HARDWARE DEVELOPMENT OF THE ROBOT

5.1. Main Hardware Components used in the Robot

5.1.1. Microcontroller MSP430G2553

Description

The Texas Instruments MSP430 family of ultra-low-power microcontrollers consists of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with five low-power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency.

The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 1 μs. The MSP430G2x13 and MSP430G2x53 series are ultra-low-power mixed signal microcontrollers with built-in 16-bit timers, up to 24 I/O capacitive-touch enabled pins, a versatile analog comparator, and built-in communication capability using the universal serial communication interface. In addition the MSP430G2x53 family members have a 10-bit analog-to-digital (A/D) converter. Typical applications include low-cost sensor systems that capture analog signals, convert them to digital values, and then process the data for display or for transmission to a host system.

Features

- Low Supply-Voltage Range: 1.8 V to 3.6 V • Universal Serial Communication Interface (USCI)
- Ultra-Low Power Consumption
- Five Power-Saving Modes
- Ultra-Fast Wake-Up From Standby Mode in C™ Less Than 1 μs
- On-Chip Comparator for Analog Signal Compare Function or Slope Analog-to-Digital
- 16-Bit RISC Architecture, 62.5-ns Instruction (A/D) Conversion Cycle Time
- 10-Bit 200-ksps Analog-to-Digital (A/D)
- Basic Clock Module Configurations Converter With Internal Reference, Sample-
- Internal Frequencies up to 16 MHz With and-Hold, and Autoscan
- Four Calibrated Frequency

- Brownout Detector
- Serial Onboard Programming,
- (LF) Oscillator No External Programming Voltage Needed,
- On-Chip Emulation Logic With Spy-Bi-Wire Capture/Compare Registers Interface
- Up to 24 Capacitive-Touch Enabled I/O Pins
- Package Options TSSOP: 20 Pin, 28 Pin, PDIP: 20 Pin, QFN: 32 Pin

Pin Diagram

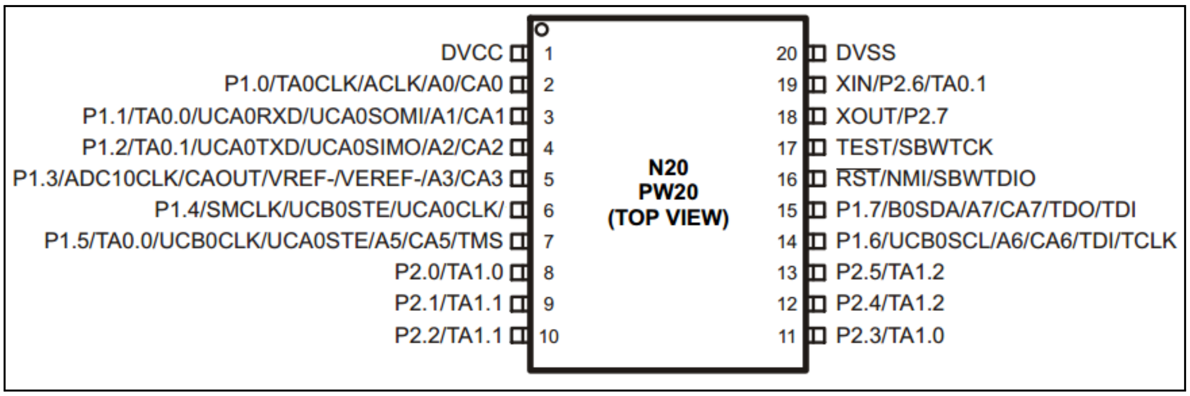

Figure 5.1: Pin Diagram of MSP430G2553

5.1.2. RF Wireless Transmission Module

Description

Wireless Transmitter Modules allow your Arduino to wirelessly communicate with other arduinos, or with radio frequency (RF) controlled devices that operate in the same frequency (433Mhz in this case).They work in pairs, meaning you need both a receiver and a transmitter to communicate with each other. The receiver has 4 pins, but we actually use 3 of them: GND (Ground), VCC (5V) and one DATA pin.

Technical Parameters of the Receiver Module

- Product Model: MX-05V
- Operating voltage: DC5V
- Quiescent Current: 4MA
- Receiving frequency:315Mhz

- Receiver sensitivity:-105DB
- Size: 30 * 14 * 7mm
- External antenna: 32CM single core wire, wound into a spiral

Technical Parameters of the Transmitter Module

- Product Model: MX-FS-03V
- Launch distance :20-200 meters (different voltage, different results)
- Operating voltage :3.5-12V
- Dimensions: 19 * 19mm
- Operating mode: AM
- Transfer rate: 4KB / S
- Transmitting power: 10mW
- Transmitting frequency: 315Mhz
- An external antenna: 25cm ordinary multi-core or single-core line
- Pinout from left → right: (DATA; VCC; GND)

