A PROJECT REPORT

On

MOBILE PICK AND PLACE ROBOT

Submitted for partial fulfilment of the requirement for the award

Of

DIPLOMA IN ELECTRONICS AND COMMUNICATION ENGINEERING PROGRAMME

BY

BATCH

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BONAFIDE CERTIFICATE

This is to certify that the project work entitled **"MOBILE PICK AND PLACE ROBOT"** *is a bonafide work carried out by* **SACHIN S (499EC21024)** *in partial fulfilment of the requirements for the award of diploma in Electronics and Communication engineering programme by the department of technical education - Bengaluru-560001, under our guidance and supervision.*

The results embodied in this report have not been submitted to any other university or institute for the award of any degree or diploma.

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DECLARATION

This is to certify that the work reported in the present project entitled **"MOBILE PICK AND PLACE ROBOT"** is a record of work done by as in the Department of Electronic and Communication engineering, **East West Polytechnic**. This report is based on the project work done entirely by us and not copied from other source. I declare that return submission presents my ideas in my own words and where other Ideas are words have been included, I have adequately cited and reference the original source. I also declare that I have adhered to all principal of academic honesty and integrity and we not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be causes for disciplinary action by the institution can also evoke penal action from the sources which have thus not be properly sited or from whom proper permission has not been taken when needed.

SACHIN S (499EC21024)

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SACHIN S (499EC21024)

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CHAPTER 01

INTRODUCTION

1.1 INTRODUCTION

The Mobile Pick and Place Robot that include pick and place module and Rover module, where robot can pick an object through the Robotic arm module and deliver it from one place to another from the rover module. The Mobile Pick and Place robot is controlled by a wireless remote in which the robot consist of six blocks. The operators can control the robot to perform the definite tasks like controlling the robotic arm and rover through manual control using the wireless remote. In this project the Arduino Nano serves as a controlling center, directing the on and off functions of motors and motor drivers which has agility designed and coded through Arduino IDE software.

The Major highlight of the project mobile pick and Place robot is the rover module. The Rover Module is used for the momentum of the Mobile Pick and Place robot like forward, backward and turn all around which makes this project unique the rover module is controlled by the wireless remote control and consist of four DC Motors which is controlled by the Arduino Nano and transmitter module. The major advantage of using the rover is it can move freely and deliver an object from one place to another.

1.2 SCOPE OF THE CAPSTONE PROJECT

The scope of capstone project on mobile pick-and-place robot includes the design and development of the robot's mechanical structure, incorporation of motors and control systems for mobility, and implementation of path planning and object handling algorithms. It encompasses the development of the HMI for remote control, power management systems optimization, and safety standards meeting. Testing and validation processes which are used to check that a robot works under different conditions, and documentation contains information about the design of the project, implementation process, and testing. For advanced features like autonomous operation and machine learning algorithms exploration may be one of the topics. The goal of the project is to remind real-world material handling and automation with a focus on innovation and applicability.

CHAPTER 02

CAPSTONE PROJECT PLANNING

2.1 CAPSTONE PROJECT PLANNING

2.1.1 Work Breakdown Structure:

- All Team members discussed about project and presented to cohort owner.
- **In Stage 1:** The team gathered essential tools and materials for constructing the Arduino-based non-magnetic movable robotic arm. This includes components like the Arduino Nano, servo motors, PCA 9685 servo motor driver, DC Motors, L298N Driver, voltage regulator, switches, wires, and cables.
- **In Stage 2:** The construction and assembly of the robotic arm and rover take placed. This involved physically building the arm and rover according to specified design parameters, utilizing non-magnetic materials for structural stability using 3D printed parts, frames and Precision assembly of components like servo motors, DC Motors and linkages to 3D frame and parts, with complex wiring of electronic components with Arduino microcontroller and motor driver. Safety protocols are observed throughout, ensuring safe construction and future operation.
- **In Stage 3:** Attention shifts to programming and control implementation. The Arduino microcontroller is programmed to interpret remote control signals, enabling precise movements of the robotic arm. Code should integrate components like servo motors and remote for smooth operation, with testing and validating functionality and adjustments are made for optimal performance, establishing a robust control interface.
- **In Stage 4:** Focuses us on testing and tuning the robotic arm's performance. Used provided guidelines, the team conducted thorough testing, adjusting variables for calibration and speed to ensure precise movement. Parameters like drive past delay are modified for optimized performance in various environments. This stage ensures the robotic arm functions effectively and reliably in real-world scenarios.

2.1.2 Time Development-Schedule:

2.1.2.1 Time Spent Per Task

- Research comparable website for better plan development: 5days
- Complete inspect of selected information from websites: 4days
- Procuring and testing of components: 5days
- Developing model: 14days
- Coding: 8days
- Checking errors and rectifying the faults: 3days
- Research to prepare a report: 10days
- Preparing for Internal Assessments: 15days
- Preparing Power Point Presentation: 06days
- Final Preparation: 10days

2.1.3 Cost Breakdown Structure:

- In the first stage of our project the cost breakdown structure is:

Work	Cost
Research similar website for better plan development	-
Fly Sky FSI6 2.4GHz Transmitter Receiver	-
Procuring Components	3000
Coding	1300
Preparing a report for internal assessment	200
Overhead cost	500
Total	**5000**

Table 2.1 First Stage of Cost Breakdown Structure

➢ In the Second stage of our project the cost breakdown structure is:

Work	Cost
Checking errors and rectifying the faults	-
Research and preparation of report	-
Preparing Power Point Presentation	-
Final presentation	2300
Overhead cost	700
Total	**3000**

Table 2.2 Second Stage of Cost Breakdown Structure

- **For the first 40days the total cost is 5000/.**
- **For the second 40 days the total cost is 3000/.**
- **The total cost of the project for 80days is 8000/.**

2.1.4 Capstone Project Risks Assessment

- **Design Risk:**

  When the control buttons are confusing, operators can make mistakes while operating the robot.
- **Coding Risk:**

  Combining the code for mobility and arm functionality introduce complexity, making it challenging and synchronization between the two systems can lead to errors, inefficiencies, or unexpected behavior during operation.
- **High Power Consumption:**

  If the robot uses too much power, its batteries run out quickly and it needs to be charged often.
- **Environmental Risks:**

  Operating it in tough conditions like high temperature places might make the robot not work as well and it has to work outside when it's raining, it could get damaged by water .

2.2 Requirement Specification

2.2.1 Functional

Functional Components used in Mobile Pick and Place Robot:

- **Arduino Nano**

Feature	Specification
Digital I/O Pins	14
PWM Output Pins	6
Analog Input Pins	8
DC Current per I/O Pin	40 mA
SPI (Serial Peripheral Interface.)	MOSI (D11), MISO (D12), SCK (D13)
I2C	SDA (A4), SCL (A5)
Input Voltage (VIN)	6-20VCG5F4\
Width	0.73 inches (18.5 mm)
Weight	Approx. 7 grams

Table 2.3 Specification of Arduino Nano

- **MG 995 Servo Motor**

Feature	Specification
Operating Voltage	4.8 – 7.2 Volts
Operating Temperature	0 – 55°C
Operational Frequency	50 Hz
Operating Motor Speed @ 6 V	0.16 sec/60 degrees
Degree of Rotation	180 degrees
Maximum Load Current Consumption	1200 mA

Table 2.4: Specifications of Servo Motor MG 995

- **SG990 Servo Motor**

Feature	Specification
Operating Voltage	+5V
Torque	2.5kg/cm
Operating Speed	0.1s/60°
Gear Type	Plastic
Rotation	0°-180°
Weight	9gm
Temperature Range	0 ºC – 55 ºC

Table 2.5: Specifications of Servo Motor SG990

- **DC Motor**

Feature	Specification
Speed	10 RPM
Voltage	12V
Torque	7 Kg-cm
Phase	Single Phase
Shaft Diameter	6mm
No Load Current	70mA (max)
Load Current	600mA (max)

Table 2.6: Specifications of DC Motor

- **L298N Motor Driver**

Feature	Specification
Motor Input Voltage	5V-35V
Logic Input Voltage	5V-7V
Continuous Current per Channel	2A
Max Power Dissipation	25W

Table 2.7: Specifications of L298N Motor Drive

- **12 V Rechargeable lead acid Battery**

Feature	Specification
Dimension	9.7 x 2.3 x 5.2 cm
Use (14.4V-15.0V)	Output Power 12V 1.3Ah
Standby (13.5V-13.8V)	Rating 1.3Ah
Weight	510 grams

Table 2.8: Specifications of 12v Rechargeable lead acid Battery

- **Fly Sky FSI6 Transmitter**

Feature	Specification
Bandwidth (KHz)	500
RF Range (GHz)	2.40 ~ 2.48
No. of channels	6
Range	300m
Remote controller weight (gm)	400
Power	6V (1.5V AA*4)
Antenna Length	26mm * 2 (dual antenna)
Transmitting Power	≤ 20dBm
RF Receiver Sensitivity	-105dbm

Table 2.9: Specifications of Fly Sky FSI6 Transmitter

- **Fly Sky FSI6 Receiver**

Features	Specifications
Band	142
2.4ghz System	AFHDS 2A, AFHDS
Code Type	GFSK
DSC Port	PS2
Output	PPM
Charger Port	No
ANT length	26mm*2 (dual antenna)
Certificate	CE0678, FCC
Model Memories	20
Channel Order	CH1: Aileron, CH2: Elevator, CH3: Throttle, CH4: Rudder, CH5: Open, CH6: Open

