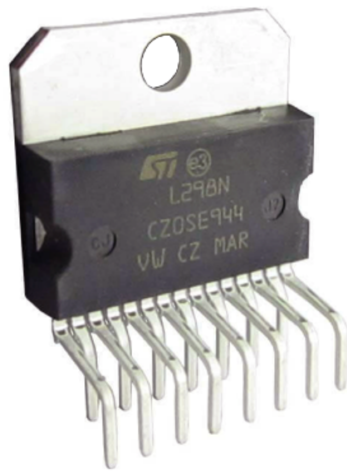
L298N Motor Diver

L298N

The L298N is a dual full-bridge motor driver designed to work with microcontrollers like Uno.



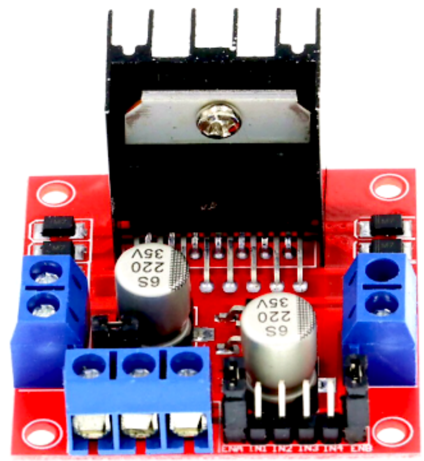


Image 1

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.

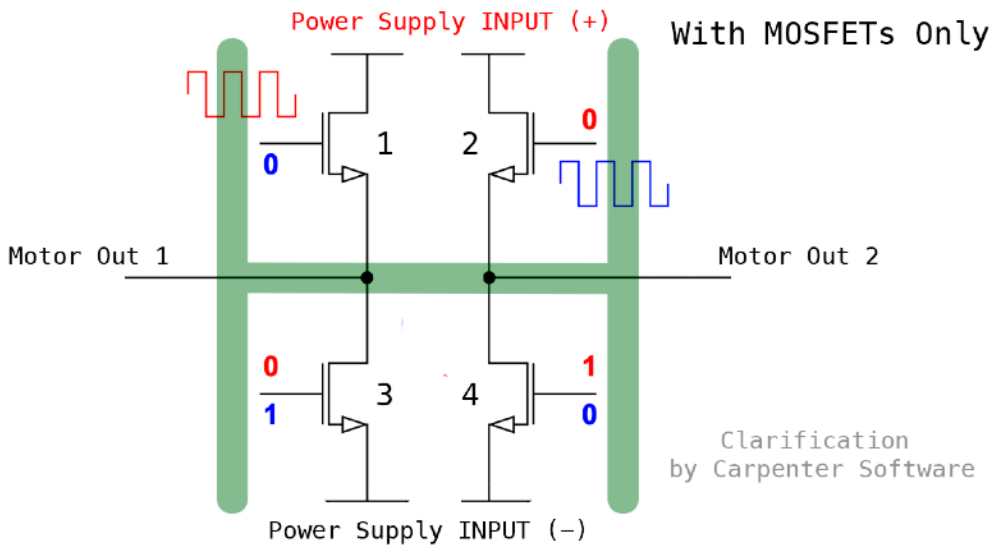
Input State

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

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 in Image 2.

Image 2



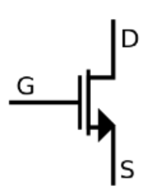
The circuit *with MOSFETs only* is a single H-bridge circuit used for driving a single motor. The circuit has four MOSFETs numbered 1 through 4. There is a power supply input and there is the output to the motor outs. Image 3 shows a N-Channel MOSFET with the three connections, the *D*rain, the *S*ource, and the *G*ate. The discussion here is that the MOSFET drains the power supply and is sourced to the motor outs if the gate is actively *HIGH*. The MOSFET gates coupled with Logic Gates control the MOSFETs as electronic switches. The logic behind this circuit only allows the four MOSFET to be in one state or another. There are other states but only two states are considered the useful states. Table 1 shows the two possible states. State 1 shows that MOSFET 1 is actively ON which directs the positive power supply to motor out 1 and MOSFET 4 is actively ON which directs the negative power supply to motor out 2. State 2 is reversed to that of state 1.

