HIGH TEMPERATURE AUTOMOBILE PROTECTION SYSTEM

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Abstract

This paper considers the design of a safety alarm system called High Temperature Automobile Protection System (HiTAPS) for ensuring the safety of children and pets locked in a parked automobile during extreme temperatures. The HiTAPS circuit consists of a Mini-Max/51C-2 microcontroller board manufactured by BiPOM Electronics along with pressure and motion sensors for detecting the presence of children and pets inside the automobile. Whenever the microcontroller detects that the temperature inside the automobile reaches extreme values, in this case above 100^0F, and either a child or pet is detected to be present in the automobile, it activates the Radio Frequency (RF) transmitter unit that sends a signal to the owner of the automobile via their handheld receiver. If there is no response within two minutes, the windows are automatically lowered and an alarm is turned ON to alert others present in the area. HiTAPS project developed as part of the senior project course where a team of four students under the supervision of a faculty mentor and three graduate assistants.

Introduction

Safety devices present in present automobiles are designed to provide safety to a person in the automobile only when it is in motion. HiTAPS was designed such that it ensures the safety of children and pets locked accidentally inside a parked automobile during extreme temperatures. HiTAPS provides additional features like more accurate child or pet detection and instant feedback to the owner when compared to the child alert alarm for automobiles [1].

The Hardware section of this paper describes how the input switches, sensors and the outputs shown in Figure 1 are interfaced to the Mini-Max/51C-2 board with the help of a relay circuit. The software implementation section provides an explanation of the program written in Micro-IDE for the operation of the ATMEL AT89C51RD2 microcontroller, and it describes in detail how the code controls the logics of I/O Expansion ports and the analog input terminals of the microcontroller.

The block diagram of the HiTAPS is shown in Figure 1. The most important part of HiTAPS is the Mini-Max/51C-2 board. It determines the logic on how HiTAPS should react to events. It includes the code, and the requirements that must be met before the horn circuit, window controller circuit and RF circuit is activated. The two built-in timers of the microcontroller are used to determine the time for which the horn, window and RF circuit should be ON. HiTAPS circuit is electrically coupled to a cigarette lighter adapter present in an automobile. HiTAPS is turned ON only when the two conditions are met, that is the engine of the automobile should be turned OFF and the doors must be closed. The system waits for two minutes before activation of the circuit and starts monitoring the temperature with the help of a temperature sensor. The pressure sensor, motion sensor and the seat belt switches are constantly monitored by the microcontroller to detect the presence of children or pets inside the automobile. Once extreme temperatures and presence of a child or pet is detected, the microcontroller activates the RF transmitter, the receiver of which is located with the owner of the automobile. The microcontroller waits for approximately two minutes for any possible response before turning ON the alarm present in the automobile to alert bystanders and automatically lowers the windows slightly to ensure safety of the child or pet present in the

