Motors

and how they work

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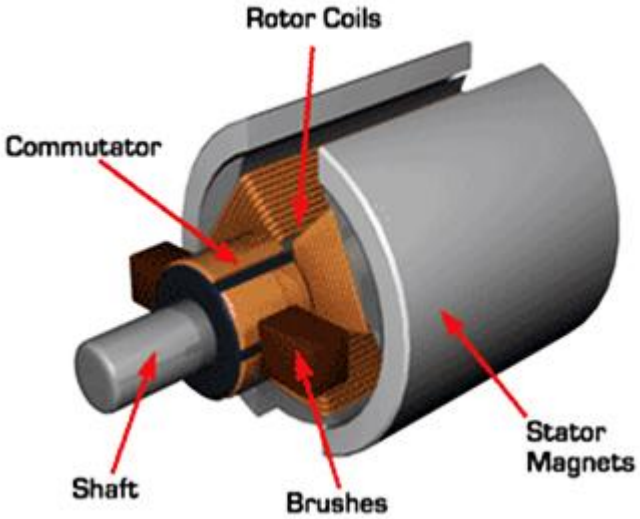
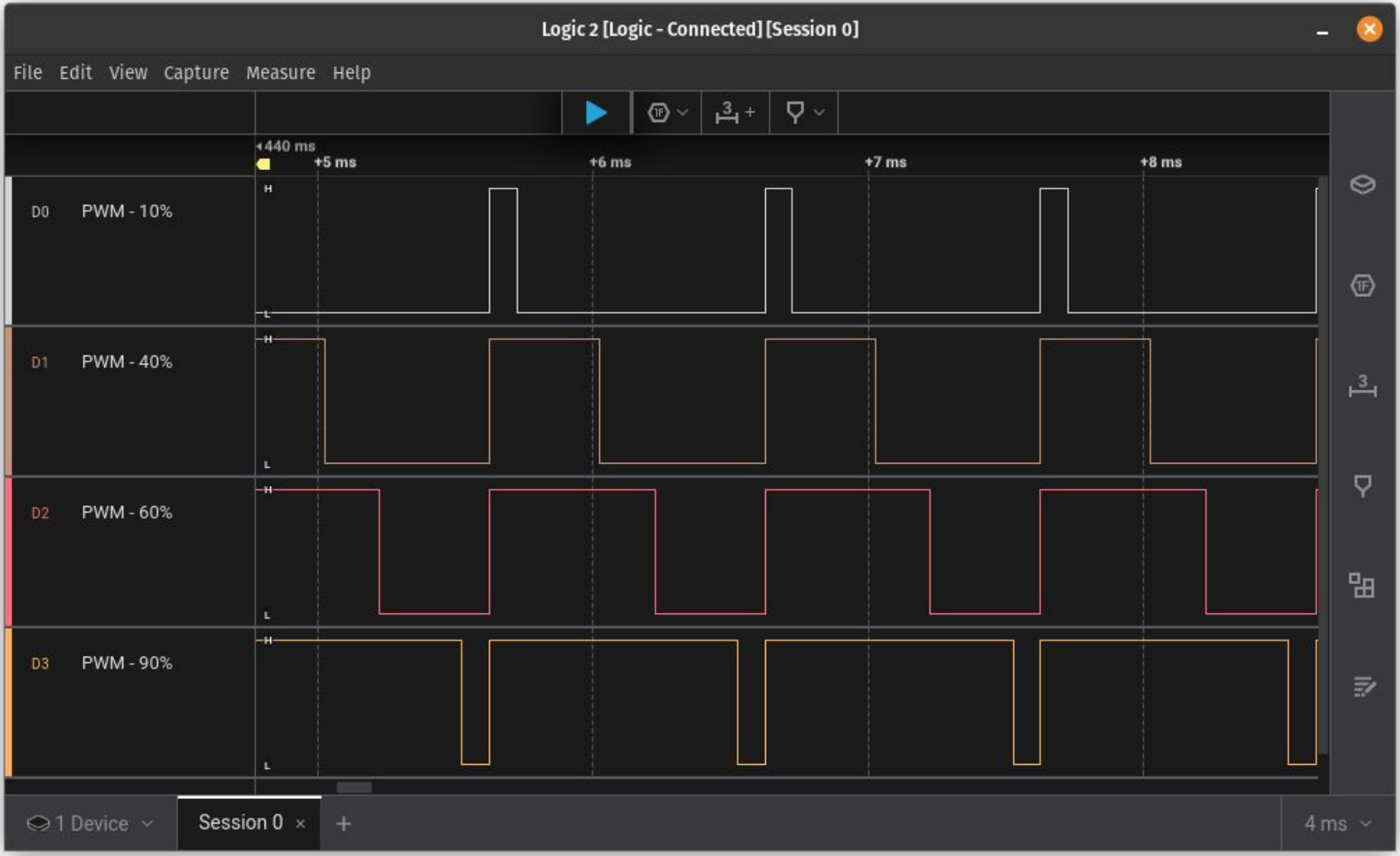
Brushed Motors