Table 1

State	MOSFET 1	MOSFET 2	MOSFET 3	MOSFET 4
1	ON	OFF	OFF	ON
2	OFF	ON	ON	OFF

The zeros (0) and ones (1) in Image 2 represent the logic voltages applied to the MOSFET gates. There are different names applied to logic voltages which themselves are either in two states, either zero (0) volts or like in most devices, the logic voltage is 5 volts. So words like *ON*, *HIGH* and even the number *1* defines the maximum logic voltage where the logic voltage for Arduino

Image 3



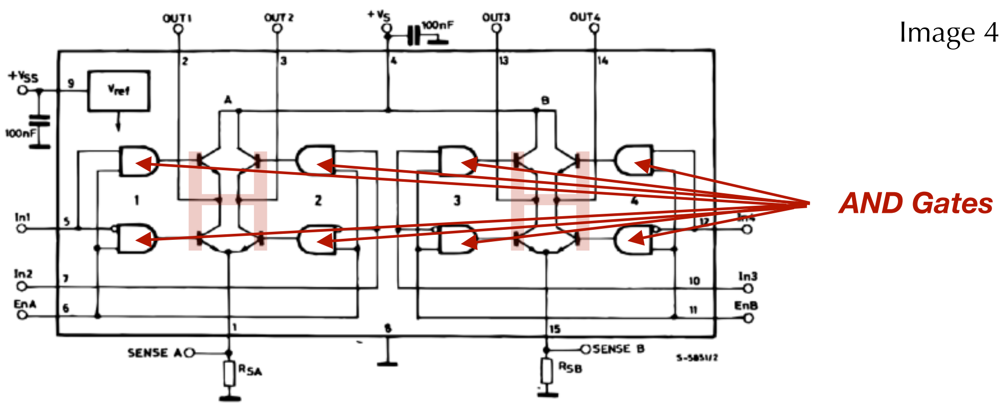
N-Channel MOSFET

Uno is 5 volts. Of course, words like *OFF*, *LOW* and even the number *0* defines the zero (0) volts. The square wave next to the MOSFET gates is called the pulse width modulation where it too has the same two states, *HIGH* and *LOW*. An important question to consider is how are the MOSFET's gates controlled in order to obtain the two possible states.

L298N Dual H-bridge Circuit

An H-bridge is built with four solid-state switches (MOSFET) controlled by 8-AND logic gates (with 4 Input-Inverters). The L298N is a dual-channel H-Bridge motor driver capable of driving a pair of DC motors. The circuit of Image 4 was taken from STMicroelectronics L298 dual full-bridge driver datasheet.

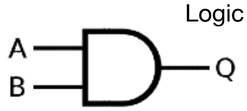
Image 4



The symbols in Image 4 are called logic *AND* gates because the logic gate is connected to each gate of the MOSFET shown in Image 4. The gate part of the MOSFET indicated by the letter *G* is shown in Image 3. The symbol for the logic gate shown in Image 5 represents an *AND* gate which has *two inputs* and *one output*.

Logic AND Gate

Image 5



The connections *A* and *B* are the inputs and *Q* is the output. Logic voltages are applied to each input that must be one of the two states which represent a switching circuit for the output. The inputs of the switching circuit can be set to either *LOW (0)* or *HIGH (1)*.

Truth Table for the *AND* Gate

Table 2

AND Gate		
Inputs		**Output**
A	**B**	**Q**
0	0	0
0	1	0
1	0	0
1	1	1

The term *logic* can be represented by using *boolean* truth tables to describe the output results. In Table 2, when both inputs *A* & *B* are set to *HIGH (1)*, then the output Q becomes *HIGH (1)* otherwise the output is set to *LOW (0)*. The truth table shows all possible *A* and *B* input states as shown in Table 2.

