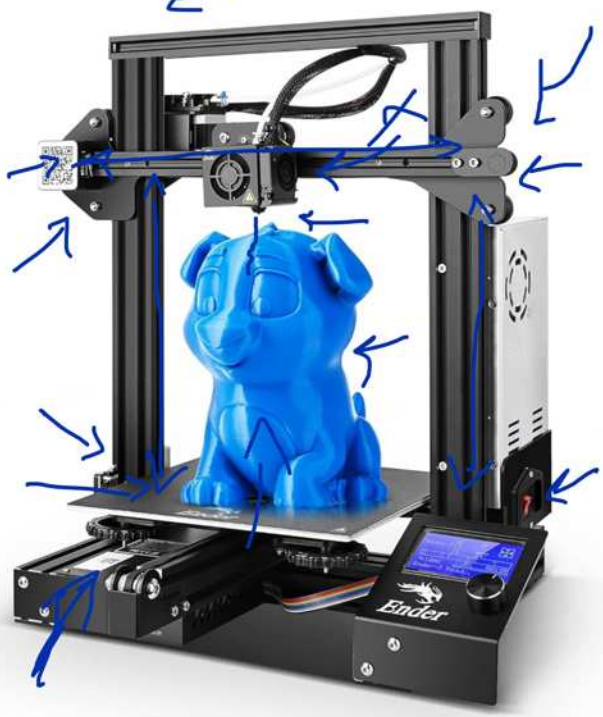
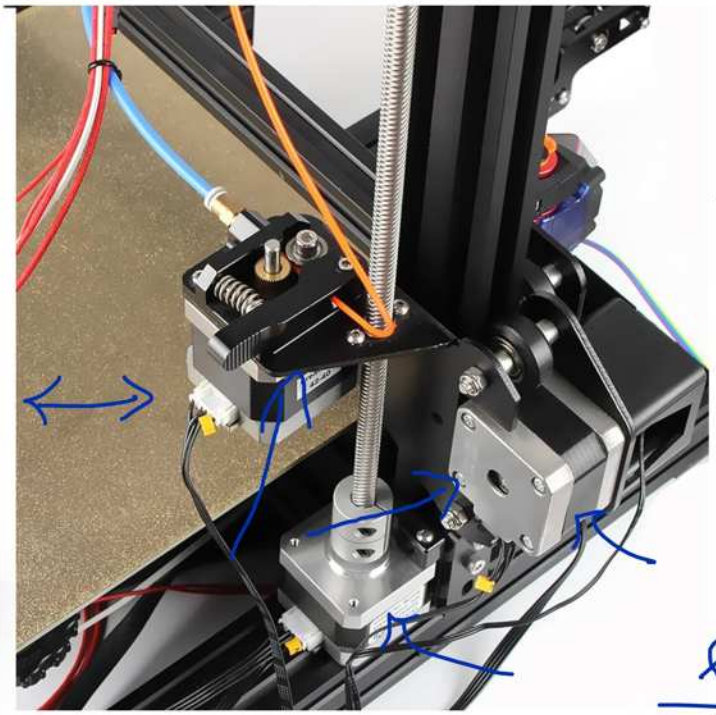
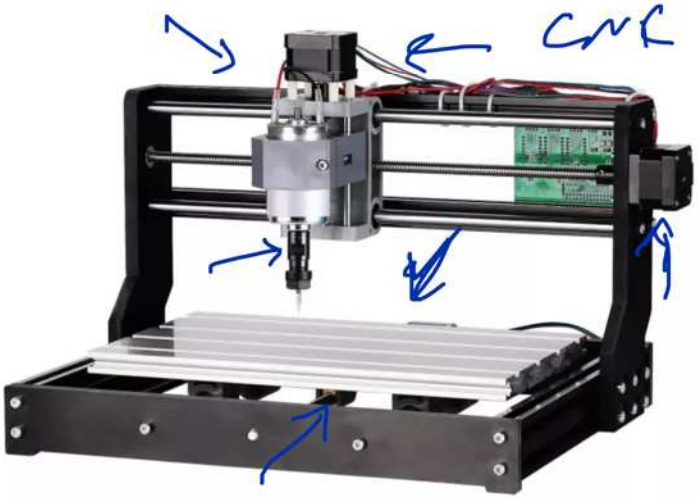
1
20°
4 ~ 8



