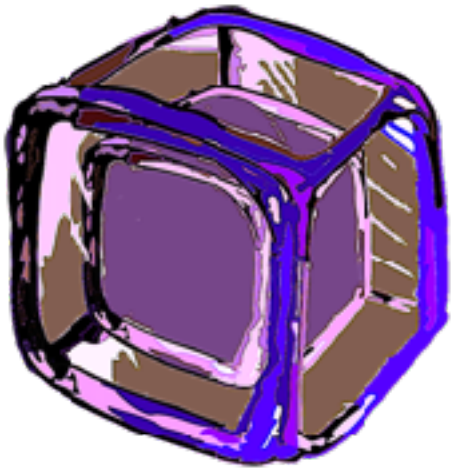
Introduction Robotics *Joystick-Uno-L298N*

AVR Bare-Metal C/C++ Programming

Bare metal refers to a computer executing instructions directly on logic hardware without loading a separate operating system. The C/C++ programming language remains a common practice in embedded systems, where microcontrollers often boot directly into a single large block from a single-purpose software often called firmware. Programing an AVR centers around the 8-bit Atmel (Microchip) family specifically the Atmega328P. The board we're using here is the Arduino Uno.

Computer Science

The practical approach to hands-on computer science is often done in a laboratory environment. In the lab, notes are often taken to answer an inquiry into connected devices while aiming to implement such devices for example in a differential drive mobile robots (DDMR). The laboratory might be part of undergraduate curriculum at a major university like MIT or it might be a simple study desk at home. The most important tool in the laboratory is the Lab-Notebook.

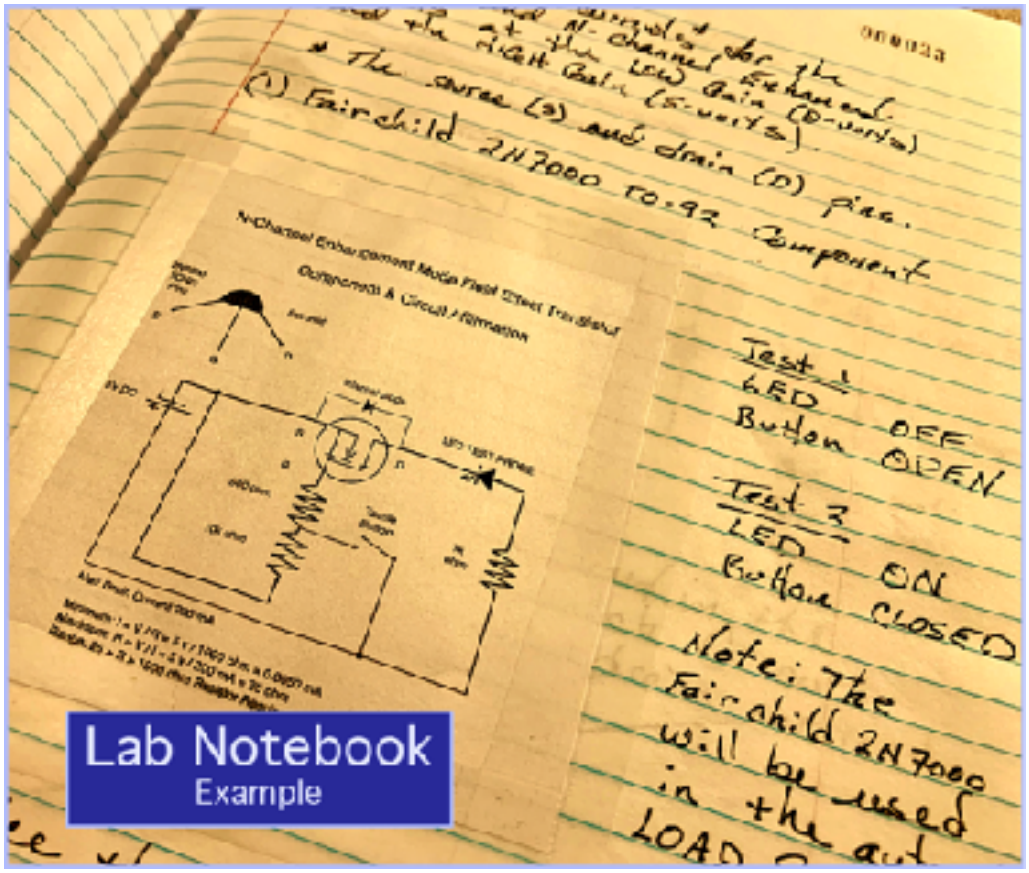


imperceptible black box

Black Box

The imperceptible black box sitting there on the lab bench. *What is it?* It is a phenomenon unmeasurable by the five senses. The use of the scientific equipment may be required to investigate such a black box. An electronic multimeter for example that is used in part of an investigation called the scientific method. The multimeter, an inexpensive device can be used to break open that imperceptible black box starting from a simple question like what can be measured from a passive electronic component like a resistor. Or better, imagine the scientific equipment required into the inquiries on quantum computing (another imperceptible black box). One might observe from an ohmmeter that the resistance measured was 50 ohms and the empirical value was recorded with at

