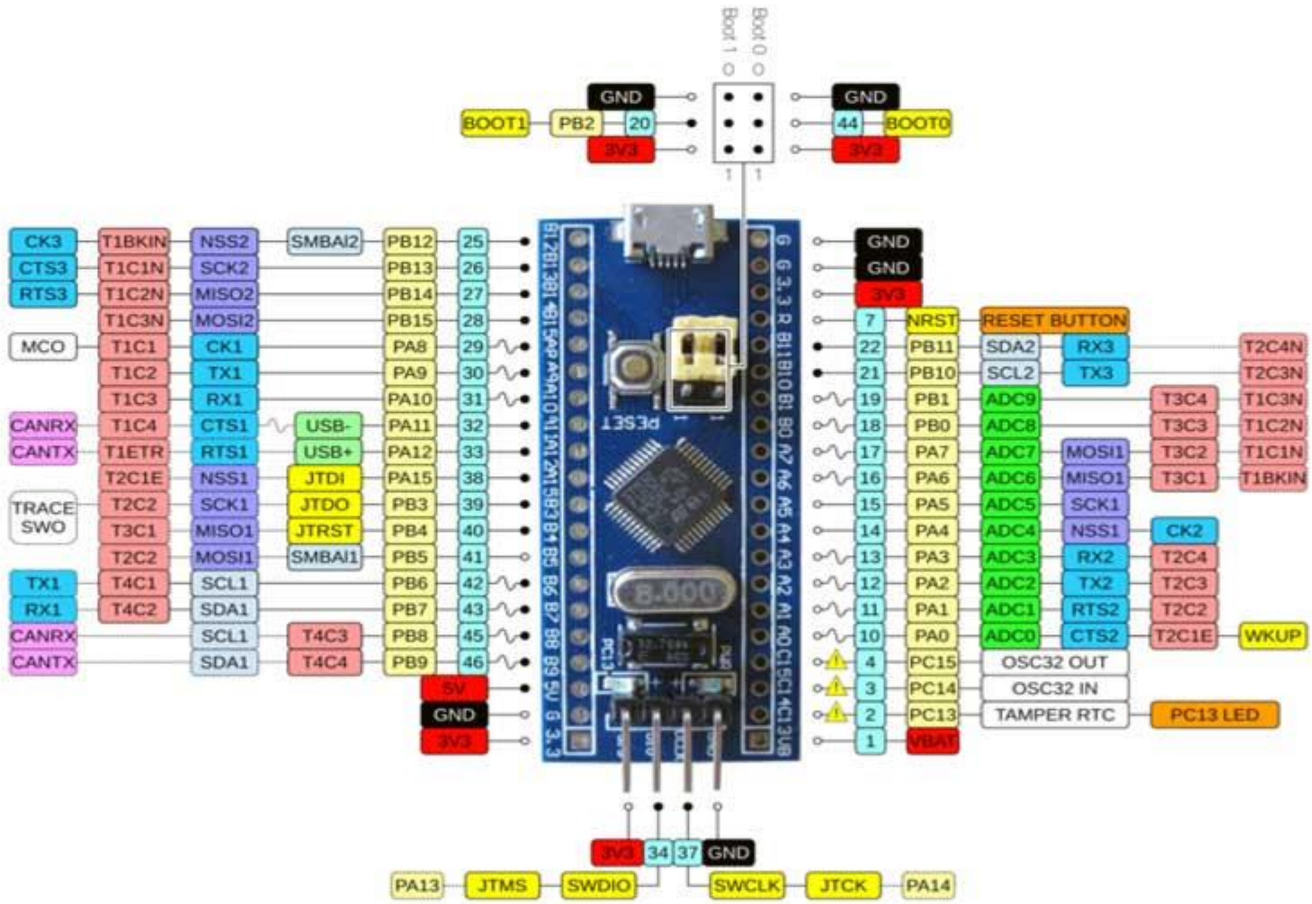
UTM ROBOCON AUTOCAR CHALLENGE

DAY1

1. Bluepill (Pinout)



- The **Bluepill** is a compact development board based on the **STM32F103C8T6** microcontroller. This 32-bit ARM Cortex-M3 microcontroller has 64 KB of Flash memory and 20 KB of SRAM, running at a maximum speed of 72 MHz.