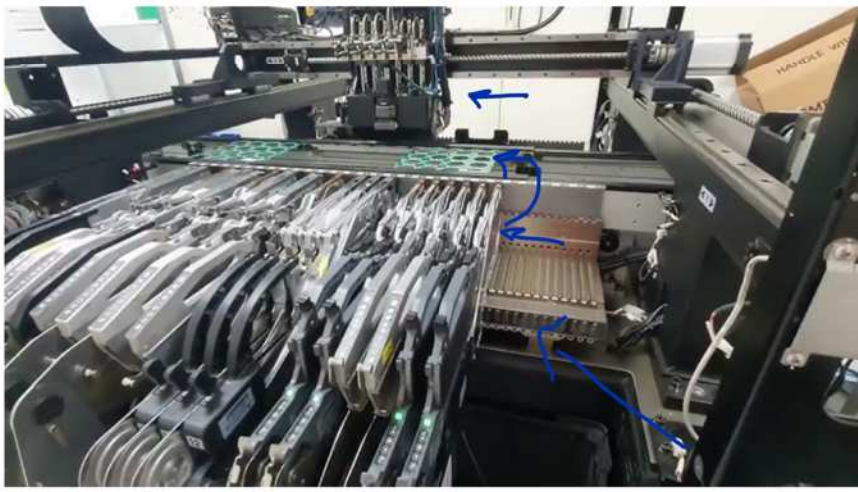


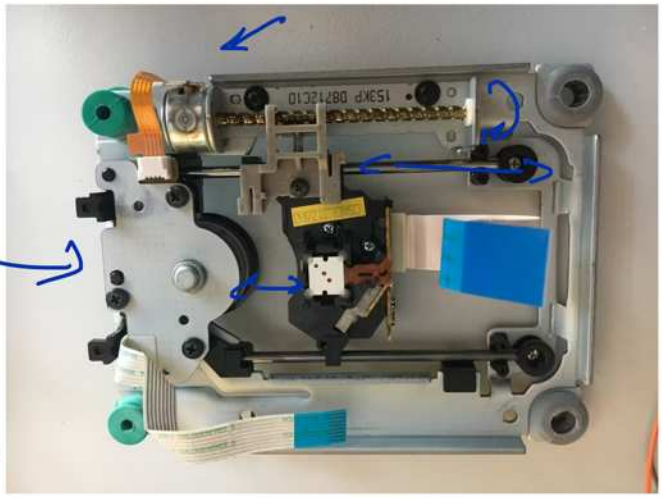
3D
Printer

X Y Z

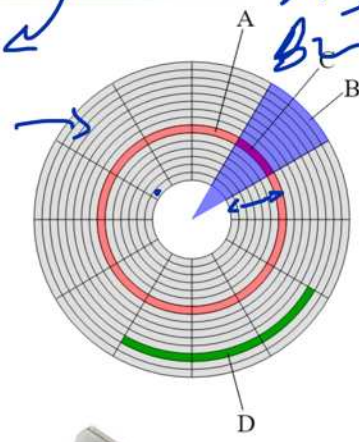