most 3 significant digits in the lab notebook. The lab notebook while using the best practices of the scientific method prevents repeating the same experiment, answering the same question because the lab notebook is a permanent record. It is a reference to be used to expand upon into other experiments to come…



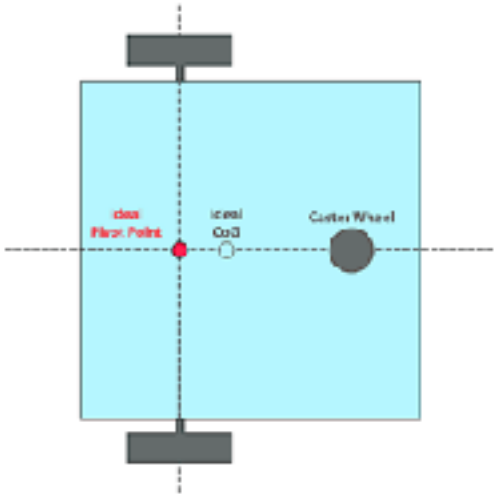
Lab Notebook

In the lab notebook example, the diagram of the 2N7000 Component & Circuit Affirmation was simply inquired by using an LED test probe. Open-circuit, LED off. Close-circuit, LED on. Upon closer scrutiny, the diagram can be referenced later for several key facts. For example, what is the difference between a limiting and a pull-down resistor and on the device silhouette, where are the actual connections for the Source (S), Gate (G), and Drain (D). Incorrect 2N7000 connections can be observed by a burnt electronic smell which is quite common in a lab. An observation by many who would like to avoid and who usually gets a standing applaud by their peers. The lab notebook is an important reference and legal document. It may contain hundreds of experiments like the Component & Circuit Affirmation lab test which are always referenced by scientist, engineer or hobbyist.

Differential Drive Mobile Robot

The robot has two independently driven wheels in front and one unpowered omnidirectional wheel in the rear. The driven wheels are motorized standard wheels with two degrees of freedom with its rotation around the wheel's axle and the contact point with the surface. The DDMR has a third wheel called a caster wheel with two degrees of freedom with its rotation around an offset steering joint.[1]

The chassis, the base frame of the robot, is a square structure or wider to reduce differential (sliding) friction by the driven wheels and any caster drag while turning. The ideal Center of



Gravity (CoG) is not necessarily along the horizontal plane of the chassis but does sit behind the Ideal Pivot Point (IPP). With the CoG close to the wheels axle line, most of its weight distribution of the robot is held by the driven wheels and not the caster. The IPP sits along the driven wheels axle line and the center line of the robot. The assumption that the environment for the robot's locomotion is on a flat and smooth surface.

C/C++ Programming Language

Code for embedded software is typically written in C/C++ programming language. Many beginners often begin with the popular Arduino integrated development environment (IDE) software and their line of Arduino boards with the Arduino Uno being their starter board. The IDE uses both the C and C++ language. The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller.

1. Roland Siegwart, Allah R. Nourbakhsh, Davide Scaramuzza, *Introduction to Autonomous Mobile Robot* (The MIT Press, Cambridge, Massachusetts, London, England; 2ed; 2004) Chapter 2 Locomotion.

Microcontroller Unit (MCU)

The ATmega328 is a single-chip microcontroller created by Atmel in the megaAVR family that has a modified Harvard architecture 8-bit RISC processor core. The microcontroller combines 32 KB in-system programming (ISP), also called in-circuit serial programming (ICSP) flash memory with read-while-write capabilities, 1 KB electrically erasable programmable read-only memory (EEPROM), 2 KB static random-access memory (SRAM), 23 general-purpose I/O lines, 32 general-purpose working registers, 3 flexible timer/counters with compare modes, internal and external interrupts, serial programmable universal asynchronous receiver-transmitter (USART), a byte-oriented 2-wire serial interface, serial peripheral interface (SPI) serial port, 6-channel 10-bit analog/digital (A/D) converter, programmable watchdog timer with internal oscillator, and 5 software-selectable power-saving modes. The device operates between 1.8 and 5.5 volts. The device achieves throughput approaching one (1) microprocessor without interlocked pipelined stages (MIPS) per megahertz (MHz).

