

DESIGN OF SEMICUSTOM PCB FOR ROBOTIC APPLICATION DEVELOPMENT

¹J Sunil Kumar, ²D Sreelakshmi, ³G Sindhura Bhargavi
¹ Associate professor, ²Associate professor, ³ Assistant professor
¹Electronics & Communication Engineering
¹Narayana Engineering College, ¹Nellore, ¹Andhra Pradesh, ¹India

ABSTRACT

To design a single hardware circuit for different robotic applications that comprises multiple slots for sensors, motors, potentiometers, LCD, switches. Arduino controller is used to implement the various robotic application and the multiple LEDs present on the board indicates the status of the different components that are associated with the application. Each component on the board is again placed with a LED which indicates the status of the component. To implement different applications with the board there is no need for changing of any connections. We can implement it just by dumping the code into the arduino. The different robotic applications can be implemented by using this hardware circuit are Line follower, Bluetooth controlled robot & Traffic light signal.

Keywords: *Arduino controller, sensors, potentiometers, Line follower, Bluetooth controlled robot & Traffic light signal.*

I. INTRODUCTION

To create a PCB Design you need to draw holes, pads and wires for the circuit. Then we send this drawing to a manufacturer or etch it our self.

Before we start drawing wires and stuff, we need to know what circuit we want to build. So we need to find or design schematics for our circuit. And we need a PCB design software. Then we are ready to begin the process.

Start by drawing the schematic diagram into the software that is chosen. The software is **KICAD** software.

1.1 Pcb Design Process

Preparing the board layout:

To draw the board, we need to transfer our schematic diagram into a drawing of our printed circuit board. Drawing a PCB is artwork. The design guidelines must be followed for drawing the circuit boards. Most PCB software will have tools that will help us to draw the board from the schematic.

A printed circuit board is made out of a special glass-reinforced epoxy laminate material. And usually, it is green. But it can come in other colors too. There will be no components on the board at the beginning. The required components are then soldered on the board.

To make a printed circuit board you need to:

1. Design schematics
2. Draw the circuit board layout
3. Get the board made

1.1.1 Design schematics

The first step is to make the schematics. We can either find a schematic diagram that someone else has designed or we can create our own from scratch. Usually we start with the drawing of the circuit. Then we draw the circuit into the design tool such as KICAD software.

1.1.2. Draw Circuit Board Layout:

The schematics are drawn in our design tool. Now we need to draw the circuit board. We need to draw the wires that connect the different components.

This is kind of like the “connect-the-dots” game we might have played when we were kids. When we drew the circuit diagram in the previous step, we told the program which components are going to be connected. Now we connect everything by drawing lines, and the program will tell us if we did it correctly.

1.1.3. Get the Board Made

With the board design finished, we are ready to get the board made. This can be done in a few different ways.

We can etch a board at home. The advantage with this is that we get the board made right away. The drawbacks are that you need to buy all this different chemicals and equipment. We can get a board made by a CNC router. This also has the advantage that we get the board made right away. But such a CNC router is often expensive.

II. DESIGN OF THE BOARD

2.1 Placement of different components:

The power supply in the board is placed at the edge. Because it will be easy to connect the battery and the heat dissipation will not effect the other components on the board. As there are connections between the Bluetooth module and arduino, the Bluetooth module is placed at the center of the board which is nearer to the arduino. The status of different components on the board whether they are ON/OFF is indicated by the LED's on the board. The different sensor slots on the board are provided with the potentiometers to control the voltage sensitivity. The distance between the analog and digital pins of arduino is 48.5mm. The distance between each pin of arduino is 2.54mm.

The voltage drive capability of the board is upto 9 volts and the operating voltage is 5 volts. IR sensor has inbuilt potentiometer .So the IR sensor slot on the board has no potentiometer provided.

The board consists of two layers .The connections on the top layer and the bottom layer are represented with two different colours in the layout which is shown below. UART protocol is used for Bluetooth module .The receiver and transmitter pins of arduino are given to the Bluetooth module. The transmitter pin of arduino is connected to the receiver pin of Bluetooth module and vice –versa.

