# Motor Driver PCB Design using L298N

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## 1 Overview

This project involves the design of a basic H-bridge motor driver PCB using the L298N IC, intended to drive a DC motor in both directions. The goal was to create a compact, robust board that could accept microcontroller signals and drive motors efficiently, with onboard voltage regulation and directional indication.

## 2 Component Selection

The table below outlines the key components used in the design:

| Component | Part Number | Reason for Selection |
|---|---|---|
| H-Bridge IC | L298N | Dual full-bridge driver, 2A/channel |
| Voltage Regulator | AMS1117-5.0V | Step-down from motor voltage to 5V |
| Flyback Diodes | 1N4007 | Clamp back-EMF from inductive load i.e. motor |
| LEDs | Red | Indicate motor direction |
| Screw Terminals | 2-pin, 5mm pitch | For motor power input and output |
| Female Pin Headers | 2.54mm pitch | For ENable and INput microcontroller signals |

Table 1: Key Components

## 3 Schematic Overview

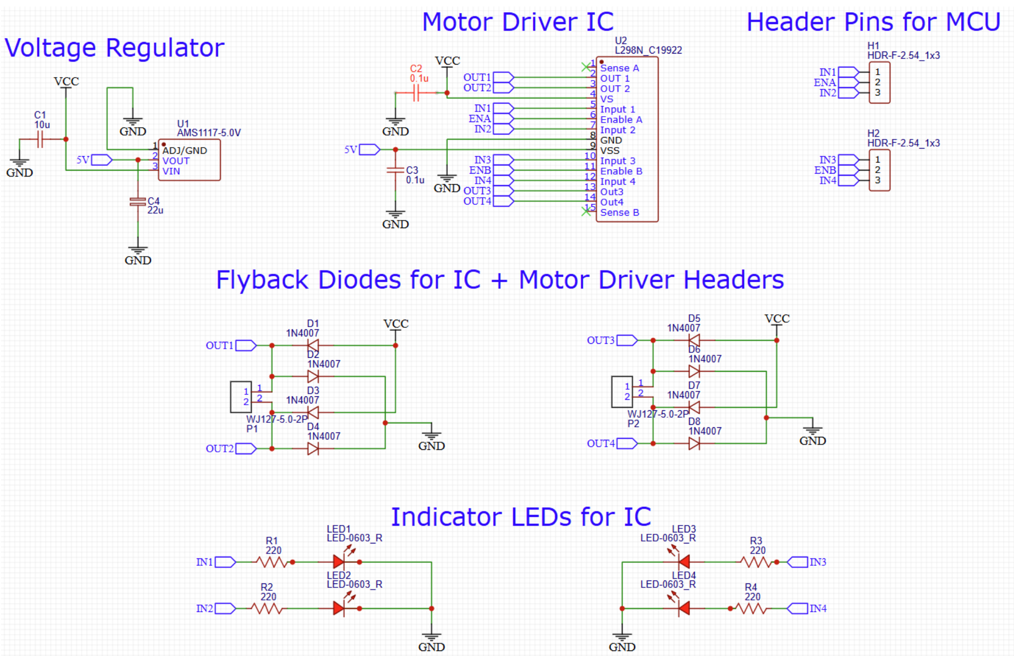



Figure 1: Circuit Schematic

The circuit is divided into the following functional blocks:

- **Power Supply**: Accepts a DC input (12V) and regulates to 5V.
- **Motor Driver IC + Header Pins**: L298N receives input from MCU (headers provided for that) and drives the motors using output pins.
- **Flyback diodes for protection of IC**: Flyback diodes across motor terminals and $V_{cc}$ protect the IC from back emf. Back emf is the voltage generated by inductive components like motors, solenoids, or relays when the current flowing through them is suddenly interrupted (in accordance with Faraday's law of electromagnetic induction).
- **Indicator LEDs**: LEDs indicate motor direction. For eg., IN1 ON, IN2 OFF means the motor will spin in forward direction.