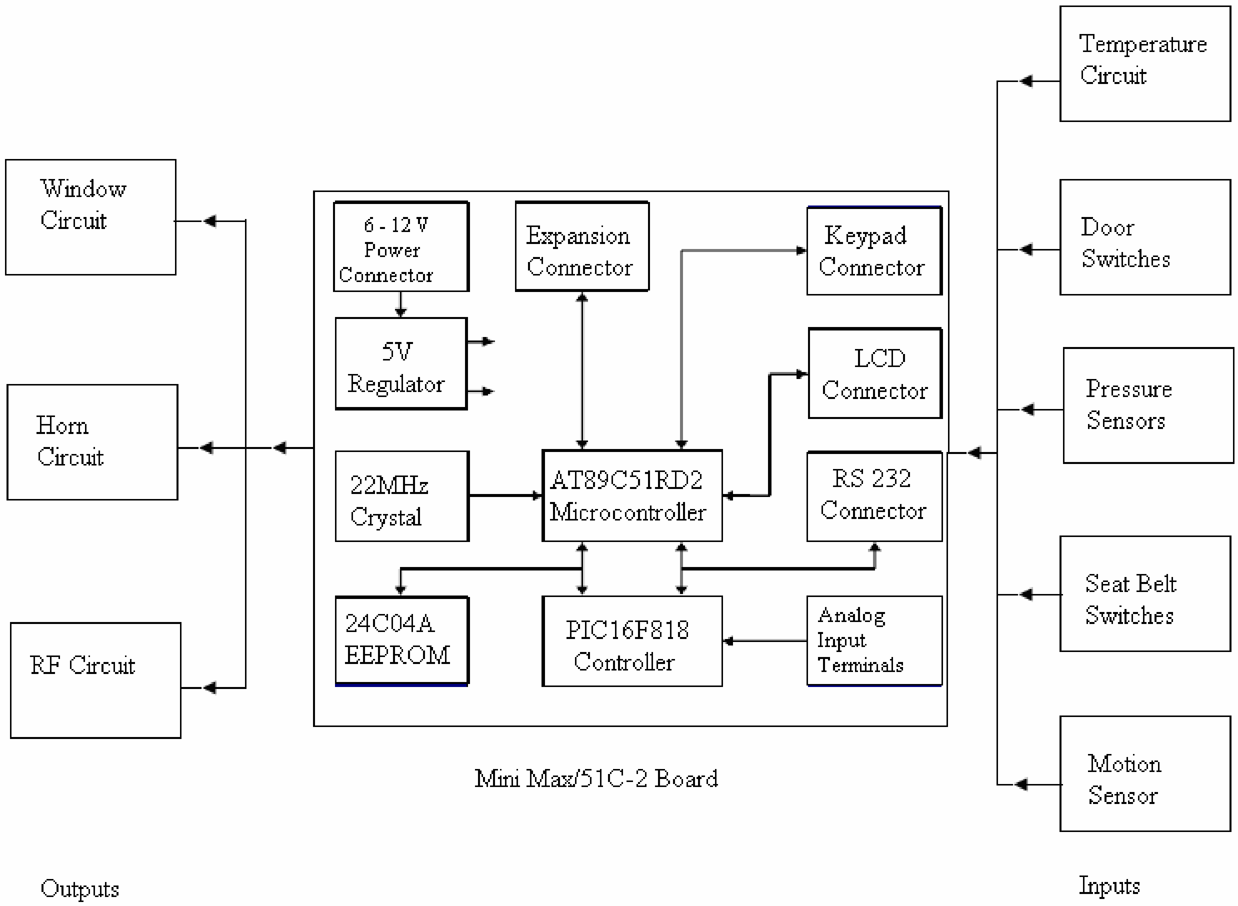

Figure 1. Block diagram of HiTAPS.

automobile. Figure 2 shows a prototype of the HiTAPS.

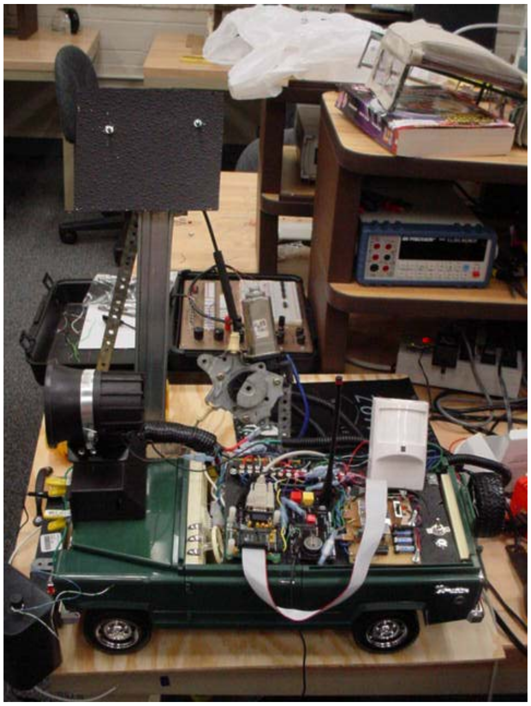

Figure 2. HiTAPS prototype.

Hardware Interface

The relay circuit for HiTAPS is constructed on a 7 X 10.25 inch piece of perforated circuit board. Figure 3 shows a schematic diagram of the HiTAPS relay controller circuit and how it connects to the Input/Output Expansion ports of the Mini-Max/51C-2 board [2].

The following is a description on how the HiTAPS circuit is interfaced with the Mini-Max/51C-2 Board. The Mini-max/51C-2 board and the Ademco 998 Motion sensor is powered with 7.5V from the MW-182R DC car adapter. A Sony 4.5V DC car cigarette lighter adapter provides power to drive the Hex inverter, ZM-X1-L Pressure sensor and LM43DZ Temperature sensor.

