REMOTE SENSING AND AUTO-PAGING DEVICE

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Abstract

The paper presents a project “Remote Sensing and Auto-paging Device” that deals with developing a home security device, which alerts the user with a message in his pager. Two sensors - an intruder sensor and a fire sensor are used. Both of them are connected to a micro-controller, which has the operator number, the pager number and the message codes stored. The micro-controller (Atmel AT89C51) drives the Dual Tone Multiple Frequency (DTMF) generator (UM91215A) connected to the telephone line. Whenever the sensors sense an intruder or fire, they give interrupt to the micro controller, which in turn, provides the input to the DTMF IC to dial the pager number (and the message code) stored in its memory. The user gets the message in his pager. The paging terminal of Easy Page, Nepal is used. The device can be applicable in many areas such as - Home Security, Hospitals and Banks, where a constant monitoring of the proceedings is a must.

1. Introduction

The remote sensing and auto-paging device alerts the user with a message in his/her pager. While monitoring a critical condition, an alarm can be set which would go off when the threshold level is exceeded and if the person is away from that particular region, it remains unmonitored. With the use of the device that alarm condition can be served and the message can be delivered to the authorized person. The block diagram of the circuitry involved in this project is shown in Fig. 1. It consists of the sensors, the comparators, a micro-controller, a DTMF dialer and a normal telephone line.

The two sensors used are – (a) Intruder sensor; and (b) Temperature sensor (Thermostat). The sensors sense the alarming conditions and give the pulse to the comparator. The comparators compare the input voltage with a threshold value and give the output as high or low. The output from it is then fed to the micro-controller as interrupt. If the output from the comparator is logic high, nothing will happen. But if any one of the comparators’ output is low, the microcontroller determines which sensor is producing that output. Then the microcontroller reads its data memory to determine the pager number and the two digit number as a code for the active sensor. The microcontroller then dials the pager number and the two digit code using the DTMF dialer IC connected to its output. The two digit code is used by the paging station (here, Easy Page, Nepal) station to deliver the respective message.
2. Design

The design is divided into 4 parts.

2.1. Sensors

2.1.1 Intruder Sensor

A simple intruder sensor can be set up using an IR LED and a photo-sensor (Fig. 2). The IR LED is connected in series with a resistor of 100 Ω and is supplied with +5V. The photodiode is connected in reverse bias mode and it detects the IR light falling on it. It produces a potential of greater than 2.5 V across it. The negative input terminal of LM 324 is maintained at 2.5V with a voltage divider using two 4.7 kΩ resistors. This voltage acts as the threshold voltage for the comparator. When the light from IR LED reaches to the photodiode, the voltage developed across photodiode is greater than the threshold voltage of the comparator resulting in the HIGH output. When an object crosses between the IR LED and the photodiode preventing the light from falling to the photodiode, no potential is developed across photodiode. The voltage at the non-inverting terminal drops below the threshold voltage resulting in the LOW output. This transition from logic high to low can be used as a trigger input to interrupt.

2.1.2 Thermistors (Fire Sensor)

Thermistor is a contraction of the term “thermal resistor”. Thermistors are generally composed of semi-conductor materials. Most thermistors have a negative temperature coefficient (NTC) of resistance i.e. their resistance decreases with increase in temperature. An increase in temperature of a metal results in greater thermal motion of the ions, and hence decreases slightly the mean free path of the free electrons. The result is a decrease in the mobility, and hence in conductivity. This high sensitivity to temperature changes makes thermistors extremely useful for precision temperature measurements control and sensor.

A fire sensor is made using a simple thermistor (Fig. 2). Here a thermistor from the starter of a fluorescent tube light is used. Under normal condition the two metals A & B of the thermistor are not in contact resulting in the output voltage of +5V. When the thermistor is heated the metal A expands and touches B forming a conducting path. At this point, the output voltage is 0V. This transition of voltage from +5V to 0V is used as trigger to the interrupt.
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Fig. 2: Overall Circuit Diagram
2.2 Dual Tone Multiple Frequency (DTMF) Dialing Circuit

The DTMF dialer used is UM91215A. In the circuit shown above (Fig. 2), the pin designated as TONE gives the tone frequency. The collector of the transistor BC547, connected to this pin, is connected to the telephone line. The capacitor C1 is used for blocking DC. An 8V relay circuit is used to connect the tip of telephone line to the DTMF circuit. Under normal conditions, the relay is switched off disconnecting the tip of the telephone line from the remaining circuit. This represents the hook ON condition.

