Electronic and electromechanical prototyping

Introduction - Motors

Corso LM 'Materiali Intelligenti e Biomimetici' – Prof. A. Ahluwalia
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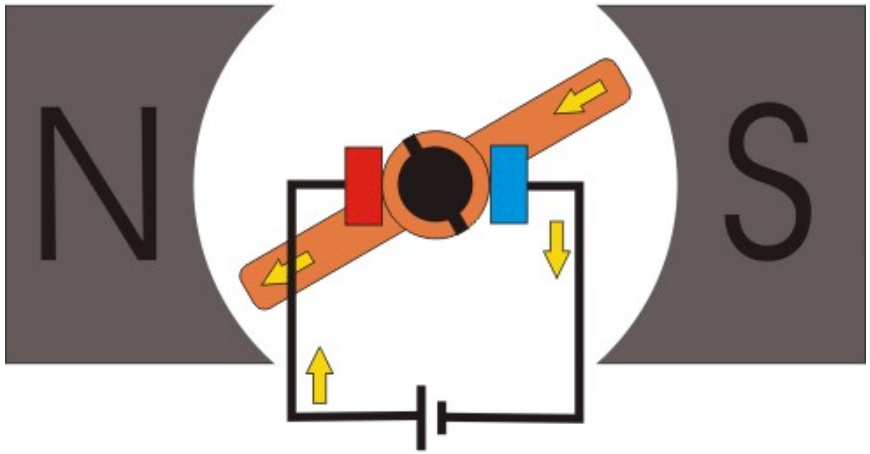
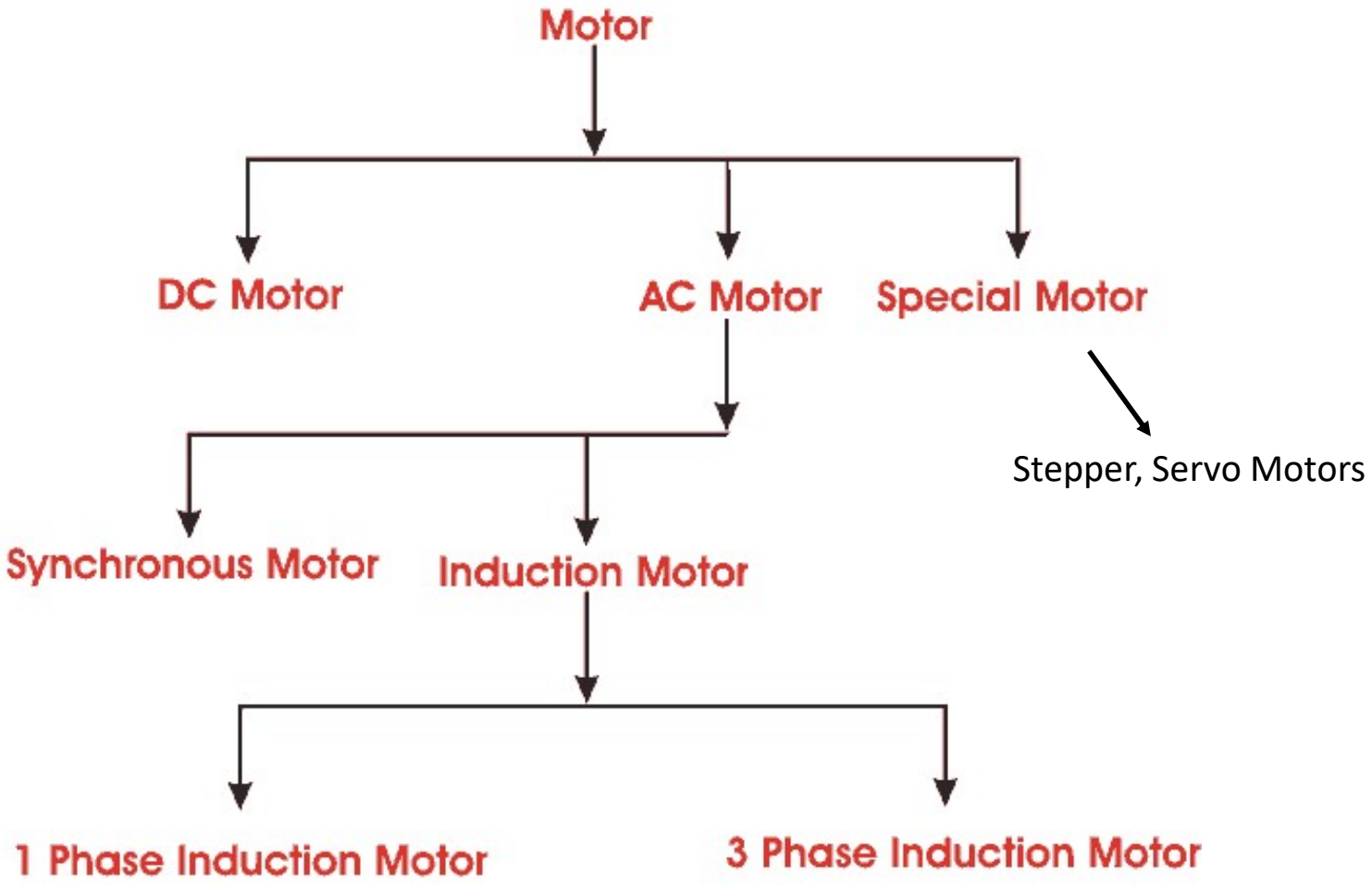
Motors