Pin Diagram of the RF Modules

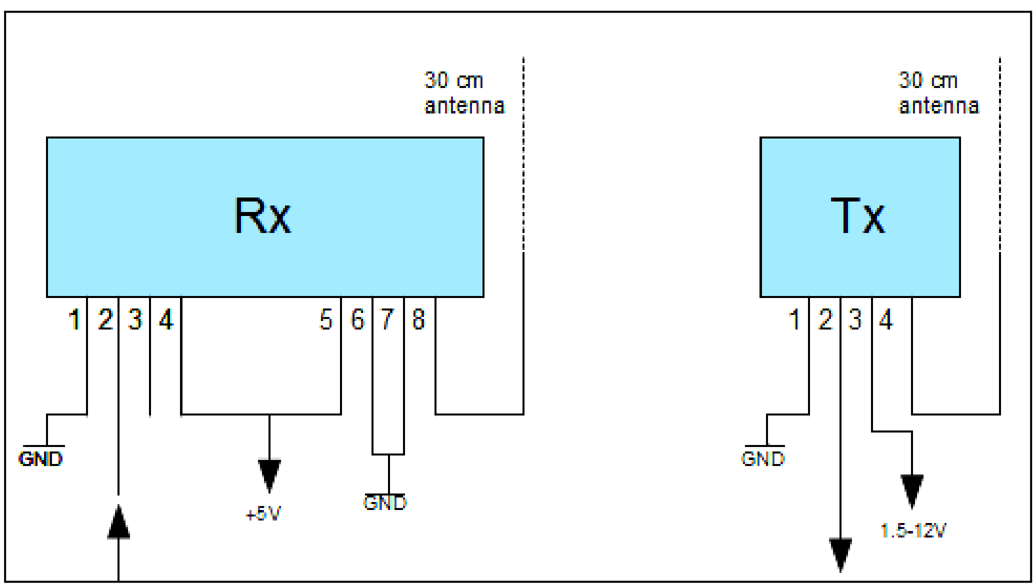

Figure 5.2: Pin Diagram of RF Modules

5.1.3. L293D Motor Driver

Description

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. Dual H-bridge Motor Driver integrated circuit (IC).It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction. As you know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, Hence H-bridge IC are ideal for driving a DC motor.

In a single l293d chip there two h-Bridge circuit inside the IC which can rotate two dc motor independently. Due its size it is very much used in robotic application for controlling DC motors. Given below is the pin diagram of a L293D motor controller.

There are two Enable pins on l293d. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge you need to enable pin 1 to high. And for right H-Bridge you need to make the pin 9 to high. If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working. It's like a switch. There are 4 input pins for l293d, pin 2,7 on the left and pin 15 ,10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.

Pin Diagram of L293D

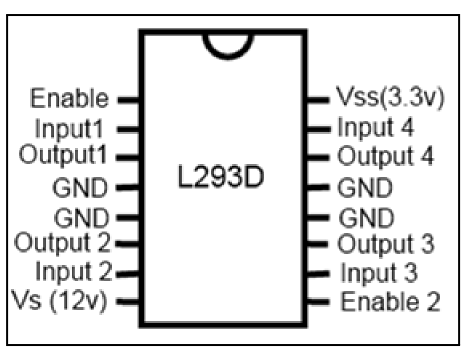

Figure 5.3: Pin Diagram of L293D

5.1.4. Color Sensors

Description

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 as shown in figure 5.1.4. This results in a large jump in the intensity, which we already know can be detected using a threshold.

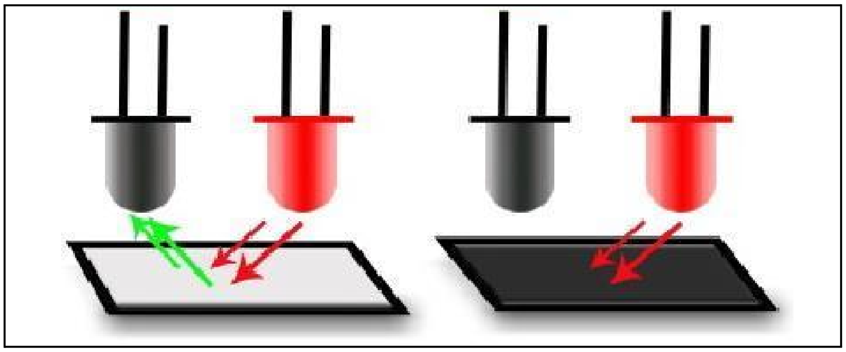

Figure 5.4: Reflection of IR light on different surfaces

5.1.5. Shift Register 74595

Description

74HCT595 is an 8-bit serial-in/serial or parallel-out shift register with a storage register and 3 state outputs. Both the shift and storage register have separate clocks. The device features a serial input (DS) and a serial output (Q7S) to enable cascading and an asynchronous reset MR input. A LOW on MR will reset the shift register. Data is shifted on the LOW-to-HIGH transitions of the SHCP input.

The data in the shift register is transferred to the storage register on a LOW-to-HIGH transition of the STCP input. If both clocks are connected together, the shift register will always be one clock pulse ahead of the storage register. Data in the storage register appears at the output whenever the output enable input (OE) is LOW. A HIGH on OE causes the outputs to assume a high-impedance OFF-state. Operation of the OE input does not affect the state of the registers. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of VCC.

Features of 74595

Features and advantages of 74595 shift registers are as follows :

- 8-bit serial input
- 8-bit serial or parallel output
- Storage register with 3-state outputs
- Shift register with direct clear
- 100 MHz (typical) shift out frequency
- Complies with JEDEC standard no. 7A
- Input levels:
- For 74HC595: CMOS level
- For 74HCT595: TTL level
- ESD protection:
- HBM JESD22-A114F exceeds 2000 V
- MM JESD22-A115-A exceeds 200 V
- Multiple package options
- Specified from -40 'C to +85 'C and from -40'C to +125'C

Pin Diagram of 74595

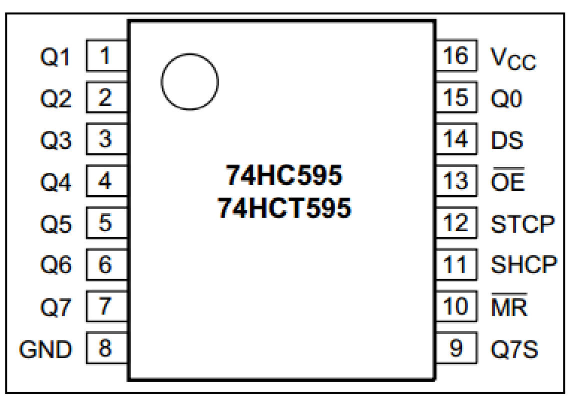

Figure 5.5: Pin Diagram of 74595

5.1.6. 7805 Voltage Regulator

Description

This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 A of output current. The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload.