Image 6

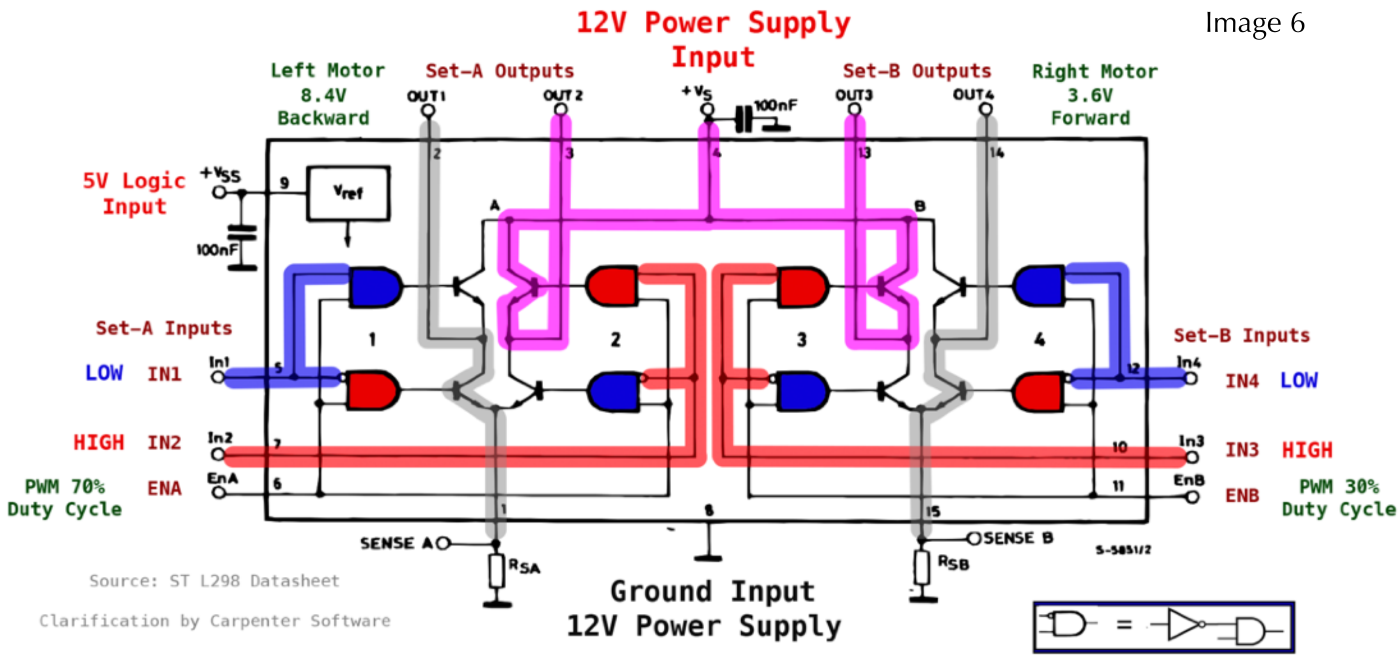
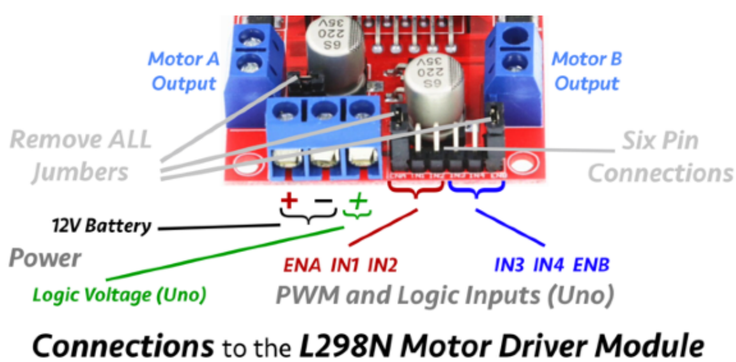


Image 6 may be daunting at first, yet the L298N circuit can be approached by divide and conquer. The inputs for the L298N shown in Image 6 as well as in Image 7 are *EnA, In1*, and *In2* which are used for the Motor ***A*** Output and the inputs *In3*, *In4*, and *EnB* which are used for Motor ***B*** Output. Notice these 6 inputs connected to the *AND* gates in Image 6.