A motor is an **electro-mechanical device** that **converts electrical energy to mechanical energy**.

The very basic principal of functioning of an electrical motor lies on the fact *that force is experienced in the direction perpendicular to magnetic field and the current*, when field and current are made to interact with each other.

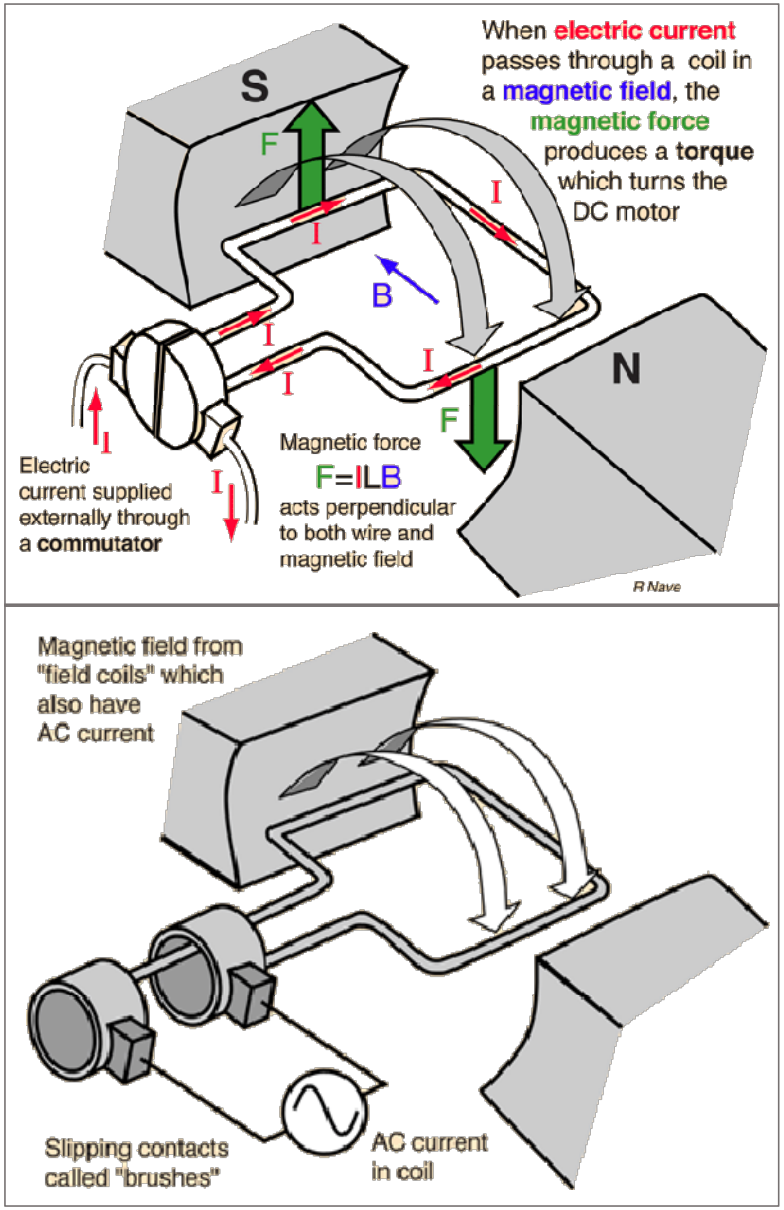



Motor
DC Motor
AC Motor
Special Motor
Stepper, Servo Motors
Synchronous Motor
Induction Motor
1 Phase Induction Motor
3 Phase Induction Motor

Types of Motors

The DC motor as the name suggests, is the only one that is driven by **direct current**.
It's the most primitive version of the electric motor where **rotating torque is produced due to flow of current through the conductor inside a magnetic field**.