For the the beginner, the technology can be overwhelming. The datasheet alone contains well over 200 pages. The one advantage using Arduino Uno with the ATmega328P microcontroller over other Arduino's boards is that the ATmega328P microcontroller can be replaced from its socket if some unfortunate electrical mishap occurs.

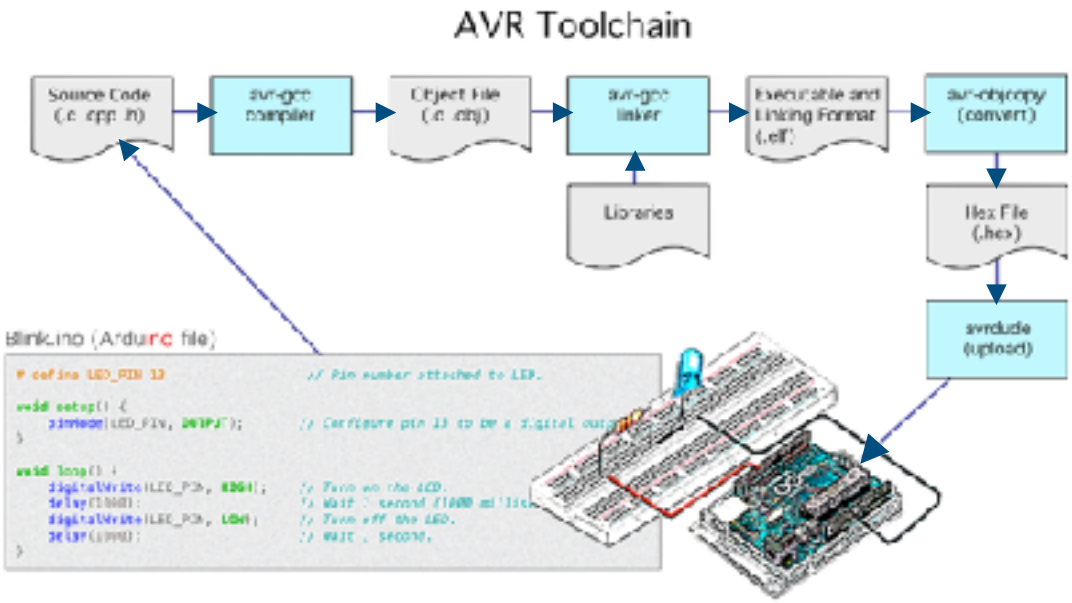
Integrated Development Environment

Arduino IDE is a cross-platform application for Windows, macOS, Linux. The IDE is used to write and upload programs called sketches (.ino) to Arduino compatible boards. Many hobbyists today uses a Linux computer like Raspberry Pi 4 (RP4) and its operating system, the Raspberry OS. The Arduino Uno board with its IDE while using it with the RP4 is very inexpensive.

AVR Toolchain

There is not a single *tool* that provides everything needed to develop software for the AVR. It takes many tools working together. Collectively, the group of tools are commonly called a toolchain, as the tools are chained together to produce the final executable application for the AVR microcontroller. The tools are built for the AVR target, the actual program names are prefixed with *avr* such as the executable compiler avr-gcc.[2] Few of the tools used under the hood by Arduino IDE are the *avr-gcc* compiler and the *avrdude* uploading tool. Lucky for us, Arduino IDE does all this out of the users sight making it seamlessly easy.

2. AVR Libc webpage, *avr-libc 2.0.0 - standard C library for AVR-GCC* (https://www.nongnu.org/avr-libc/user-manual/overview.html) visited August 2021.



Manifest

The following list of robotic components is the starting point. Once mastered, the novice is ready for bigger and better gadgets.

- **Thumb Joystick**

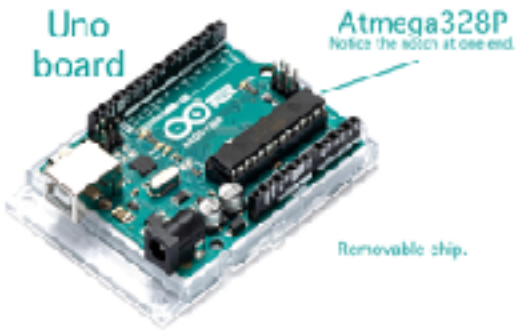
  The analog 2-axis thumb joystick with button by Makerfabs. The joystick has two analog (*10k potentiometers*), you'll need two analog (*ADC*) reading pins on your microcontroller to determine X and Y.