The 4 sets of *AND* gates cleverly designed are indicated by the numbered sets 1 through 4. From here on, *EnA, In1*, and *In2* inputs are discussed. Comparing Images 4 and 6, input *IN1* and input *ENA* are connected to two *AND* gates in set 1 but notice that one of the *AND* gates has a *circle*.

Image 7



The circle represents an *inverted* input called the *complement* but here it is attached to only one of the inputs of each set of *AND* gates. In Image 9, the symbol represents the complement gate also called the inverted gate. Notice that the only inputs to set 1 are the *ENA* input and the *IN1* input where *IN2* is connected to set 2 which can be ignored for now. When *IN1* input is *LOW* indicated by the color blue its corresponding *AND* gate is also blue which indicates that its output is *LOW*. The other logic gate is also connected by the *IN1* input but it is red because the circled input inverted the *AND* gate output to HIGH. The *ENA* input on the other hand carries the PWM signal which can be considered *HIGH* at all times. Whatever the *IN1* state might be, its counterpart will always have an opposite output.

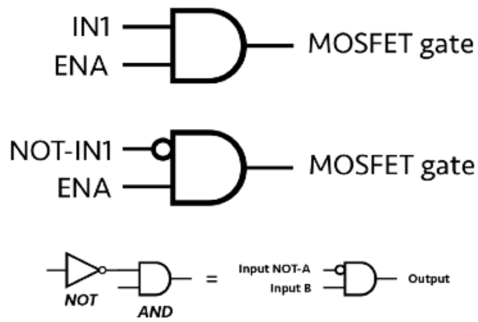
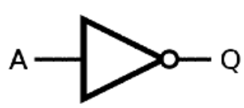


Image 8

With that said referring back to Image 6 using Image 11, a larger view, follow the inputs of the supply voltage to the outputs for the motor outs. The gray shade shows how the current for the negative connection has bypassed the MOSFET when its gate is set to *LOW*. The same is true for the pink shade which shows how the current for the positive connection bypasses the MOSFET when its gate is set to LOW. What is important here, when comparing the two sets, 1 and 2, of the AND gates connected by the inputs *IN1* and *IN2* , the sets are also opposite which confirms state 2 of Table 1.

Image 9



Complement or Inverted Gate

COMPLEMENT Gate

Input A	Output Q
0	1
1	0

Table 3

The truth table, Table 4, for the L298N *AND* gates sets 1 and 2 inputs: *ENA*, *IN1*, and *IN2*, shows that state 6 matches the inputs and outputs of Image 11 which also agrees with state 2 of Table 1. Table 4 also shows the output polarity of the supply voltage where only four states make any sense whereby they're the only four useful states of the circuit.

Table 4

Truth Table: L298N Set-A Inputs: ENA IN1 IN2

	PWM	Input Gates				Output Polarity		
State	ENA	IN1	oIN1[2]	IN2	oIN2[2]	OUT 1	OUT 2	Motor
1	0	0	1	0	1	-	-	?
2	0	0	1	1	0	-	+	Stop[1]
3	0	1	0	0	1	+	-	Stop[1]
4	0	1	0	1	0	+	+	?
5	1	0	1	0	1	-	-	?
6	1	0	1	1	0	-	+	Backward
7	1	1	0	0	1	+	-	Forward
8	1	1	0	1	0	+	+	?

Key

Logic ***HIGH*** (1) - For the Arduino Uno, this is about 5V.