In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.

Pin Diagram of 7805

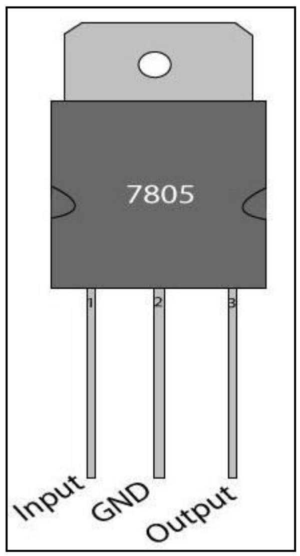

Figure 5.6: Pin Diagram of 7805

5.1.7. 4x4 Matrix Keypad

Description

Typically one port pin is required to read a digital input into the controller. When there are a lot of digital input that has to be read, it is not feasible to allocate one pin for each of them. This is when a matrix keypad arrangement is used to reduce the pin count.

Therefore, the number of pins that are required to interface a given number of inputs decreases with increase in the order of the matrix. Example: If the matrix is 2×2, you will need 2 pins for the rows and 2 pins for the columns in such a case there is no difference in the cost of reading that many inputs. But if you consider a 10×10 matrix you will just need 20 pins (10 for the rows and 10 for the columns) to read 100 digital inputs.

Initially, all switches are assumed to be released. So there is no connection between the rows and columns. When any one of the switches are pressed, the corresponding rows and columns are connected (short circuited). This will drive that column pin (initially high) low. Using this logic, the button press can be detected. The colors red and black is for logic high and low respectively.

Here are the steps involved in determining the key that was pressed :

- Step 1: The first step involved in interfacing the matrix keypad is to write all logic 0's to the rows and all logic 1's to the columns. In the image, black line symbolizes logic 0 and red line symbolizes logic 1. For now let us assume that, the circled key is pressed and see how the key press can be detected by a software routine.
- Step 2: Now the software has to scan the pins connected to columns of the keypad. If it detects a logic 0 in any one of the columns, then a key press was made in that column. This is because the event of the switch press shorts the C2 line with R2. Hence C2 is driven low.
- Step3: Once the column corresponding to the key pressed is located, the next thing that the software has to do is to start writing logic 1's to the rows sequentially (one after the other) and check if C2 become high. The logic is that if a button in that row was pressed, then the value written to that row will be reflected in determined column (C2) as they are short circuited.
- Step 4 : The procedure is followed till C2 goes high with logic high is written to a row. In this case, a logic high to the second row will be reflected in the second column. We already know the key press happened at column 2. Now we have detected that the key is in row 2. So, the position of the key in the matrix is (2,2) Once this is detected, it's up to us to name it or provide it with a task in the event of the key press.

Diagram of 4x4 Matrix Keyboard

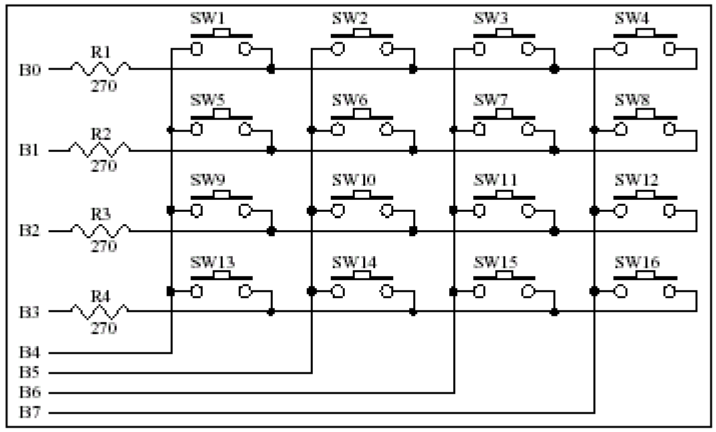

Figure 5.7: Diagram of 4x4 Matrix Keyboard

5.1.8. IR Collision Avoidance Module

Description

The principle of operation of an infrared sensor is based on infrared light that is reflected when hitting an obstacle. An IR receiver captures the reflected light and the voltage are measured based on the amount of light received.

Infrared sensors are used in a wide range of applications including here proximity robotic applications for distance and object detection, or color detection and tracking. As a disadvantage, IR sensors have bad performance in strong sunlight and many applications where this type of sensor is used are designed for indoor use. But these sensors are very cheap and easily available.