  Connections

  1. GND: (-) ground negative lead from 7805.
  2. 5V: (+) positive lead from 7805.
  3. X: (***A0***) Uno Analog Pin.
  4. Y: (***A1***) Uno Analog Pin.
  5. SW: (***2***) Switch Uno Digital Input Pin.

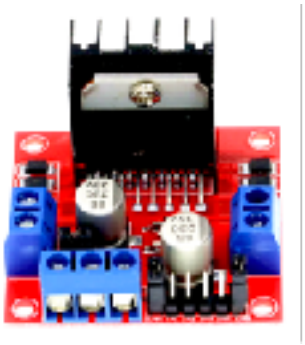
- **MCU - (*Atmega328P*)**

  Arduino Uno Board.
  - The USB connection from a Linux computer like Raspberry Pi 4 (*RP4*) using Raspberry OS using Arduino IDE to Arduino Uno.
  - The 5V USB can be supplied by RP4, but it's recommended to use Arduino Uno's 9V power supply pin.



- Notice in the Electronics Lab image, there is the Uno-Black-Wire connecting a ground to all components in the circuits. Although it is hard to see from the image between the 5V bus and the 14V bus, the buses are grounded together by a small black wire. The reason for Uno's ground connections would make a complete circuit with the Arduino Pins. See image and schematic.

- **L298N Motor Driver Module**



The L298N is a dual full-bridge motor driver designed to accept standard TTL logic levels.

Connections

Power Output Stage

The L298N integrates two power output stages (***A*** & ***B***). The power output stage is a bridge configuration and its outputs can drive an inductive load in common or **differential** mode, depending on the **state** of the inputs

Input State

Each bridge is driven by means of four gates the input of which are ***In1***, ***In2***, ***EnA*** and ***In3***, ***In4***, ***EnB***. The ***In*** inputs are used to set the bridge *states* with the ***En*** input used for **pulse width modulation** (PWM). PWM is a digital pulse length that varies a logic voltage from 0 to 5V. Thus PWM is used to adjust the motor speed. All inputs are Transistor-Transistor Logic (TTL) compatible. TTL is exactly what the Atmega328P uses…

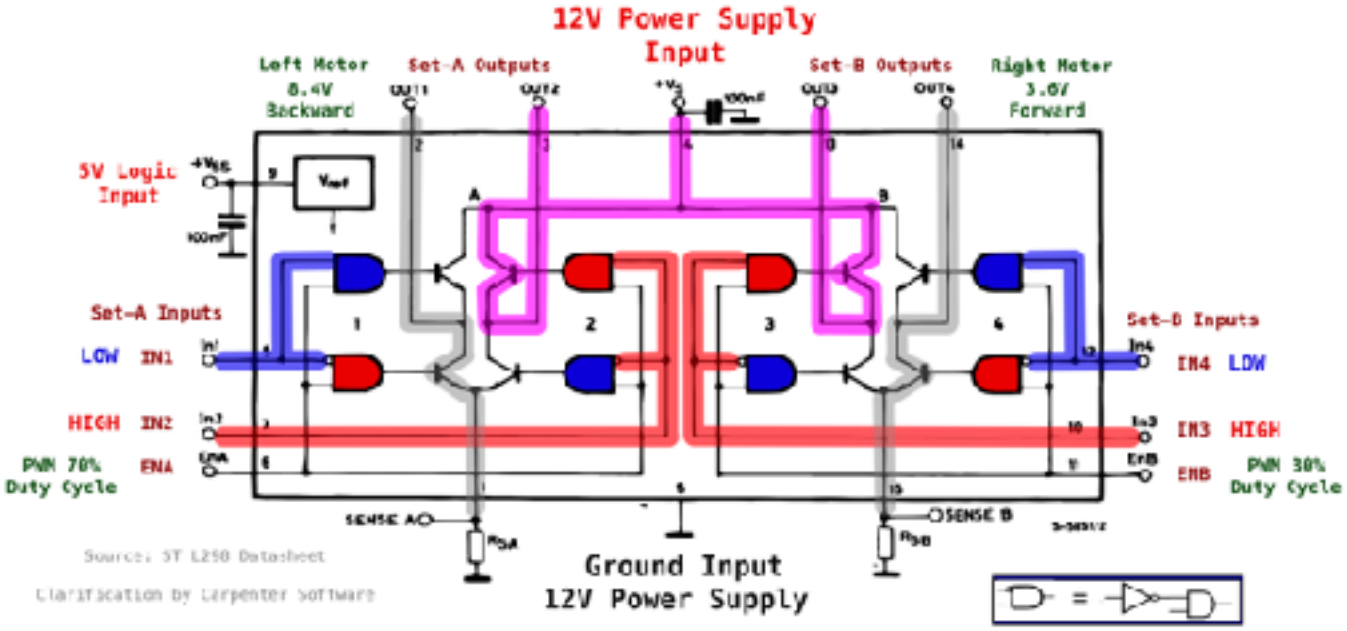
- **Two Geared Motors** 12V with ***brackets*** (*Gear Ratio around 1:75*) fastened to cheap Walmart cutting board with machine screws.