Very common

Central core rotates and magnets are fixed to the case. Electrical current through the coil causes a magnetic field which interacts with the fixed magnets. As the core rotates, the brushes switch circuits and cause the core to be magnitized differently. Brushes are often made of carbon and will wear down with use.

Motor speed can be changed by varying the voltage.


Logic 2 [Logic - Connected] [Session 0]
File Edit View Capture Measure Help
440 ms
+5 ms
+6 ms
+7 ms
+8 ms
D0 PWM - 10%
D1 PWM - 40%
D2 PWM - 60%
D3 PWM - 90%
H
L
1 Device
Session 0
4 ms

Brushed Motors

Check your HBridge to determine the max frequency.

Duty cycle of PWM signal will be the percentage of the motor voltage.

Frequencies below 20 kHz often produce an audible whine from the motor.

Brushed Motors

Normally use 1 or 2 PWM signals to drive an H-Bridge.

3 different modes (varies depending on HBridge controller):

Drive/Coast (aka PWM on HBridge Enable line)

Drives motor when PWM high, coasts when low

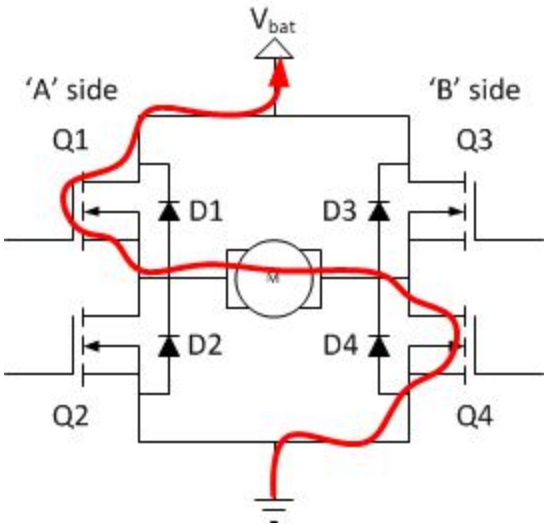
Signed Magnitude:

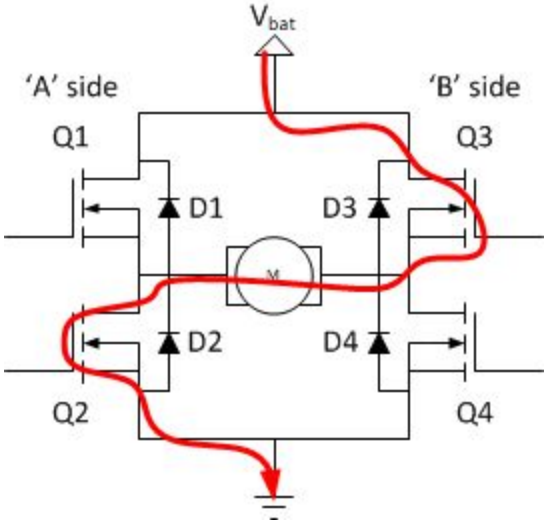
Drives motor when PWM high - brakes when low

Locked AntiPhase:

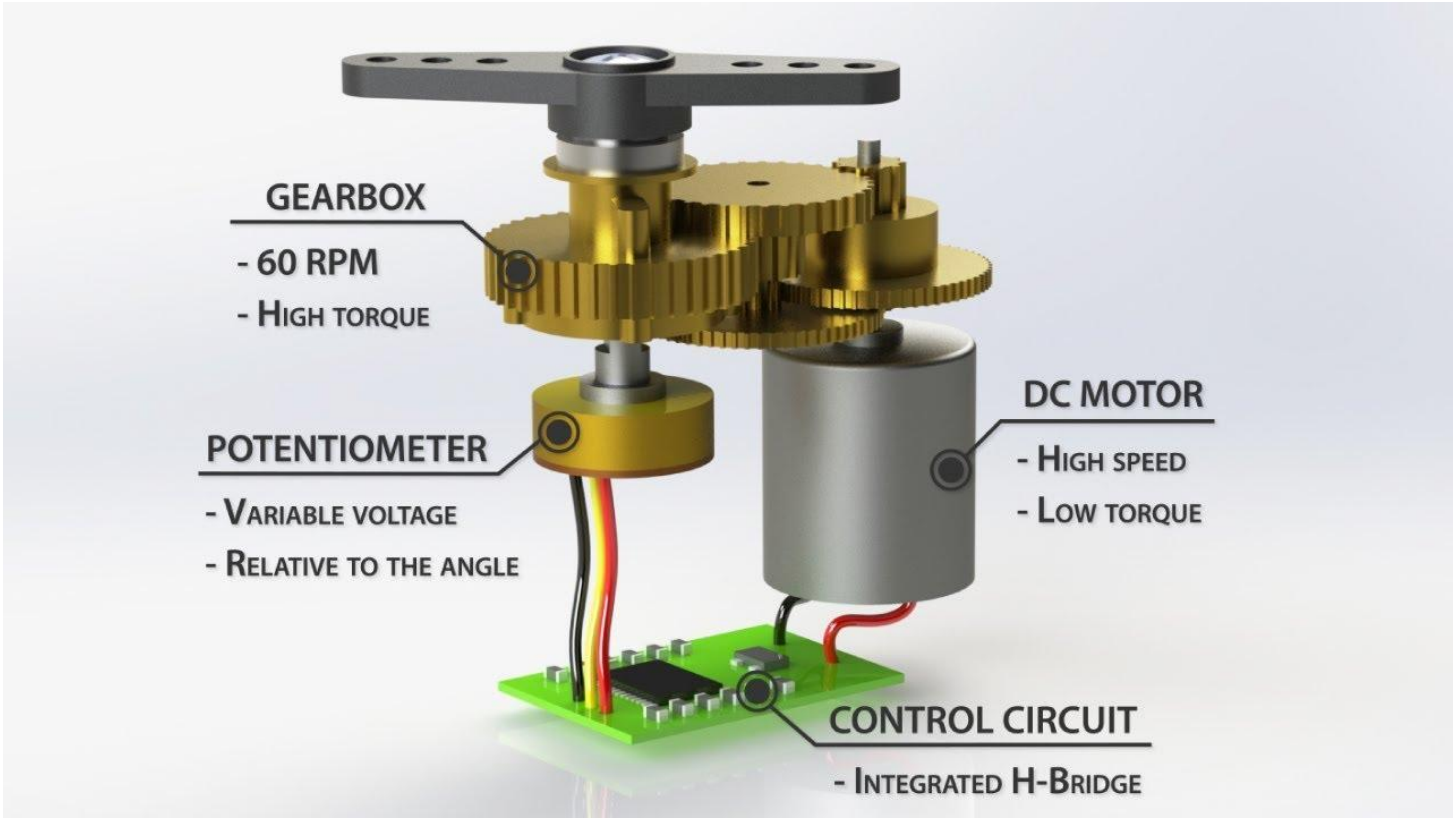
Drives motor one way when high,