Diagram of IR Collision Avoidance Module

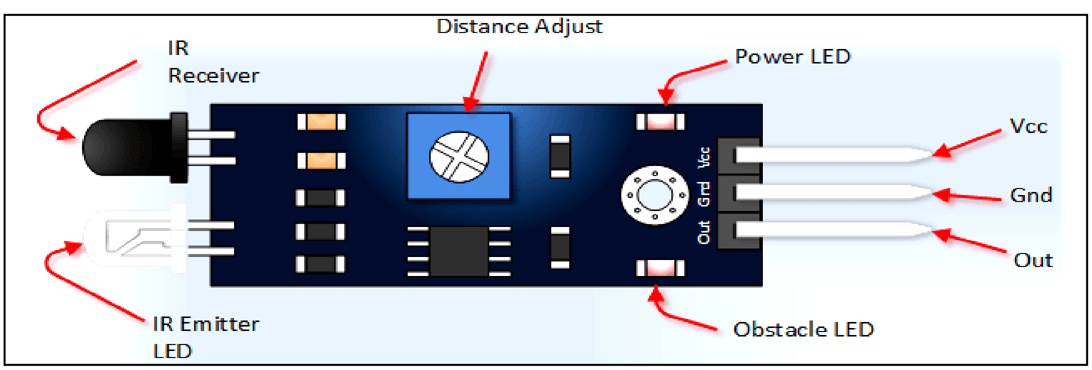

Figure 5.8: IR Collision Avoidance Module

5.2. Development of Printed Circuit Boards (PCBs)

5.2.1. Board A - Processing and Wireless Communication Unit

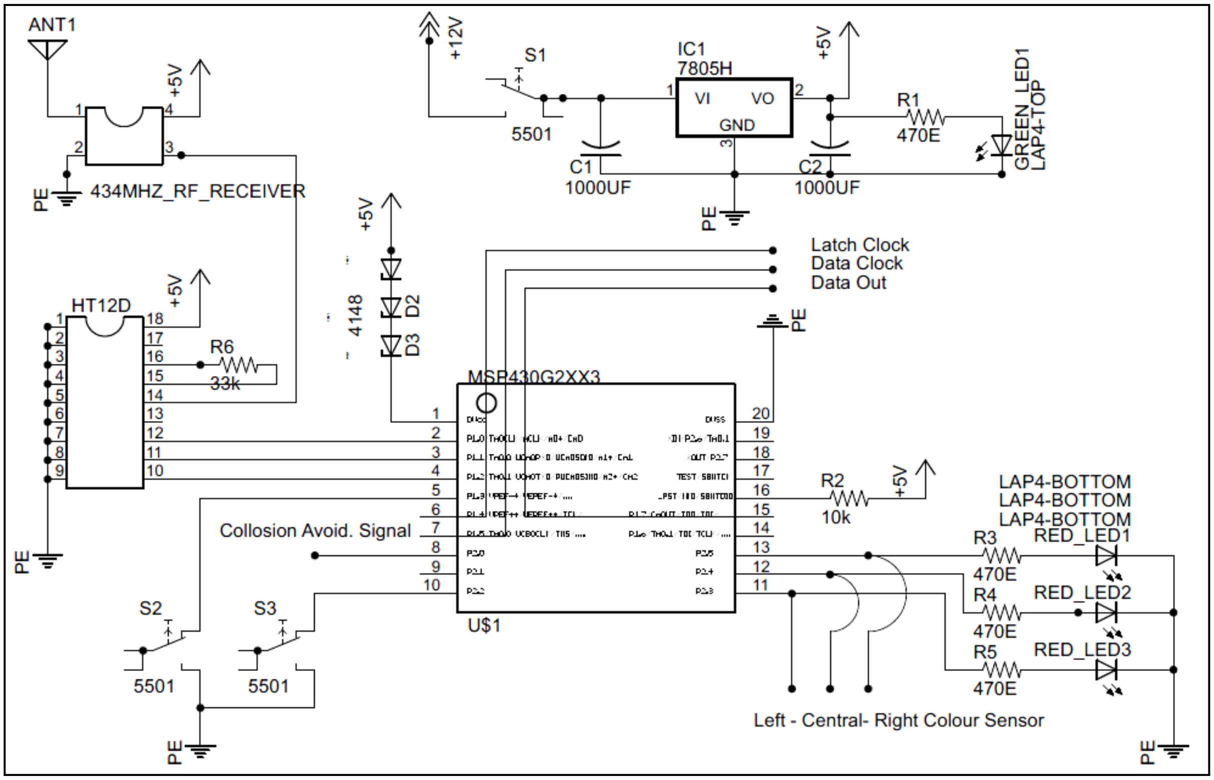

Figure 5.9: Circuit Diagram of Board A - Computation and Wireless data transmission Unit