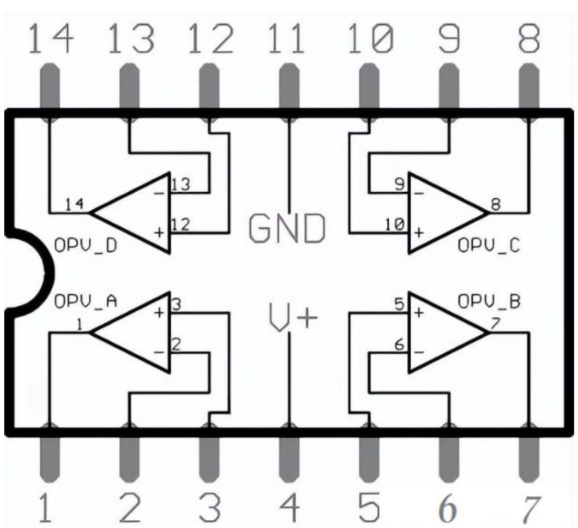
- **Pinout:**

Category	Pin Name	Details
Power pins	3.3V, 5V, GND	○ 3.3V – Regulated output voltage from the onboard regulator (drawing current is not recommended), can also be used to supply the chip. ○ 5V from USB or onboard regulator can be used to supply the onboard 3.3V regulator. ○ GND – Ground pins
Analog Pins	PA0 – PA7 PB0 – PB1	Pins act as ADCs with 12-bit resolution
Input/output pins	PA0 – PA15 PB0 – PB15 PC13 – PC15	37 General-purpose I/O pins.
Serial	TX1, RX1 TX2, RX2 TX3, RX3	UART with RTS and CTS pins
External interrupts	PA0 – PA15 PB0 – PB15 PC13 – PC15	All digital pins have interrupt capability

PWM	PA0 – PA3 PA6 – PA10 PB0 - PB1 PB6 – PB9	15 PWM pins total
SPI	MISO0, MOSI0, SCK0, CS0 MISO1, MOSI1, SCK1, CS0	2 SPI
Inbuilt LED	PC13	LED to act as a general-purpose GPIO indicator
I^2C	SCL1, SDA1 SCL2, SDA2	Inter-Integrated Circuit communication ports
CAN	CAN0TX, CAN0RX	CAN bus ports

2. Working Principle of LM324

LM324 Pinout:



Pin Number	Pin Name	Description
1	OUTPUT1	The output of Op-Amp 1
2	INPUT1-	Inverting Input of Op-Amp 1
3	INPUT1+	Non-Inverting Input of Op-Amp 1
4	VCC	Positive Supply Voltage
5	INPUT2+	Non-Inverting Input of Op-Amp 2
6	INPUT2-	Inverting Input of Op-Amp 2
7	OUTPUT2	The output of Op-Amp 2
8	OUTPUT3	The output of Op-Amp 3
9	INPUT3-	Inverting Input of Op-Amp 3
10	INPUT3+	Non-Inverting Input of Op-Amp 3
11	VEE, GND	Ground or Negative Supply Voltage
12	INPUT4+	Non-Inverting Input of Op-Amp 4
13	INPUT4-	Inverting Input of Op-Amp 4
14	OUTPUT4	The output of Op-Amp 4

- The LM324 is a quad operational amplifier (op-amp) integrated circuit that contains four independent, high-gain amplifiers. It is widely used in various analog applications due to its versatility and cost-effectiveness. Here’s a detailed overview of its working principle:

Working Principle:

- The LM324 operates by amplifying the difference between two input voltages. Each op-amp within the LM324 can be configured in various ways, including as an amplifier, comparator, or integrator. The basic operation involves:

1. **Input Stage:** The op-amp has two inputs: the non-inverting input (+) and the inverting input (-). The output voltage (*Vout*) is determined by the relationship between these two inputs.
    - If the voltage at the non-inverting input is greater than that at the inverting input, the output will swing high (close to the positive supply voltage).
    - Conversely, if the inverting input voltage exceeds that of the non-inverting input, the output will swing low (close to ground or negative supply voltage).
2. **Power Supply:** The LM324 can operate from a single power supply ranging from 3V to 32V, or from dual supplies (±1.5V to ±16V). This flexibility allows it to be used in various circuit configurations without needing additional biasing components.
3. **Low Input Offset Voltage:** The LM324 features a low input offset voltage (typically around 2mV), which enhances its accuracy in applications where precise voltage comparisons are necessary.