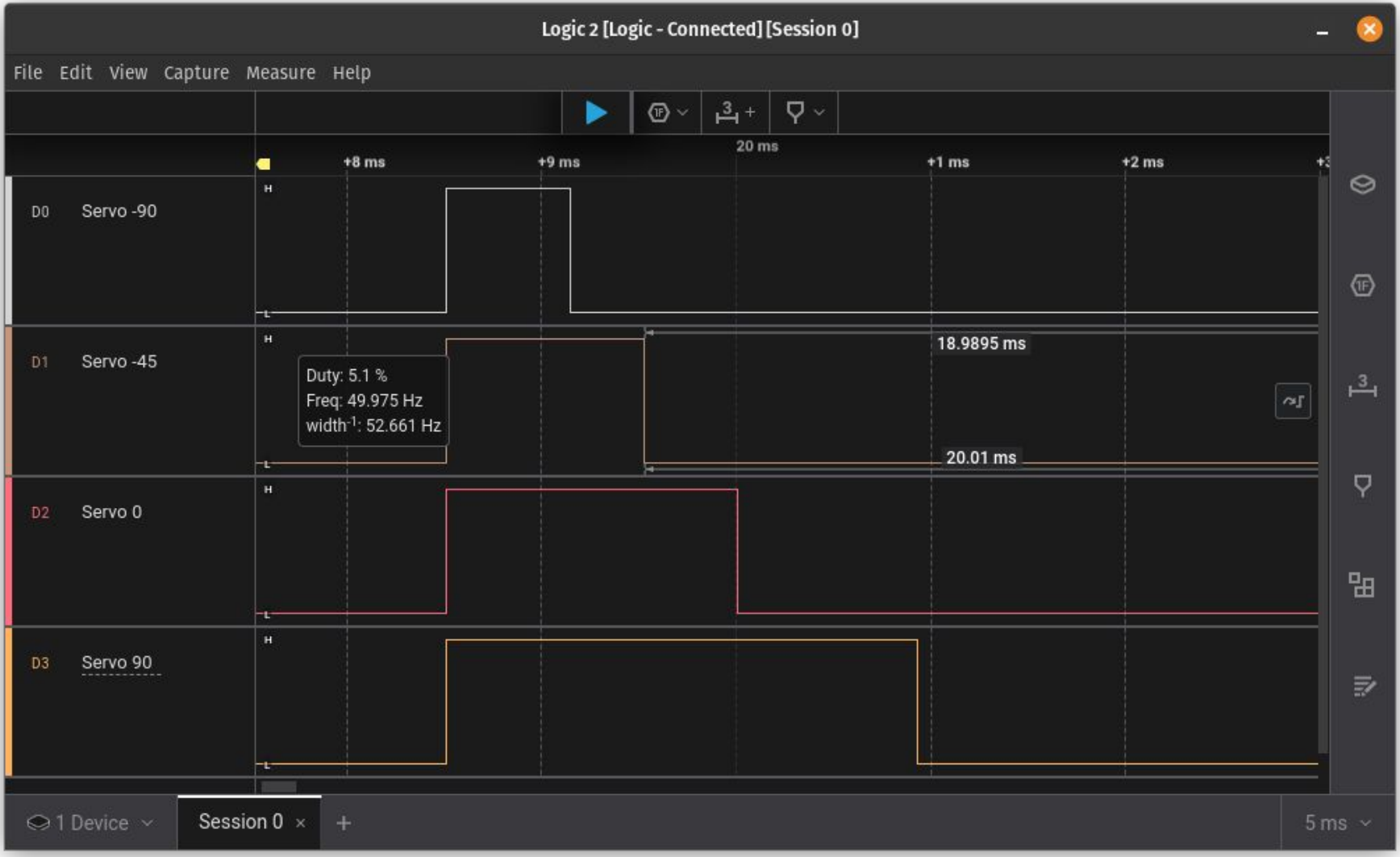
drives the motor the other way when low.