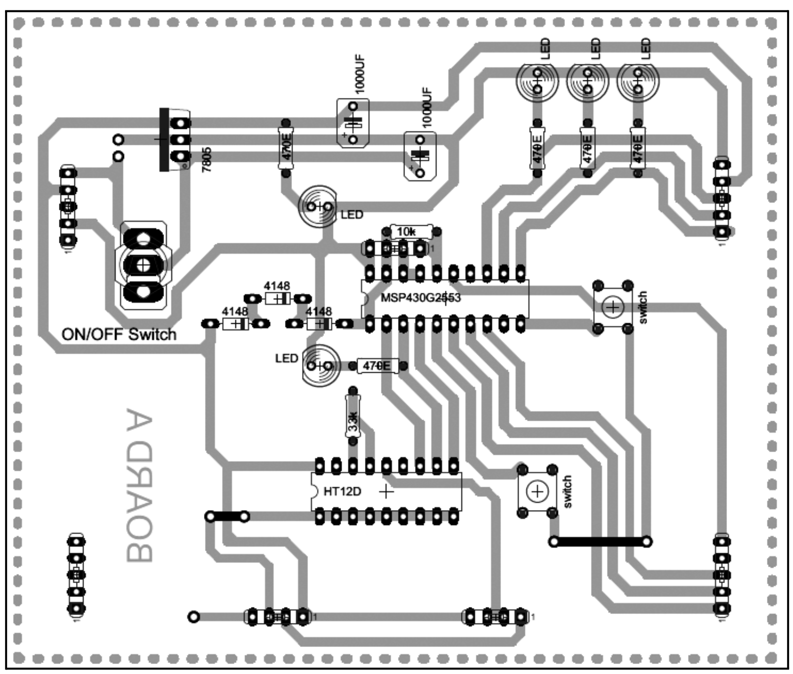

Figure 5.10: PCB Design of Board A

5.2.2. Motor Driver and Collision Avoidance Unit

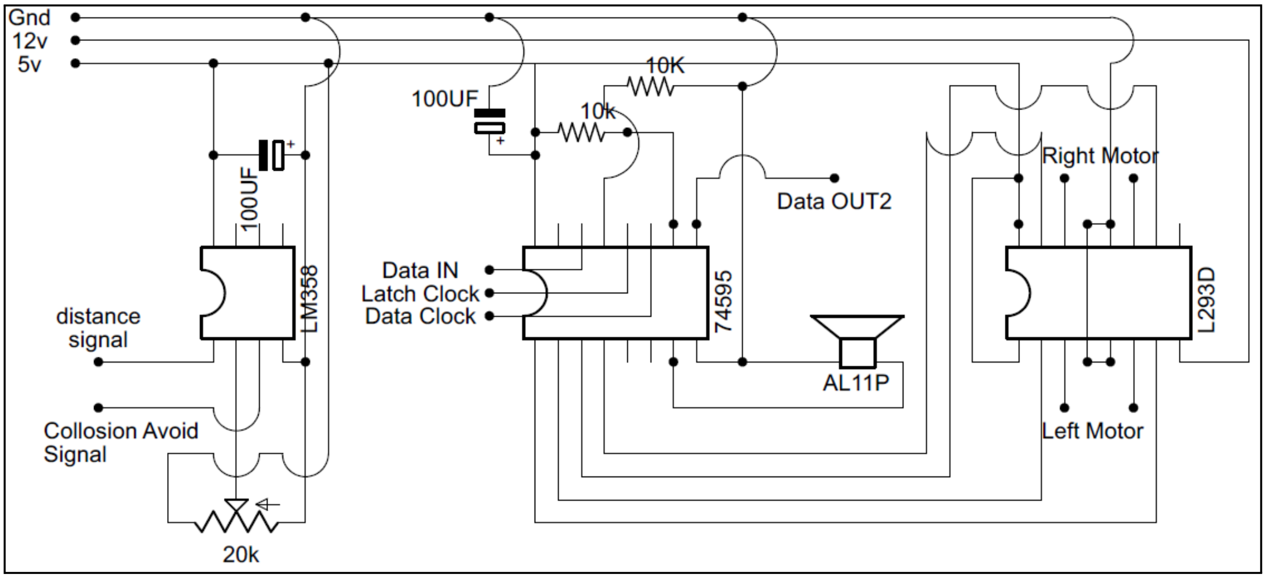

Figure 5.11: Circuit design of Board B - Motor Driver and Collision Avoidance System