The relay is turned ON/OFF using the transistor SL100. Since the direct output from the controller is unable to drive the transistor, a buffer is used. The output from the microcontroller is fed to the buffer. The output of the buffer is able to drive the transistor. Switching the transistor ON allows the current to flow through the relay turning it ON which connects the tip of telephone line to the rest of the circuit. The resistance of 220 Ω across the tip and the ground makes the potential between them 8V signifying the hook off condition.

The zener of 3.9V clips the 5V into 3.9V and applies it to the Vdd. The MODE IN pin is grounded to operate the IC in DTMF mode. The HK pin is grounded to signal the IC of hook-off position. A crystal oscillator of 3.58 MHz is connected across OSC1 and OSC0 (pin 3 & pin 4). The Vss pin is connected to the ground potential. The rows and column pins (pin 10-16) are connected to the output port (port 2) of the microcontroller (AT89C51). For the tone to be generated two pins, one each from the row and the column (of the DTMF IC) should be at zero potential. For e.g.: to dial 1, the pins R1 & C1 should be at zero potential.

2.3 Microcontroller (AT89C51)

The microcontroller used is Atmel AT89C51. The pin configuration AT89C51 microcontroller has 40 pins IC (Fig.2). There are three 8-bit I/O ports.

2.4 Paging Terminal

The paging terminal used is Easy Page, Nepal (currently not in service). Any paging terminal could be used. However, the user needs to have a message code (for a sensor message) set-up at the terminal.

3. Software

The software part in this project is associated with the sensing of interrupt and producing appropriate output from the microcontroller to provide an input to the DTMF IC. The assembly language of 8051 families of microcontrollers is used in the software section. When the sensors give interrupt, the software checks which interrupt is activated then it branches to the appropriate subroutine to provide input to the DTMF to dial necessary numbers. Also a 15-minute delay is introduced, using internal time, between successive redialing.

3.1 Concept

Since the external interrupts and timer are used, a few special function registers have to be loaded with appropriate values. To enable the external interrupts 0 and 1 and Timer 1, the Interrupt Enable (IE), SFR register is loaded with 8dh, TCON is initialized to 45h. This sets the external interrupts 1 and 0 as edge triggered. Also the Timer 1 is turned ON. The TMOD register is loaded with 10h to set Timer 1 in mode 1 i.e. 16 bit timer. As mentioned in the sections above, to dial a number through DTMF IC two pins (one each from row and column sections) should be
at 0 potential. For example, to dial 1 the pins \( \overline{RI} \) and \( \overline{CI} \) should be at 0 potential while others in state other than 0 potential. The output from the controller to dial number 1 is binary 10111011 (HEX BB). Similarly the output from the controller for other numbers can be determined. The numbers to be dialed are stored in a look up table. When an interrupt occurs the following operations take place.

1. Branch to ISR
2. Set and clear necessary flags
3. Hook OFF (Turn relay ON)
4. Read protocol number from look up table and dial it.
5. Wait for 10 seconds
6. Dial pager number and three asterisk
7. Dial two code number according to active interrupt
8. Dial hash
9. Hook ON (Turn relay OFF)

After dialing for particular interrupt the interrupt is disabled for 15 minutes. This is done in order to introduce a delay of 15 minutes before redialing, if the interrupt is still present. This is necessary due to following reason - When the number is dialed the paging station sends the message to the subscriber. The pager beeps or vibrates to indicate the user of the arrival of the message. The pager keeps on beeping at a regular interval until the user checks the message, and hence a repeated dialing is not required.