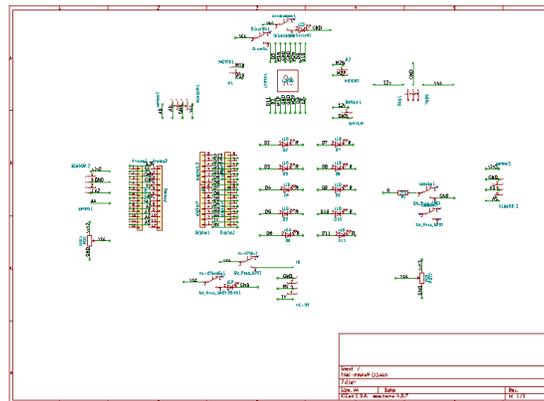


Fig 2.1 Schematic of the board

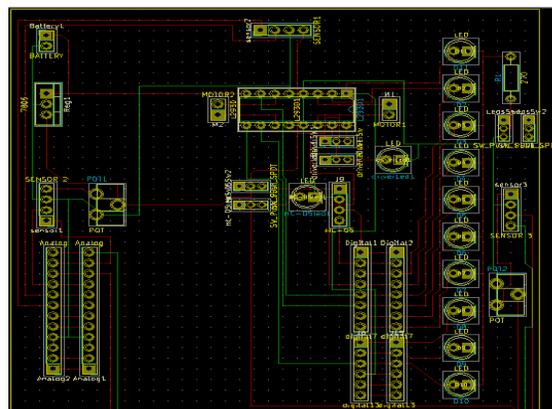


Fig 2.2 layout of the board

III. HARDWARE

3.1 ULTRASONIC SENSOR:

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

3.2 ULTRASONIC DETECTION – BASICS & APPLICATION:

Ultrasonic detection is most commonly used in industrial applications to detect hidden tracks, discontinuities in metals, composites, plastics, ceramics, and for water level detection. For this purpose the laws of physics which are indicating the propagation of sound waves through solid materials have been used since ultrasonic sensors using sound instead of light for detection.

3.2.1 Principle of ultrasonic detection:

Sound wave:

Sound is a mechanical wave travelling through the mediums, which may be a solid, or liquid or gas. Sound waves can travel through the mediums with specific velocity depends on the medium of propagation. The sound waves which are having high frequency reflect from boundaries and produces distinctive echo patterns.

3.2.2 Laws of physics for sound waves:

Sound waves are having specific frequencies or number of oscillations per second. Humans can detect sounds in a frequency range from about 20Hz to 20 KHz. However the frequency range normally employed in ultrasonic detection is 100 KHz to 50MHz. The velocity of ultrasound at a particular time and temperature is constant in a medium.

$$W = C/F \text{ (or) } W = CT$$

Where W = Wave length

C = Velocity of sound in a medium

F = Frequency of wave

T=Time Period

The most common methods of ultrasonic examination utilize either longitudinal waves or shear waves. The longitudinal wave is a compression wave in which the particle motion is in the same direction of the propagation wave. The shear wave is a wave motion in which the particle motion is perpendicular to the direction of propagation. Ultrasonic detection introduces high frequency sound waves into a test object to obtain information about the object without altering or damaging it in any way. Two values are measured in ultrasonic detection.

The amount of time, taking for the sound to travel through the medium and amplitude of the received signal. Based on velocity and time thickness can be calculated.

Thickness of material = Material sound velocity X Time of Flight

Transducers for Wave Propagation and particle detection:

For sending sound waves and receiving echo, ultrasonic sensors, normally called transceivers or transducers will be used. They work on a principle similar to radar that will convert electrical energy into mechanical energy in the form of sound, and vice versa.

The commonly used transducers are contact transducers, angle beam transducers, delay line transducers, immersion transducers, and dual element transducers. Contact transducers are typically used for locating voids and cracks to the outside surface of a part as well as measuring thickness. Angle beam transducers use the principle of reflection and mode conversion to produce refracted shear or longitudinal waves in the test material.

Delay line transducers are single element longitudinal wave transducers used in conjunction with a replaceable delay line. One of the reasons for choosing delay line transducer is that near surface resolution can be improved. The delay allows the element to stop vibrating before a return signal from the reflector can be received.