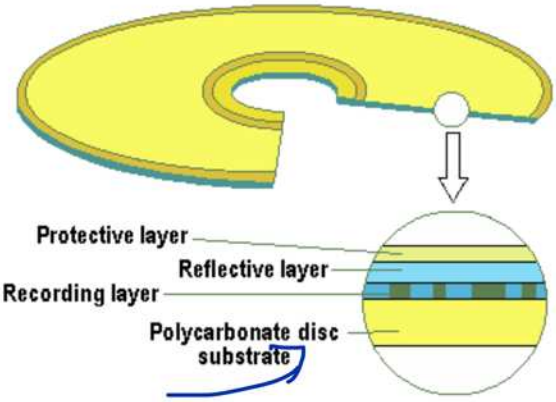
CNC

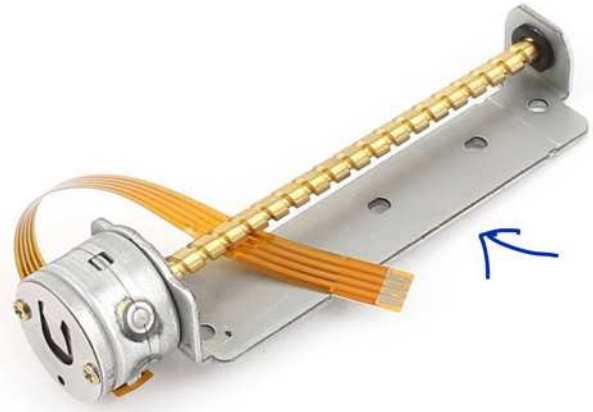


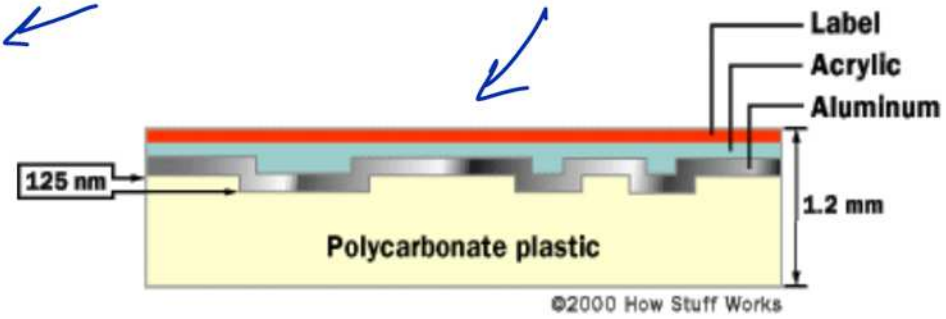


CD
DVD