Applications

The LM324 can be utilized in multiple applications including:

- Voltage Comparators: By comparing two voltages, it can provide a digital output that indicates which voltage is higher. This is useful in battery management systems and overvoltage protection circuits.
- Signal Conditioning: It amplifies signals from sensors (like temperature or pressure sensors), enabling them to be processed by other circuits.

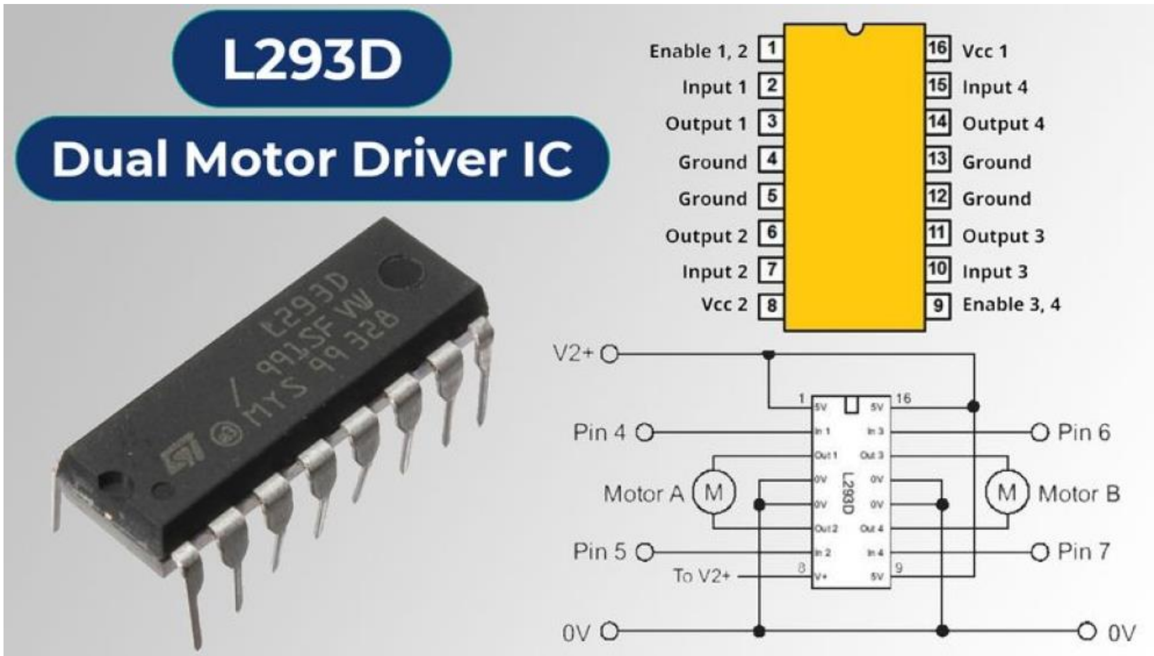
- Active Filters: The LM324 can implement various filter designs (low-pass, high-pass, etc.) to process audio or communication signals effectively.
- Waveform Generators: It can generate different waveforms (square, triangular, sine) by configuring op-amps into integrator and differentiator circuits.

Example Circuit

A common application circuit using the LM324 is a simple LED control circuit based on light-dependent resistors (LDRs). In this setup:

- An LDR changes resistance based on light exposure.
- The op-amp compares the LDR voltage with a reference voltage set by a potentiometer.
- Depending on the comparison result, it turns an LED on or off, demonstrating basic comparator functionality.

3. Working Principle of L293D



- The L293D is a dual H-bridge motor driver integrated circuit (IC) designed to control the direction and speed of DC motors. Its working principle is based on the H-bridge configuration, which allows for bidirectional control of motors.

a. Explain the working concept of a H-bridge.

H-Bridge Configuration

- An **H-bridge** circuit enables a motor to rotate in both directions by reversing the polarity of the voltage across the motor.
- The L293D has two H-bridges, each with four switching transistors (in a configuration resembling the letter "H") that allow current to flow in two directions.

b. How to control the direction of the motor?

