proposed an indoor security system using PIR sensors to detect intruders that used a wireless sensor network to send images to the owner over the Internet. Once the sensor detected an intruder, a signal was sent to a robot that could jump into place and capture images of the sensor pathway.

A smart home system was further introduced in [10] using PIC16F778A, designed to detect intruders and fires. An infrared sensor and GSM model were used to detect issues and an SMS was sent via wireless channels to the owner. In [11], a security system was proposed using PIR and reed switch sensors to detect humans near the installation point. After it detected an intrusion, a buzzer sound was generated, and a message sent to the owner via GSM technology. A multi-task security system was proposed in [12] to address issues with gas, fire, humidity, temperature, and intruder detection. The intruder detection segment used a PIR sensor to detect any moving objects, activating a camera through an ARM microcontroller to capture images to be sent to the owner via email. An SMS was also sent to the owner’s mobile using wireless radio frequency (RF) and GSM technology. In [13], a surveillance system was presented using a PIR sensor, a Raspberry Pi, and internet of things (IoT) technologies. When an intruder was detected, the camera was enabled to take live video to be sent to the owner’s webpage in addition to informing the owner via SMS, phone call, and email. A comparison between camera based motion detection algorithms was then made in [14], and the best one used in a surveillance system with IoT technique to send events to the user’s server. In [6], a security system for smart homes was designed using various sensors and GSM/GPRS techniques. The intruder detection segment of this system was implemented using a PIR sensor, an Arduino board, an infrared camera, and a buzzer. After detecting an intruder with the PIR sensor, the system set on a buzzer alarm and informed the owner by sending an alert notification to his/her mobile via GSM. Furthermore, the owner could examine the event based on online video captured by the infrared camera and sent to the mobile application.

3. PIC overview

A Programmable Intelligent Computer (PIC) is sometimes known as Peripheral or Programmable Interface Controller and its chips are divided into several groups, classified according to the size of their data “word”. An example of an 8-bit PIC is the PIC16F887, whose internal structure features a central processing unit (CPU), several different types of memory, timers, I/O ports, an analogue to digital converter (ADC), and serial communication ports as shown in figure 1 [15].

Microchip company produces many types of PIC that are characterised by their different features; the PIC16F887 has medium specifications and is suitable for implementing several applications, being a low cost, high quality and easily available chip that can accommodate multiple electronic circuits or
projects. Its five I/O ports can support a wide range of control applications, and in addition, the ADC makes this type of PIC more suitable for applications that deal with analogue signals such as temperature, pressure and audio signals. Further information on the PIC16F887 was introduced by Microchip in [15] and [16].

4. Touch Alarm Circuits
An alarm circuit that is sensitive to a touch is based on the current flowing into a dedicated “touch” wire. This small signal may be amplified to produce an alarm signal such as a buzzer, a light, a message, or a phone call. There are thus several different implementations of a touch alarm circuit, and some of these circuits are briefly explained below.

4.1. Transistor-based Circuit
A touch alarm circuit can be constructed using bipolar transistors; here, the circuit is comprised of a coupled amplifier, a loudspeaker, and touching plates, as shown in figure 2 [17].

The touching plates are two conductive strips made of copper, aluminium, or similar metals that are placed over one another such that they conduct when someone touches or presses them. In the normal case, the T1 and T2 transistors are in a cut-off state and no current flows in the capacitor C1 branch. When the two touching plates are connected, however, the current flows through the emitter of T2, enabling the alarm circuit. The complimentary pair amplifier of T3 and T4 transistors

Figure 1. Block diagram of the PIC16F887 contents [15]

Figure 2. Circuit diagram of the transistor-based alarm circuit [17]
receives positive feedback through R3 and C2, which determine, in addition to T3’s bias voltage, the oscillation frequency of the generated sound.

4.2. The 555 Timer-based Circuit
A simple touch-based alarm circuit using a 555 timer is shown in figure 3. The 555 timer is triggered through pin 2 by a touch on the sense plate. As a result, pin 3 is activated, causing the light diode to be continuously emitted until it is reset by a change in the logic level of pin 4 from high to low [18].

![Circuit diagram of a 555 timer-based alarm circuit](image)

Figure 3. Circuit diagram of a 555 timer-based alarm circuit [18]

This circuit can be modified to overcome this reset problem and ensure more accurate alarms by using an RC connection to hold the output for a certain period of time. Figure 4 shows a modified version of the circuit introduced in figure 3 [18].