# 4 PCB Layout

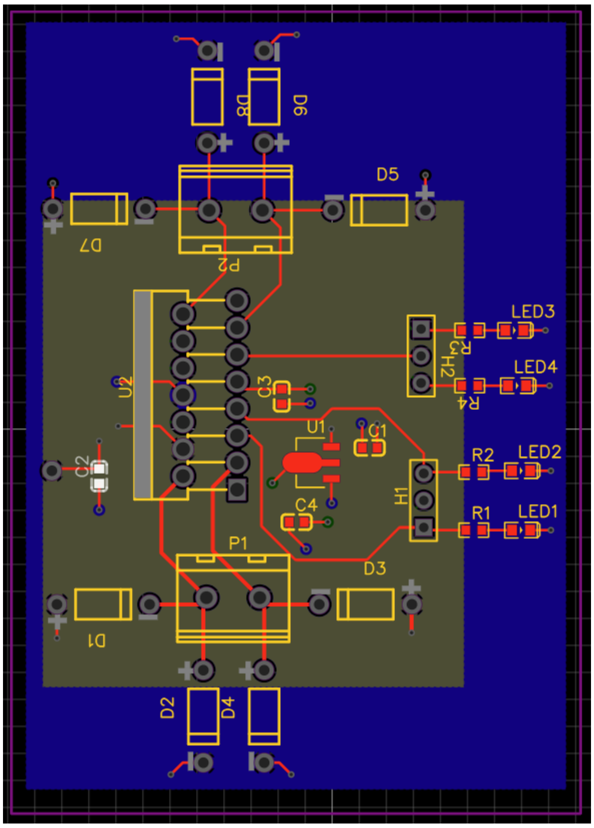
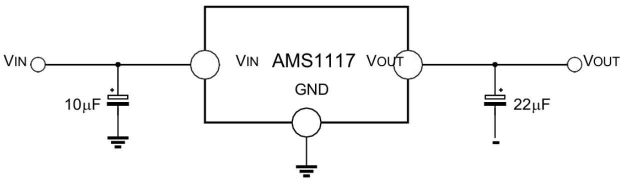


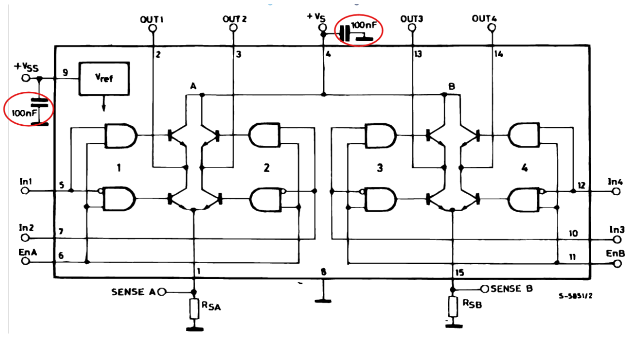

Figure 2: PCB Layout

## 4.1 Key layout considerations

- L298N placed centrally to minimize trace lengths.
- Flyback diodes located close to motor output pins.
- Wide traces used for motor outputs (up to 2A current).
- Decoupling capacitors placed near regulator and IC power pins.




(a) AMS1117-5.0V Block Diagram




(b) L298N Block Diagram

Figure 3: Capacitor placement and values (as mentioned in datasheets)

## 4.2 PCB Layers

- The designed PCB uses a 4-layer structure to manage power distribution, signal integrity, and heat dissipation effectively. The layer order (from top to bottom) is as follows :
  1. **Layer 1 - Top Layer:** Component placement and signal routing.
  2. **Layer 2 - Ground Plane (GND):** Provides low-impedance return paths and EMI shielding.
  3. **Layer 3 - 12V Power Plane:** Distributes high-current motor supply voltage while being shielded between two quieter planes.
  4. **Layer 4 - 5V Logic Plane:** Supplies clean logic-level power for microcontrollers and indicators.
- The rationale behind this stack-up order was :
  - **Top-GND adjacency:** Allows clean return paths for high-speed or noisy signals, improving signal integrity and reducing EMI.
  - **12V plane between GND and 5V:** Helps shield noisy high-current motor power from sensitive logic traces.
  - **5V on the bottom:** Keeps low-noise logic supply farthest from the top signal layer and physically separated from motor power. This layer can also be used for testing or breakout pads if needed.
  - **Via efficiency:** Allows vias from top-layer components to directly connect to internal power planes with short vertical distance.
- Advantages of a 4-layer PCB over a 2-layer PCB :
  - **Cleaner and safer power distribution:** A 4-layer PCB allows implementation of dedicated copper planes for GND, 12 V and 5 V. These copper planes are capable of carrying high currents with low resistance and low voltage drop. They also reduce IR losses and heating. In a 2-layer PCB, most connections would be routed with traces. Wider traces would take up more space and also introduce voltage drops.
  - **Scalability and reliability:** A 4-layer PCB is easier to upgrade or modify for more channels (dual motor, higher current). It provides better mechanical stability due to extra layers. On the other hand, a 2-layer PCB can feel "hacked together" for more complex circuits.