Table 2.10: Specifications of Fly Sky FSI6 Receiver

- **High Beam LED Light**

Features	Specifications
Power	30W
Colour Temperature	Warm White (around 3000 Kelvin)
Voltage	DC 30V-32V
Current	Information not available (possibly around 900mA based on similar products)
Beam Angle	Wide (likely around 120 degrees)
Parameter	Super bright intensity, SMD package (likely), aluminium base for heat dissipation

Table 2.11: Specifications of High Beam LED Light

- **BC 547 Transistor**

Features	Specifications
Maximum Collector-Base Voltage	80V
Maximum Collector-Emitter Voltage	45V
Maximum Emitter-Base Voltage	6V
Continuous Collector Current	100mA
Total Power Dissipation	500mW
DC Current Gain (Typical)	110 - 800
Transition Frequency (Typical)	100MHz
Operating and Storage Temperature	-55°C to +150°C

Table 2.12: Specifications of BC 547 Transistor

- **7805 5V Regulator IC**

Features	Specifications
Output Voltage	5V
Input Voltage (Recommended)	7V to 35V
Dropout Voltage (Typical)	2V
Output Current	Up to 1A
Thermal Shutdown	Yes
Short Circuit Protection	Yes
Operating Temperature Range	0°C to +125°C
Package	TO-220, TO-92

Table 2.13: Specifications of 7805 5V Regulator IC

- **Buck and Boost Convertor**

Features	Specifications
Input Voltage Range	3V - 40V
Output Voltage Range (Boost)	1.5V - 35V
Output Voltage Range (Buck)	1.25V - 37V
Maximum Output Current	2A (LM2577S)
Conversion Efficiency	Up to 92%
Switching Frequency	50 kHz - 1.2 MHz
Operating Temperature Range	-40°C to +85°C
Size	Approximately 43mm x 20mm x 14mm (L x W x H)
Weight	Approximately 14g

Table 2.14: Specifications of Buck and Boost Convertor

- **PCA9685 Servo Motor Driver**

Features	Specifications
Channels	16
Resolution	12-bit (4096 steps)
PWM Frequency	24 Hz to 1526 Hz (typical)
Duty Cycle	0% to 100%
Output Driver	Programmable: Open-Drain (25mA sink) or Totem-Pole (25mA sink, 10mA source)
Supply Voltage	2.3 V to 5.5 V
Input/Output Voltage Tolerance	5.5 V
I2C Interface	Yes
LED Current (Direct Drive)	Up to 25mA

Table 2.15 Specifications of PCA968

- **On/Off Selecting Switch**

Specification	Value
Type	SPDT (Single Pole Double Throw)
Voltage Rating	125 VAC / 250 VAC
Current Rating	5A @ 125 VAC / 2A @ 250 VAC
Material	Metal
Insulation Resistance	> 1000 MΩ (Megaohms)
Operating Temperature	-25°C to +85°C
Electrical Life	10,000+ cycles
Mechanical Life	50,000+ cycles

Table 2.16: Specifications of on/off Switch

2.2.2 Quality Attributes

- **Accuracy:** Our robot's ability is to precisely position and manipulate objects according to predefined parameters
- **Scalability:** The capability to expand or adapt the robot's functionalities to meet changing requirements or handle increased workload.
- **Adaptability:** Ability to adjust to changing environments or tasks without significant reconfiguration.
- **Versatility:** Capability to handle a wide range of objects in terms of size, shape, and weight.
- **User Experience:** Focus on commands from operator.
- **Customizability:** Ability to tailor the robot's functionality, interfaces, or behaviors to specific user preferences or application requirements.

2.2.2.1 Non-Functional Test Types

- **Visual Tests:** Tested the circuit connection of Arduino Nano and other components visually using circuit diagram.
- **Communication Test:** Tested the communication between the transmitter and the Receiver Module through a performance test.
- **Performance Tests:** During the performance test, a Lego piece was set up as an object at Point B, while the robot was positioned at Point A, approximately 5 meters away. The robot's headlight was turned on, causing it to flash, and then the remote control was activated. Switching the toggle to high, labelled as R, activated Rover mode for the robot. Moving the joystick on the left side, labelled as x, controlled its movement, while moving the joystick on the right side, labelled as y, directed it toward the Lego piece.

  Once the robot reached the Lego piece, the mode was switched to Robotic Arm Mode by toggling the switch to low, also labelled as R. Pulling the joystick on the right side downward controlled the arm's movement along the y, while pushing the joystick on the left side forward positioned it over the Lego piece along the x. The gripper was adjusted using the grip optimizer, labelled as G, on the remote control, and the Lego piece was picked up from Point B.

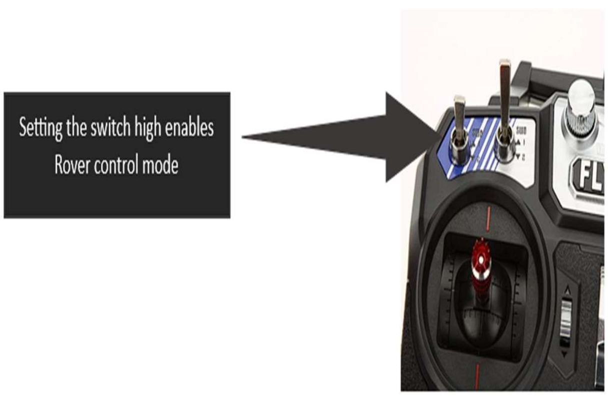
Then the mode was switched back to Rover mode, and the robot returned to Point A. It then dropped the Lego piece, completing the performance test.

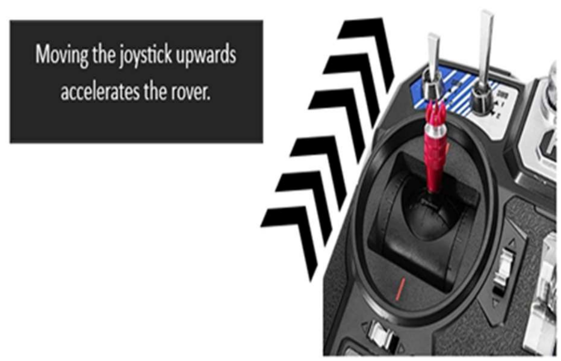
➢ **Other Performance Tests:**

- Tested the momentum speed and grasping force of Robotic Arm through performance test.
- Tested angular momentum of robotic Arm and speed and torque of rover through performance test.

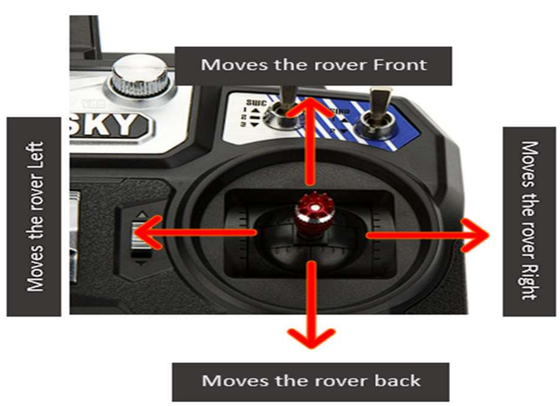
2.3 User Input

i. Rover Control Mode:





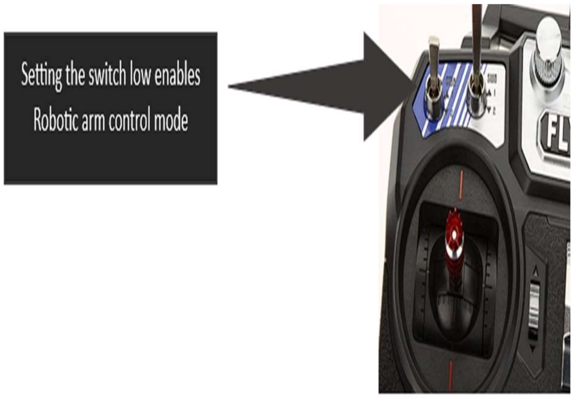
(a) **(b)**



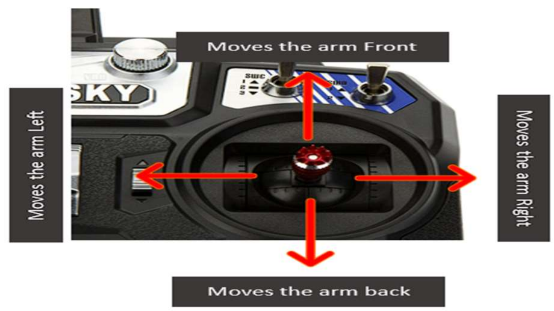
(c)