![Circuit diagram of a modified 555 timer-based alarm circuit](image)

Figure 4. The 555 timer-based alarm circuit with automatic reset and multiple alarm capacity [18]
The 555 timer in this circuit is operated in a monostable mode, with the time period determined by the ratio between R1 and C1. It is triggered by touching the sense plate connected to pin 2 via the C3 capacitor for the purpose of increasing the charge accumulation. The 555 timer-based alarm circuit works by harnessing stray capacitance related to the toucher’s body that affects the sense plate’s ability to remain at ground potential. After triggering the 555 timer, pin 3 drives the output circuit to produce an alarm signal, and an external device can be activated through the normally opened pins of the relay.

4.3. The Op-Amp-based Circuit

The op-amp based touch alarm circuit is comprised of two op-amps; one is used to amplify the input signal, while the other acts as a comparator. Figure 5 shows the circuit diagram of the op-amp based touch alarm circuit [19].

![Circuit diagram of an op-amp-based alarm circuit](image)

**Figure 5.** Circuit diagram of an op-amp-based alarm circuit [19]

The operation of this circuit is similar to the 555 timer circuit, with the touch plate sensitive to the induced electricity of the human body. If the plate is touched by a human finger or palm, the generated voltage at the inverting input (pin 2) of the first op-amp (IC1) is amplified and fed to the second op-amp (IC2) via the non-inverting input (pin 3). This leads to activation of the output of IC2 (pin 6), which in turn causes the bipolar transistor (T1) to turn on and produce an alarm sound and light an LED.

5. The proposed PIC-based alarm system

The CPU is the main part of a PIC, and this can be used to execute any program code within its instruction set. This facility makes PIC reliable for implementation in most electronic circuits, including those used in control applications. Figure 6 shows the block diagram of the proposed PIC-based alarm system.

![Block diagram of the proposed PIC-based alarm system](image)

**Figure 6.** Block diagram of the proposed PIC-based alarm system
The first stage of the proposed system is the sensing terminal, where a signal is transferred to where someone touches a knob directly connected to this terminal. Even a small amount of voltage at this terminal activates the pin responsible for accepting the touch signal and causes it to make a “decision”. When the PIC receives a signal, it thus sends this signal to the alarm unit, which in turn alerts the owner in a manner compatible with the applied technique. If the owner is near the secured area place, a buzzer sound can be used. Otherwise, a message is sent to the owner or to the police station with the precise address information.

6. Experiments
To evaluate the efficiency of the proposed system, two different circuits are implemented using 555 timers and a PIC, as explained in the following sections.

6.1. Experiment 1: A 555 timer-based circuit
In this experiment, the warning system is implemented using 555 timers, with the triggering unit similar to the circuit shown in figure 4. All electronic components and their connections are installed on a breadboard and a 12 V DC is supplied to the circuit. In this circuit, the alarm signal is set as a buzzer sound and the alarm unit designed as shown in figure 7, based on that used in [1].

As shown in the circuit diagram, the main components of the alarm unit are two 555 timers, a bipolar junction transistor (BJT), and a loudspeaker. The function of the two 555 timers is to produce a tone like a siren, connected in such a way to operate in stable mode. The aim of using the BJT is to amplify the output of the first timer such that it is compatible with the power of the loudspeaker, which is about 5 W.

After this, the alarm unit is modified by adding a wireless communication alert using GSM technique. The ability to use mobile communication in this system is very important, especially when the owner is far away from the secured area. In this circuit, a relay is added to act as a switch to establish a connection between the transmitter and receiver. The transmitter mobile is set to either make a call using the fast calling service or to send an SMS. It is worth noting that the normal fast calling is accomplished by pressing a dedicated key in the phone’s keypad previously set to make a call to a specific phone. However, in the alarm system, instead of the key being pressed, the two terminals of the button switch of that key are connected to the normally open conducting pins of the relay using two copper wires. If the communication network is busy or there is no response from the owner, the mobile is set to continuously recall the number until a response is achieved. The circuit diagram of using a wireless communication is shown in figure 8.
The circuit sometimes launches an alert without anyone touching the sensor, which may be due to the induced signals from the peripheral devices that may affect the current flowing in pin 2 of the 555 timer. This problem is solved by reducing the value of R2. Figure 9 shows an implementation of the warning system with mobile call and SMS.