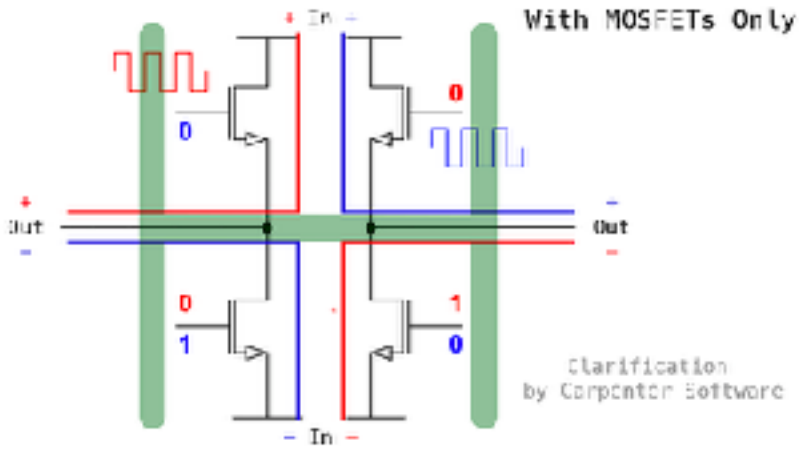
2 12V DC Motors with gears (approx. gear ratio 1:75

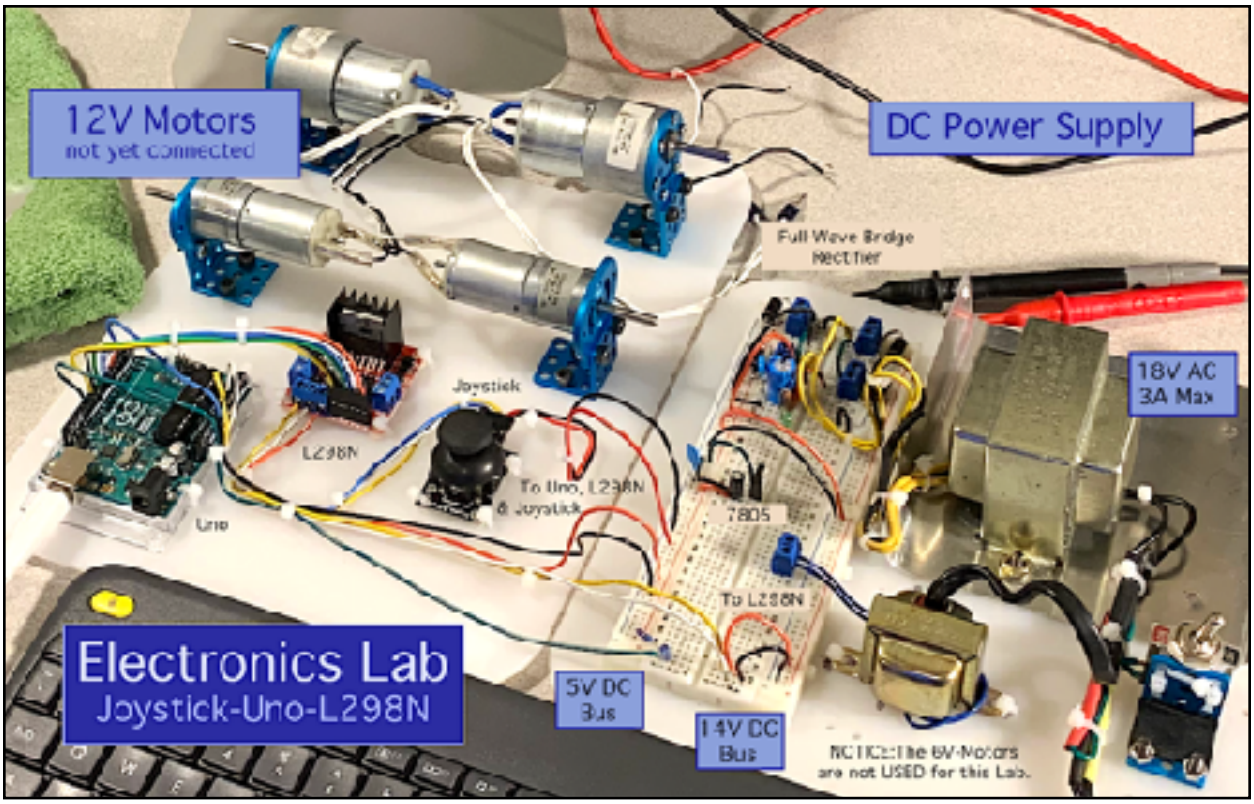
- **Power Supply** 12V DC *(2-3A max)* with breadboard and passive components (*Electronics Outlet*). Notice that many components are fasten to a lab board (*a cheap cutting board from Walmart*) held on by wire-ties (*also from Walmart*).

