EMBEDDED ROBOT FOR SAFETY AND SECURITY PURPOSES

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Abstract— This project proposes an embedded system for safety and security purpose using RF Transceiver. It is embedded as part of a complete device including hardware and mechanical parts.The proposed robot is easy to design and implement both in hardware and software aspects. It uses low cost microcontroller, high sensitivity gas , fire, temperature, metal detector and infrared sensor, wireless AV camera and RF Transceiver to support reliable and robust wireless communication network. The robot integrates both safety and security functions and is useful in variety of applications.

Index Terms— PIC18F452, Handheld Unit, Base Unit, TV Tuner Card, Wireless AV Camera.

I. INTRODUCTION

Mini robot is a controlled robot. An embedded system is designed to perform specific control functions within a larger system, often with temporal constraints. It is embedded as part of a complete device often including hardware and mechanical parts. The key characteristic is being dedicated to handle a particular task. Robot and robotic technologies represent practical applications of physics, computer science, electronics and electrical concepts. It provides a very powerful and flexible approach to demonstrate a variety of engineering concepts. Robots are currently used in situations where human safety is an issue. Robotic technology is used to deal with hazardous situations such as dealing with suspicious packages.

II. OBJECTIVE AND MOTIVATION

The objective of the work is to build a Robot that can enter the region that is considered hazardous, collect the information about the environment there and hence control the further possible damage.

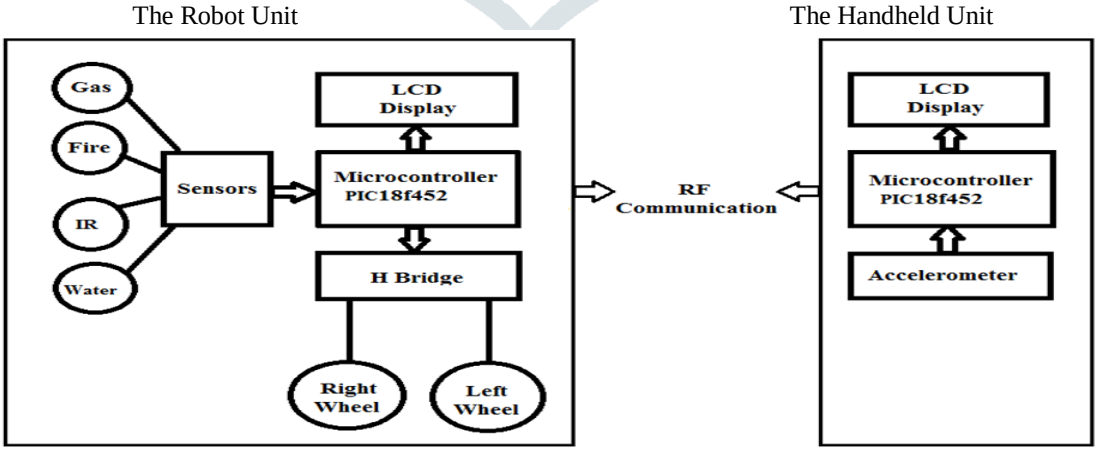
The motivation of the project is to create a Robot with unique controls that can be used for all the purposes. Large organizations and companies reap many benefits from robotic technologies as robots are less expensive than paying human workers over a long run and robots are not prone to injure themselves.

III. INTEGRATION

The PIC18F452 microcontroller is embedded at both the Robot and the handheld unit with C program which processes the received sensor data and provides an alarm through RF communication. The mobile robot is a battery powered and controlled using the handheld unit.

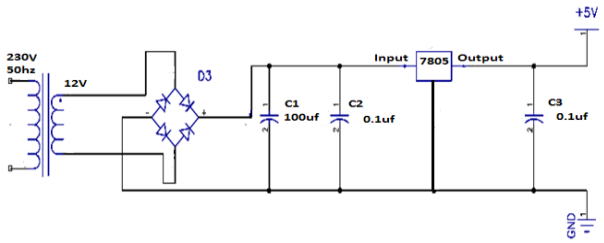
The project is structured so that it breaks down into two main components, the robot and the hand held unit. The requirements of the project are:

- Sensor requirements like the Gas, Fire, IR, Water.
- Alarm Monitoring requirements.
- Signal conditioning requirements.
- Isolation of sensors through Relays.