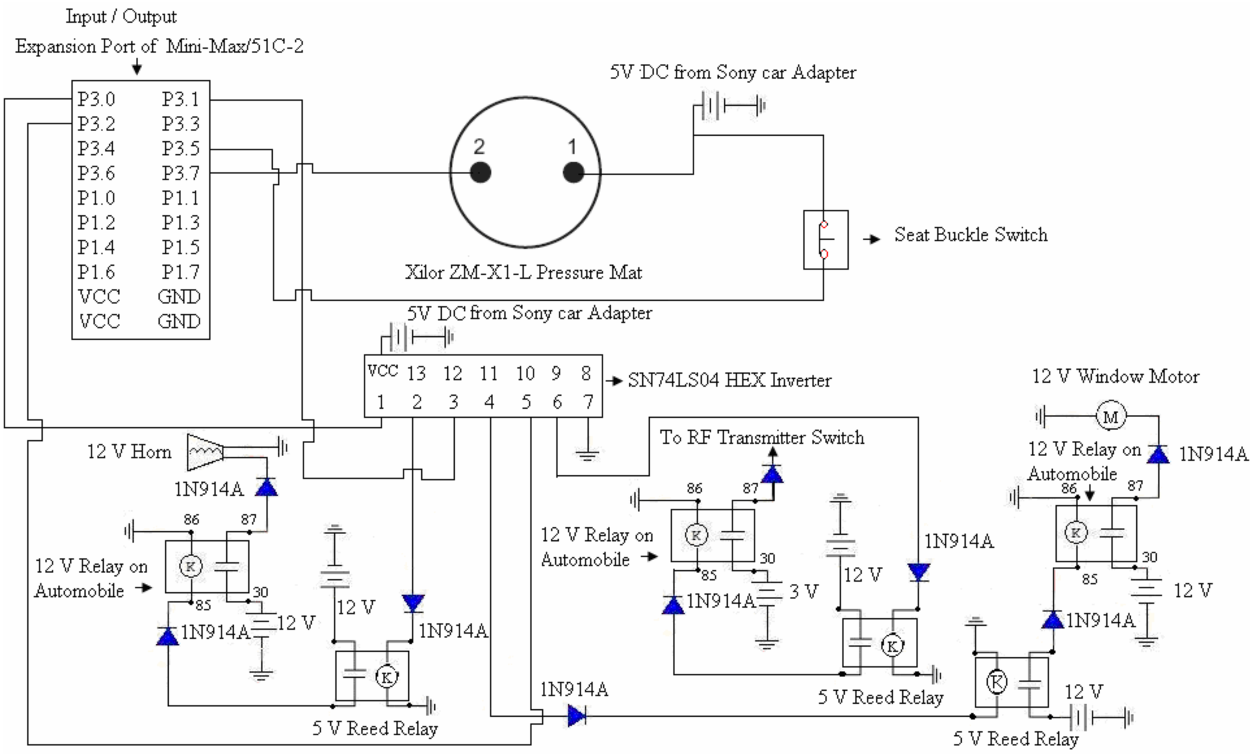

Figure 3. HiTAPS Relay Controller Board circuit interconnections.

Pins 1, 3 and 5 of SN74LS04 Hex Inverter [3] are connected to the pins P3.0, P3.1, P3.2 of the I/O expansion port that are set as output ports in the microcontroller program. Ports 3.0, 3.1 and 3.2 are connected to the Hex inverter to control the activation of horn, window motor and RF transmitter switch respectively. The Mini-Max/51C-2 board sets each port of the board to logic high at initial startup which would trigger the 5V and 12V relay respectively resulting in activation of the horn, window and RF transmitter circuitry connected to the relays outputs. By setting the ports to logic low with the help of programming and using the Hex Inverter to energize the relay proved to be successful in controlling the activation of horn, window and RF transmitter circuit. The two types of relays used in HiTAPS circuit are 5V DC/1A SPST Reed relays and Bosch 30A SPDT 12V automotive relay. The three 5V Reed relays are energized by the pins 2, 4, and 6 of the SN74LS04 Hex inverter respectively. The output from the 5V reed relays is connected to pin 85 that is used as the input to energize the 12V automotive relay. When the coil between pin 85 and 86 is energized with 5V, the connection between pin 30 and 87 is closed, thereby activating the external device connected to pin 87. 1N914A Diodes are connected between the Hex inverter and the 5V Reed relays, and in between the 5V and 12V relays to prevent unwanted current and voltage feedback produced by the car charging and voltage system from reaching the Hex inverter. The RF circuit is used to page the owner or parent that there is someone in the car. It consists of a transmitter and receiver. The receiver is carried by the driver or parent on their keys. The RF transmitter is implemented in HiTAPS circuitry. To accomplish this goal, the Linx EVAL-433-LC-S-ND RF transmitter and receiver are used which are set at a frequency of 433MHz. Both the transmitter and receiver are powered by a CR2032, 3V battery connected to the RF transmitter circuit. The range of the transmitter and the receiver is 1000 ft.