Figure: 2.1 Steps to operate Rover control mode

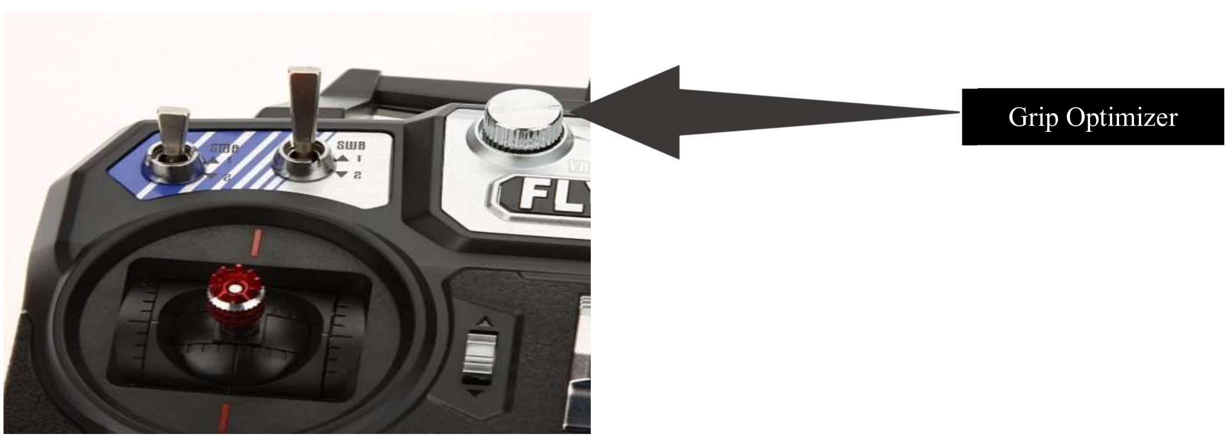
ii. Robotic Arm Mode:



(a) **(b)**



(c) **(d)**



(e)

Figure: 2.2 Steps to operate Robotic Arm Mode

2.2.4 Technical constraints

1. **Payload Capacity:** Robotic arms have a limit to the weight they can lift and manipulate. Exceeding this limit can cause damage to the arm or compromise its accuracy and functionality.

2. **Reach and Workspace:** Robotic arms have a defined reach and workspace within which they can operate effectively. Beyond this range, the arm may not be able to reach or manipulate objects accurately.

3. **Speed and Precision:** Balancing speed and precision is a challenge for robotic arms. Increasing speed may sacrifice precision, while prioritizing precision may slow down operation. Finding the optimal balance is crucial for specific tasks.

4. **Power Supply and Energy Consumption:** Robotic arms require sufficient power to operate efficiently. Limited battery life or insufficient power supply can restrict their usage time and affect productivity. Managing energy consumption is essential for prolonged operation and cost-effectiveness

2.3 DESIGN SPECIFICATION

2.3.1 Chosen System Design

Rather than using Arduino Nano we can also use other system designs such as Raspberry Pi, Microcontroller Based system and Nvidia Jetson Nano

2.3.2 Discussion of Alternative System Designs

- **Raspberry Pi:** The Raspberry Pi offers a versatile solution for a mobile pick and place robot. It comes equipped with GPIO pins and supports various programming languages, facilitating the interface with motors and actuators necessary for robotic tasks. Its processing capabilities allow for the execution of complex algorithms for navigation and object manipulation. Moreover, it supports camera modules, enabling advanced vision-based functionalities such as object detection and recognition. Its compact size makes it suitable for mobile applications while providing sufficient computational power for real-time decision-making.
- **Microcontroller-based System:** Another option is to employ a microcontroller-based system like the STM32 series. These microcontrollers are designed for low-power operation and real-time processing, making them ideal for embedded

applications. Equipped with built-in peripherals such as timers, ADCs, and communication interfaces, STM32 microcontrollers can efficiently control motors and communicate with external devices. Their compact form factor and cost-effectiveness make them suitable for mobile robotics applications where space and budget constraints are crucial considerations.

- **Jetson Nano:** The NVIDIA Jetson Nano is tailored for high-performance computing in AI and robotics applications. It features a CUDA-capable GPU and multiple CPU cores, enabling the execution of deep learning algorithms for tasks like object detection and localization. With GPIO pins and support for popular AI libraries like TensorFlow and PyTorch, the Jetson Nano seamlessly integrates with motors, and actuators. It's hardware-accelerated video encoding and decoding capabilities enable real-time processing of camera feeds, facilitating advanced vision-based navigation and object manipulation. Despite its computational prowess, the Jetson Nano remains energy-efficient, making it suitable for mobile robotics projects requiring AI-driven functionalities.

2.3.2.1 Reason For selection of Arduino Nano

Arduino Nano was chosen as the primary system for our project, The reasons for this decision to choose Arduino Nano is:

- **Cost-effectiveness:** Arduino Nano is relatively inexpensive compared to some alternatives, making it suitable for projects with budget constraints.
- **Ease of Use:** Arduino Nano is known for its beginner-friendly interface and extensive community support. Its simplicity makes it an excellent choice for those new to electronics and programming.
- **Compact Size:** Arduino Nano's small form factor allows it to be easily integrated into projects with limited space.
- **Adequate Performance:** It can handle tasks such as data processing, and simple control operations effectively.
- **Low Power Consumption:** Arduino Nano typically consumes less power compared to more powerful alternatives, making it suitable for battery-powered applications or projects with power constraints.
- **Availability:** Arduino Nano boards are widely available from various vendors, making them accessible for procurement.

2.3.3 Details Description of Components

- Arduino Nano
- Servo motors (MG995, SG990)
- DC motors
- L298N Motor Driver
- 12v lead acid Battery
- Fly Sky FSI6 2.4GHz Transmitter and Receiver
- High beam LED
- BC547 Transistor
- 7805 5V Regulator IC
- Buck and Boost Convertor
- PCA 9685 Servo Motor Driver
- On/Off Selecting Switch

- **Arduino Nano**

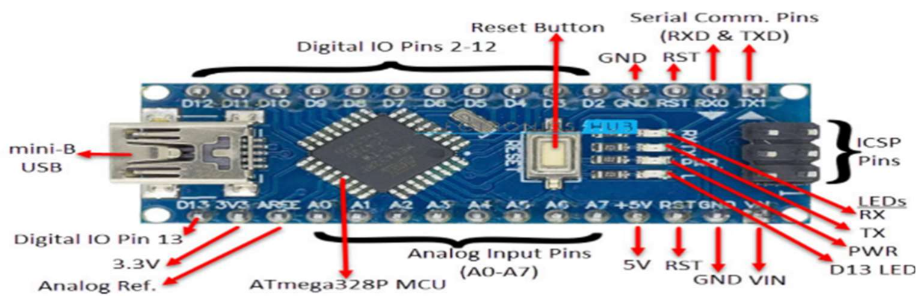


Figure 2.3: Arduino Nano

The Arduino Nano is a compact microcontroller board built around the ATmega328P chip, operating at a clock speed of 16 MHz with 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM, it offers a versatile platform for enthusiasts, educators, and professionals to create interactive projects and prototypes. Featuring a variety of digital and analog I/O pins, including 14 digital I/O pins (6 of which support PWM output), 8 analog inputs, and support for communication protocols like SPI and I2C, the Nano can interface with and control various components such as servo motors, DC motors, LEDs, and more. For a mobile pick and place robot, the Arduino Nano serves as the central processing unit, managing inputs from remote commands via the 2.4GHz transmitter receiver, and controlling like servo motors for picking and placing objects, as well as DC motors for robot mobility. Its small size makes it ideal for integration into the compact form factor of a robot, allowing for efficient space utilization within the design. The Nano can be powered through the 7805-voltage regulator IC, which steps down the voltage from a 12V lead-acid battery to a stable 5V supply suitable for powering the Nano and other 5V components. By utilizing libraries and writing code in the Arduino IDE.

- **Servo Motor MG995**

Figure 2.4: Servo Motor MG 995

The MG995 is a widely used servo motor well-suited for various robotic and RC (Remote Control) applications, including mobile pick-and-place robot like us. This servo is known for its high torque, offering a range typically between 10kg/cm to 13kg/cm at 4.8V to 6V, which allows it to handle significant loads relative to its size. It operates within a voltage range of 4.8V to 7.2V, making it compatible with a variety of control systems and power supplies.It comes with a standard three-wire interface (power, ground, and signal), making it compatible with most microcontrollers, including Arduino platforms. The signal wire is used to control the position of the servo shaft, which can typically rotate between 0 and 180 degrees, although the actual range might slightly vary depending on the specific implementation.

- **Servo Motor SG990**

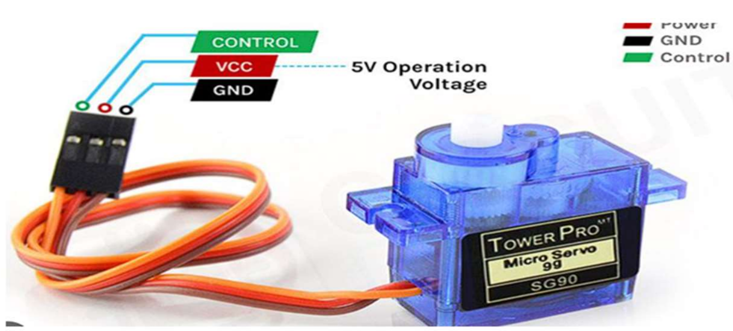


Figure 2.5: Servo Motor SG 990

The MG90 motor's specifications make it an ideal choice for the arm of an RC mobile pick and place robot. Its compact size and light weight of only 9 grams won't weigh down the robot's design, allowing for potentially faster movement and better overall mobility. The low operating voltage of +5V means we can power it with common battery packs, simplifying the robot's power system and making it more user-friendly. Despite its small size, the motor packs a punch with a torque of 2.5kg/cm, capable of lifting and placing a surprising amount of weight for its size. This allows the robot to handle a variety of objects might encounter in a typical pick and place application.