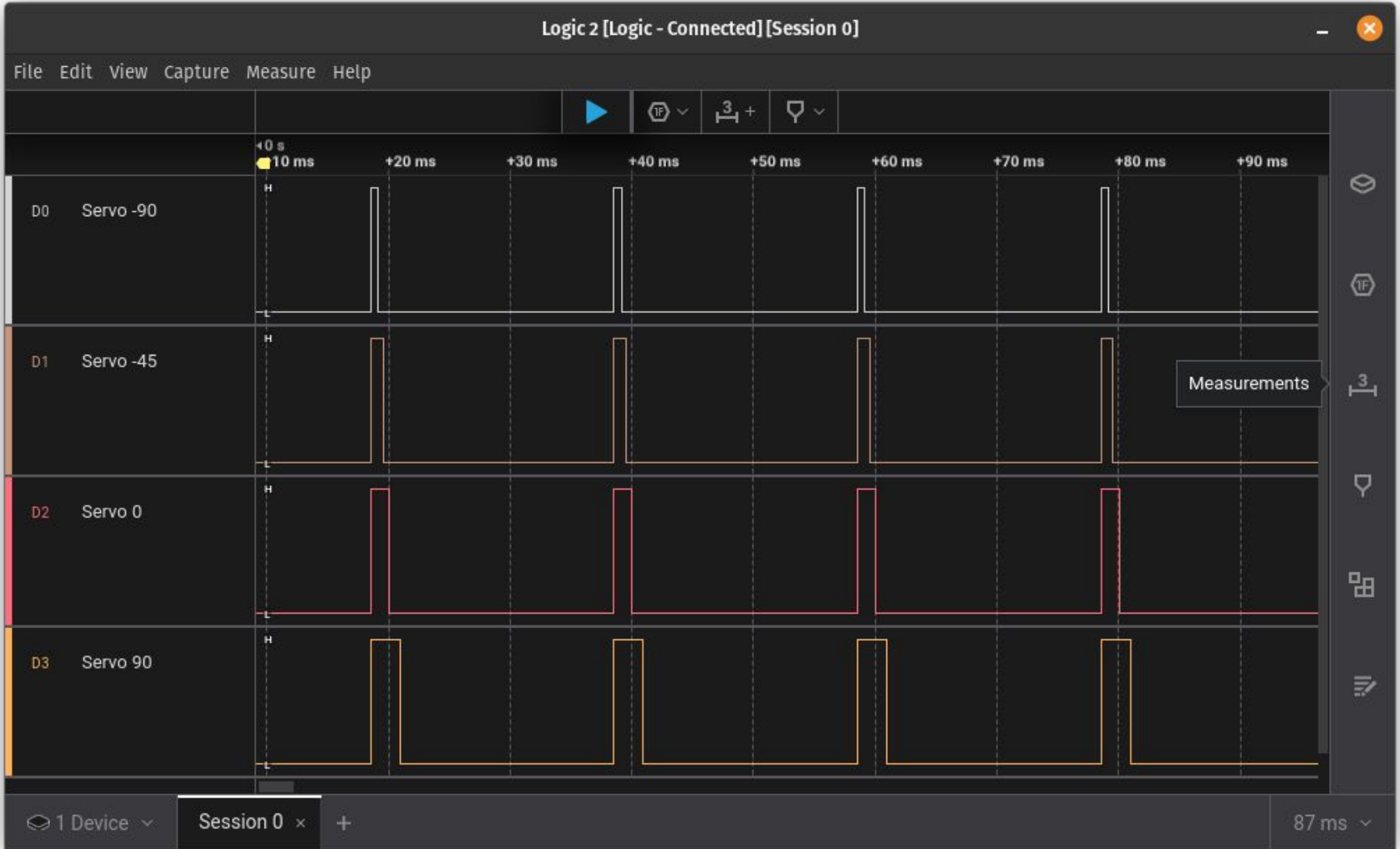




RC Servo Motors




Logic 2 [Logic - Connected] [Session 0]
File Edit View Capture Measure Help
20 ms
+8 ms
+9 ms
+1 ms
+2 ms
D0 Servo -90
D1 Servo -45
Duty: 5.1 %
Freq: 49.975 Hz
width-1: 52.661 Hz
18.9895 ms
20.01 ms
D2 Servo 0
D3 Servo 90
1 Device
Session 0
5 ms


Logic 2 [Logic - Connected] [Session 0]
File Edit View Capture Measure Help
0 s
10 ms
+20 ms
+30 ms
+40 ms
+50 ms
+60 ms
+70 ms
+80 ms
+90 ms
D0 Servo -90
D1 Servo -45
D2 Servo 0
D3 Servo 90
Measurements
1 Device
Session 0
87 ms

RC Servo Control

Pulses nominally 1 millisecond to 2 milliseconds wide. Many servos will go 0.5 msec to 2.5 msec.

Pulses should be sent approx 50-60 Hz

Many servos can be modified for continuous rotation by removing the potentiometer and replacing it with a resistor bridge.

Some people call this PWM, but it’s very limited. If you picked 50 Hz (duty cycle is 20 milliseconds) then 1 msec is 5% and 2 msec is 10% so your PWM has to stay in a very limited range.