The power supply unit

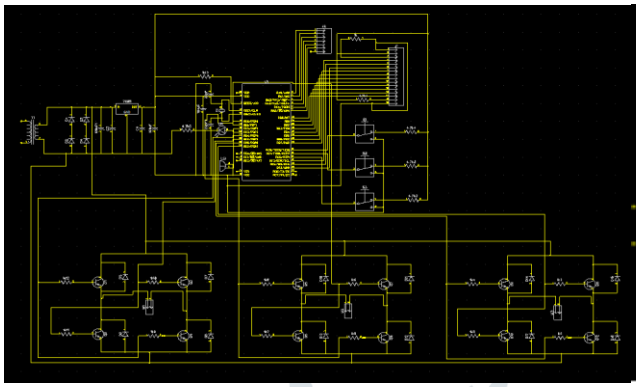
The below figure shows the power supply section. A power supply section gives the regulated DC power supply of +5 Volts using LM7805 fixed voltage regulator. Rectification of the AC supply is carried out using four IN4007 diodes connected to pin 1 of LM7805.Pin 2 is connected to ground and Pin 3 is connected to VCC. The output of this section is filtered.



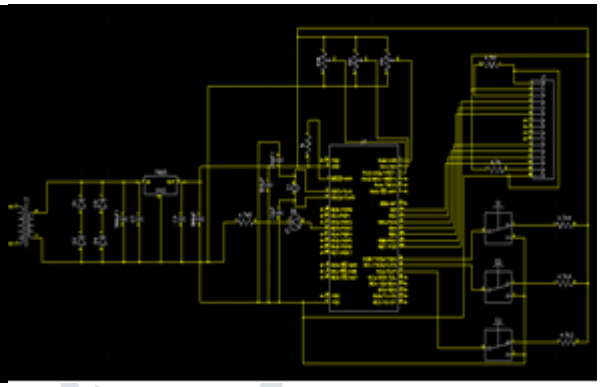
The Power Supply

The Base Unit and the Handheld Unit

As shown in the figure the integration consists of five sections on the Robot (the base unit). The power supply, the microcontroller, the display, the sensor and the motor driver sections. The Handheld unit consists of the power supply, the microcontroller, the display and the accelerometer sections.



The Base unit



The Handheld Unit

The Robot:

The main components of the Robot circuitry are a microcontroller PIC18F452, five sensors, two H-Bridges as motor drivers, relay boards motors, snubbing diodes, RF transceiver module. The power supply unit provides regulated 5V dc to the microcontroller. The input voltage of 12V ac is given using three 4V batteries connected in series. A switch connected in series with the battery powers the Robot board ON or OFF. The H bridge motor drivers can supply up to 1.2A for the motors, which is enough for the DC motors to produce enough torque to move the entire robot. It contains 2 H-bridges, to allow the Robot to move forward, backward, and turn by turning the direction of motors in clockwise or counter clockwise direction, and stopping the robot. The collected sensor data are sent to the microcontroller and is displayed on the LCD. These data are simultaneously sent to the HHU. The receiver receives the commands from the HHU and moves the motor in the specified direction. In the meantime, the camera which is mounted on the top of the Robot captures the images of the targeted area and sends it to the local system through a TV Tuner card.

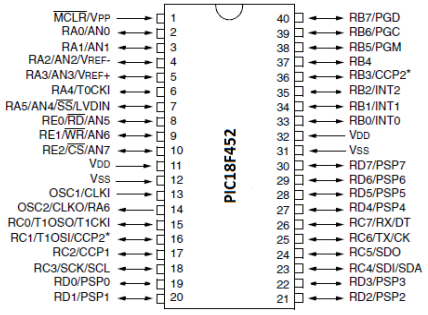
The Handheld Unit (HHU):

On the HHU, the power supply unit provides the regulated 5Vdc to the microcontroller. 9VAC input is given using a battery. The accelerometer is used as the tilt sensor from which the directions for the movement of the Robot are given. This Robot can move forward, backward, right, left and can be stopped. These commands are processed by the microcontroller PIC18F452 and the corresponding details about the direction of the Robot will be displayed on the LCD. At the same time, these commands will be sent through the RF transceiver to the base unit. The RF transceiver is powered by 5V and connected directly to the RX and TX of the microcontroller to communicate through UART. The communication is serial and uses I2C protocol.