- **DC Motor**

Figure 2.6: DC Motor

This motor, coded with a speed of 10 RPM and a voltage requirement of 12V, offers a unique combination of power and control for mobile pick and place robot. While its speed might seem slower compared to other options, this can be an advantage in a pick and place application. The slower speed allows for more precise and controlled movements, crucial for carefully picking up and placing objects without damaging them. Its torque of 7 Kg-cm provides ample strength for handling various objects within robot's intended use case. The single-phase design simplifies wiring and control, while the 6mm shaft diameter is a common size, making it compatible with a wide range of wheels, gears, and other robotic components.

The low no-load current of 70mA helps conserve battery life when the motor isn't actively working, and the 600mA maximum load current ensures it can handle the demands of lifting and placing objects. Overall, this motor offers a balance of controlled speed, adequate power, and efficient operation, making it a suitable choice for specific pick and place robot applications where precise movements are prioritized over high speed.

- **L298 Motor Drive**

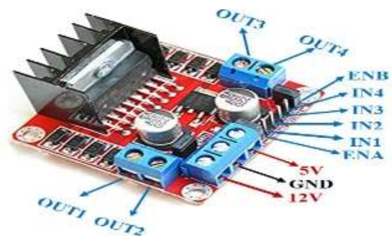


Figure 2.7: L298 Motor Drive

The L298 motor driver is a versatile choice for controlling the two DC motors in RC mobile pick and place robot. It boasts a wide operating voltage range of 5V to 35V, allowing us to use various battery packs for flexibility. Additionally, the separate logic input voltage of 5V to 7V simplifies connection to microcontrollers commonly used in robotics projects. Each channel can handle a continuous current of 2A, meaning it can power most small DC motors typically used in mobile robot. This combination of features makes it a robust and adaptable solution for driving robot's motors.

- **12v Rechargeable lead acid Battery**

Figure 2.8: 12v Rechargeable lead acid Battery

In Mobile pick and place robot, the choice of power source is critical for ensuring optimal performance and efficiency. The specification provided outlines a 12V rechargeable lead-acid battery tailored for such applications. With a output power of 12V and 1.3Ah, this battery offers a reliable power supply for driving the motors and other components of the robot. Its standby rating of 1.3Ah ensures consistent performance during both active operation and idle periods, crucial for sustained functionality in pick and place tasks.

Weighing in at 510 grams, this battery strikes a balance between power output and portability, making it suitable for integration into the RC mobile pick and place robot without adding excessive weight. Its voltage range of 14.4V to 15.0V during use and 13.5V to 13.8V in standby mode ensures stable power delivery throughout different operational phases, essential for maintaining precise control over the robot's movements. Moreover, the rechargeable nature of the battery enhances convenience and cost-effectiveness, allowing for multiple cycles of use without the need for frequent replacements.

- **Fly Sky FSI6 Transmitter and Receiver**

(a) **(b)**

Figure 2.9: Fly Sky FSI6 (a)Transmitter and (b)Receiver

The Fly Sky FSI6 Transmitter system: It provides an ideal solution for controlling a mobile pick and place robot with precision and reliability. With a bandwidth of 500 KHz and RF range spanning from 2.40 to 2.48 GHz, it ensures stable communication even in crowded wireless environments. The system offers six channels, allowing for control options, enabling users to navigate the robot seamlessly and manipulate its movements with ease. The remote controller, weighing 400 grams and range of 300 meters.

Utilizing a power source of 6V (using four 1.5V AA batteries), the Fly Sky FSI6 system ensures long-lasting performance, enabling uninterrupted operation of the pick and place robot during tasks. Its dual antenna design and enhances signal reception and transmission, reducing the likelihood of signal dropout or interference. With a transmitting power of ≤ 20dBm and an impressive RF receiver sensitivity of -105dBm (decibels relative to one milliwatt), the system guarantees reliable communication between the remote controller and the robot, even over considerable distances or in challenging conditions.

The FSi6 receiver module: It operates within Band 142 and employs a 2.4GHz system utilizing both AFHDS 2A and AFHDS (Automatic Frequency Hopping Digital System) protocols, ensuring robust communication between the transmitter and receiver units. With GFSK modulation (Gaussian Frequency Shift Keying) modulation, it efficiently encodes digital signals for transmission, while the PS2 DSC (Digital Serial Communication) port facilitates additional peripheral integration. Outputting in PPM format, the module enables precise control over servos and motors. Its dual antenna configuration enhances signal reception, and certifications such as CE0678 and FCC attest to compliance with relevant standards. Equipped with 20 model memories and customizable channel mapping, the FSi6 receiver module offers flexibility and reliability for controlling the RC mobile pick and place robot across diverse operational scenarios.

- **High Beam LED Light**

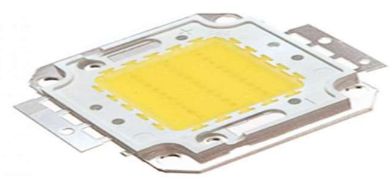


Figure 2.10: High Beam LED Light

The integration of the Othmro High Power LED Chip, boasting 30W output and emitting a warm white light, within a mobile pick and place robot heralds a significant advancement in industrial automation. With its super bright intensity, this LED chip offers unparalleled illumination in the robot's operational environment. The DC 30V-32V power requirement aligns seamlessly with the robot's power system, ensuring optimal performance without the need for extensive modifications.

The specifications provided offer detailed insights into the Othmro 1Pcs High Power LED Chip. It operates at a power of 30W, indicating its ability to emit a considerable amount of light. The colour temperature is specified as warm white, typically around 3000 Kelvin, which suitable for various applications. The voltage requirement of DC 30V-32V ensures compatibility with the power systems commonly found in industrial setups.

- **BC 547 Transistor**

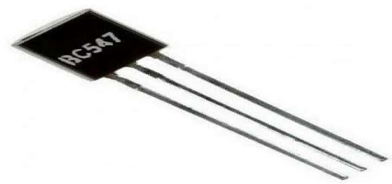


Figure 2.11: BC 547 Transistor

The BC547 transistor, commonly employed in various electronic applications, offers pertinent specifications for integration within a mobile pick and place robot. With a maximum collector-base voltage of 80V but uses and a collector-emitter voltage of 45V, the BC547 transistor ensures robust performance in driving motors within the robot's mechanism. Its continuous collector current rating of 100mA allows for efficient control of small to moderate-sized motors commonly used in mobile robotics. Additionally, with a total power dissipation of 500mW and a transition frequency of 100MHz, the BC547 exhibits adequate thermal characteristics and switching speed, respectively, contributing to the robot's responsiveness and reliability. These specifications collectively enable the BC547 transistor to serve as a reliable component in the control circuitry of a mobile pick and place robot, facilitating precise manipulation and movement tasks.

- **7805 5V Regulator IC**

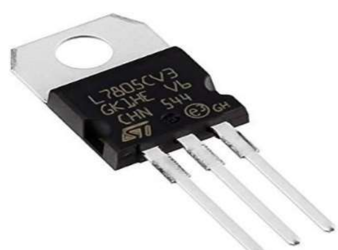


Figure 2.12: 7805 5V Regulator IC

The 7805-voltage regulator integrated circuit (IC) is an essential component for maintaining a stable 5-volt power supply in a mobile pick and place robot utilizing RC (remote control) technology. With a maximum output current of 1A, the 7805 IC ensures consistent voltage supply to the robot's control systems, including the receiver unit, servos, and any other electronic components requiring a 5-volt power source. Its compact size, built-in thermal protection, and wide operating temperature range make it an ideal choice for integration into the robot's design, ensuring reliable performance in various mobile environments controlled remotely.

- **Buck and Boost Convertor**

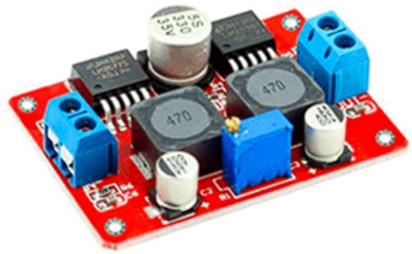


Figure 2.13: Buck and Boost Convertor

The DC-DC Step Up Down Boost Buck Voltage Converter Module, with its input voltage range spanning from 3V to 40V and output voltage capabilities ranging from 1.5V to 35V (for boost mode) and 1.25V to 37V (for buck mode), offers versatile power regulation suitable for various components of a mobile pick and place robot. With a maximum output current of 2A (for LM2577S), it ensures sufficient power delivery to drive motors and control systems. Its high conversion efficiency of up to 92% and wide operating temperature range from -40°C to +85°C ensure reliable performance in diverse environments. Compact in size (approximately 43mm x 20mm x 14mm) and lightweight (approximately 14g), it provides a space-saving and lightweight solution ideal for integration into the robot's design, optimizing its mobility and efficiency.