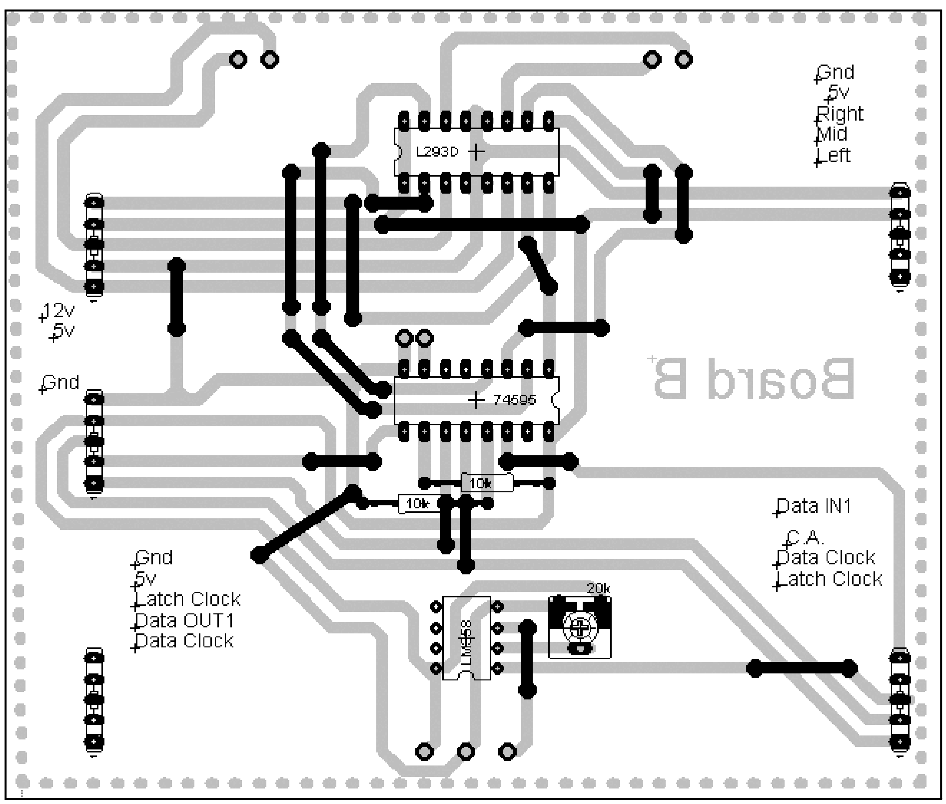

Figure 5.12: PCB Design of Board B

5.2.3. Board C - Artificial Landmark Sensing Unit

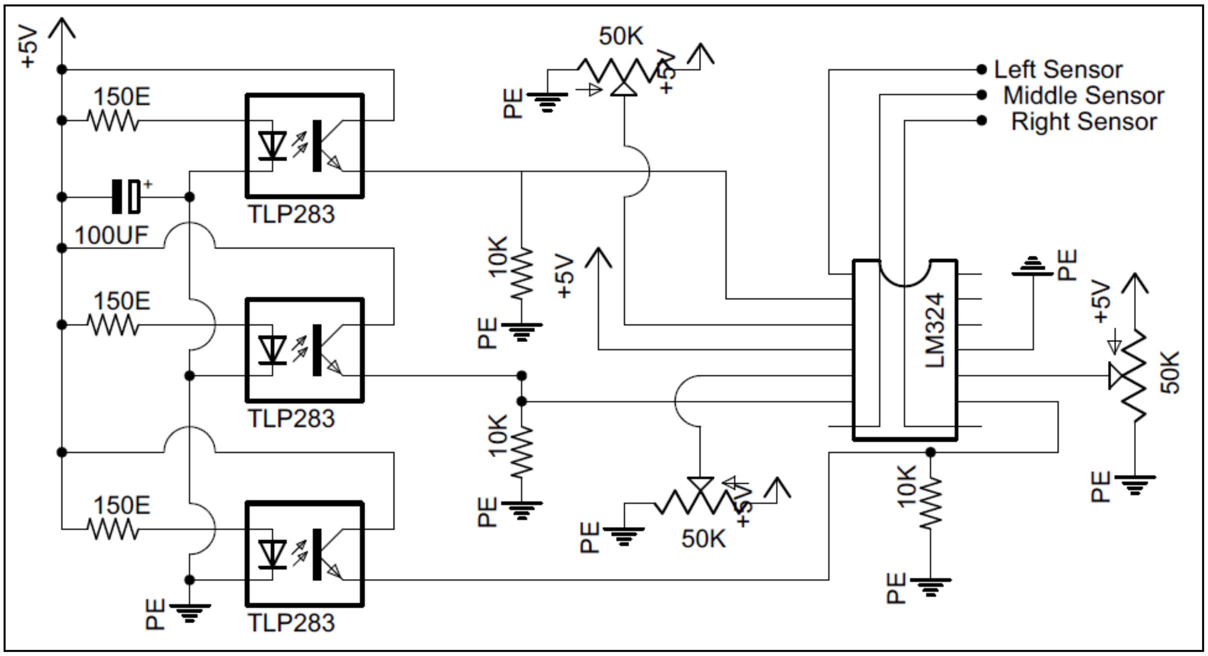

Figure 5.13: Circuit diagram of Board C - Landmark Sensing Module

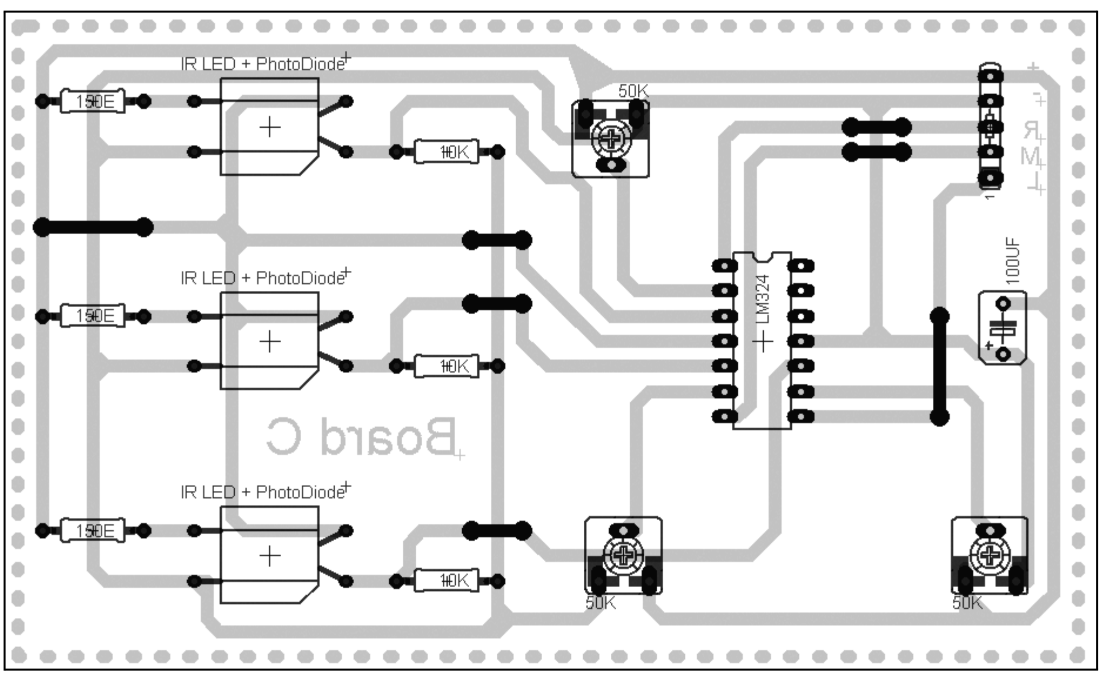

Figure 5.14: PCB Design of Board C