The input pin 1 of the pressure sensor is connected to a 5V Sony car adapter and the output pin 2 is connected to pin P3.7 of the I/O expansion port of Mini-Max/51C-2 board. Pin P3.7 is set as an input port that waits to receive a logic high signal when pressure of more than 5psi is applied upon any area of the pressure mat. The pressure mat that is 12 X 9 X 0.1 inch in dimensions can be placed easily inside the cushion of a seat in an automobile to detect the presence of children or pets inside an automobile. The Seat buckle which is also used to detect the presence of a person inside the automobile just acts like a switch, when the buckle is inserted into the socket the switch is closed. The input connector of the seat buckle is connected to the 5V source from the Sony car adapter and the output connector is connected to pin P3.3 of the I/O Expansion port. This port is set as an input port that waits to receive a logic high signal when the seat buckle is fastened. Figure 4 shows the relay circuit built for HiTAPS.

Figure 5 shows how the temperature and motion sensors are interfaced to the analog input terminals of the Mini-Max/51C-2 board. The LM34DZ temperature sensor from National Instruments [4] was used to detect the temperature in HiTAPS. The temperature sensor is an 8-pin Dual In-Line package. Only 3 pins have connections and the other pins have no connections. 5V Sony car adapter and the ground of the sensor is grounded into the analog port ground that shares a common ground with the entire HiTAPS circuitry. The temperature sensor operates in the range of -50^0 to $+300^0$ F. The Analog port pin A4 is used to read the temperature from the V_{out} of the LM34DZ temperature sensor. The Ademco 998 PIR motion sensor [5] has a range of 50 X 50 feet and is used to detect any motion inside the automobile. The motion sensor has three connectors: a positive, ground and a relay connector respectively. The positive connecter is connected to 7.5V MW-182R DC car adapter, the ground connector is grounded and the relay connector is connected to analog port pin A0 of the Mini-Max/51C-2 board. When any motion is detected inside the automobile, the relay connector output is set to logic high.

Three Switches were used to simulate the ignition of the automobile, turning the HiTAPS circuit OFF manually and closing of the automobile doors respectively. A key switch