## 4.3 Component Value Decisions

After consulting the datasheet of the components, I found :

- The AMS1117-5.0V voltage regulator requires a 10 $\mu$F capacitor at the input ($V_{in}$) and a 22 $\mu$F tantalum capacitor at the output ($V_{out}$).

- The L298N motor driver IC requires 0.1 $\mu$F decoupling capacitors placed close to the power supply pins $V_s$ and $V_{ss}$.
- Standard LEDs require a minimum resistance of 100 Ω (calculation shown below). Therefore, I used a standard resistance of 220 Ω.

**Calculation:**

| **ABSOLUTE MAXIMUM RATINGS** ($T_{amb}$ = 25 °C, unless otherwise specified) **TLMS110., TLMO1100, TLMY1100, TLMG1100, TLMP1100** | | | | |
|---|---|---|---|---|
| **PARAMETER** | **TEST CONDITION** | **SYMBOL** | **VALUE** | **UNIT** |
| Reverse voltage [1] | | $V_R$ | 12 | V |
| DC forward current | $T_{amb} \leq 75$ °C | $I_F$ | 30 | mA |
| Surge forward current | $t_p \leq 10$ μs | $I_{FSM}$ | 0.5 | A |
| Power dissipation | | $P_V$ | 90 | mW |
| Junction temperature | | $T_j$ | +120 | °C |

Figure 4: Absolute Maximum Ratings for LED

Since the maximum forward current is 30 mA and the LED typically operates at a forward voltage of 2 V (as mentioned in the datasheet), the minimum resistance is

$$R_{\text{min}} = \frac{5\,\text{V} - 2\,\text{V}}{30\,\text{mA}} = 100\ \Omega$$

## 4.4 Power Ratings

- Motor supply voltage = 12 V
  Note : the maximum input voltage for AMS1117-5.0V is 15 V and the maximum supply voltage for L298N is 50 V.
- Logic voltage (i.e. $V_{ss}$) = 5 V

## 4.5 Trace widths

### 4.5.1 L298N

($V_S$ = 42 V; $V_{SS}$ = 5 V, $T_j$ = 25 °C; unless otherwise specified)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_S$ | Supply voltage (pin 4) | Operative condition | $V_{IH}$ +2.5 | | 46 | V |
| $V_{SS}$ | Logic supply voltage (pin 9) | | 4.5 | 5 | 7 | V |
| $I_S$ | Quiescent supply current (pin 4) | $V_{en}$ = H; $V_i$ = L; $I_L$ = 0 | | 13 | 22 | mA |
| | | $V_{en}$ = H; $V_i$ = H; $I_L$ = 0 | | 50 | 70 | mA |
| | | $V_{en}$ = L; $V_i$ = X | | | 4 | mA |
| $I_{SS}$ | Quiescent current from $V_{SS}$ (pin 9) | $V_{en}$ = H; $V_i$ = L; $I_L$ = 0 | | 24 | 36 | mA |
| | | $V_{en}$ = H; $V_i$ = H; $I_L$ = 0 | | 7 | 12 | mA |
| | | $V_{en}$ = L; $V_i$ = X | | | 6 | m |
| $V_{iL}$ | Input low voltage (pins 5, 7, 10, 12) | | –0.3 | | 1.5 | V |
| $V_{iH}$ | Input high voltage (pins 5, 7, 10, 12) | | 2.3 | | $V_{SS}$ | V |
| $I_{iL}$ | Low voltage input current (pins 5, 7, 10, 12) | $V_i$ = L | | | –10 | μA |
| $I_{iH}$ | High voltage input current (pins 5, 7, 10, 12) | $V_i$ = H ≤ $V_{SS}$–0.6V | | 30 | 100 | μA |
| $V_{enL}$ | Enable low voltage (pins 6, 11) | | –0.3 | | 1.5 | V |
| $V_{enH}$ | Enable high voltage (pins 6, 11) | | 2.3 | | $V_{SS}$ | V |
| $I_{enL}$ | Low voltage enable current (pins 6, 11) | $V_{en}$ = L | | | –10 | μA |
| $I_{enH}$ | High voltage enable current (pins 6, 11) | $V_{en}$ = H ≤ $V_{SS}$–0.6V | | 30 | 100 | μA |
| $V_{CEsat (H)}$ | Source saturation voltage | $I_L$ = 1A | 0.95 | 1.35 | 1.7 | V |
| | | $I_L$ = 2A | | 2 | 2.7 | V |
| $V_{CEsat (L)}$ | Sink saturation voltage | $I_L$ = 1A [1] | 0.85 | 1.2 | 1.6 | V |
| | | $I_L$ = 2A [1] | | 1.7 | 2.3 | V |
| $V_{CEsat}$ | Total drop | $I_L$ = 1A [1] | 1.80 | | 3.2 | V |
| | | $I_L$ = 2A [1] | | | 4.9 | |
| $V_{sens}$ | Sensing voltage (pins 1, 15) | | –1 [2] | | 2 | V |