L298N & Typical H-Bridge Circuit

An H-bridge is an electronic circuit that switches the polarity of a voltage applied to a load. These circuits are often used in DC motors to run forwards or backwards. The typical graphical representation of an H-bridge is shown as a circuit. An H-bridge is built with four solid-state switches (MOSFET) controlled by 8-AND (with 4-Input-Inverter) logic gates. The L298N is a dual-channel H-Bridge motor driver capable of driving a pair of DC motors.





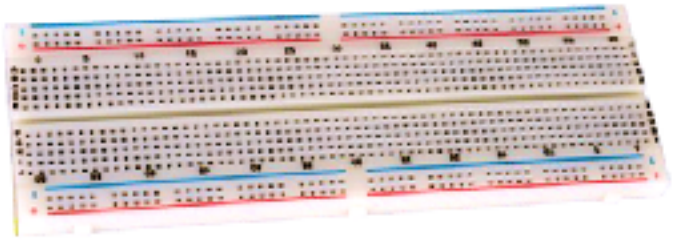


Electronics Lab Board

The programmer does not really need a robot, so let's do this in a simpler way by building something cheaper called an electronics lab board (by attaching the components using a cheap cutting board). Notice the wire-ties holding the components onto the board. See image.

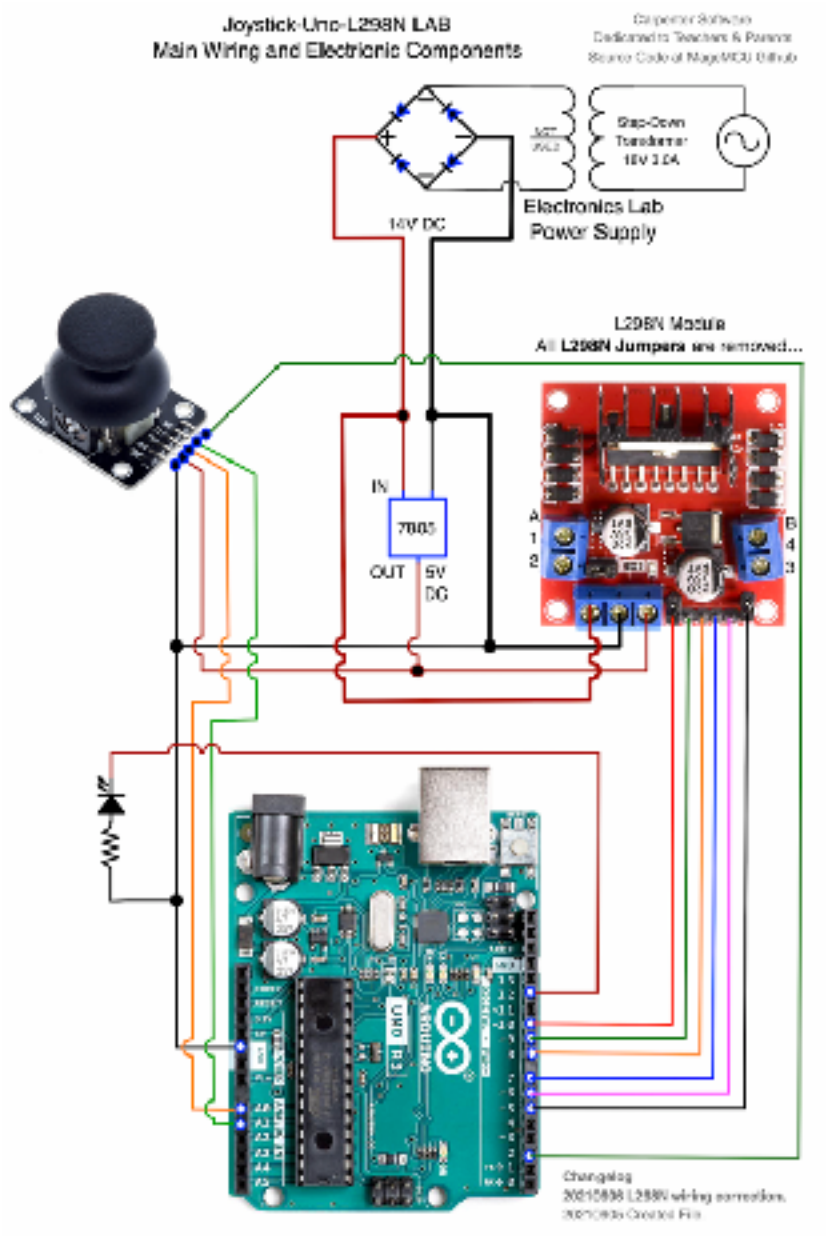
Breadboard, Wires & Electronics Active & Passive Components