Direction Control

The L293D has **two input pins per H-bridge** (Input1/2 for Motor1 and Input3/4 for Motor2). Changing the state of these pins (HIGH or LOW) determines the direction of current flow, hence controlling the motor direction.

By activating specific pairs of switches in the H-bridge, the current flow through the motor can be controlled:

1. Clockwise Rotation: Close switches S1 and S4 while keeping S2 and S3 open.
2. Counterclockwise Rotation: Close switches S2 and S3 while keeping S1 and S4 open.
3. Stop: Close both pairs of switches or leave them open.

Pin Configuration

- The L293D has a total of 16 pins, which include:
- Input Pins: Control the direction of each motor (IN1, IN2 for Motor A; IN3, IN4 for Motor B).
- Output Pins: Connect to the motors (OUT1, OUT2 for Motor A; OUT3, OUT4 for Motor B).
- Enable Pins: Control the operation of each motor (ENA for Motor A; ENB for Motor B).
- Power Pins: Provide power to the internal logic (VSS) and to the motors (VS).

c. How to control the speed of the motor?

Speed Control

- Speed can be controlled using **Pulse Width Modulation (PWM)** on the Enable pin. By adjusting the duty cycle of the PWM signal, the average voltage across the motor is changed, thus controlling its speed.
- A higher duty cycle results in higher average voltage to the motor, increasing its speed.
- A lower duty cycle reduces the average voltage and slows down the motor.

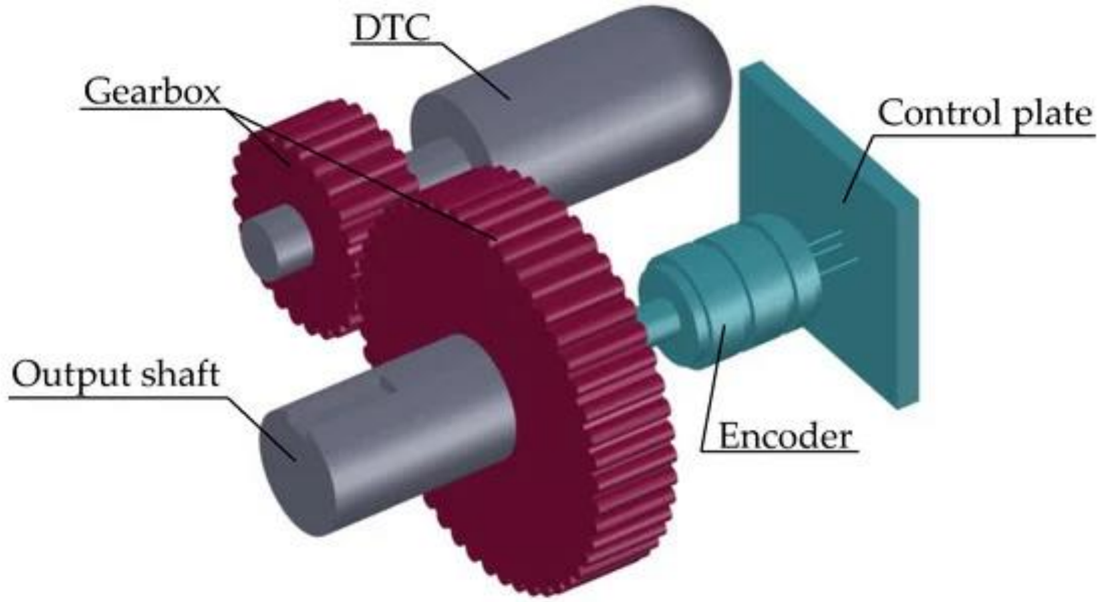
Current Handling

- The L293D can handle continuous currents up to 600 mA per channel with peak currents reaching 1.2 A. This makes it suitable for driving small to medium-sized DC motors effectively.

Applications

- The L293D is commonly used in robotics and automation projects where precise control over motor direction and speed is required. It can drive:
- Two DC motors simultaneously.
- Stepper motors.
- Inductive loads like relays.

4. Controlling a Servo Motor



Working Principles of Servo Motor Control

1. Basic Structure of Servo Motors

- A servo motor is typically composed of:
- Motor: Provides the mechanical movement.
- Feedback Device: Often an encoder or potentiometer that provides position feedback.
- Controller: Processes the feedback and sends commands to the motor to achieve desired movements.

a. How to control a servo?