AC motors are driven by **alternating current.**
Here the rotor **is magnetically locked with stator rotating magnetic field and rotates with it**.
The speed of these machines are varied by varying the frequency (f) and number of poles (P).



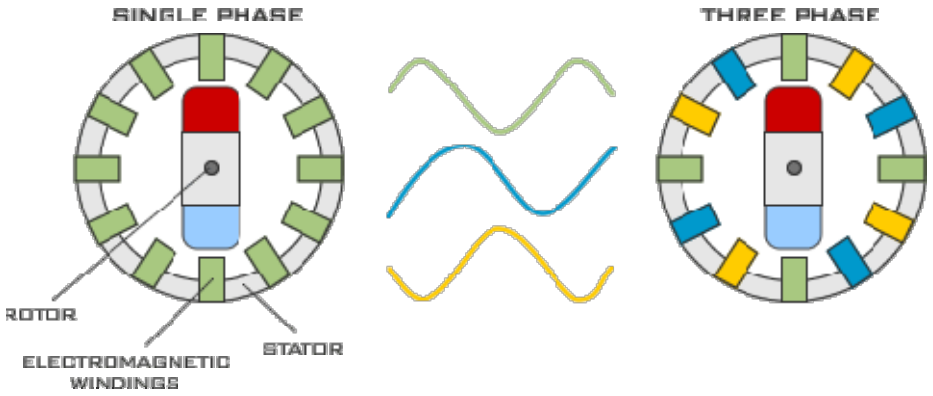
Types of AC Motors

The synchronous motor always runs at **synchronous speed (Ns)**, which is the speed of rotation of the magnetic field.
The speed of the rotor of this motor is same as the rotating magnetic field.
(p =num. of poles, f= supply frequency)

$$N_s = \frac{120f}{p}$$

The induction motor (asynchronous motor) runs at a speed lesser than synchronous speed, because the rotating magnetic field that is produced in the stator will generate a current flux in the rotor which will make the rotor to rotate. The **rotating speed (s)** is governed by varying the slip which gives the difference between **synchronous speed (N_s)** and **rotor speed (N_r)**.

$$s = \frac{N_s - N_r}{N_s}$$

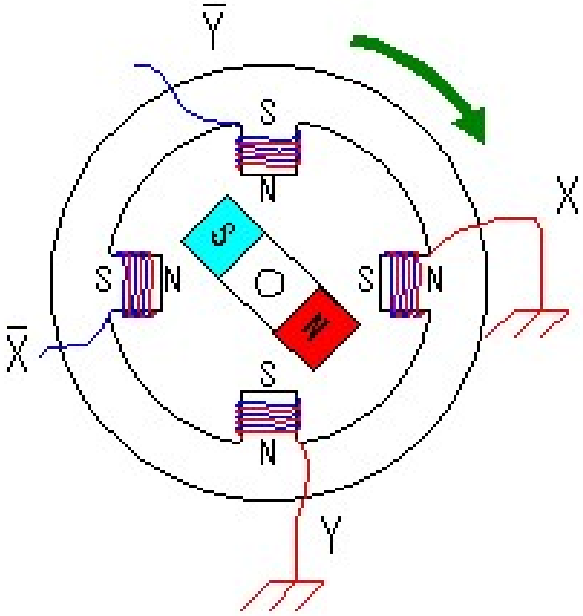


Stepper

A stepper motor is a **type of DC motor that rotates in steps**.
When electrical signal is applied to it, the motor rotates in steps:

- The **speed of rotation** depends on the *rate at which the electrical signals are applied*;
- The **direction of rotation** is dependent on the *pattern of pulses* that is followed.

A stepper motor is made up of a **rotor**, which is normally a *permanent magnet*. A **stator** is another part which is in the form of *winding*.
The magnetic property of the stator changes and it will selectively attract and repel the rotor, thereby resulting in a stepping motion for the motor.
In order to get correct motion of the motor, a **stepping sequence** has to be followed. This stepping sequence gives the *voltage that must be applied to the stator phase*.
Normally a 4 step sequence is followed. When the sequence is followed from step 1 to 4, we get a **clock wise rotation** and when it is followed from step 4 to 1, we get a **counter clockwise rotation**.