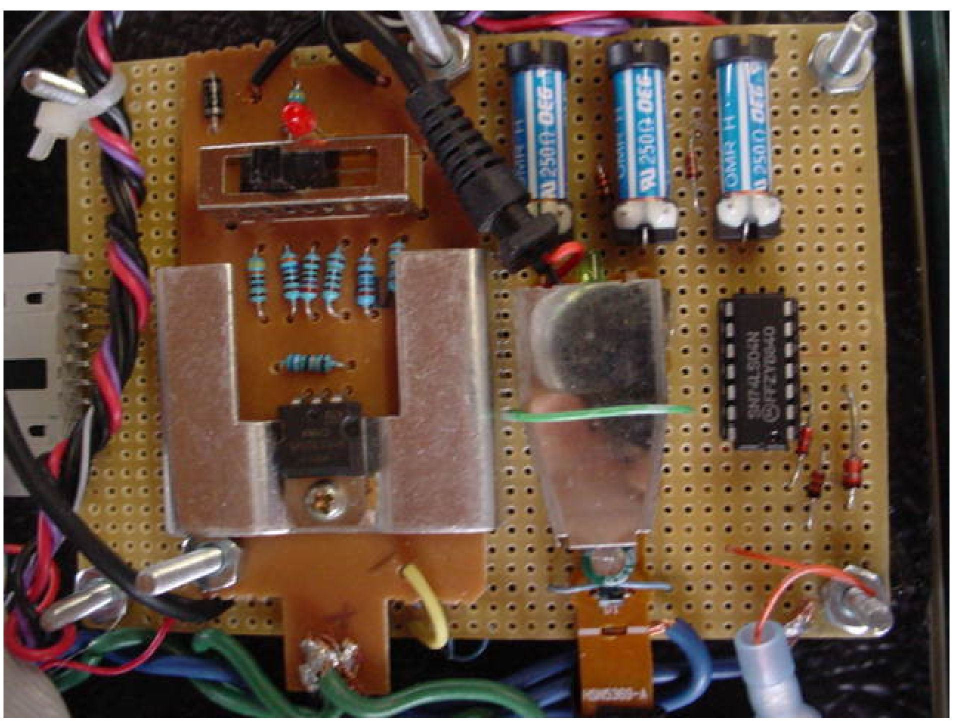

Figure 4. HiTAPS relay circuit.

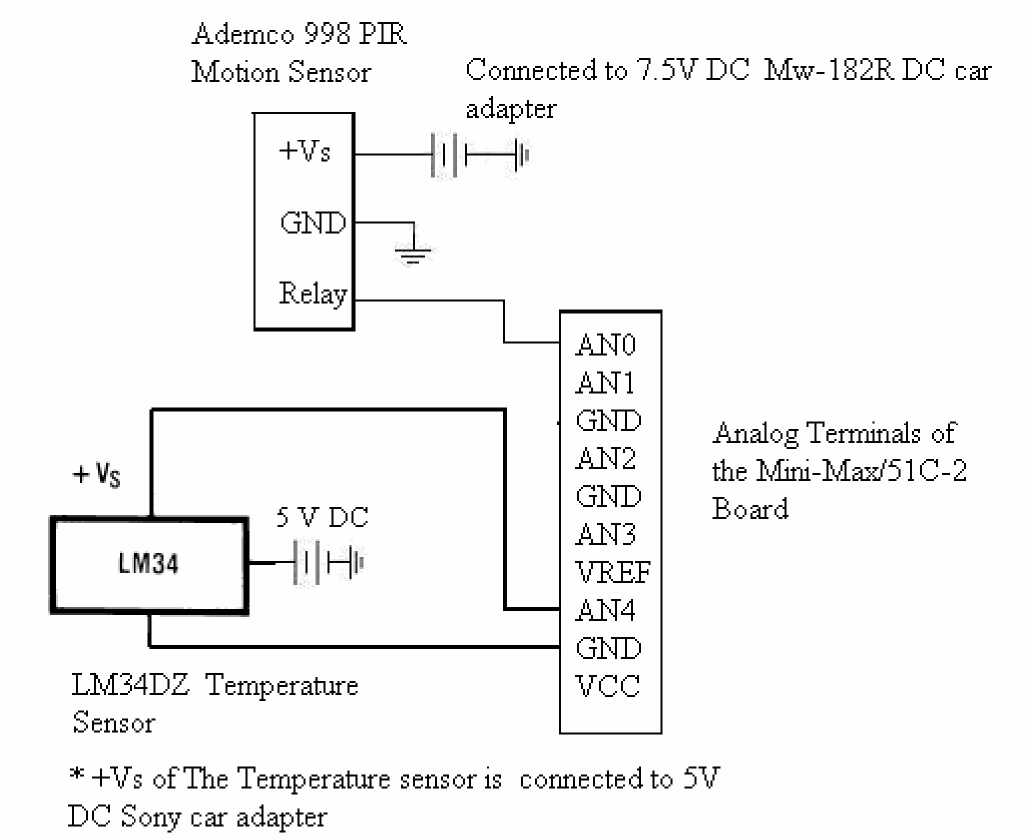

Figure 5. Interfacing temperature sensor and motion sensor to the analog terminals of Mini-Max/51C-2 board.