Bl

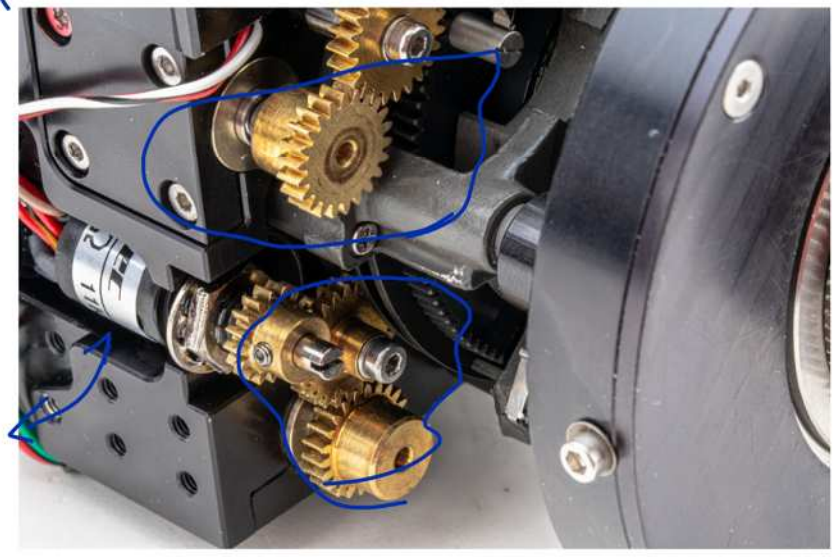








DSLR



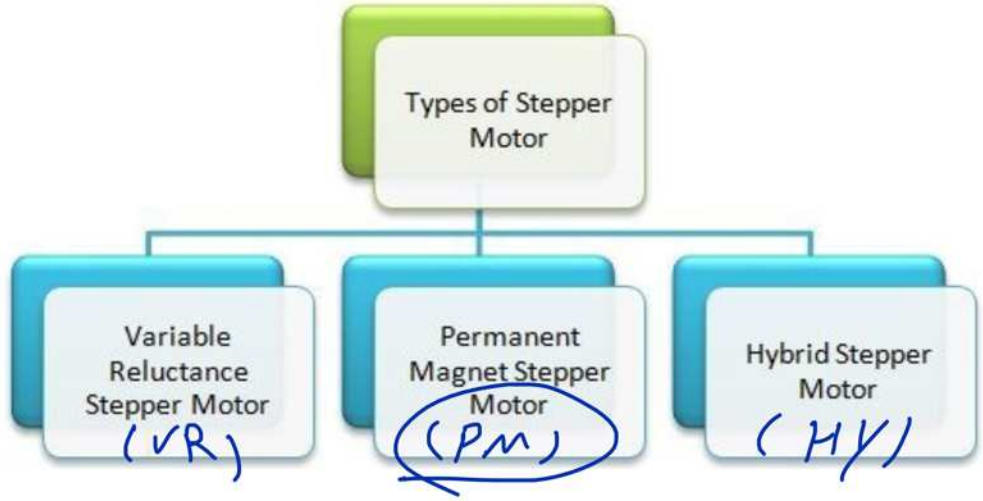
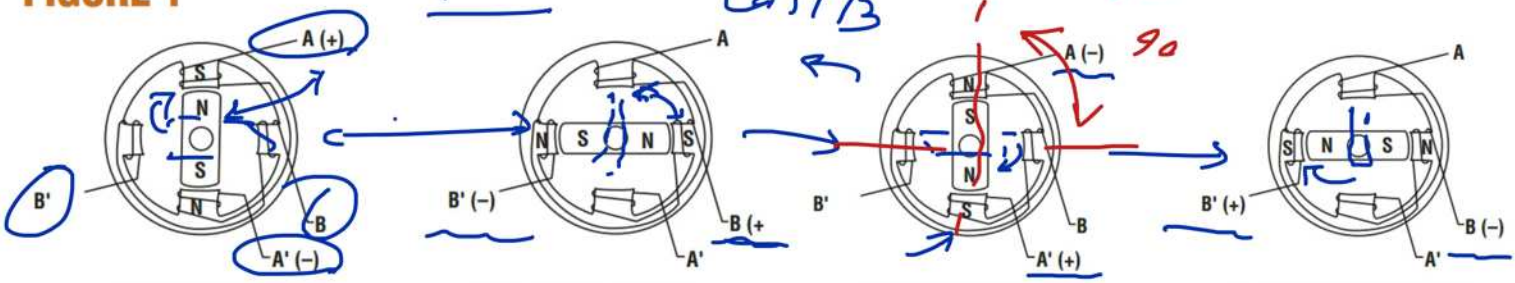