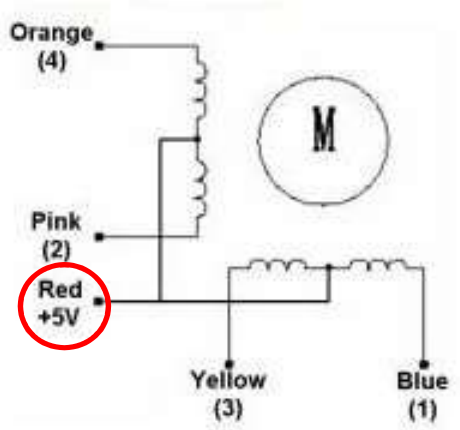


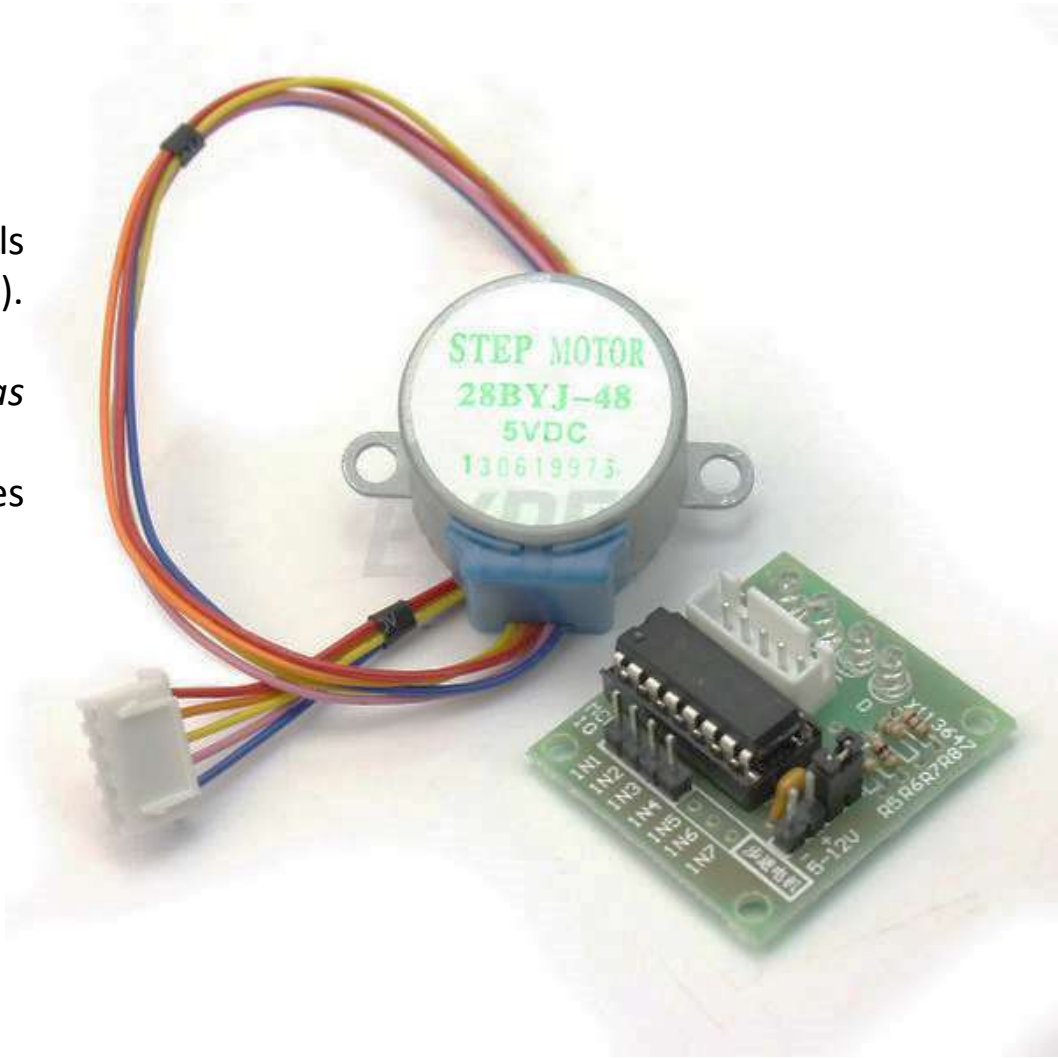
X	$\overline{X}$	Y	$\overline{Y}$
0	1	0	1
1	0	0	1
1	0	1	0
0	1	1	0

Stepper: 28BYJ-48

28-BYJ48 is an **Unipolar Stepper Motor**
The unipolar stepper motor has five or six wires and four coils (actually two coils divided by center connections on each coil).