IV. HARDWARE DESCRIPTION

PIC18F452 Microcontroller:

PIC18F452 microcontroller is an 8-bit microcontroller and has an instruction set that is compatible with the C compiler. It has 32K of flash program memory, 1536bytes of on-chip RAM and 256 bytes of data EEPROM. The instructions are 16 bits wide and the data path is of 8 bits. It has three external interrupt pins and all the interrupts including the internal interrupts can be prioritized. It has four timers out of which two are 8 bit timers and the other two are 16 bit timers. It has an addressable USART module, a 10 bit ADC. Conversion also during the SLEEP mode is the added benefit for using this ADC. It is reprogrammable and has a programmable code protection. It has five ports designated as Port A, Port B, Port C, Port D and Port E and all these ports are bi-directional ports.



The Liquid Crystal Display:

Hitachi's LCD HD44780 module is used. The nominal operating voltage for LED backlights is 5V at full brightness.
The LCD requires 3 control lines from the microcontroller:

1. Enable (E): This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly.
2. Read/Write (R/W): This line determines the direction of data between the LCD and microcontroller. When it is low, data is written to the LCD. When it is high, data is read from the LCD.
3. Register select (RS): With the help of this line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD.

MQ6 Gas Sensor:

The MQ6 Gas Sensor Module determines the presence of LPG gas and other bio hazardous gases. The proposed system interfaces the gas sensor module with the PIC18F452 microcontroller. The on-board microcontroller provides initial heating interval after power up and then starts to measure LPG sensor output. If the LPG or the other gas level is in the range of 200 to 10000ppm, then it will inform to the host controller by pulling the output Pin to high and starts to blink the on-board status LED. This sensor module is placed in the movable robot which can be used to detect gas leakage at home and industry, and are suitable for detecting of LPG, iso-butane, propane, LNG. A Sensitive tuner is always available in this sensor module, which is mainly used to manually adjust to set the density of the Gas.

IR Sensor:

Infrared sensors are also capable of measuring the heat being emitted by an object and detecting motion. In this project we use IR sensor as an obstacle detector. The emitter is a IR LED (Light Emitting Diode) and the detector is a IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, its resistance and correspondingly, its output voltage, change in proportion to the magnitude of the IR light received. The IR sensor that is used requires supply voltage in the range of 2V to 15 V and 30s warm up time.

The Fire Detector:

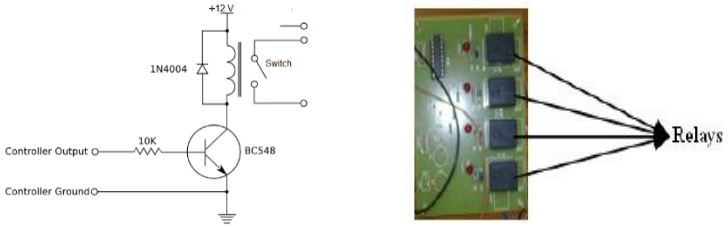
When the same IR sensor is tuned to low sensitivity it can be used to detect heat and hence can be used as a Fire sensor.

Water Sensor:

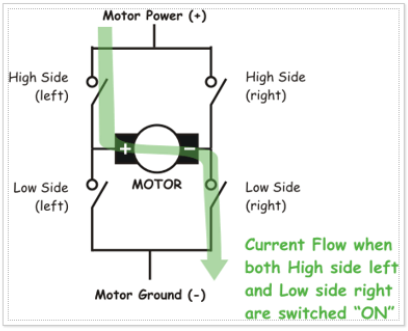
The water indicator is two wires one connected to +5V and the other to the ground. As water is a good conductor of electricity when these two wires are immersed in water at the same time a complete path for the current to flow is formed and hence the circuit will be shorted to ground. This signal moves to the pin of the microcontroller which is allotted for the water sensing through a relay. Once the corresponding pin goes low, the microcontroller confirms that the presence of water and the displays "WATER DETECTED" on the LCD.