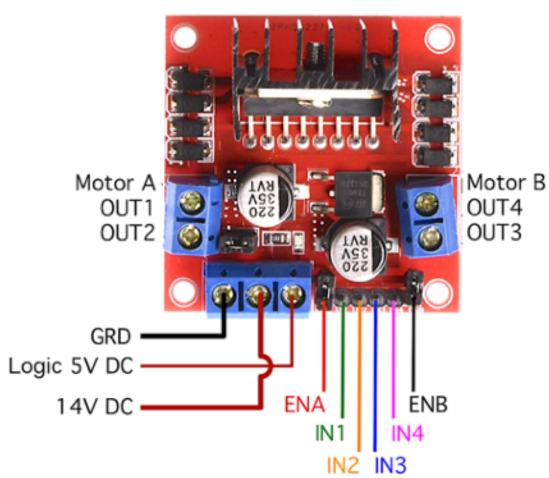
Logic ***LOW*** (0) - Zero (0) volts.

1. As the PWM signal for the ENA approached zero (0), the robot comes to a stop.

2. oIN1 and oIN2 are the inverted AND gates where the Inputs A are inverted as Input Not-A. See Image 8.

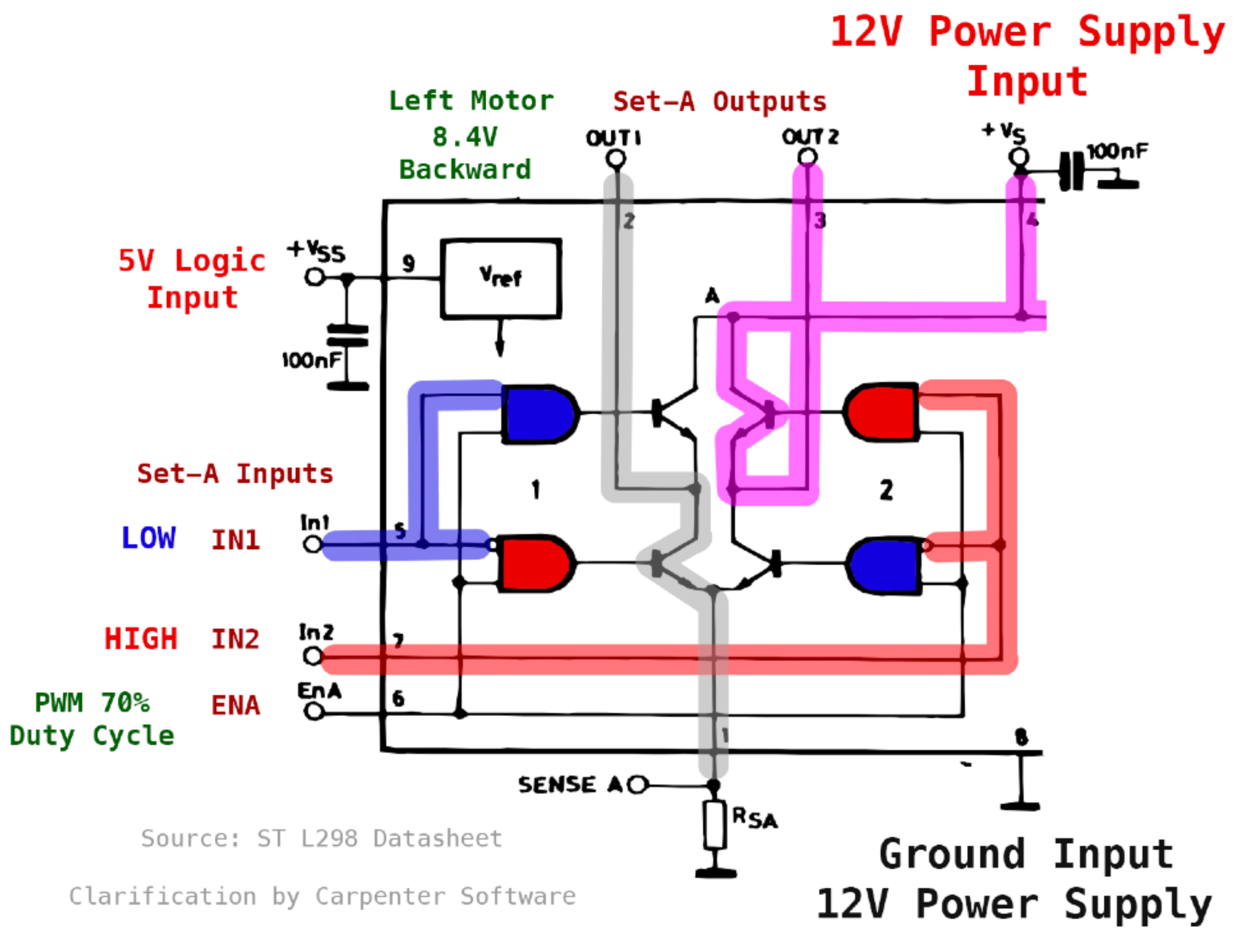
Upon closer scrutiny of Image 11, the motor moves backward because the output polarity is reversed from that of the forward polarity. The motor is using 8.4 volts from a 12 volt battery because the PWM is at 70 percent Duty Cycle. The recommended method to stop the motors is to set the PWM to *LOW*.