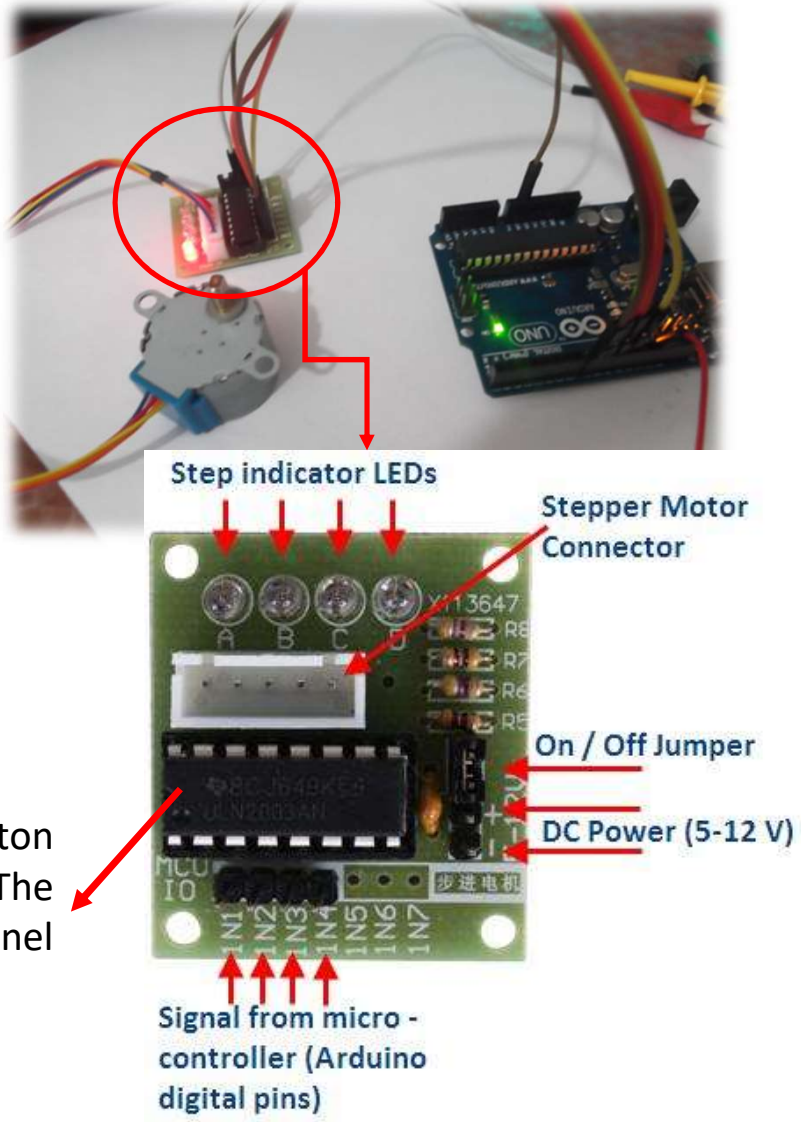
The center connections of the coils are tied together and used as the power connection.
They are called unipolar steppers because power always comes in on this one pole.





Stepper - Driver

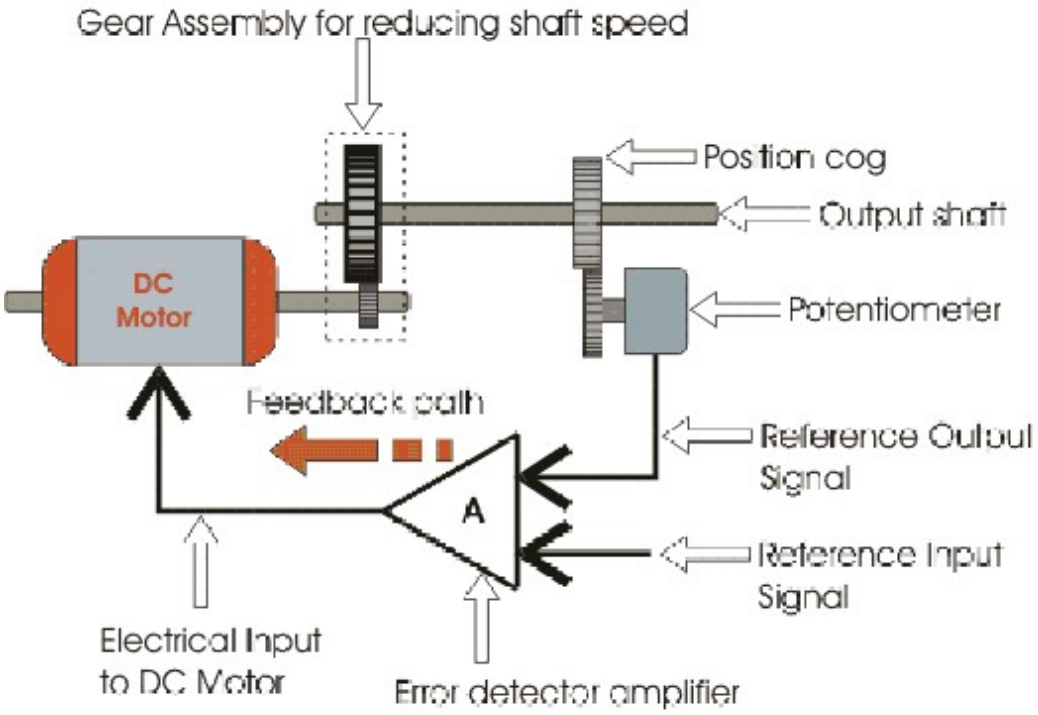
A stepper motor driver is a **circuit which is used to drive a stepper motor**.
Driver IC's (i.e. chip) are available at reasonable costs and are easier to implement in terms of assembling. The *drivers must be selected to suit the motor ratings in terms of current and voltages*.
A stepper motor may run at voltages varying from 5 V to 12 V and similarly the current draw will be somewhere in the range of 100 mA to 400 mA.