To introduce a delay between the redial, the concept of software based real time clock is used using in-built timers of the micro-controller. With crystal of 10 MHz, the timer clock rate is 10MHZ/12 [6] i.e. timer 1 will increment 833333.333 times per second. The 16 bit timer will count from 0 to 65535 before resetting. So the Timer 1 overflow 833333.333/65535=12.71 times per Sec. Simply by counting the number of overflows, we can keep track of seconds passed. It is not possible for it to overflow 0.71 times. The timer 1 needs to be set up to overflow at some frequency to add up nicely to 1 second intervals. For timer 1 to start counting from 0 to 65535 and overflow back to 0 will take 0.079 seconds. Instead of overflowing every 0.079 seconds, allowing timer 1 to overflow 0.05 seconds will exactly produce 1 second after 20 overflows. Based on the clock used, timer 1 has to be incremented 41666 times for 0.05 seconds to pass. To do that, the counter needs to start counting from 65536-41666 = 23869 and not 0. When it resets to 0 after overflow, it is once again initialized to 23869. Counting the number of overflows keeps track of seconds passed.

### 3.2 Algorithm

**Interrupt service routines**

A. For interrupt 0
   1. Set vector 0 flag
   2. Disable interrupt 0

B. For interrupt 1
   3. Set vector 1 flag
   4. Disable interrupt 1

**Main program**

A. Start
   1. Initialize special function registers and variables.
   2. Check vector 0 flag
If yes, Call dial1
3. Check vector 1 flag
   If yes, Call dial2

B. Dial1
1. Clear vector 0 flag.
2. Initialize 15 minute delay counter.
3. Dial numbers with proper code for interrupts 0.

C. Dial2
1. Clear vector 1 flag.
2. Initialize 15 minute delay counter.
3. Dial numbers with proper code for interrupts 1.

4. Output

Depending on the sensor that detects the variable, a message code is sent to the paging terminal which is then received by the user on his/her pager.

![Fig. 3: Message when the intruder and fire sensors are active](image)

5. Applications

This product can be applicable in many areas where a constant monitoring is required such as:

1. *Home security:* This device helps to constantly monitor a specific area. A user can immediately respond to the problem due to the quick conveying of the message.

2. *Hospitals:* This device can be further improved for use in the medical fields. In hospitals or nursing homes, if there is any change in patient’s condition (as read by medical monitoring equipment), the sensor can interrupt the microcontroller and the respective message can be sent to the doctors or the nurses.

3. *Banks:* Financial institutions have certain type of restricted areas and lockers, which can be monitored constantly using this device. However, a CCTV can be a better choice.

4. *Public addressing:* This device can also be used for public addressing. The same message can be delivered to a large number of people (eg. a fire warning for more than one user).
6. Limitations

1. Number of inputs: The microcontroller used i.e. AT89C51 consists of only two interrupts. The sensors are connected to those two available interrupts. Hence, this device currently can handle only two sensors.
2. Number of pagers: In this device, only one pager number has been used. The messages can be displayed only in that pager whose number is stored in the memory.
3. Changing the pager number: The pager number is stored in the microcontroller’s memory. If the pager number needs to be changed, the microcontroller should be reprogrammed.
4. Message display: The message currently displayed depends on the code provided by the paging station. This restricts the user from sending the message of his/her choice.

7. Future Improvements

Using the input ports instead of interrupts of the microcontroller and using multiplexing techniques, more number of sensors can be used. The program (for the microcontroller) can be modified to send the message to more number of pagers as well as different messages to different pagers. A keypad can be interfaced with the controller to allow the user to change the pager number as desired and also change the delay between the redialing. The user can also be allowed to send message of his choice. For that a device should be designed which can code the stored message to a format acceptable by the TAP (Telocator Alphanumeric Protocol) protocol of the paging terminal.

8. Conclusion

A remote sensing and auto paging device has been designed which can inform the user of an abrupt change in the proceedings (which the user wants monitored) with a message on his pager. The design currently uses two sensors – intruder and fire. The heart of the design is the ATMEL AT89C51 micro-controller and uses UM91215A DTMF dialer to dial the paging station. This device has a great scope of further enhancement.

References

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