Image 10



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

Image 11



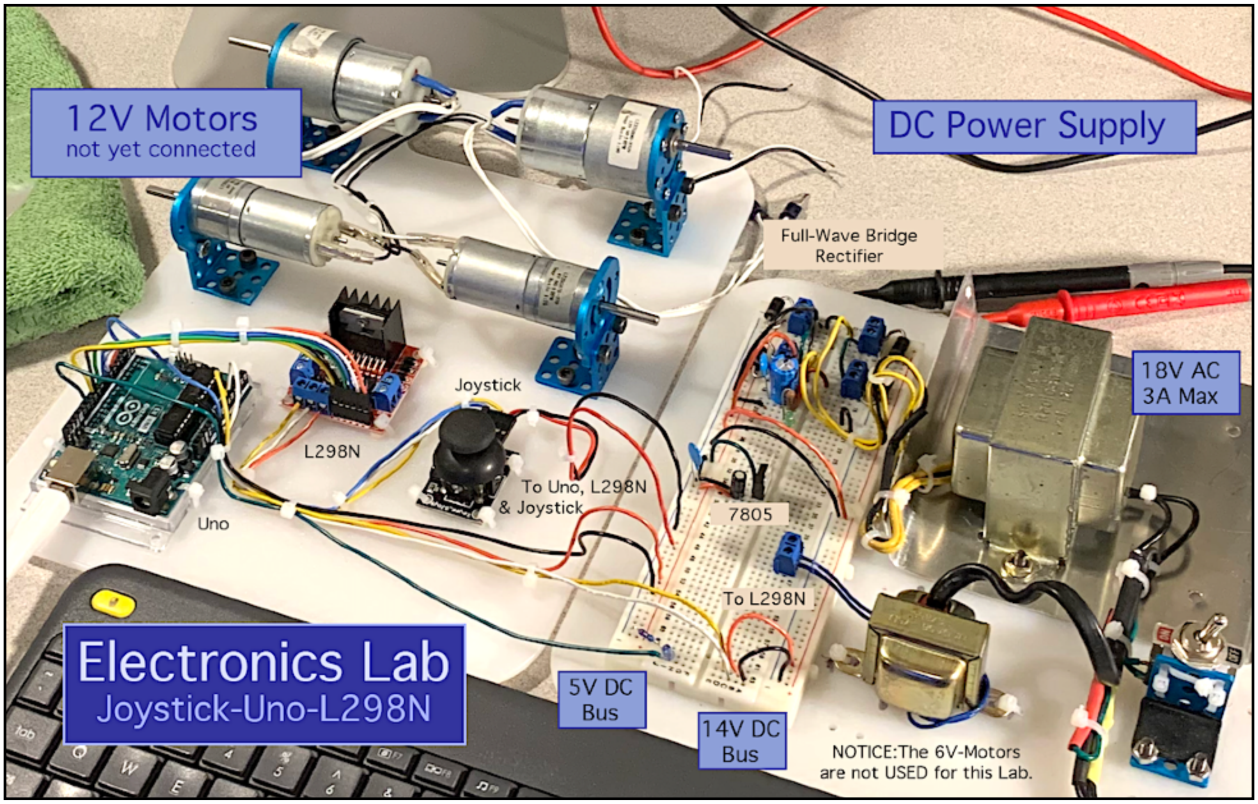
The connections to the L298N shows the Power and the Inputs and Outputs in Image 10. The wiring diagram in Image 12 shows the complete testing circuit with image 13 showing the complete Electronics Lab for the Joystick, Uno and the L298N.