The ULN2003A contains seven darlington transistor drivers all in one package. The *ULN2003A can pass up to 500 mA* per channel and has an internal voltage drop of about 1V.

Types of Motor 4 - Servo

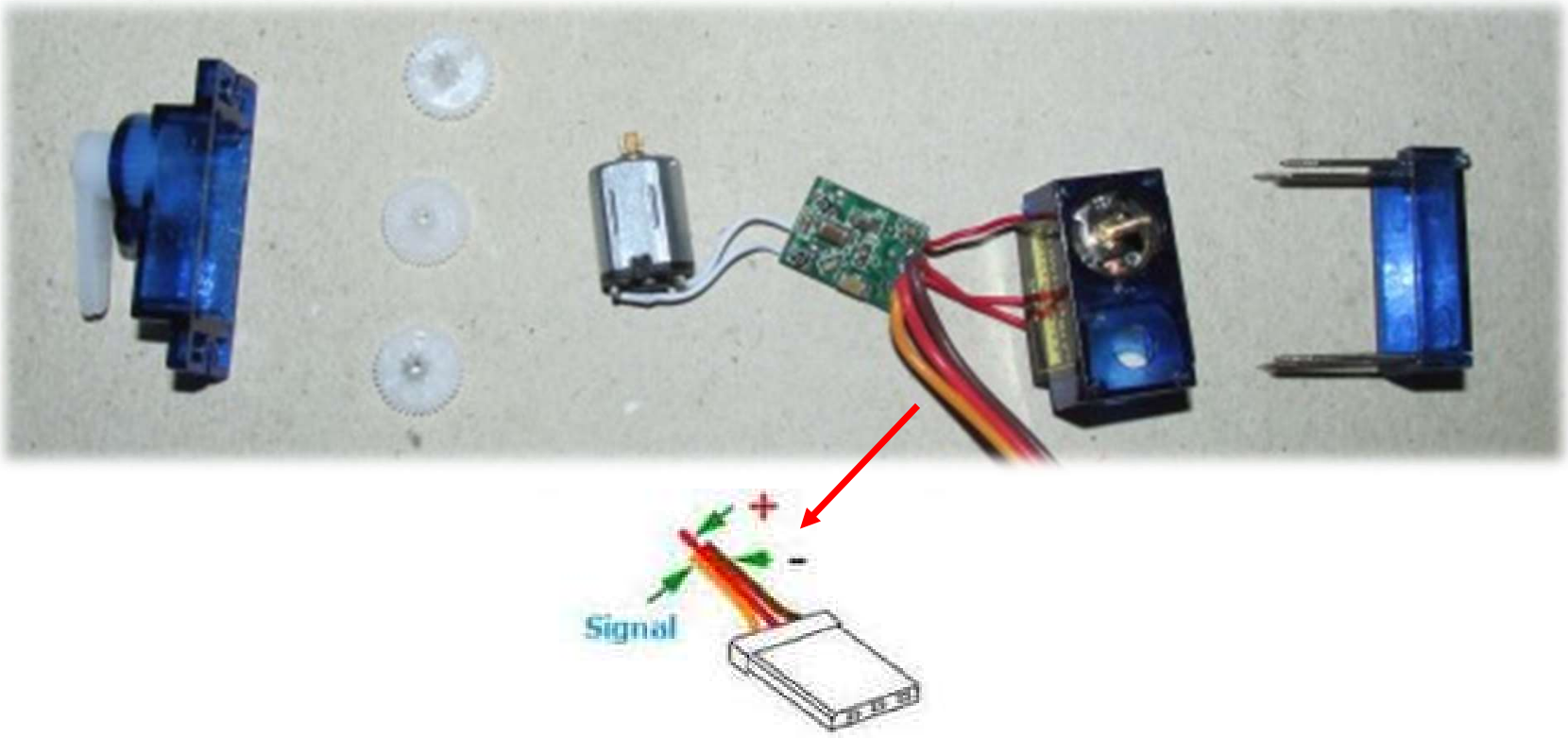
A servo system mainly consists of a **small DC motor**, a **potentiometer**, **gear arrangement** and a **feedback system.**