Relays:

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. A readymade relay board with three relays is used in the project. The circuit of the relay and the readymade relay board are as follows.



The Motor Driving Circuit:



High Left	High Right	Low Left	Low Right	Description
On	Off	Off	On	Motor runs clockwise
Off	On	On	Off	Motor runs anti-clockwise
On	On	Off	Off	Motor stops or decelerates
Off	Off	On	On	Motor stops or decelerates

DC Motor:

A 12V DC Geared Motor is used in variety of robotics applications which is available in wide range of RPM and Torque.
Features:

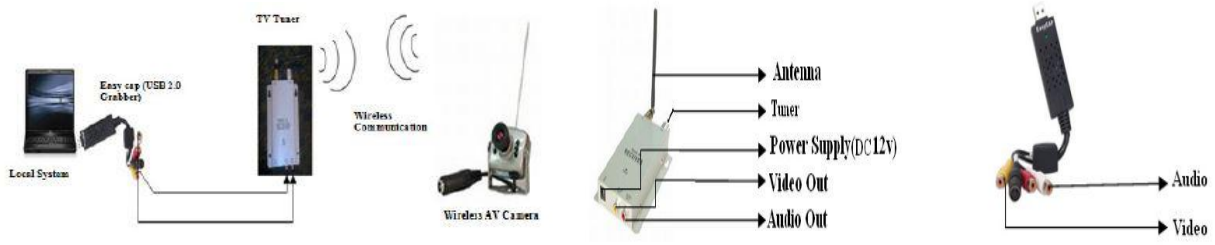
- 30RPM 12V DC motors with Gearbox
- 6mm shaft diameter with internal hole
- 2kgcm torque
- Load current = 300 mA(Max)

The Caster Wheel:

It is a compound wheel that is designed to be mounted to the bottom of a larger object so as to enable that object to be easily moved. They are available in various sizes, and are commonly made of rubber, plastic, nylon, aluminum, or stainless steel.

Wireless AV Camera:

It is small and having delicate appearance, good performance with high-quality picture and sound transmitting and receiving capability. It supports minimum of 100m transmission distance without block and can be used on TV, monitor, LCD, etc. including adaptive bracket and supports easy installation. The AV signal from the camera is sent to the TV tuner (ZEB-TU 1000) is an Audio-Video adapter that can capture high-quality audio-video files directed by USB 2.0 interface without soundcard.



RF Transceiver:

This RF module comprises of an RF Transmitter and an RF Receiver. We use two transmitter/receiver (Tx/Rx) pairs operates at a frequency of 433 MHz and 315MHz. The RF transmitter receives serial data and transmits wirelessly through RF through its antenna. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter. Transmission through RF is better than ZIG BEE because the signals through RF can travel through larger distances around 50m making it suitable for long range applications.

V. SOFTWARE DESCRIPTION

Interfacing of microcontroller with ADC, LCD, MEMORY, etc. has been carried out using various software modules. The control program is written in C language.

Steps for compiling, linking and downloading software in to the Microcontroller:

Step 1: Create new project
Step 2: Select the device for the Target
Step 3: Add files to the source
Step 4: Build and Link the target program
Step 5: Compile the program
Step 6: Create Hex file from the source file
Step 7: Download the Hex file
Step 8: Burn he program to the Microcontroller