Electronics Lab

In an electronics laboratory, whether at home, at school or at professional lab, safety comes first. Image 12 shows a desktop electronics lab boards. One is the power supply and the other is the study board for the joystick, Uno and the L298N. The board also has 6 volt and 12 volt motors to test while programming the MCU. Study each of the electronic components before assembling the lab boards. Use a Lab Notebook to maintain information needed for each component. With the Lab Notebook, the experiments may finally illustrate a circuit affirmation.

The electronic schematic is shown in Image 13. It was designed knowing how each electrical component operated and how to connect the components. Careful lab notes were taken along the way and afterwards, reviewing the lab notes bore new ideas for the next design. Who knows what the new design will bring.

Image 12



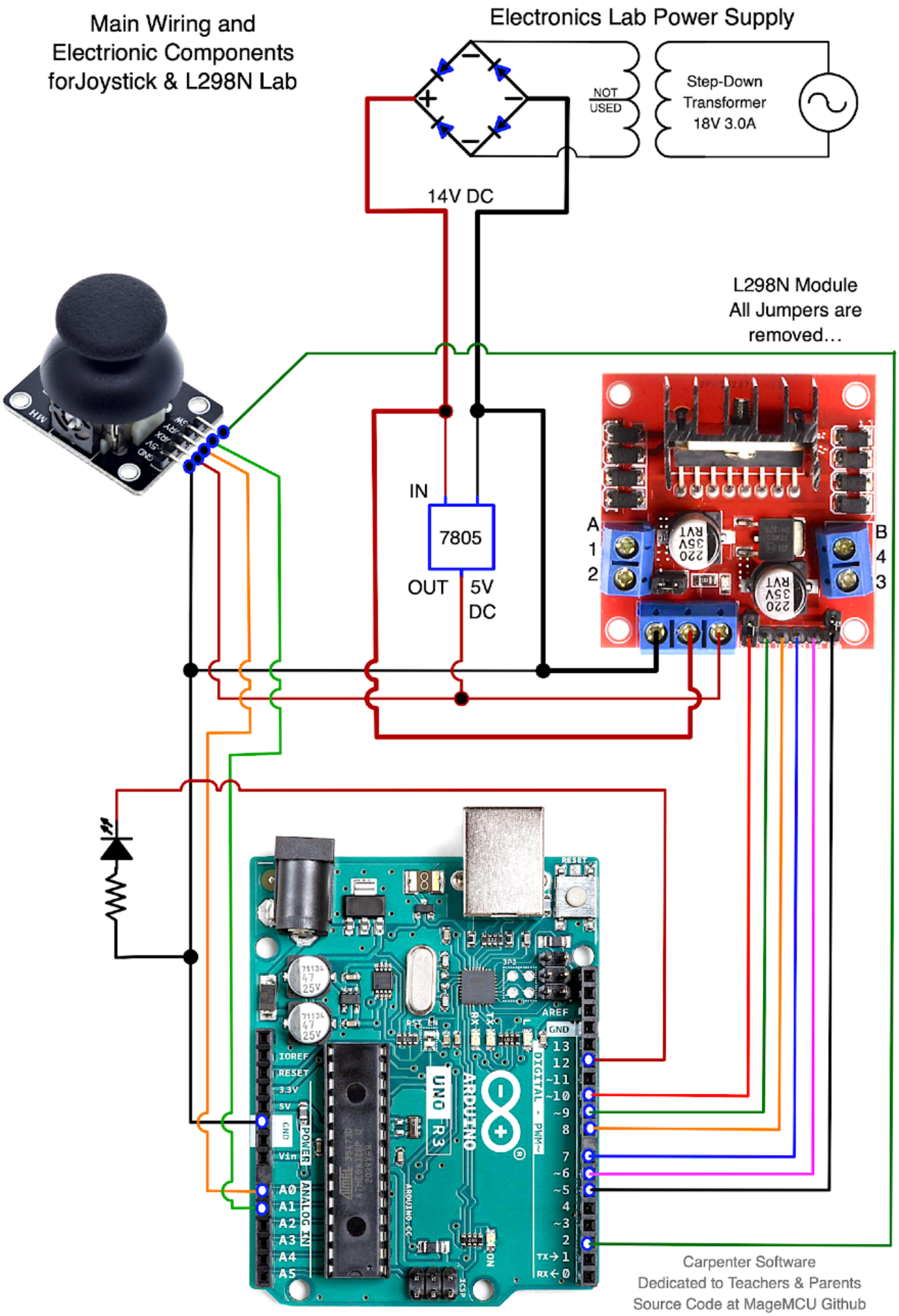
When one compares the lab work with the electronic schematic there should not be any *surprises*. Always double check the wiring connections for correctness.