FIGURE 1

PM

Coil A
Coil B

$\frac{360}{90} = 4$

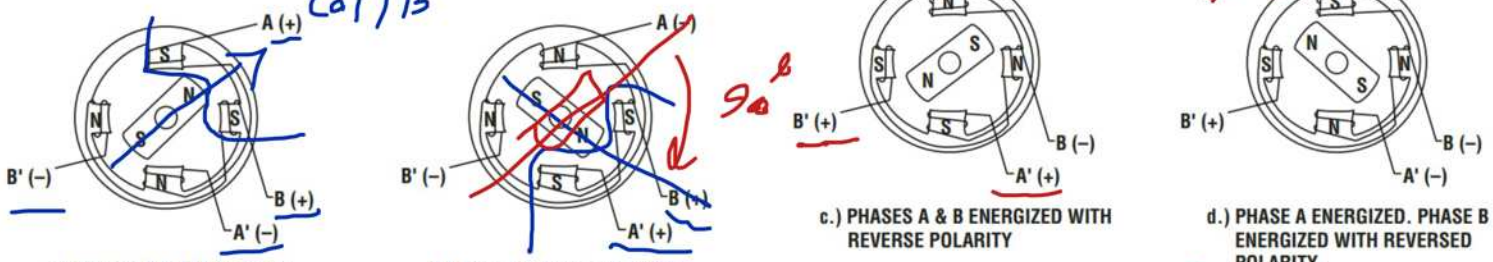


Wave - full step

Torque

FIGURE 2

Coil A
Coil B



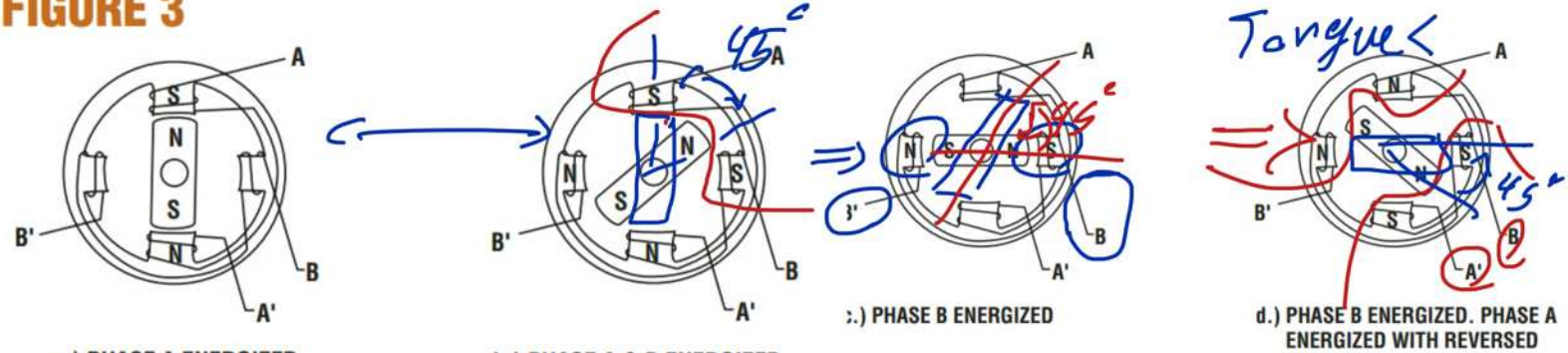
Torque

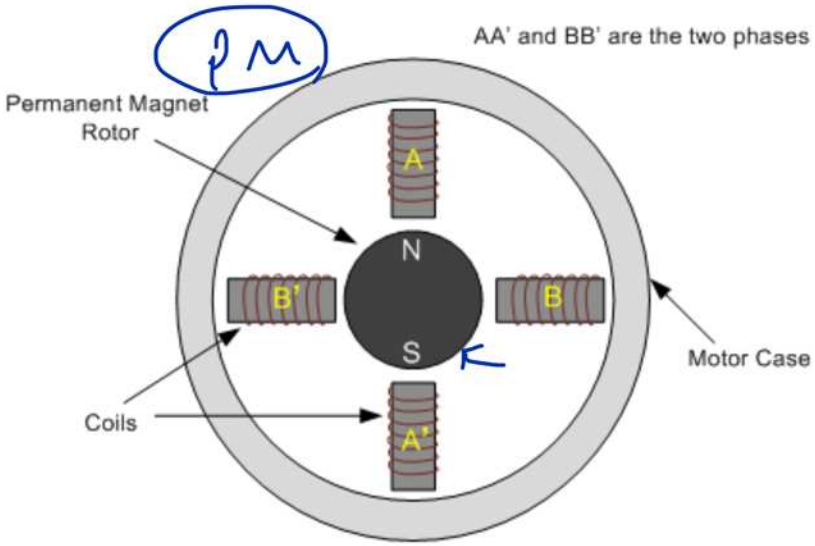