Algorithm for Robot

1. Define libraries, ports and configure CPU
2. Set and initialise the LCD, timer and the counter (timer and counter are cleared) and declare temporary variables c1, c2, c3, c4, c5, c6.
3. If PortA.1==0 then,
   start the timer→ display 'OBSTACLE DETECTED' and send 'o' through RF tx.
   Once the timer interrupt arises (timer has overflown now) i.e., If TMR0IE && TMR0IF ==1 then,
   increment the counter, clear TMR0IF, c1□c1+counter
   Check if c1==3.
   If YES then clear the TMR0IF, counter and c1 and move to the next sensor
   If NO then clear the counter and move to the motor control part.
   If NO then clear c1 and move to the next sensor
4. If PortA.2==0 then,
   start the timer→ display 'HUMAN DETECTED' and send 'h' through RF tx.
   Once the timer interrupt arises (timer has overflown now) i.e., if TMR0IE && TMR0IF ==1 then,
   increment the counter, clear TMR0IF, c2□c2+counter
   Check if c2==3.
   If YES then clear the TMR0IF, counter and c2 and move to the next sensor
   If NO then clear the counter and move to the motor control part.
   If NO then clear c2 and move to the next sensor
5. If PortA.3==0 then,
   start the timer→ display 'METAL DETECTED' and send 'm' through RF tx.
   Once the timer interrupt arises (timer has overflown now) i.e., if TMR0IE && TMR0IF ==1 then,
   increment the counter, clear TMR0IF, c3□c3+counter
   Check if c3==3.
   If YES then clear the TMR0IF, counter and c3 and move to the next sensor
   If NO then clear the counter and move to the motor control part.
   If NO then clear c3 and move to the next sensor

6. If PortA.5==0 then,
   start the timer→ display 'RAIN DETECTED' and send 'r' through RF tx.
   Once the timer interrupt arises (timer has overflown now) i.e., if TMR0IE && TMR0IF ==1 then,
   increment the counter, clear TMR0IF, c4□c4+counter
   Check if c4==3.
   If YES then clear the TMR0IF, counter and c4 and move to the next sensor
   If NO then clear the counter and move to the motor control part.
   If NO then clear c4 and move to the next sensor
7. If PortE.0==0 then,
   start the timer→ display 'GAS DETECTED' and send 'g' through RF tx.
   Once the timer interrupt arises (timer has overflown now) i.e., if TMR0IE && TMR0IF ==1 then,
   increment the counter, clear TMR0IF, c5□c5+counter
   Check if c5==3.
   If YES then clear the TMR0IF, counter and c5 and move to the next sensor
   If NO then clear the counter and move to the motor control part.
   If NO then clear c5 and move to the next sensor
8. If PortE.1==0 then,
   start the timer→ display 'FIRE DETECTED' and send 'f' through RF tx.
   Once the timer interrupt arises (timer has overflown now) i.e., if TMR0IE && TMR0IF ==1 then,
   increment the counter, clear TMR0IF, c6□c6+counter
   Check if c6==3.
   If YES then clear the TMR0IF, counter and c6 and move to the next sensor
   If NO then clear the counter and move to the motor control part.
   If NO then clear c6 and move to the next sensor.
9. Motor control part :
   If rxdata==L then move left
   If rxdata==R then move right
   If rxdata==F then move forward
   If rxdata==B then move backward
   Otherwise stop
10. Move to step 2

The display of message in all the above cases goes on until the timer overflows which also includes many delays in between. This algorithm was first tested by placing switches in place of the sensors.