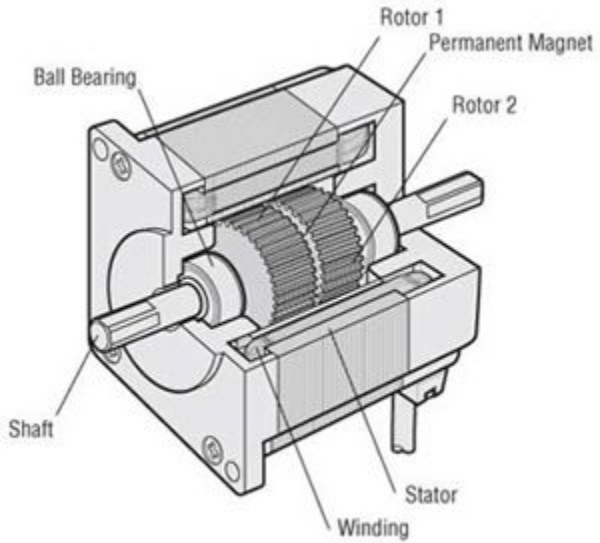
Smart Servo

Smart Servos typically have a microcontroller on the control board and often use serial, CAN, or I2C communication protocols. Can typically control position, speed, torque, etc.

Uses fewer MCU signals - can have multiple servos on a single bus.

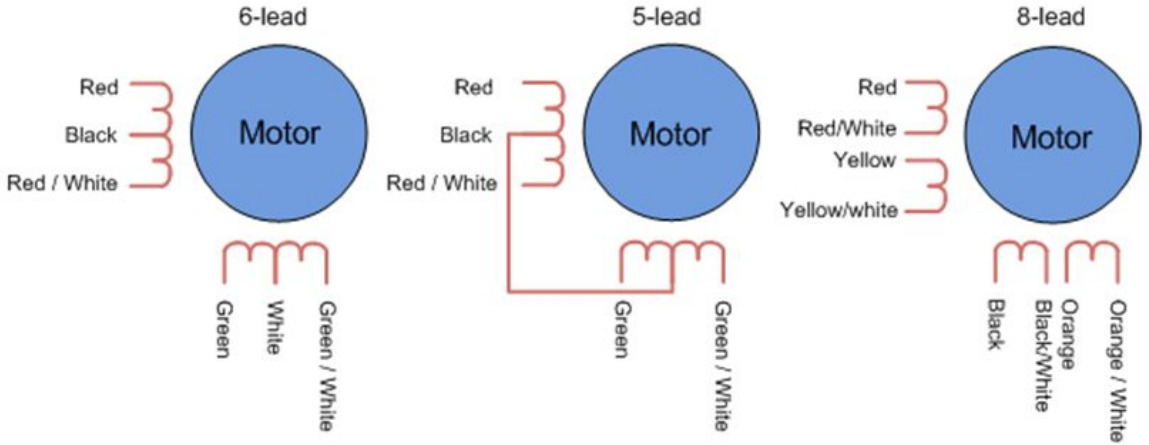
For example: WaveShare Bus Servo or Robotis Dynamixel servos.

Stepper Motors



Motor Structural Diagram: Cross-Section Parallel to Shaft

Stepper motors are a type of brushless motor. They typically have 4, 5, 6 or 8 wires (the 4 wire looks like the 6 wire without the center taps). The 4 & 6 wire configurations are called bipolar. The 5 wire is called unipolar. The eight wire can be wired either way.



Unipolar Stepper Motor

Stepper Motors

You can use a multimeter to identify which wires are connected to a coil, if it isn't documented.

Steppers often have a fairly low voltage rating (3-4v) but are run at much higher voltages (I run mine at 48v). This is accomplished by using a chopper driver which applies the higher voltage but limits the current going through the coil and cuts off the voltage when the current is reached. If you were to measure the voltage across the coils, you'd see that it doesn't exceed the lower voltage (so it's like PWM).