![Circuit diagram of the 555 timer-based wireless communication alarm system](image)

**Figure 8.** Circuit diagram of the 555 timer-based wireless communication alarm system

![System implementation](image)

**Figure 9.** System implementation (a) Overall system with warning call (b) Received warning message
6.2. Experiment 2: A PIC-based circuit

In this experiment, the 555 timers are replaced with a PIC such that the circuit can generate multiple different alarm signals; however, in this work, these are limited to a buzzer sound and mobile alerts. Figure 10 illustrates the circuit diagram for the PIC-based alarm circuit.

![Figure 10. Circuit diagram of the PIC-based alarm system](image)

As illustrated in figure 10, the touching terminal is connected to pin RD3 of the PIC16F887, while pins RD1 and RD2 are connected to the two output terminals, the loudspeaker (LS1) and the BJT (Q1), respectively. The purpose of these two outputs is to generate two alarm signals, the buzzer sound and a remote warning. The remote warning is activated via pin RD2 connected to Q1 to enable the relay to make a connection between the transmitter device (a mobile phone) and the receiver device. Two voltage sources are used in this circuit, a 5 V and a 12 V. The 5 V is used for the PIC16F887, whereas the 12 V is used to magnetise the relay coil.

This PIC is programmed using the micro C language dedicated to programming PICs, and an Easy PIC v7 board [20] is used for this purpose. The input pin RD3 is programmed to be at high level voltage (logic 1) when no touch signal is detected, and set to logic 0 else. When someone touches the sensor terminal, the resistance of the hand makes the voltage at pin D3 to be less than 2.5 V, due to the voltage divider with R1, which the PIC considers this voltage to be a logic 0. Output pins RD1 and RD2 are programmed to respond to the status of RD3, such that they are activated only when there is an input, i.e. RD3=0. RD1 is programmed to either produce continuous or discrete sounds with a possibility of being turned off, while the second output (RD2) enables the current to flow through the relay coil, allowing Q1 to act as a switch to pull the coil terminal to the ground.

After the sensor is touched, an SMS is sent to the remote owner’s device using GSM techniques. In addition to the SMS, an instant call is made with the owner’s device to achieve more precision. This call is repeated until the reply button on the owner’s device is pressed. Another step can also be added here, which is informing the police about the event by sending an SMS to the police station including the precise position or address.

A touch-based alarm system has an advantage of touch sensing confirming the existence of an intruder. However, the system may fail to detect intruders where they use gloves to avoid leaving fingerprints, as these act as an insulator between the human body and the touch sensor. This problem can be overcome using the two-plate method implemented in transistor-based circuit. Another solution is the implementation of a micro switch like that used in refrigerator doors to trigger the fridge light or
a photo diode switching circuit. The switch conducts when the door is opened and produces an alarm signal; however, this increases the danger level because of the removal of a security barrier.

6.3. Comparative results

In order to select a suitable circuit for the design of a touch alarm system, a comparison is made between the PIC-based circuit and the other circuits examined previously, as seen in Table 1.

|                      | 555 timer, Op-Amp and Transistor-based circuits | PIC-based circuit |
|----------------------|-----------------------------------------------|-------------------|
| More electronic components | Fewer electronic components                 |                   |
| More wiring connections      | Fewer wiring connections                  |                   |
| Sensitive                  | No sensitivity                             |                   |
| No update                  | Updatable                                   |                   |

As illustrated in Table 1, the PIC-based circuit has several advantages over other circuits:

1. The reduced number of electronic components in the PIC-based circuit makes it more cost effective.
2. As more wiring connections are used in non-PIC-based circuits, the probability of system failure from connection failures or from environmental devices that induce electromagnetic signals is increased.
3. The PIC-based circuit can be updated by adding new code and reassigning the functions of the PIC’s pins.

It is worth noting that the 555-timer based circuit used in [1] utilised a buzzer sound as an alarm signal. Based on the advantages of PIC, constructing this alarm system using PIC is preferable, and in addition to the buzzer sound, alarm signals are wirelessly sent to tackle the problem of remote monitoring.

7. Conclusion

The proposed work presents a high reliability warning system that is effective in protecting designated areas or objects from unauthorised access. Two types of the warning circuit are implemented, a 555 timer-based circuit and a PIC-based circuit. The experiments show that the PIC-based circuit has several advantages in terms of cost, size, system failure, sensitivity, and future updates. Most of these advantages arise from the programming techniques that the PIC is based on. In addition, as well as producing a buzzer sound, the PIC system can also send a warning signal to the owner’s device or to the police station using a GSM technique.

In the future, this system can be improved by implementing additional technologies such as smart cameras and multiple sensors to overcome the difficulties faced by this application. Furthermore, the system may be connected to a smartphone through an Android application that employs cloud computing for greater efficiency.
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