- A servo motor is controlled using a **pulse-width modulation (PWM)** signal, where the width of the pulse determines the angle of the motor shaft.
- Typical servos use a 20 ms pulse cycle, with a 1–2 ms pulse width for positioning:

- 1 ms pulse ≈ 0°.
- 1.5 ms pulse ≈ 90°.
- 2 ms pulse ≈ 180°.

b. Servo Pinout:

- **Power Pin (Red)**: Typically connected to 5V.
- **Ground Pin (Black/Brown)**: Connected to the ground of the power source.
- **Signal Pin (Yellow/White)**: Receives the PWM signal to control the position.

Pulse Width Modulation (PWM)

- PWM is a common technique for controlling the position and speed of servo motors. It generates pulses of varying widths, where the width of the pulse determines the angle or speed of rotation.
- The PWM signal is sent to the control input of the servo, where:
    - A wider pulse corresponds to a larger angle or higher speed.
    - A narrower pulse results in a smaller angle or lower speed.
- This method allows for smooth trajectory movements between positions, enhancing control precision.

Closed-Loop Control

- Servo motors operate in a closed-loop system, where feedback from the motor is continuously compared with the desired position or speed.
- The controller adjusts the motor's input based on this feedback to minimize errors, ensuring accurate positioning and speed control.

- Commonly used in high-precision applications, this method can involve PID (Proportional, Integral, Derivative) controllers to fine-tune performance.

Torque Control

- In torque control mode, the servo drive adjusts the current supplied to the motor based on the measured torque.
- This is particularly useful in applications where maintaining a specific force is critical, such as in screw tightening machines.

Speed Control

- Speed control utilizes feedback from an encoder to maintain a set speed. The drive continuously compares actual speed with desired speed and adjusts accordingly.
- This method allows for effective operation under varying load conditions, making it suitable for dynamic applications.

3. Feedback Mechanisms

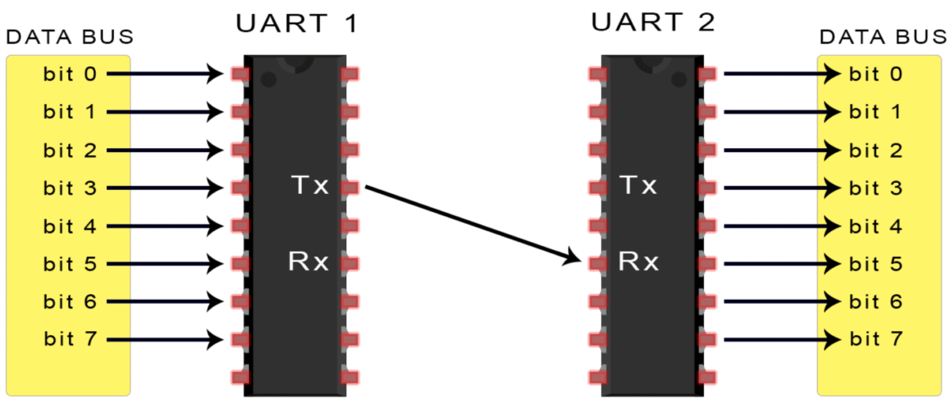
- Feedback mechanisms are crucial for achieving precise control:
- Encoders: Provide real-time position data to the controller, allowing for accurate adjustments.
- Potentiometers: Sometimes used for simpler applications where less precision is acceptable.

4. Applications of Servo Motors

- Servo motors are widely used across various industries due to their precision and reliability. Common applications include:

- Robotics: For precise arm movements and joint control.
- CNC Machines: For accurate milling and cutting operations.
- Automotive: In applications like steering systems and automated assembly lines.

5. UART Communication



UART is a hardware communication protocol that facilitates asynchronous serial communication. Unlike synchronous protocols, UART does not require a clock signal to synchronize data transmission between devices. Instead, it uses start and stop bits to frame each data packet, allowing the receiving device to determine when to read the incoming data.

Key Components

- Transmitter: Converts parallel data from a device (like a microcontroller) into serial format.
- Receiver: Converts the incoming serial data back into parallel format for processing.
- Baud Rate Generator: Controls the timing of data transmission and reception.