- **PCA9685 Servo Motor Driver**

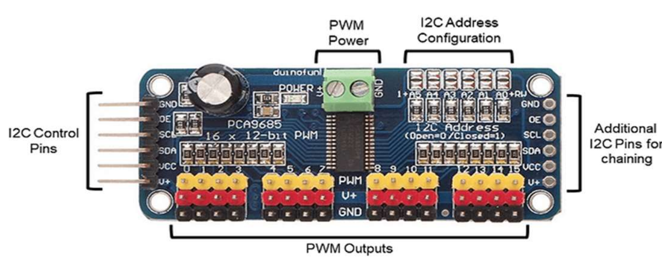


Figure 2.14: PCA9685

In the Mobile Pick and Place Robot, the PCA9685 is a critical component within the robotic arm circuit, tasked with controlling the movement of five servo motors. With 16 channels and a 12-bit resolution (offering 4096 steps), the PCA9685 allows for precise positioning of each servo motor, ensuring accurate manipulation of the robotic arm. Its adjustable PWM frequency, ranging from 24 Hz to 1526 Hz and ensures compatibility with a wide range of servo motors. Operating within a supply voltage range of 2.3V to 5.5V, the PCA9685 is well-suited for integration into the robot's power system. With its I2C communication interface, the PCA9685 seamlessly communicates with the main microcontroller, such as an Arduino Nano, facilitating precise servo control. Leveraging these specifications, the PCA9685 enables efficient and accurate manipulation of the robotic arm, enhancing the overall functionality and performance of the Mobile Pick and Place Robot

- **On/Off Selecting Switch**

Figure 2.15: On/Off Selecting Switch

The on/off switch specified for the mobile pick and place robot module is a Single Pole Double Throw (SPDT) type. Constructed from metal, it ensures durability and reliability in operation. Operating within a temperature range of -25°C to +85°C, it boasts an electrical life of over 10,000 cycles and a mechanical life exceeding 50,000 cycles, ensuring long-term usability and performance. In mobile pick and place robot it is installed in the power circuit, this on/off selecting switch provides users with a robust and dependable means of controlling the system's power state, contributing to the overall efficiency and safety the mobile pick and place robot.

CHAPTER 03

APPROACH AND METHODOLOGY

3.1 Technology

The mobile pick-and-place robot project integrates mobility and Robotic arm functionalities using a combination of hardware and software technology. A microcontroller, which is an Arduino Nano, serves as the central control unit for coordinating the robot's operations. Actuators, including servo motors (such as MG995 and SG990) for the arm and DC motors coded at 10 RPM for mobility, are managed independently, allowing for separate control of each function. While the mobility platform and arm functionalities operate independently, a switch on the transmitter enables seamless switching between the two modes of operation, ensuring flexibility in task execution. Wireless communication technology, A 2.4GHz Transmitter and Receiver, facilitates remote operation and coordination of both functions. Additionally, power management components such as the 12V lead-acid battery and voltage regulators ensure a stable power supply for the robot's operations. Through software development, used Arduino IDE software and programmed in languages like C++, the microcontroller manages the switching between mobility and arm functions and coordinates their actions to perform tasks efficiently and accurately. This integration of mobility and arm functionalities, with the flexibility to switch between robot and operator to navigate its environment and execute pick-and-place tasks with precision and versatility.

3.2 Methodology

In this Arduino-based non-magnetic mobile robotic arm follows specific principles and methods. Initially determined what the arm needs to do and any limits like size or cost. Then, chosen the right parts such as motors, actuators, and an Arduino board that fit needs of our project. Next, to design the arm using computer software, to code in such way that it should make sure it can move and hold things and move properly. After that, figured out how to fit the electronics inside the arm and make sure everything works together. Once all been planned about printing the parts using a 3D printer and put them together. Then, wrote code for the Arduino to control the arm's movements with mobility. After testing to make sure it everything works right without any error and created an easy way for operator to operate the robot. Finally, this method helps to make a robotic arm that works well and meets all objectives.

3.3 Programming

```
#include <Wire.h>
// Include Adafruit PWM Library
#include <Adafruit_PWMServoDriver.h>
#define MIN_PULSE_WIDTH       650
#define MAX_PULSE_WIDTH       2350
#define FREQUENCY             50

Adafruit_PWMServoDriver pwm = Adafruit_PWMServoDriver();

// Define Input Connections
#define CH1 3
#define CH2 5
#define CH3 6
#define CH4 9
#define CH5 13
#define CH6 10
 // Integers to represent values from sticks and pots
int ch1Value;
int ch2Value;
int ch3Value;
int ch4Value;
int ch5Value;
int speed1=11;
int ma1=12;
int ma2=8;
int mb1=7;
int mb2=2;
int light=13;
int controlA = ch1Value ;
int controlB = ch2Value;
```

```
int controlC = ch3Value;
int controlD = ch4Value;
int motorA = 0;
int motorB = 4;
int motorC = 8;
int motorD = 12;

// Boolean to represent switch value
bool ch6Value;
 // Read the number of a specified channel and convert to the range provided.
// If the channel is off, return the default value
int readChannel(int channelInput, int minLimit, int maxLimit, int defaultValue){
  int ch = pulseIn(channelInput, HIGH, 30000);
  if (ch < 100) return defaultValue;
  return map(ch, 1000, 2000, minLimit, maxLimit);
}

// Read the switch channel and return a boolean value
bool readSwitch(byte channelInput, bool defaultValue){
  int intDefaultValue = (defaultValue)? 100: 0;
  int ch = readChannel(channelInput, 0, 100, intDefaultValue);
  return (ch > 50);
}

void setup(){
  // Set up serial monitor
  Serial.begin(115200);
  pwm.begin();
  pwm.setPWMFreq(FREQUENCY);

  // Set all pins as inputs
```

```
  pinMode(CH1, INPUT);
  pinMode(CH2, INPUT);
  pinMode(CH3, INPUT);
  pinMode(CH4, INPUT);
  pinMode(CH5, INPUT);
  pinMode(CH6, INPUT);

  pinMode(speed1,OUTPUT);
  pinMode(ma1,OUTPUT);
  pinMode(ma2,OUTPUT);
  pinMode(mb1,OUTPUT);
  pinMode(mb2,OUTPUT);
  pinMode(light,OUTPUT);
}
 void loop() {
  ch6Value = readSwitch(CH6, false);
  Serial.print(" | Ch6: ");
  Serial.print(ch6Value);
  if(ch6Value==0){
    // Get values for each channel
    ch1Value = readChannel(CH1, -100, 100, 0);
    ch2Value = readChannel(CH2, -100, 100, 0);
    ch3Value = readChannel(CH3, 0, 257, 0);
    ch4Value = readChannel(CH4, -100, 100, 0);

// Print to Serial Monitor
    Serial.print("Ch1: ");
    Serial.print(ch1Value);
    Serial.print(" | Ch2: ");
    Serial.print(ch2Value);
    Serial.print(" | Ch3: ");
```

```
    Serial.print(ch3Value);
    Serial.print(" | Ch4: ");
    Serial.println(ch4Value);
  if(ch1Value>20){
      analogWrite(speed1,255);

      digitalWrite(ma1,HIGH);
      digitalWrite(mb1,HIGH);
      digitalWrite(ma2,LOW);
      digitalWrite(mb2,LOW);
      Serial.println("Right");
    }
    else if(ch1Value<-20){
      analogWrite(speed1,255);

      digitalWrite(ma2,HIGH);
      digitalWrite(mb2,HIGH);
      digitalWrite(ma1,LOW);
      digitalWrite(mb1,LOW);
      Serial.println("Left");
    }

    else if(ch2Value<-20){
      analogWrite(speed1,ch3Value);

      digitalWrite(ma1,HIGH);
      digitalWrite(mb2,HIGH);
      digitalWrite(ma2,LOW);
      digitalWrite(mb1,LOW);
      Serial.println("Back");
    }
```

```
else if(ch2Value>20){
  analogWrite(speed1,ch3Value);

  digitalWrite(ma2,HIGH);
  digitalWrite(mb1,HIGH);
  digitalWrite(ma1,LOW);
  digitalWrite(mb2,LOW);
  Serial.println("Front");
}

else if(ch2Value<20 && ch2Value>-20){
  analogWrite(speed1,0);

  digitalWrite(ma2,LOW);
  digitalWrite(mb1,LOW);
  digitalWrite(ma1,LOW);
  digitalWrite(mb2,LOW);
  Serial.println("off");
}
else if(ch4Value>20)
digitalWrite(light,HIGH);

else if(ch4Value<20)
digitalWrite(light,LOW);
}
 if(ch6Value==1){
 ch1Value = readChannel(CH1, 500, 900, 600);
 ch2Value = readChannel(CH2, 700, 50, 512);
 ch3Value = readChannel(CH3, 900, 380, 702);
 ch4Value = readChannel(CH4, 0, 1023, 512);
 // Print to Serial Monitor
```

```
    Serial.print("Ch1: ");
    Serial.print(ch1Value);
    Serial.print(" | Ch2: ");
    Serial.print(ch2Value);
    Serial.print(" | Ch3: ");
    Serial.print(ch3Value);
    Serial.print(" | Ch4: ");
    Serial.println(ch4Value);
//Control Motor A
    moveMotor(controlA, motorA, ch1Value);

    //Control Motor B
    moveMotor(controlB, motorB, ch2Value);

    //Control Motor C
    moveMotor(controlC, motorC, ch3Value);

    //Control Motor D
    moveMotor(controlD, motorD, ch4Value);
}
 delay(100);
}
void moveMotor(int controlIn, int motorOut, int ch)
{
  int pulse_wide, pulse_width, potVal;

  // Read values from potentiometer



  // Convert to pulse width
  pulse_wide = map(ch, 0, 1023, MIN_PULSE_WIDTH, MAX_PULSE_WIDTH);
```

```
pulse_width = int(float(pulse_wide) / 1000000 * FREQUENCY * 4096);

//Control Motor
pwm.setPWM(motorOut, 0, pulse_width);
```

3.4 Fabrication

In this project, it is designed as simple mobile pick and place robot, which has an ability pick and place the objects.