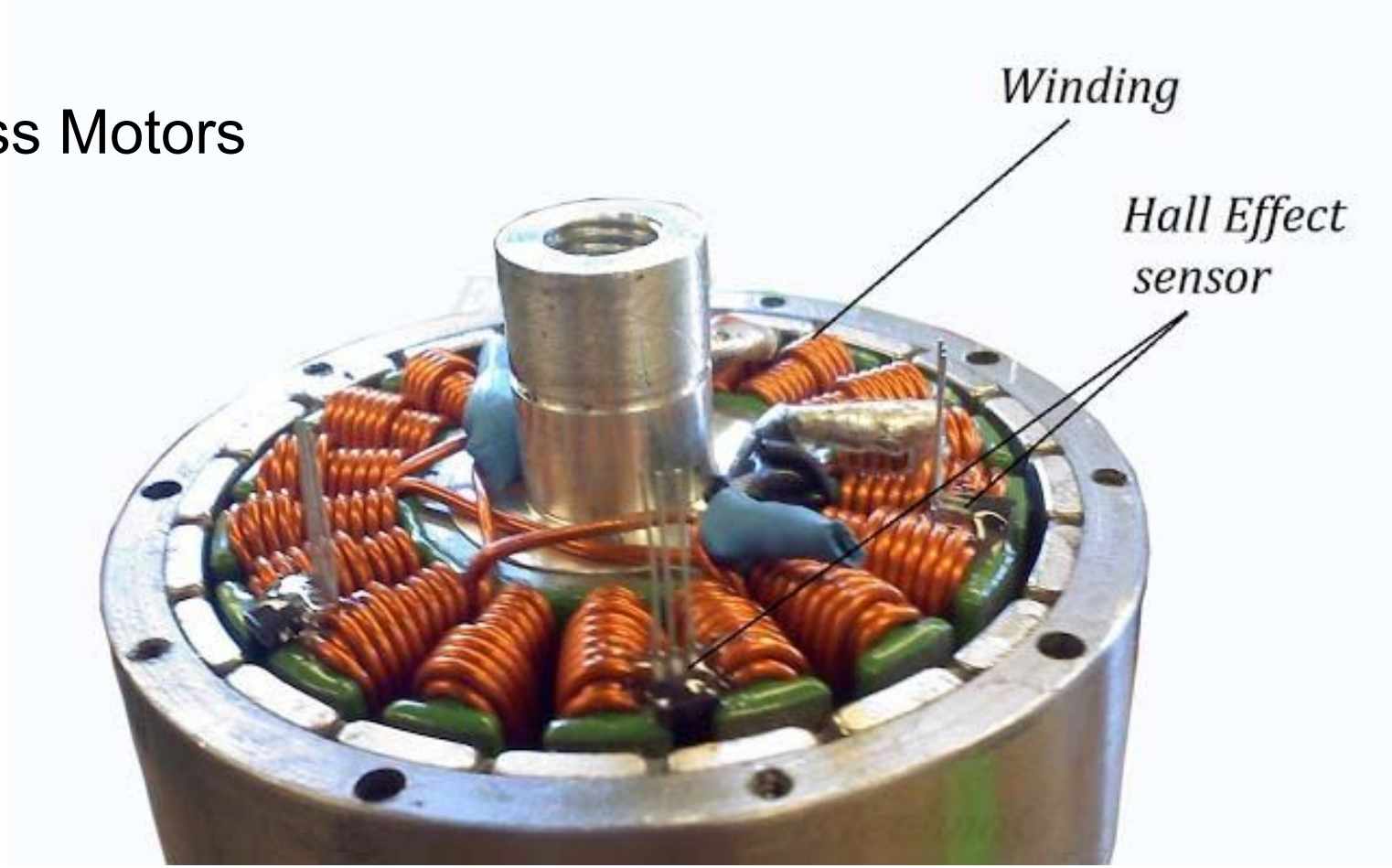
Stepper Motors

Microstepping is a technique of applying voltages to 2 coils simultaneously to move the rotor to a position part way between 2 positions.

This is used primarily to smooth out the motion to prevent harmonics rather than providing additional positional accuracy.

Steppers typically have a harmonic frequency and hitting that frequency will often cause the stepper to stall.

Brushless Motors



Brushless Motors

Have non-rotating coils.

Rotating portion can be inside coils (inrunner) or outside coils (outrunner).

Typically have 3 coils.

Typically use specialized controller boards.

Control circuitry will depend on the controller board. Some use RC-Servo stye control. Some have serial, CAN, etc interfaces (like the ODrive).

Brushless Motors