Data Transmission Process

1. Data Preparation: The transmitting UART receives data in parallel from a data bus.
2. Packet Formation: The transmitter appends:
   - Start Bit: Signals the beginning of the data packet (usually a low signal).
   - Data Bits: Typically, 5 to 9 bits representing the actual data.
   - Parity Bit (optional): Used for error checking.
   - Stop Bit(s): Signals the end of the packet (high signal).
3. Serial Transmission: The complete packet is sent serially from the transmitting UART to the receiving UART over two wires (TX for transmit, RX for receive).
4. Reception and Processing:
   - The receiving UART detects the start bit and begins sampling the incoming bits at the configured baud rate.
   - It discards the start bit, parity bit, and stop bit, converting the remaining bits back into parallel format for further processing.

Baud Rate

The baud rate defines how many bits per second can be transmitted over the UART interface. Both transmitting and receiving devices must be configured to use the same baud rate to ensure proper communication. Common baud rates include 9600, 115200, etc.

Advantages

- Simplicity: Requires only two wires for communication (TX and RX), making it easy to implement.

- Robustness: Can operate reliably over long distances.
- Flexibility: Supports various configurations (simplex, half-duplex, full-duplex).

Disadvantages

- Speed Limitations: Generally slower than other protocols like SPI or I2C.
- Not Full Duplex by Default: While some implementations support full-duplex communication, standard UART typically transmits in one direction at a time.

Applications

UART is extensively used in various applications due to its ease of use:

- Connecting microcontrollers to peripherals (e.g., GPS modules, Bluetooth devices).
- Serial communication in embedded systems.
- Data logging applications where simple point-to-point communication is needed.

6. Safety Precautions for Soldering

Before Soldering

1. Workspace Preparation:
   - Clean and Organize: Ensure your workspace is clean, clear of unnecessary items, and dry to prevent accidents and fire hazards.

- Ventilation: Work in a well-ventilated area to disperse harmful fumes produced during soldering. Use fume extractors or fans if necessary.

2. Personal Protective Equipment (PPE):
    - Wear Protective Gear: Use safety glasses or goggles to protect your eyes from solder splashes and fumes. Long sleeves and gloves can protect your skin from burns and contact with hazardous materials.
    - Avoid Loose Clothing: Ensure that clothing is fitted to prevent it from catching on equipment or coming into contact with hot surfaces.
3. Equipment Inspection:
    - Check Tools: Inspect the soldering iron and electrical cords for any damage, such as frayed wires or cracked insulation. Ensure all equipment is in good working condition before use.
4. Material Safety Data Sheets (MSDS):
    - Review Safety Information: Familiarize yourself with the MSDS for the solder and flux you will be using to understand any hazards associated with these materials.

During Soldering

1. Soldering Technique:
    - Use Proper Tools: Always use tweezers or clamps to hold components being soldered to avoid burns from hot materials.
    - Never Touch Hot Surfaces: Avoid direct contact with the soldering iron tip, which can reach temperatures up to 400°C (752°F).
2. Iron Handling:

- Rest the Iron Safely: Always return the soldering iron to its stand when not in use; never lay it down on your workbench as this can cause burns or fires.
- Turn Off When Not in Use: Unplug or turn off the soldering iron when it is not actively being used to prevent accidental burns or fire hazards.

3. Fume Management:
    - Avoid Inhalation of Fumes: Minimize exposure to fumes by ensuring proper ventilation and using fume extractors when necessary. Avoid inhaling smoke from heated solder and flux.

After Soldering

1. Cleanup Procedures:
    - Dispose of Waste Properly: Dispose of lead solder and dross in designated hazardous waste containers. Ensure these containers are labeled correctly and kept closed when not in use.
    - Clean Work Area: Wipe down surfaces with a damp cloth to remove any residual solder or flux that may contain hazardous materials.

2. Personal Hygiene:
    - Wash Hands Thoroughly: After completing your work, wash your hands with soap and water to remove any lead residue or contaminants from the solder.
    - Avoid Eating or Drinking Nearby: Do not eat or drink in the soldering area to prevent ingestion of lead or other hazardous materials.
3. First Aid Preparedness:

- Know First Aid Measures: In case of burns, cool the affected area under cold running water for at least 15 minutes. Seek medical attention for severe burns covering large areas.