The real fun begins when programming these devices together. The observations and the behavior as one programs the microcontroller are all recorded in the lab notebook.

Once the main circuit for the overall schematic has been confirmed, it's time to build the robot.

These three main components, the joystick, the microcontroller, Uno, and the L298N motor driver, are enough to get stated in robotics at home. This project could take an entire year to study and to build a robot. Enjoy and have fun.

Image 13


Main Wiring and
Electrionic Components
forJoystick & L298N Lab
Electronics Lab Power Supply
NOT USED
Step-Down
Transformer
18V 3.0A
14V DC
L298N Module
All Jumpers are
removed…
IN
7805
OUT
5V
DC
A
1
2
B
4
3
Carpenter Software
Dedicated to Teachers & Parents
Source Code at MageMCU Github

DISCLAIMER (Carpenter Software & Github)

Any Information, including the Electronic Schematics and the Software (AI_ES_S) is provided as is, without any representation or warranty of any kind, either express or implied, including without limitation any representations or endorsements regarding the use of, the results of, or performance of the AI_ES_S, its appropriateness, accuracy, reliability, or correctness.

The entire risk as to the use of AI_ES_S is assumed by Licensee (MIT).

Carpenter Software LC (AUTHOR) does not assume liability for the use of this AI_ES_S. In no event will the AUTHOR be liable for additional direct or indirect damages including any lost profits, lost savings, or other incidental or consequential damages arising from any mishap, or the use or inability to use these AI_ES_S, even if AUTHOR has been advised of the possibility of such damages.

The MageMCU GitHub account is a living workspace used by the AUTHOR for the AUTHOR and if by consequence the AI_ES_S is used by a Licensee then the Licensee is solely responsible.

Parents and Teachers

Parents and Teachers: This Github Account is restricted to minors. When working with electricity of any kind, they should be directed and instructed by a responsible mentor. A USER (Licensee) must be at least 13 years of age when using GitHub.

Minors (Children) and Teenagers

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

Carpenter Software
revision 20211108 edited…
revision 20210906 Jesse Carpenter