5.2.4. Board B - Display Unit

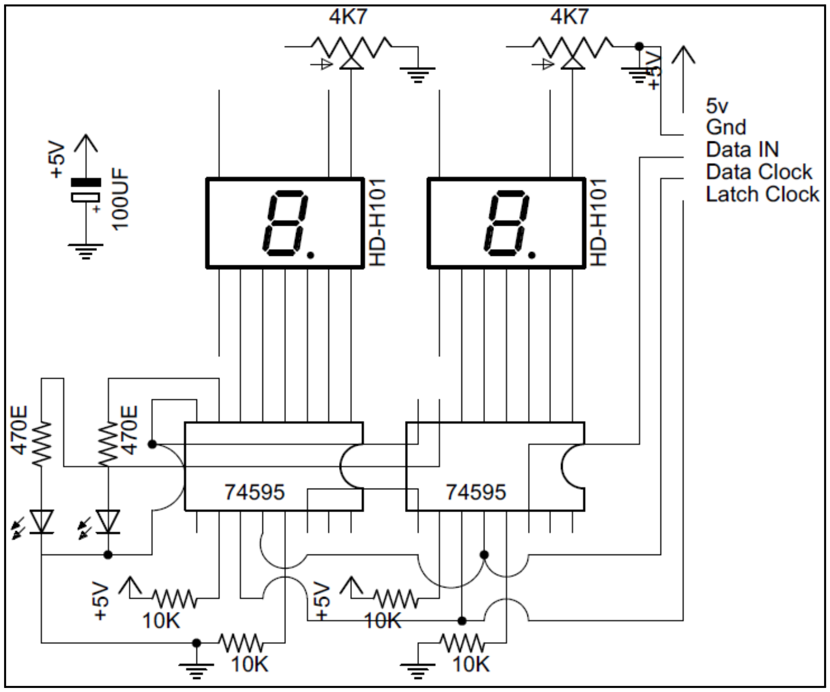

Figure 5.15: Circuit diagram of Board D - Display unit

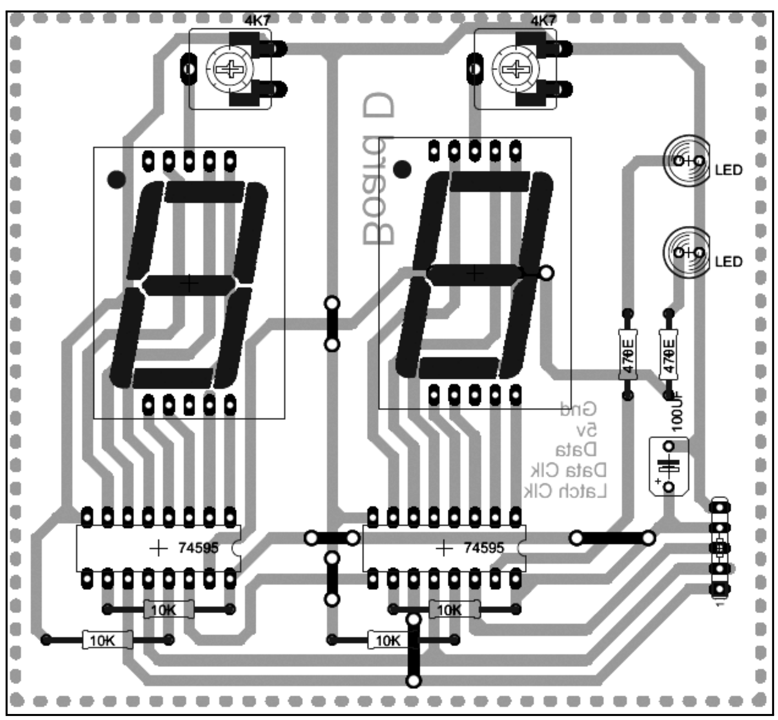

Figure 5.16: PCB Design of Board D

5.2.5. Board E - Remote Controller of the robot

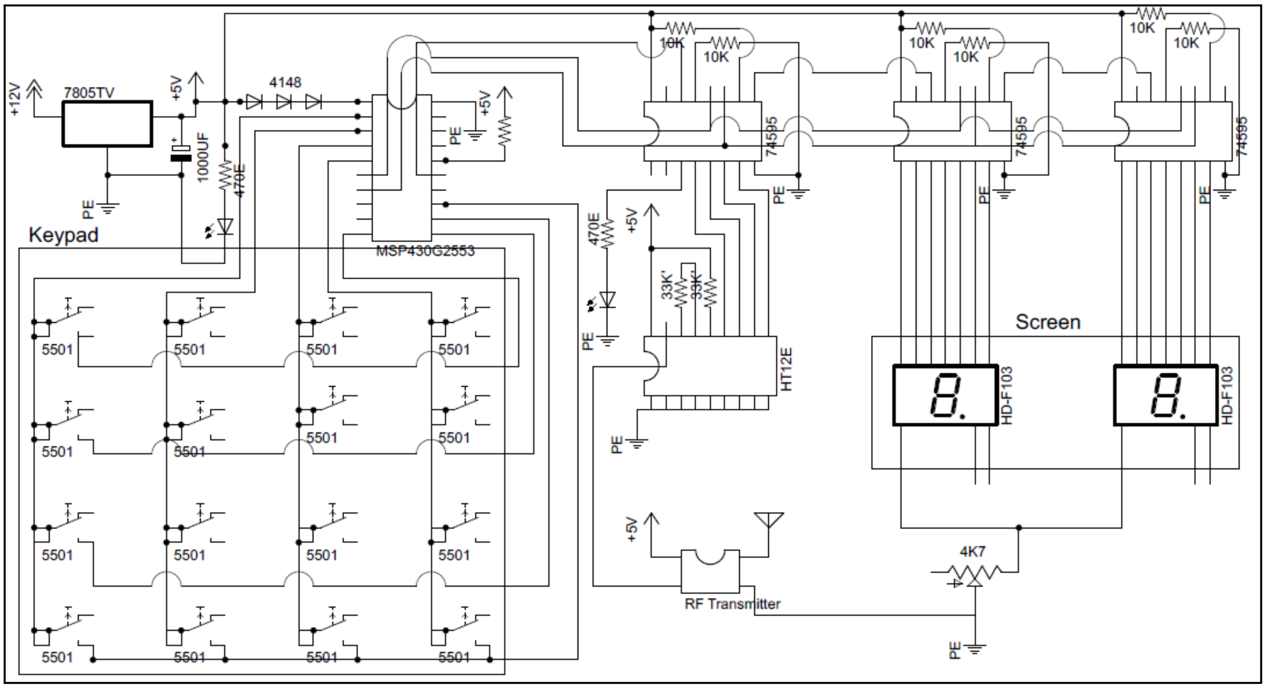