The components used to construct the mobile pick and place robot is mentioned below:

- Rover circuit
- LED Circuit
- Arduino Nano
- Robotic Arm Circuit
- Receiver Circuit
- Power Circuit

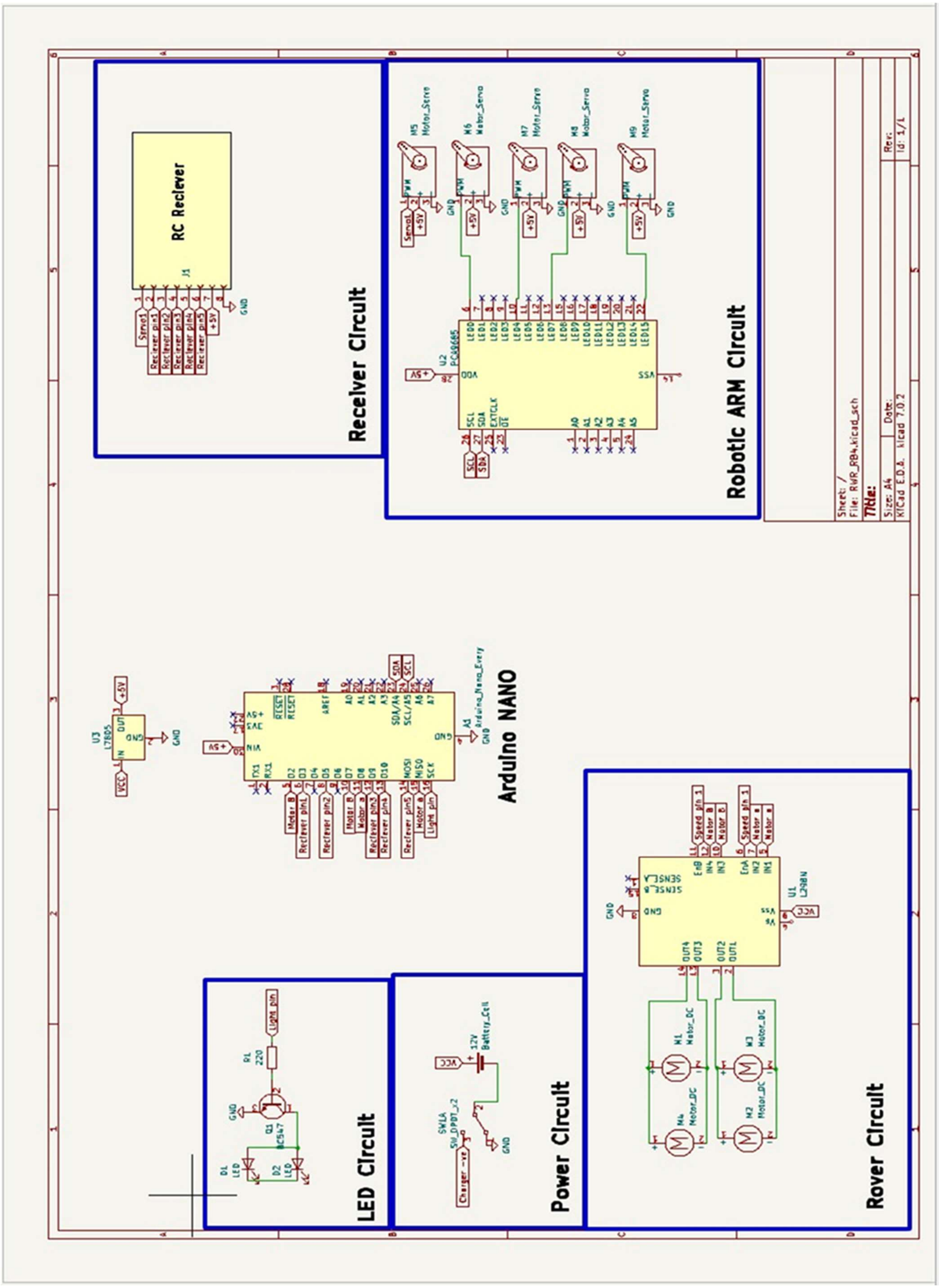


Figure 3.1: Circuit Diagram of Mobile Pick and Place Robot

Rover Circuit Connections:

- The Rover consists of four DC Motors controlled via L298N H bridge motor driver. The Motor driver is connected to Arduino nano, Arduino nano controls the speed and directions of the motors through PWM signals. The motor driver is powered by Arduino and the motors are powered by 12V external power supply.
- The PCA 9685 is a Servo motor driver which uses i2c communication protocol.
- The module is powered using Arduino 5V logic and the servo motors are powered externally using 5V power supply.
- The servo motor which is connected to the receiver is mapped to the voltage regulator in the transmitter.
- The SCL and SDA pin is connected to Arduino Nano.

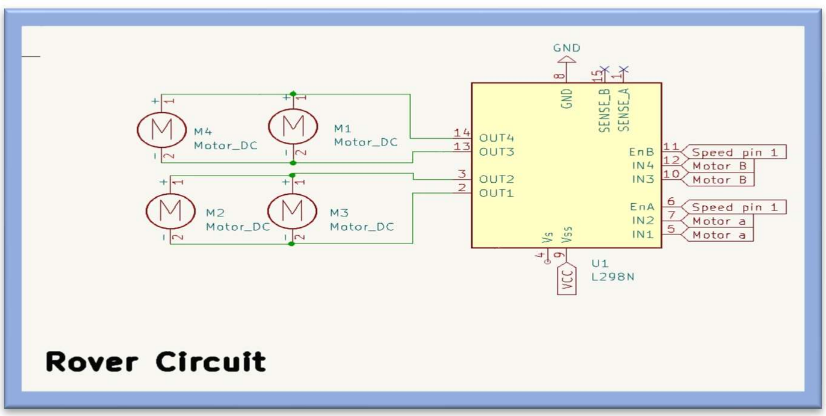


Figure 3.2: Rover circuit

LED Display Circuit Connections:

Two high power LEDs are connected in parallel to collector of BC547 transistor, the base of BC547 is Connected to digital pin 13 of Arduino nano.

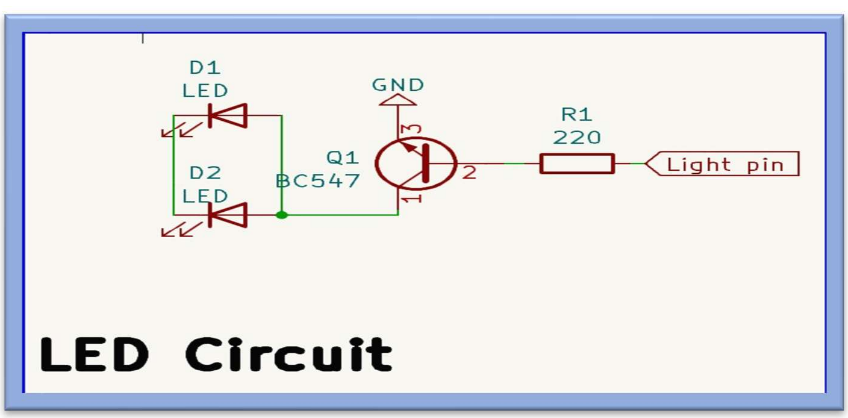


Figure 3.3: LED circuit

Arduino Nano Connections:

In Robotic Arm Circuit the SDA (Serial DAta line) and SCL pin (Serial Clock Line) is connected to Arduino Nano. In Rover Circuit the motor driver is powered by Arduino and the motors are powered by 12V external power supply, the Motor driver is connected to Arduino nano, it controls the speed and directions of the motors through PWM signals. In LED Circuit the base of BC547 transistor is Connected to digital pin 13 of Arduino nano. In Receiver Circuit Receiver is connected to Digital Pins Arduino nano.