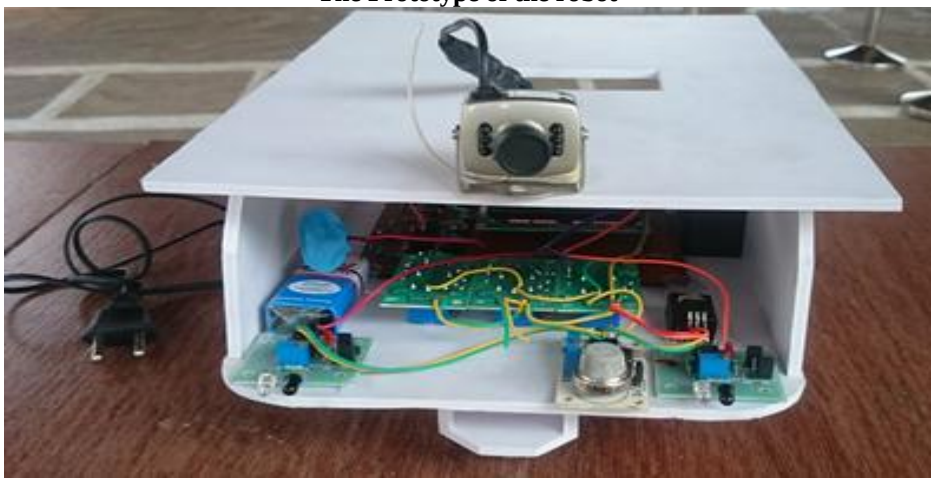
Algorithm for Hand Held unit

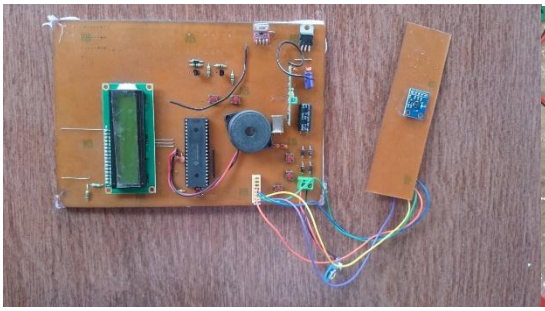
1. Define libraries, ports and configure CPU and initialise the LCD.
2. Receiving character through RF receiver:
   If rxdata=='o' then, display "OBSTACLE DETECTED" and switch ON the buzzer.
   elseif rxdata=='h' then, display "HUMAN DETECTED" and switch ON the buzzer.
   elseif rxdata=='m' then, display "METAL DETECTED" and switch ON the buzzer.
   elseif rxdata=='r' then, display "RAIN DETECTED" and switch ON the buzzer.
   elseif rxdata=='g' then, display "GAS DETECTED" and switch ON the buzzer.
   elseif rxdata=='f' then, display "FIRE DETECTED" and switch ON the buzzer.
3. Send the accelerometer commands through the RF transmitter.
4. Move to step 2

VI. RESULT

The prototype of the robot is shown in the below figure. The robot has two wheels which are used for moving backward, forward, left and right turns. The RF at the robotic side and the Handheld unit is used for transmitting the data from microcontroller to the local system .The proposed robot is a battery powered and compact system.

The Prototype of the robot





The Handheld Unit

The Base Unit

VII. CONCLUSION AND FUTURE SCOPE

The proposed robot can be used in war field, mines, power station, military operations, industries, research and educational institutions and so on. The Robotic movement is controlled by HHU through the local system. The presence of bio hazardous gases like LPG, iso-butane, propane, LNG and alcohol were detected through MQ6 Gas Sensor which is placed at the robot. The obstacle, rain and fire can also be detected. The sensed parameters are sent to the local system through the RF Transceiver which is presented at both the ends, that is at the robot and at the HHU. At the same time an alarm is raised. A wireless AV camera resides at the robot; sends the robotic environment information to the local system. The video streaming is simultaneously done at both the local and HHU system (web server). TV tuner is the source to receive the image signals from wireless AV camera and send that signals to the Local system. This system can be used wherever the safety and security are the major threat.

In future this work may be enhanced in such a way that, whenever a picture is captured then a Camera can immediately send an email of the picture. The data collected by each of the sensor can be sent to the local system. Cloud applications can be used to store these data on a database in the internet. The gas leakage whenever sensed, an alert message can be sent as an email or SMS to the user. When used by the security department, each sensor data can be sent through email to the officer. More sensors like metal detector, PIR for motion detection can be added to the Robot for higher applications.

VIII. ACKNOWLEDGMENT

We are presenting the project “Embedded Robot for safety and security purposes” with pleasure and satisfaction.As we present this project , we take this opportunity to thank all those who have encouraged us to come out of this venture thus making it possible. We would like to sincerely express our gratitude towards all those people who have helped us in making our project a success. Behind every achievement there is immense pleasure and gratitude to those who activated it, without whom it ever have come existence. We thank our HOD , Dr.Somashekara Bhat for allowing us to undertake this project and for his constant encouragement. We Express our heartfelt gratitude to our guide Mr.Vasanth Kumar P Professor of Electronics and Communication Department, for his guidance during the preparation and successful completion of the project.We would also like to express our heartiest and profound gratitude to all the teaching and non teaching staff of the Electronics &Communication Engineering Department who have cooperated with us during the various stages of the project.

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