- The device is controlled by a <u>feedback</u> signal generated by comparing output signal and reference input signal. Hence, the primary task of a servomechanism is to **maintain the output of a system at the desired value** in the presence of disturbances.
- *During rotation of the shaft, the knob of the <u>potentiometer</u> also rotates* and creates an **varying electrical potential that is taken to the error detector feedback amplifier** along with the input reference commands i.e. input signal voltage.
- The <u>gear mechanism</u> is used to **step down the high rpm of the motor shaft to low rpm at the output shaft** of the servo system (small DC motor will rotate with high speed but the torque generated by its rotation will not be enough to move even a light load).

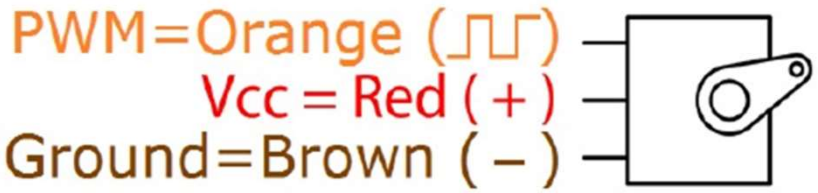
Servo: 2G90

The Tower Pro SG90 servo is one of the cheapest servo motors that you can find on the market. (Even if it is cheap, don’t try to rotate the servo motor by hand because this may damage the motor!!)

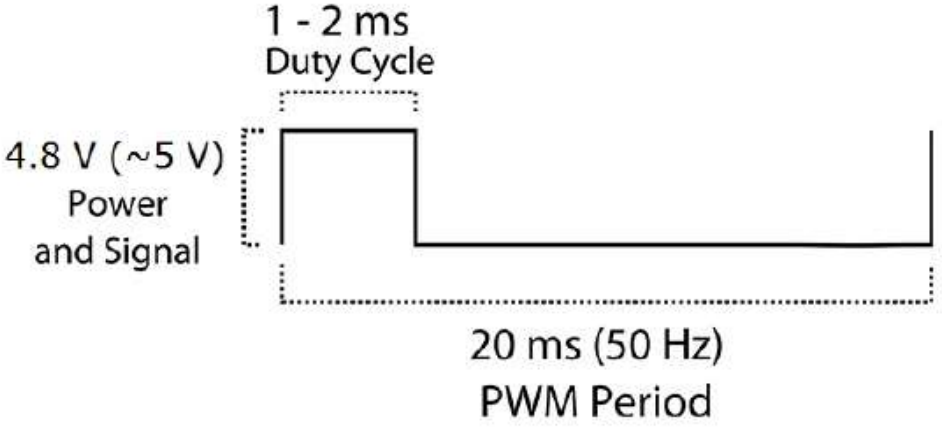


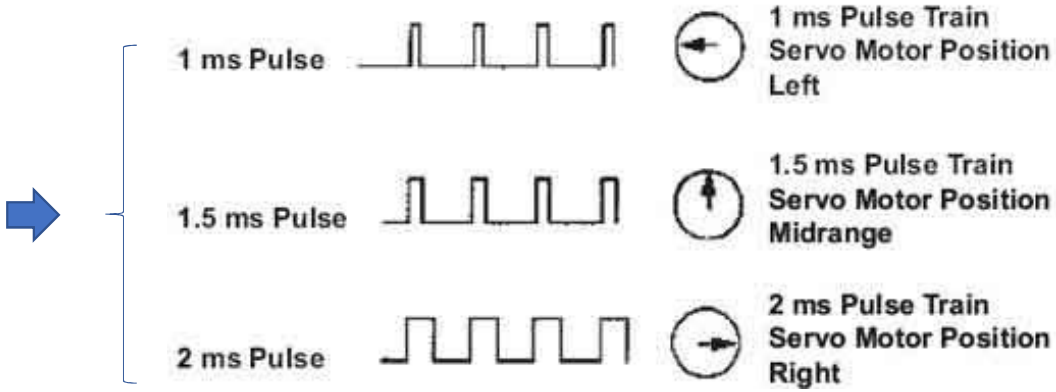
Servo Motor - Control

The servo motor has three terminals.
1. Position signal (PWM Pulses)
2. V_{cc} (From Power Supply)
3. Ground



The **servo motor angular position is controlled by applying PWM** (Pulse Width Modulation) **pulses** of specific width.
The *duration* of pulse varies from about 1 ms for 0 degree rotation to 2 ms for 180 degree rotation.
The pulses need to be given at *frequencies* of about 50Hz to 60Hz.