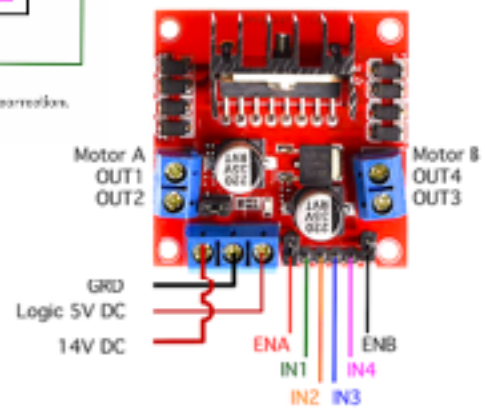
Breadboards are one of the most fundamental pieces when learning how to build circuits. This board has 4 power supply buses which could supply *3.3*, *5*, *6* & *9* volts at the same time. Each bus could share the same ground connection.



If one is new to electronics, search through the internet or research through the public library or buy a book.

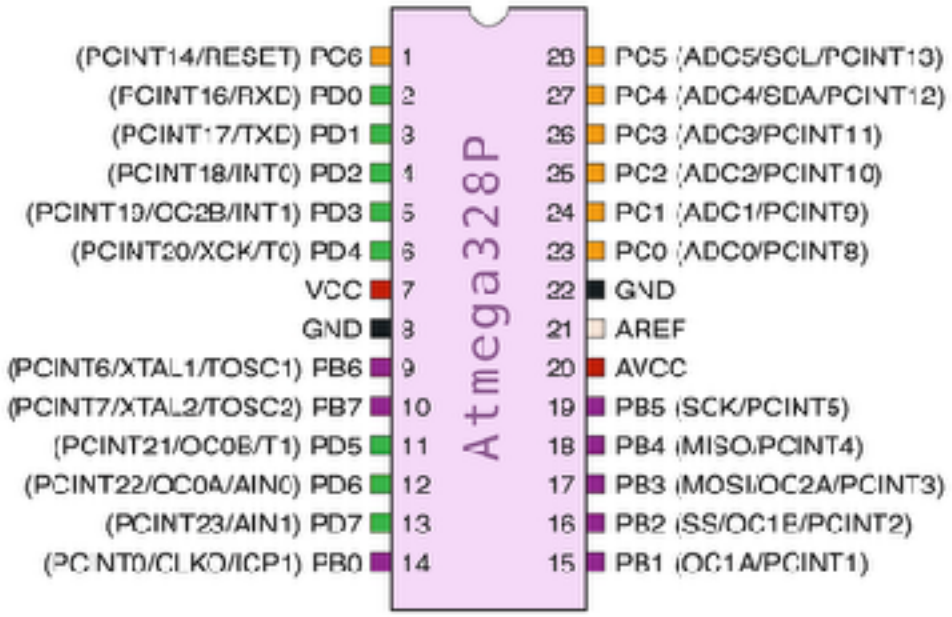
The Joystick-Uno-L298N Wiring Diagram

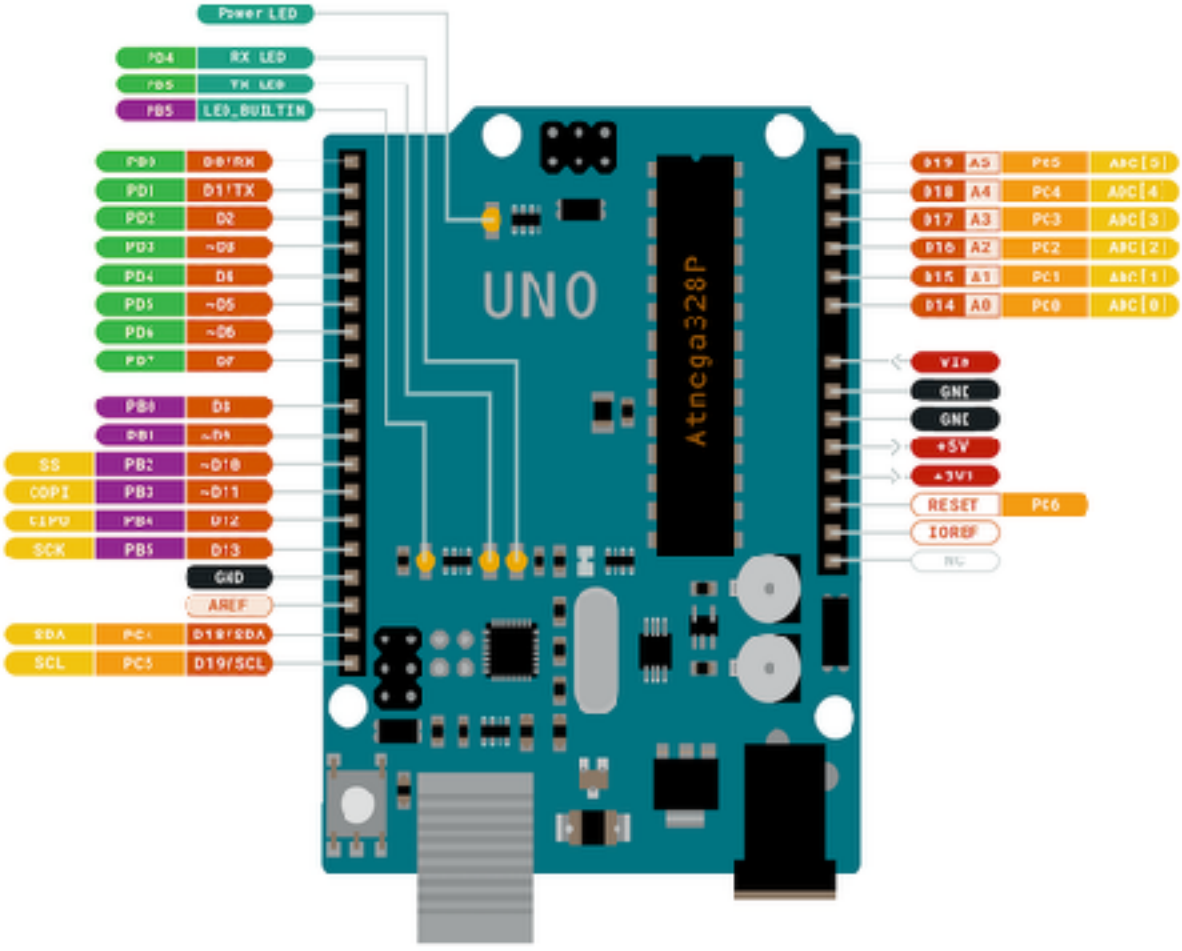




Output		Input
Set A:	Motor A	ENA, IN1, IN2
Set B:	Motor B	ENB, IN3, IN4

Atmega328P & Uno Pin Mapping





Where to find the Source Code

Software titled ***Joystick Uno L298N*** by MageMCU at Github.

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All children and teenagers, please consult with your parent (your guardian, your mentor or your teacher) before experimenting with any of these electronic circuits. Never work with electricity alone. Electricity Kills.

The code may be download by MageMCU at GitHub. The manifest chosen contain some of the most inexpensive items. The circuit has been tested over several years. Anyone who wants to volunteer to teach, please educate our children for the world to come…

–Jesse Carpenter

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