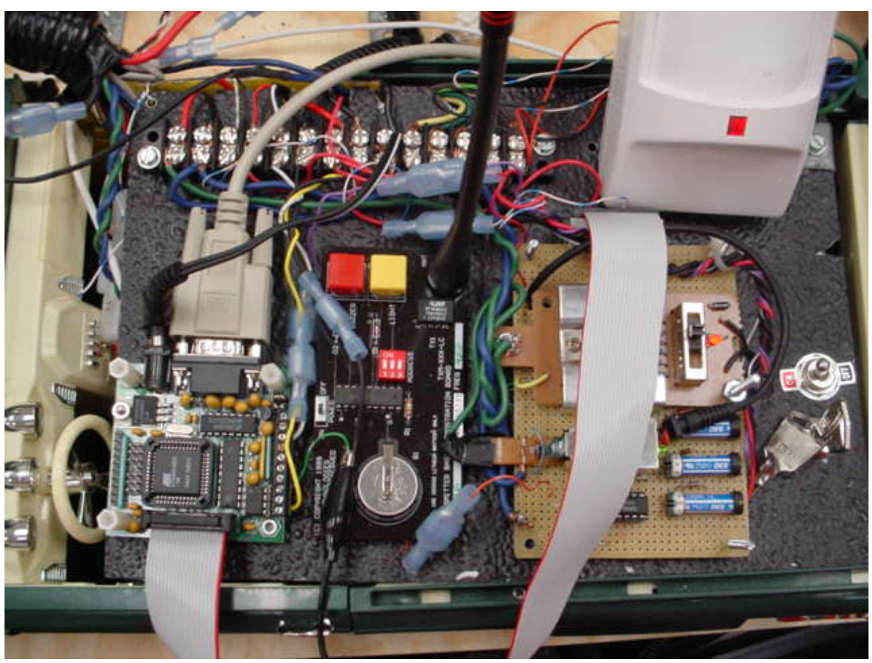

Figure 6. Mini-Max/51C-2 Interfacing Board.

was used to simulate the ignition of the car. When the ignition is turned OFF in the automobile, the ignition module of the automobile is grounded; this same ground is used by the HiTAPS to activate the circuit. When the HiTAPS system is activated automatically, the user can turn OFF the circuit manually, overriding the normal function of the system using this toggle switch. A push button switch is used to simulate the opening and closing of the door. When the door is closed, the switch is closed and the ground is applied to the circuit, which activated the HiTAPS circuitry. All three switches are setup in parallel with each other. Once the push button and the key switches are active i.e. they are in closed position; the circuit of HiTAPS becomes active. Figure 6 shows the Mini-Max/51C-2 board interface with the RF transmitter, motion sensor and the pressure sensor.

Software Implementation

The software for programming the microcontroller was written in MicroC language. BiPOM Electronics provides MICRO-IDE to compile and debug the programs in MicroC programming language and then download the program into the Mini-Max/ 51C-2 board using this IDE. An Analog to Digital Converter code is written to convert the values provide by the LM34DZ temperature sensor and the Motion sensor into appropriate digital format.

The HiTAPS circuit is activated only when the door switch and the key ignition switch are closed. The description of the operation of the code is shown in Figure 7. First, the pressure and seat belt circuitry is initialized by setting the ports to logic high and low simultaneously. The microcontroller checks if any of its input ports is high, i.e. it checks if there is a logic high signal from the pressure sensor, motion sensor or the seat buckle. When any one of the input ports is high the microcontroller starts monitoring the temperature. When the temperature goes above 100^0 F, the I/O port pin P3.2 is set to logic high, which activates the RF transmitter. If the door is not opened within a delay of 2 minutes, the I/O port pins P3.1 and P3.0 are set to logic high, which activates the window motor and the alarm circuit respectively. I/O port pin P3.1 is set to logic high only for a short delay of time so that the windows are lowered 1 inch so that it provides safety to the child or pet inside the automobile, and also ensures safety from any automobile theft.

Conclusion

This paper described a circuit that was developed to interface an ATMEL 89C51 microcontroller with various sensors and switches in order to control the operation of the alarm and safety system. Development of the hardware and software for this project has laid the groundwork for future projects that involve the use of ATMEL microcontrollers as life saving devices. Future modifications of the HiTAPS will allow interfacing of GPS system to the expansion ports so that the location of the automobile can be sent to alert the Emergency Services located in that area.

References

1. Carolyn M. Thornton, *Child Alert Alarm for Automobiles,* U.S Patent Number 5,966,070, October 1999.

2. *MINI-MAX/51C-2 Single Board Computer Technical Manual,* BiPOM Electronics, Houston, Texas, September 2004.

3. *Motorola SN74LS04 Hex Inverter Datasheet*, Motorola Corporation, Austin, Texas, 1978.

4. *LM34 Precision Fahrenheit Temperature Sensors Datasheet,* National Semiconductors, Santa Clara, California, July 1999.

5. *PIR Motion Sensor Manual*, Honeywell Security & Custom Electronics, Syosset, New York, 2004.