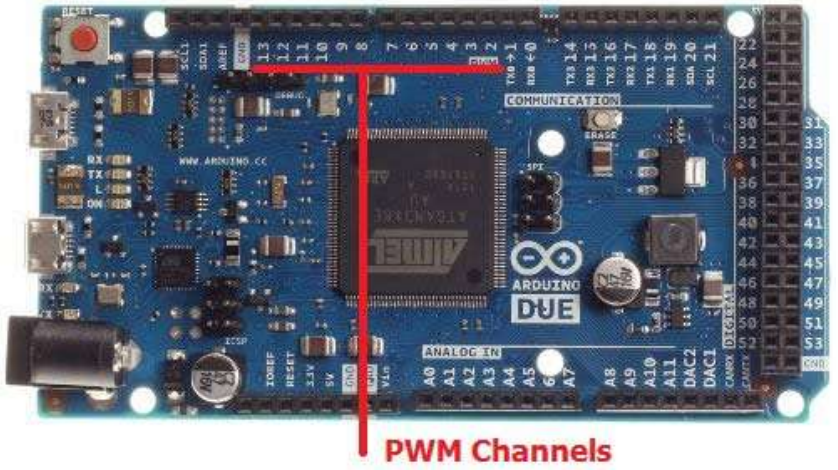
PWM with Arduino Due

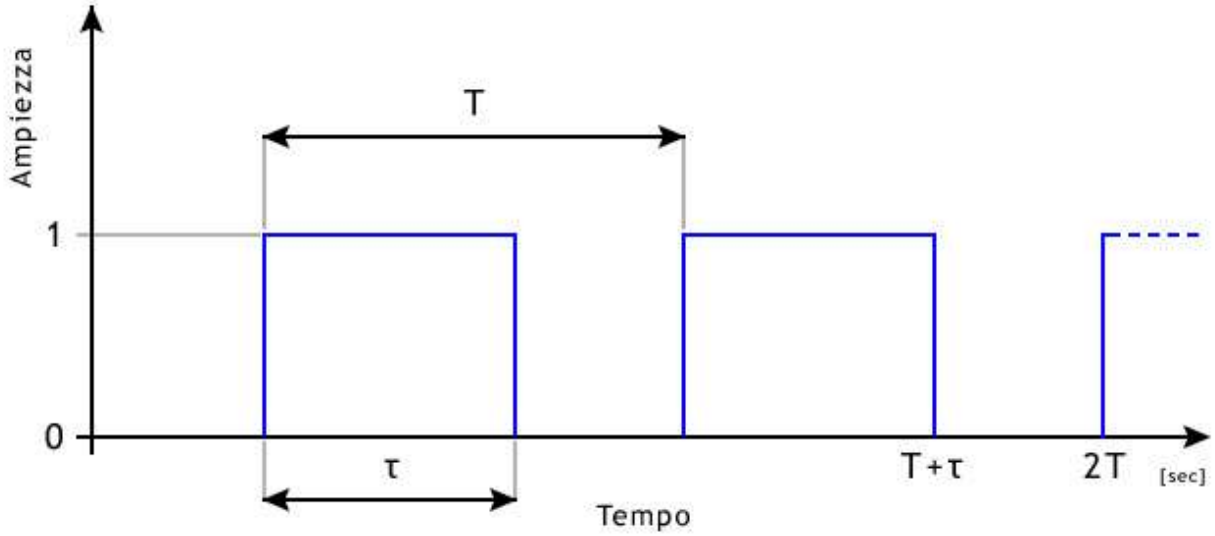
There are **12 PWM Channels** (Pin 2 to Pin 13)

pinMode(pin, OUTPUT)
analogWrite(pin, value)

d

The default PWM resolution is to 8-bit, which can be changed to 12-bit resolution using the *analogWriteResolution()* function.





Duty cicle: $d = \frac{\tau}{T}$

Stepper vs. Servo Motor

Both the stepper motor and servo motor are used primarily in **position control applications,** but there lies a difference in their working and construction.

- In the stepper motor, the position is controlled thanks to the *magnetic attraction of the rotor with the magnetized coil of the stator*. In a servo motor the *position is controlled by the specialized circuit and the feedback mechanism*, which generates an error signal to move the motor shaft.

- Servos are usually limited to a **0-180 degree** range, while a stepper motor can **rotate continuously.**

References

- https://www.electrical4u.com/electrical-motor-types-classification-and-history-of-motor/
- http://www.instructables.com/id/BYJ48-Stepper-Motor/