Figure 5.17: Circuit diagram of Board E - Remote Controller of the robot

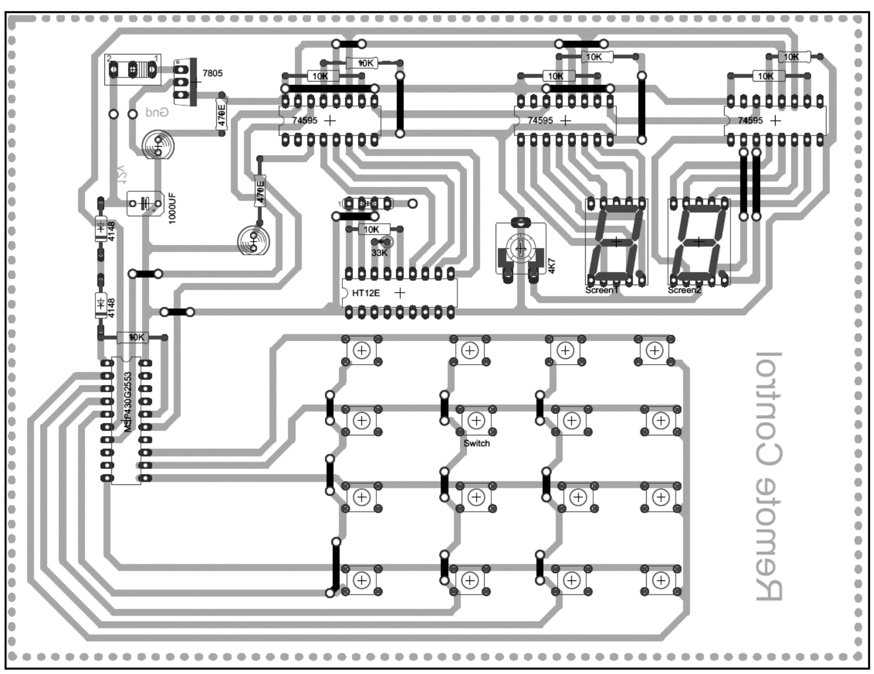

Figure 5.18: PCB Design of Board E

5.3 Placement of Boards on the Robot

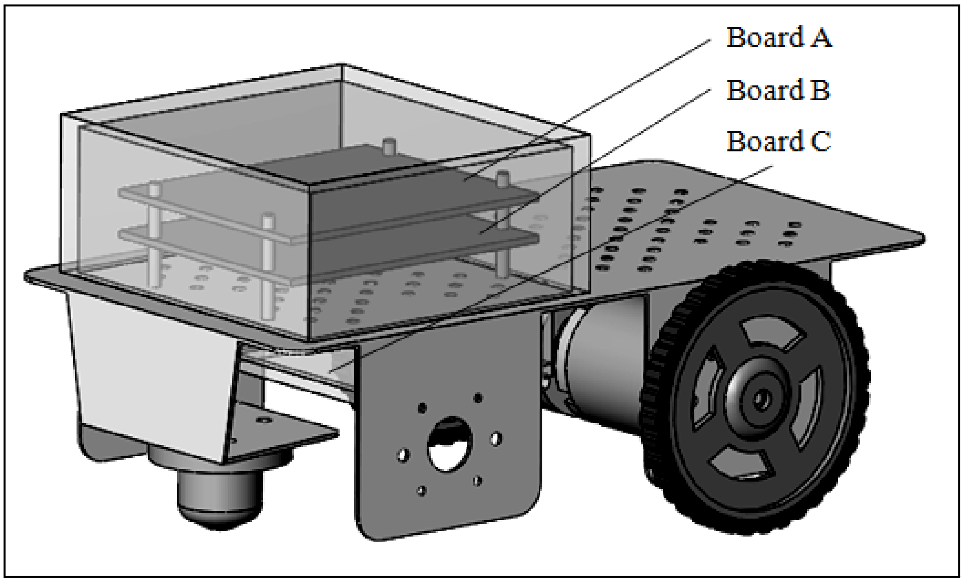

Figure 5.19: Placement of Board A,B and C on the robot