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/************************************************************************
        Description: High Temperature Automobile Protection System.
************************************************************************/
#include <8051io.h>
#include <8051bit.h>            /* Bit set/clear macros */
#include <8051reg.h>
#define ADC_UNIT                 0x18
#define CADC_UNIT                0x17
ERRCODE WriteCADC( register UBYTE cadc);
ERRCODE ReadCADC( register UBYTE* cadc);
ERRCODE ReadADC( register UBYTE channel, register UINT* adc);
main()
{  register UBYTE cadc;   register UINT adc;
   register UINT mo_val;  register UINT temp_val;
/********* Initialize UART to 9600 baud rate   **********/
     serinit(9600);
/********* Initialize Pressure Sensor Circuitry *********/
   setbit(P3.7);    clearbit(P3.7);
/*********   Initialize Seat Belt Circuitry     *********/
   setbit(P3.5);    clearbit(P3.5);
   ReadCADC(&cadc);
   for(;;)
   {
    for (cadc =0; cadc <5; cadc++)
    {
     ReadADC( ADC_UNIT+cadc, &adc);
     ReadADC( ADC_UNIT+4, &temp_val); /**  Read the value of temperature  **/
     if (cadc == 4 && adc > 200) /** Check if temperature is above 100^0 F **/
     {
       ReadADC(ADC_UNIT+0,&mo_val);
       if (mo_val<200) /**** check for motion inside the car using motion sensor*****/
       {
      RFactive();
        delay(120000); //delay time for 2 min before activating Window and horn
        alarmon();
       }
       /**check for presence of any pet or child using pressure sensor & seat belt
          seat belt switch **/
       else if(tstbit(P3.7) &&! tstbit(P3.5))
       {
        RFactive();
        delay(120000); //delay time for 2 min before activating window and horn
        alarmon();}
       }
    }   delay(500);
   }
}
/*** Function to start the window motor, Horn and the RF transmitter ***/
alarmon()
{ clrbit(P3.1);   /***** start window motor down ******/
  delay(2000);    // activate window for 2 sec
  setbit(P3.1);   /*****  stop window motor      ******/
  clrbit(P3.0);   /*****     sound alarm         ******/
}
RFactive()
{/***** Beep the RF reciever *******/
while(1)
{
  clrbit(P3.2); /***** set low to activate RF transmitter ******/
  delay(3000);
  setbit(P3.2);  delay(3000);
/***** start the clock after function called above, upon reaching 2 minutes and
         turn the horn alarm ON  */
}
}
```

Figure 7. MicroC code for software implementation.

Biographical Information

Patrick Boodram is a graduate from the University of Houston's College of Technology, with a bachelor's degree in Computer Engineering Technology. His interests lie in developing a foundation to sharpen his technical skills in the electronics field. He is a graduate of San Jacinto College North with an associate degree in Electronics Technology. Patrick currently resides in Houston, Texas.

Tony R. Brown obtained a bachelors degree in Computer Engineering Technology at the University of Houston He plans to attend Prairie View A&M to pursue another bachelor and masters in computer engineering in the fall of 2006 after his time away for military duty.

Richard A. McNeilly is a graduate with bachelor's degree in Computer Engineering Technology. His interests lie in developing a foundation to successfully hone his technical abilities with computers and computer networks. He is a Grenadian national and a graduate of Presentation Brother's College in his home country. He currently resides in his home country of Grenada.

Malika Mohammed is a graduate with a bachelor's degree in Computer Engineering Technology Her interests lie in developing a foundation to successfully utilize her technical abilities in industrial settings. She currently resides in Houston, Texas but is pursuing a career in her field of study. She plans to continue her education by obtaining a Masters degree and even go on to strive for a Ph.D. degree in the future, probably in engineering or technology.

Ravula Mahesh is currently doing his Masters in Electrical Engineering at the University of Houston. He holds a B.E. (2004) in Electronics and Communication Engineering from Osmania University, India. He is currently working as a Teaching assistant in the ET Department since fall 2004. His area of expertise includes microcontroller interfacing and programming, data communications and networking.

Dr. Farrokh Attarzadeh is an associate professor in the Engineering Technology Department, College of Technology at the University of Houston. He teaches software programming, operating systems, digital logic, and is in charge of the senior project course in the Computer Engineering Program. He has been with the University of Houston since 1983. His areas of interests are in software development, embedded systems, robotics and electromechanical folk art. He can be reached at FAttarzadeh@uh.edu.