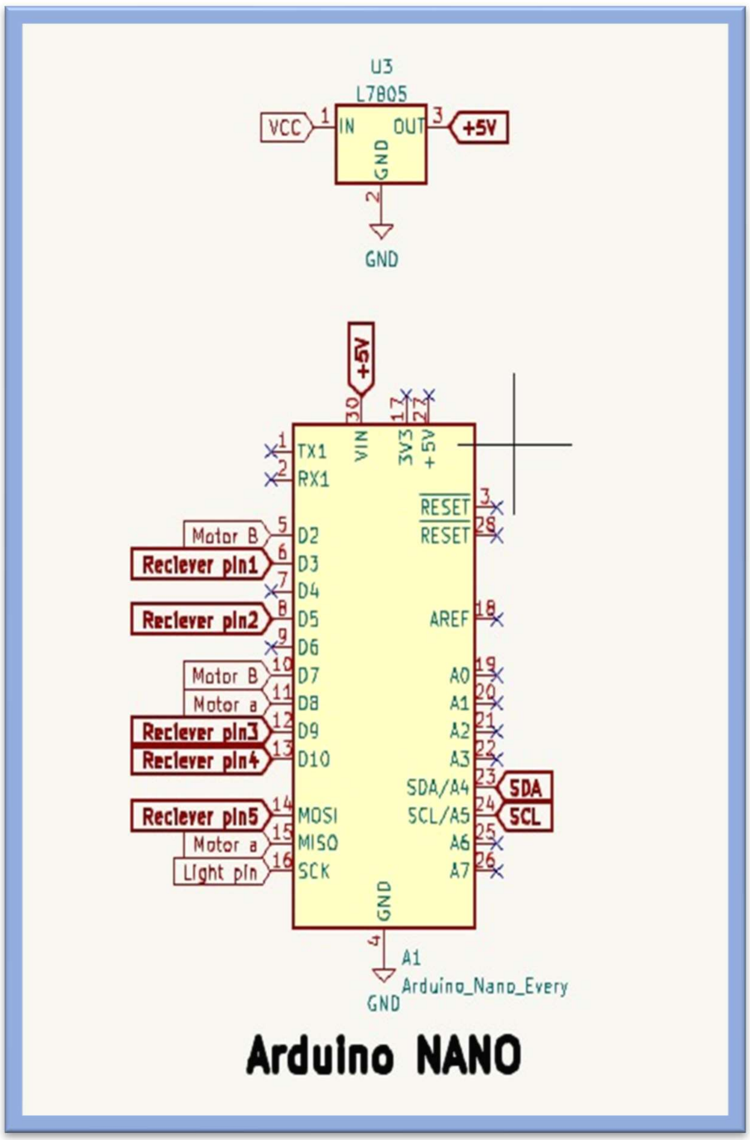


Figure 3.4 Arduino Nano

Robotic Arm Circuit Connections:

In Robotic Arm Circuit total of 5 Servo motors are used in the project, out of which 4 are connected to PCA 9685 servo motor driver and one servo motor is connected directly to Receiver. The PCA 9685 is a Servo motor driver which uses I2c (Inter-Integrated communication) protocol. The module is powered using Arduino 5V logic and the servo motors are powered externally using 5V power supply. The servo motor which is connected to the receiver is mapped to the voltage regulator in the transmitter. The SCL and SDA pin is connected to Arduino Nano.

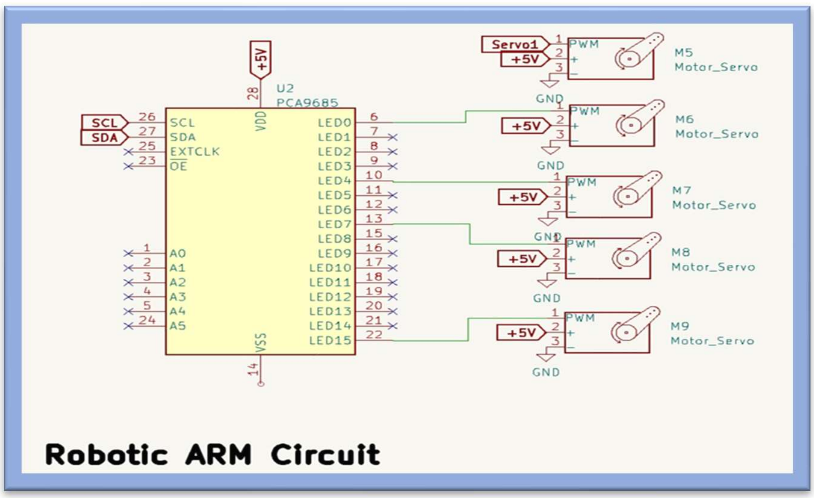


Figure 3.5: Robotic circuit

Receiver Circuit Connections:

The Receiver is connected to Digital Pins Arduino nano. One of the Servo is directly connected the receiver module. The receiver module is powered through 5V external voltage.

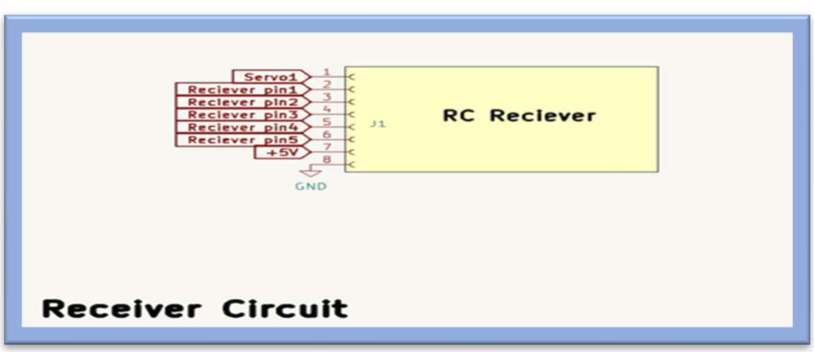


Figure 3.6 Receiver circuit

3.5 Circuit Connections

- Test the components before circuit connections
- Connection for Arduino Nano and receiver Module is shown in table 1.1

- Connection of Arduino Nano and Receiver Module in Table 3.1

Arduino Nano	Receiver Module
PIN 3	Channel 1
PIN 5	Channel 2
PIN 6	Channel 3
PIN 9	Channel 4
PIN 10	Channel 5

Table 3.1: Connection of Arduino Nano and Receiver Module

- Connection of Arduino Nano and PCA9685 Servo Motor Driver is shown in Table 3.2

Arduino Nano	PCA 9685 Servo Motor Driver
A4	SCL
A5	SDA

Table 3.2: Connection of Arduino Nano and PCA 9685 Servo Motor Driver

- Connection of Arduino Nano and L298N Motor Driver is shown in Table 3.3

Arduino Nano	L298N Motor Driver
PIN 11	Speed 1
PIN 12	Motor A
PIN 08	Motor A
PIN 07	Motor B
PIN 02	Motor B
PIN 13	Light

Table 3.3: Connection of Arduino Nano and L298N Motor Driver

- Connection of PCA9685 Servo Motor Driver and 4 Servo motors is shown in Table 3.4

PCA 9685 Servo Motor Driver	Servo Motor
PIN 6	M6
PIN 10	M7
PIN 13	M8
PIN 22	M9

Table 3.4: Connection of PCA9685 Servo Motor Driver and 4 Servo motors

- Connection of L298N Motor Driver (Output PIN) and DC Motors is Shown in Table 3.5

<table>
<tr><th>L298N Motor Driver (Output PIN)</th><th>DC Motors</th></tr>
<tr><td>PIN 14</td><td rowspan="2">M1&M4</td></tr>
<tr><td>PIN 13</td></tr>
<tr><td>PIN 3</td><td rowspan="2">M2&M3</td></tr>
<tr><td>PIN 2</td></tr>
</table>

Table 3.5: Connection of L298N Motor Driver and DC Motors

a. The Motor A is M4&M3.
b. The Motor B is M1&M2.

- Connection of L298N Motor Driver (Input PIN) and DC Motors is shown in Table 3.6

<table>
<tr><th>L298N Motor Driver (Input PIN)</th><th>DC Motors</th></tr>
<tr><td>PIN 12</td><td rowspan="2">Motor B</td></tr>
<tr><td>PIN 10</td></tr>
<tr><td>PIN 7</td><td rowspan="2">Motor A</td></tr>
<tr><td>PIN 5</td></tr>
</table>

Table 3.6: Connection of L298N Motor Driver (Input PIN) and DC Motors

- Connection of Arduino Nano and DC Motors in Table 3.7

Arduino Nano	DC Motors
PIN 5	Motor B
PIN 10	
PIN 11	Motor A
PIN 15	

Table 3.7: Connection of Arduino Nano and DC Motors

- Connection of Receiver module to 1 Servo Motor in Table 3.8

Receiver Module	Servo Motor
Channel 1	M5

Table 3.8: Connection of Receiver module to 1 Servo Motor

- Connect the Battery and Arduino Nano.
- Make the above connection using connection wires.

3.5 Procedure

- The 3D model of the complete project is designed using AutoCAD fusion.
- The 3D model is printed and all the required components are fixed in accordance with the circuit diagram.
- The FS-i6 receiver is connected to the Arduino Nano and then tested with the transmitter.
- The values from the transmitter are set accurately using the buttons provided.
- The code is dumped into the Arduino microcontroller.
- The switch in the Transmitter is used to switch between the rover and robotic arm modes.
- The Mobile Pick and Place Robot is now completed.

CHAPTER 04

TEST AND VALIDATION

4.1 TEST AND VALIDATION

Fig 4.1 Testing of mobile pick and place robot

4.1.1 Testing

- **Visual Test:** Tested the circuit connection of Arduino Nano and other components visually using circuit diagram.
- **Communication Test:** Tested the communication between the transmitter and the Receiver Module through a performance test.
- **Performance Test:** During the performance test, a Lego piece was set up as an object at Point B, while the robot was positioned at Point A, approximately 5 meters away. The robot's headlight was turned on, causing it to flash, and then the remote control was activated. Switching the toggle to high, labelled as R, activated Rover mode for the robot. Moving the joystick on the left side, labelled as x, controlled its movement, while moving the joystick on the right side, labelled as y, directed it toward the Lego piece.

  Once the robot reached the Lego piece, the mode was switched to Robotic Arm Mode by toggling the switch to low, also labelled as R. Pulling the joystick on the right side downward controlled the arm's movement along the y, while pushing the joystick on the left side forward positioned it over the Lego piece along the x. The gripper was adjusted using the grip optimizer, labelled as G, on the remote control, and the Lego piece was picked up from Point B.