The major advantages offered by immersion transducers over contact transducers are Uniform coupling reduces sensitivity variations, Reduction in scan time, and increases sensitivity to small reflectors.

3.2.2 Operation of ultrasonic sensors:

When an electrical pulse of high voltage is applied to the ultrasonic transducer it vibrates across a specific spectrum of frequencies and generates a burst of sound waves. Whenever any obstacle comes ahead of the ultrasonic sensor the sound waves will reflect back in the form of echo and generates an electric pulse. It calculates the time taken between sending sound waves and receiving echo. The echo patterns will be compared with the patterns of sound waves to determine detected signal's condition.

3.3 Applications involving Ultrasonic detection:

The distance of obstacle or discontinuities in metals is related to velocity of sound waves in a medium through which waves are passed and the time taken for echo reception. Hence the ultrasonic detection can be used

for finding the distances between particles, for detecting the discontinuities in metals and for indicating the liquid level.

3.4 Ultrasonic Distance Measurement

Ultrasonic sensors are used for distance measuring applications. These gadgets regularly transmit a short burst of ultrasonic sound to a target, which reflects the sound back to the sensor. The system then measures the time for the echo to return to the sensor and computes the distance to the target using the speed of sound within the medium.

Different sorts of transducers are utilized within industrially accessible ultrasonic cleaning devices. An ultrasonic transducer is affixed to a stainless steel pan which is filled with a solvent and a square wave is applied to it, conferring vibration energy on the liquid.

3.4.1 Features of Ultrasonic Distance Sensor:

1. Supply voltage: 5V (DC).
2. Supply current: 15mA.
3. Modulation frequency: 40Hz.
4. Output: 0 – 5V (Output high when obstacle detected in range).
5. Beam Angle: Max 15 degree.
6. Distance: 2cm – 400cm.
7. Accuracy: 0.3cm.
8. Communication: Positive TTL pulse.

3.5 IR SENSOR

IR Sensors work by using a specific light sensor to detect a select light wavelength in the Infra-Red (IR) spectrum. By using an LED which produces light at the same wavelength as what the sensor is looking for, you can look at the intensity of the received light. When an object is close to the sensor, the light from the LED bounces off the object and into the light sensor. This results in a large jump in the intensity, which we already know can be detected using a threshold.

IR detectors are little microchips with a photocell that are tuned to listen to infrared light. They are almost always used for remote control detection - every TV and DVD player has one of these in the front to listen for the IR signal from the clicker. Inside the remote control is a matching IR LED, which emits IR pulses to tell the TV to turn on, off or change channels. IR light is not visible to the human eye, which means it takes a little more work to test a setup.

3.6 Radiation Thermometers:

IR sensors are used in radiation thermometers to measure the temperature depend upon the temperature and the material of the object and these thermometers have some of the following features

1. Measurement without direct contact with the object.
2. Faster response
3. Easy pattern measurements

3.7 Flame Monitors:

These types of devices are used for detecting the light emitted from the flames and to monitor how the flames are burning. The Light emitted from flames extend from UV to IR region types. PbS, PbSe, Two-color detector, pyro electric detector are some of the commonly employed detector used in flame monitors.

3.8 Moisture Analyzers:

Moisture analyzers use wavelengths which are absorbed by the moisture in the IR region. Objects are irradiated with light having these wavelengths (1.1 μm , 1.4 μm , 1.9 μm , and 2.7 μm) and also with reference wavelengths. The Lights reflected from the objects depend upon the moisture content and is detected by analyzer to measure moisture (ratio of reflected light at these wavelengths to the reflected light at reference wavelength). In GaAs PIN photodiodes, Pbs photoconductive detectors are employed in moisture analyzer circuits.

3.9 Gas Analyzers:

IR sensors are used in gas analyzers which use absorption characteristics of gases in the IR region. Two types of methods are used to measure the density of gas such as dispersive and non dispersive.

3.10 Bluetooth Module hc-05:

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate)3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It

uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature).

The Bluetooth module HC-05 is a MASTER/SLAVE module. By default the factory setting is SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices. The user can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to your embedded project, etc.

Hardware Features:

Typical -80dBm sensitivity.