Figure 5: Electrical Characteristics of L298N

To calculate the traces routing to the L298N, it is important to look at it's electrical characteristics, particularly the various currents each pin expects :

- Pin 4 ($V_s$) supplies current to the H-bridge outputs (OUT1-OUT4). Now this current depends on the motor load and not te internal logic. However, the peak output current is **2 A**. Therefore, I kept the trace width according to a current of **4 A** (2A per H-bridge side).

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_S$ | Power supply | 50 | V |
| $V_{SS}$ | Logic supply voltage | 7 | V |
| $V_I$, $V_{en}$ | Input and enable voltage | –0.3 to 7 | V |
| $I_O$ | Peak output current (each channel): | | |
| | • Non repetitive (t = 100 ms) | 3 | A |
| | • repetitive (80% on –20% off; $t_{on}$ =10 ms) | 2.5 | A |
| | • DC operation | 2 | A |
| $V_{sens}$ | Sensing voltage | –1 to 2.3 | V |

Figure 6: Absolute Maximum Ratings for L298N

Using a **trace width calculator**, I found out the required width as **40 mil**.

- Pin 9 ($V_{ss}$) powers the internal logic. From the datasheet, the maximum quiescent current is **6 mA**. So, I kept the default **10 mil** trace because it can **handle upto 1 A of current**.

- Pins 8, 13 (GND) return the total current from motor and logic. So, I planned for the same capacity as $V_s$ with a **40 mil** trace width.

- Pins 5 - 12 (IN and EN) are all logic-level CMOS inputs and thus require negligible current ( **0.1 mA**) which can be taken care of with the default **10 mil** trace.

- Pins 2, 3, 13 and 14 (OUT) carry the motor current, supplied by $V_s$. As a result, I designed my traces to carry a maximum of **2 A** current, which requires a trace width of **15 mil**.

### 4.5.2 AMS1117-5.0V

- AMS1117 is a linear voltage regulator, so input current ≈ output current, plus a tiny bit of quiescent current.

- The output current is given as **1 A** in the datasheet.

**FEATURES**

- **Three Terminal Adjustable or Fixed Voltages***
  **1.5V, 1.8V, 2.5V, 2.85V, 3.3V and 5.0V**
- **Output Current of 1A**
- **Operates Down to 1V Dropout**
- **Line Regulation: 0.2% Max.**
- **Load Regulation: 0.4% Max.**
- **SOT-223, TO-252 and SO-8 package available**

Figure 7: Features of AMS1117

Therefore the input current can also be taken to be around **1 A**.

- A trace of **10 mil** is sufficient to handle this current.

### 4.5.3 Other components

- The diodes can take peak current of 30 A. However, since they are connected to the OUTx pins, they will hardly ever receive current beyond **2 A**. So, I have routed all the traces to and from the diodes with a width of **15 mil**.

- As mentioned before, the forward voltage drop for the LEDs is 2 V and the current is **8 mA**. This can be easily handled by **10 mil** traces.
- Decoupling capacitors don't require wide traces to GND because they only carry transient pulses. The same goes for the trace connected to power supply.

## 5 Conclusion

The designed motor driver PCB successfully integrates the required features: bi-directional control of a DC motor, onboard regulation, LED direction indicators, and flyback protection. It is suitable for use in educational robots and embedded motor control projects.