Then the mode was switched back to Rover mode, and the robot returned to Point A. It then dropped the Lego piece, completing the performance test.

Other Performance Tests:

- Tested the momentum speed and grasping force of Robotic Arm through performance test.
- Tested angular momentum of robotic Arm and speed and torque of rover through performance test.

4.1.2 Test Approach

➢ **Visual Testing:**
  - Verifying the robot's circuit connection visually.

➢ **Performance Testing:**
  - Evaluating the performance of the robotic arm and rover's mobility practically.
  - Testing the arm's speed and precision in executing movements, both unloaded and with payloads.

➢ **Communication Testing:**
  - Tested the communication between the transmitter and the Receiver Module.

➢ **Other testing**
  - Testing it moment speed, gasping force, angular momentum, speed and torque of rover etc.…,

4.1.3 Features Tested

Features tested in mobile pick and place robot are :

- Battery
- Connecting wires
- 10RPM Motor

➢ **Battery** : It is tested using digital multimeter. By attaching the multi meter probes, to battery's positive and negative terminal monitor the multimeter led display.

- **Connecting wires :** It is tested using multimeter. By keeping the positive and negative probes of multimeter to one end to another end of connecting wire, once it got connected the buzzer will ring**.**
- **DC Motor**: Tested 10 RPM which is coded to motor, we powered it using a battery and measured its RPM using a true tachometer.

4.1.4 Features Not Tested

Features not tested in mobile pick and place robot are :

- Arduino nano
- L298N Motor driver
- Servo Motor
- PCA Servo motor driver
- Selecting Switches
- High Beam LED Light

4.1.5 Findings

- During testing, the rover didn't reverse as expected. The issue was identified in the code and corrected.
- There was insufficient acceleration, which was traced back to a coding fault. This error was rectified and corrected.
- The gripper adjustment failed because of a faulty connection between the receiver module and the servo motor drive. The problem was resolved by replacing the wire.
- The gripper couldn't securely hold objects and would drop them due to the material used (Polylactic Acid) it is thermos plastic. To address this, rubber was inserted onto the gripper to improve its ability to handle objects.

4.1.6 Inference

A mobile pick-and-place robot is a device designed to pick up an object and move it from one location to another. It can be operated using the transmitter remote control. This robot typically features a rover mechanism for free movement in any direction and an arm for grasping and transporting objects.

CHAPTER 05

BUSINESS ASPECTS

5.1 BUSINESS ASPECTS

5.1.1 The Market and Economic Outlook

5.1.1.1 Market Analysis

The global market size for pick and place robots was valued at $2,313.53 million in 2022 and is expected to grow to $5,782.76 million by 2028, with a Compound Annual Growth Rate (CAGR) of 16.5%. By 2030, the market is projected to reach $10.9 billion, with a CAGR of 23.9% from 2023 to 2030. Pick and place robots are industrial robots that pick-up objects and place them in specific positions. They are often used in low-volume commerce segment for quickly and accurately place products onto conveyor belts or other production equipment. Mobile pick and place robots are particularly good at transporting goods from one location to another, which is essential in large warehouses and distribution centers.

5.1.1.2 Industry Segmentation

These pick and place robots are ideal for handling small, lightweight items commonly found in e-commerce fulfillment, electronics assembly, and pharmaceutical packaging.(a) Simple Pick and Place: These robots perform basic pick-up and placement tasks with minimal programming or customization and mobility.(b) E-commerce and Retail: These sectors heavily rely on mobile pick and place robots for efficient order fulfillment in warehouses and distribution centers.

5.1.1.3 Industry Overview

The mobile pick and place robot market is a dynamic market where it established players like ABB and Bosch Rexroth, with their vast industrial automation experience, face off against nimble startups like Fetch Robotics, known for their innovative warehouse-specific solutions. Some of recent developments in the market include:

- **Enhanced AI and Machine Learning (ML):** Robots are becoming smarter with AI and ML. Companies like Locus Robotics (https://locusrobotics.com/)

are developing robots that can adapt to changing warehouse layouts and product placements, improving picking efficiency.

- **Advanced Gripper Technology:** Universal grippers capable of handling a wider variety of terms are being developed Soft Robotics (https://www.softroboticsinc.com/) is a leader in this area, creating grippers that mimic the grasping ability of the human hand.
- **Vision System Improvements:** Depth perception, 3D object recognition, and object identification in cluttered environments are being enhanced. Amazon Robotics (https://www.amazon.jobs/en/teams/amazon-robotics) utilizes advanced vision systems in their robots for faster and more accurate picking.
- **Increased Payload Capacity:** Robots are being designed to handle heavier loads. Boston Dynamics (https://bostondynamics.com/) recently unveiled its "Stretch" robot capable of lifting and carrying up to 80 lbs., expanding their application range.

5.1.2 Competitive Landscape

The below following companies for competition like:

a. **Established Players:** ABB (Switzerland) and Bosch Rexroth (Germany).
b. **Startups:** Fetch Robotics (USA) and Geek+ (China).
c. **Tech Giants Entering this competition:** HUAWEI (China) and Amazon Robotics (USA).

The market for mobile pick-and-place robots is bustling, with big names like ABB and Bosch Rexroth competing against innovative startups like Fetch Robotics. Collaboration is a big strategy, with companies teaming up to move forward faster. This lets them use each other's strengths and combine established expertise with new ideas. The focus is on innovation, with AI and machine learning helping robots do more complex tasks. As technology gets better and costs go down, more businesses are expected to start using mobile pick-and-place robots, changing how warehouses, supply chains, and industries work all around the world

5.1.3 Possible clients

The potential clients and customers for mobile pick and place robots come from a wide range of industries experiencing high demand for automation and efficiency. The breakdown of some key customer segments as mentioned below:

- **E-commerce and Retail:**
  - **Warehouses and fulfillment centers:** These businesses handle a high volume of orders with tight delivery timelines. Mobile pick and place robots can significantly improve picking and packing efficiency, reducing labor costs and order fulfillment times.
  - **Retail stores:** Robots can automate tasks like inventory management, restocking shelves, and even assisting customers with product retrieval.

- **Manufacturing:**
  - **Machine tending:** Robots can load and unload materials from machines, freeing up human workers for more complex tasks and ensuring machine uptime.
  - **Quality control:** Robots equipped with vision systems can perform automated inspections, ensuring product quality.

- **Automotive Industry**:
  - **Assembly lines:** Robots can handle car parts of various sizes and weights, assisting with tasks like engine and transmission assembly.
  - **Painting and welding:** Robots can perform these tasks with greater precision and consistency compared to humans, improving quality and safety.

- **Food and Beverage Industry:**
  - **Warehousing and distribution:** Robots can automate tasks like palletizing, packaging, and picking food and beverage products, ensuring hygiene and efficiency.
  - **Production lines:** Robots can handle delicate food items or heavy packaging tasks, minimizing product damage and worker strain.

- **Logistics and Distribution Centers:**
    - **Warehouses:** Robots can streamline order picking, sorting, and transportation of goods within warehouses, improving overall logistics efficiency.
    - **Distribution centers:** Robots can assist with loading and unloading trucks, expediting the movement of goods.

- **Healthcare and Pharmaceuticals:**
    - **Pharmaceutical packaging:** Robots can ensure sterile handling and precise movement of medications and medical devices.
    - **Hospitals and labs:** Robots can automate tasks like transporting samples and medications, reducing human error and improving efficiency.

5.2 Financial Consideration

- In the first stage of our project the cost breakdown structure is:

Work	Cost
Research similar website for better plan development	-
Fly Sky FSI6 2.4GHz Transmitter Receiver	-
Procuring Components	3000
Coding	1300
Preparing a report for internal assessment	200
Overhead cost	500
Total	**5000**

Table 5.1 :First Stage of Cost Breakdown Structure

- In the Second stage of our project the cost breakdown structure is:

Work	Cost
Checking errors and rectifying the faults	-
Research the prepare a report	-
Preparing Power Point Presentation	-
Final presentation	2300
Overhead cost	700
Total	**3000**

Table 5.2 Second Stage of Cost Breakdown Structure

- **For the first 40days the total cost is 5000/.**
- **For the second 40 days the total cost is 3000/.**
- **The total cost of the project for 80days is 8000/.**

5.3 Conclusion and Future scope

5.3.1 Conclusion

This research was to design and fabricate a mobile pick and place robot having five degrees of freedom with the rover module that can be used for demonstrative and educational purposes and this has been achieved. The robot arm is meant to perform a pick and place operation and rover module for mobility this pick and place concept makes use of servomotors and DC gear motors for mobility which is controlled by the Arduino nano board. In order to control the movement of the servomotors and gear motor controlled through wireless remote controller to interface with the Arduino nano board.

5.3.2 Future scope

The mobile pick-and-place robot holds significant promise for the future of industrial automation. If use metal instead of 3D materials in its mechanical structure. This shift could enhance the robot's durability and performance, particularly in demanding industrial environments where robustness is crucial. Additionally, advancements in metalworking technologies may enable the creation of lighter yet stronger components and it can have capacity to withhold mass, further improving the robot's efficiency and agility. Moreover, as the capabilities of robotics continue to evolve, there's the exciting prospect of integrating with artificial intelligence algorithms into the robot's design, enabling it to adapt and learn in real-time. These developments could lead to even greater precision, efficiency, and versatility in industrial applications, ultimately revolutionizing manufacturing and logistics processes on a global scale.