1. Up to +4dBm RF transmit power.
2. 3.3 to 5 V I/O.
3. PIO (Programmable Input/ Output) control.
4. UART interface with programmable baud rate.
5. With integrated antenna.
6. With edge connector.

Software Features:

1. Slave default Baud rate: 9600, Data bits:8, Stop bit:1,Parity:No parity.
2. Auto-connect to the last device on power as default.
3. Permit pairing device to connect as default.
4. Auto-pairing PINCODE:"1234" as default.

3.10 ARDUINO UNO BOARD:

Arduino is a single-board microcontroller meant to make the application more accessible which are interactive objects and its surroundings. The hardware features with an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models consists a USB interface, 6 analog input pins and 14 digital I/O pins that allows the user to attach various extension boards.

The Arduino Uno board is a microcontroller based on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button. This contains all the required support needed for microcontroller. In order to get started, they are simply connected to a computer with a USB cable or with a AC-to-DC adapter or battery. Arduino Uno Board varies from all other boards and they will not use the FTDI USB-to-serial driver chip in them. It is featured by the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

IV. SOFTWARE

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR studio and the newer Atmel studio.

The Arduino project provides integrated development environment (IDE), which is a cross-platform application written in a programming language java. It originated from the IDE for the language processing and wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching and syntax highlighting and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operations menus.

A program written with the IDE for Arduino is called a sketch. Sketches are saved on the development computer as text files with the files extension.ino. Arduino Software (IDE) PRE-1.0 saved sketches with the extension.pde

The Arduino IDE supports the language C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the wiring project, which provides many common input and output procedures. User-written code only requires two basics functions, for starting the sketch and the main program loop, that are compiled and linked with a program stubmain into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into Arduino board by a loader program in the board's firmware

V. APPLICATIONS

Applications are line follower robot, Bluetooth controlled robot, Obstacle avoidance robot, Voice controlled robot, Light following robot, Traffic light controller.

VI. EXPERIMENTAL RESULTS

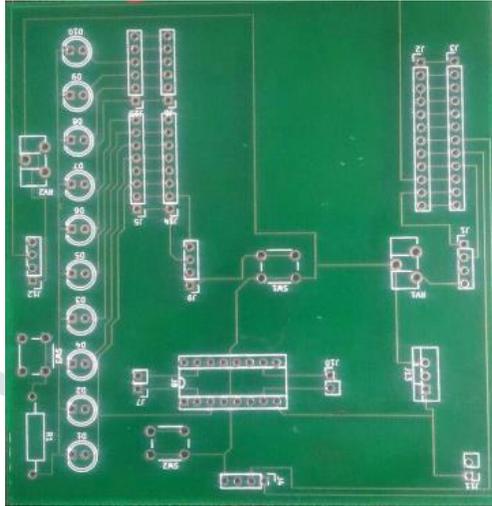


Fig 6.1 PCB board design

A single hardware circuit is designed with various slots for arduino, motor driver, led's, sensors and Bluetooth module. This board makes it possible to drive many applications without changing any connections just by changing the codes for particular application. This type of circuit helps in saving the time and it also reduces the system complexity.

VII. ADVANTAGES AND DISADVANTAGES

The main advantages of this project are:

1. Saves lot of time.
2. Reduces system complexity.
3. Easy understandability of the circuit.

The following is the disadvantage:

Any misplace of the battery terminals may lead to the damage of the entire board.

VIII. FUTURE SCOPE AND CONCLUSION

This board is a semi customized board which is used to implement a numerous applications with the help of different slots. This board can be modified further by providing additional pins for the arduino to implement a few more applications.

This type of board design reduces the system complexity and saves time. There is no need to get confused with large number of connections.

To implement different applications with the board, there is no need of varying of connections. It is possible just by changing the codes for different applications.

IX. REFERENCES

1. <http://kicad-pcb.org/about/kicad/>
2. <https://kicad.en.softonic.com>Windows>Education&Reference>Science>
3. www.robotiksistem.com/robotics_applications.html
4. https://www.researchgate.net./publication/258280512_Printed_circuit_boards_A_review_on_the_perspective_of_sustainability.