$\frac{360}{90} = 4$ full step

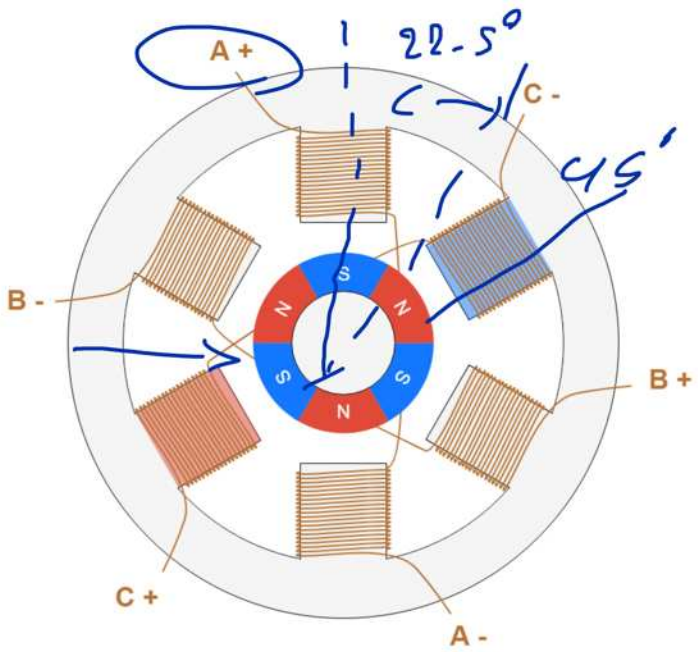
90 → 45

Half step 45°

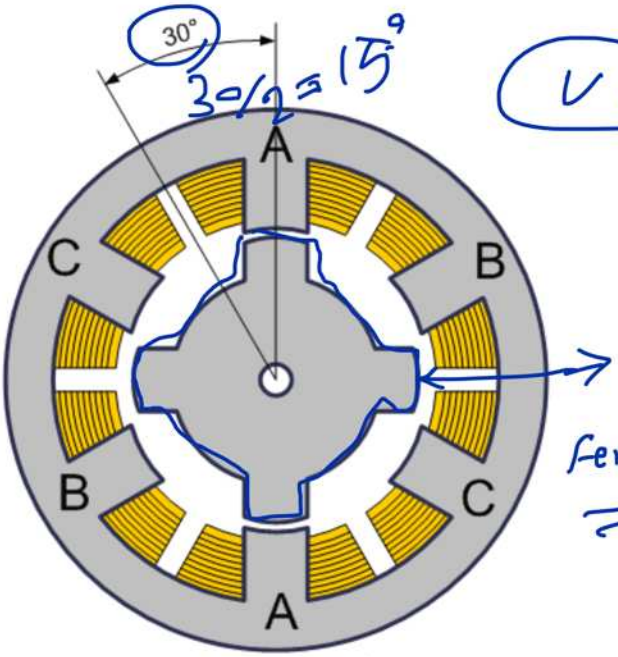
FIGURE 3

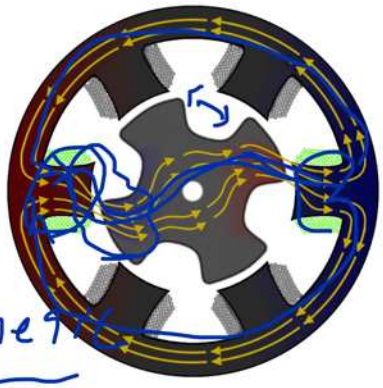


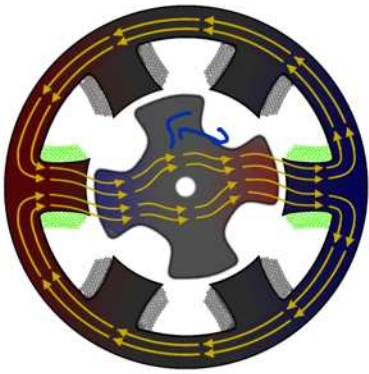




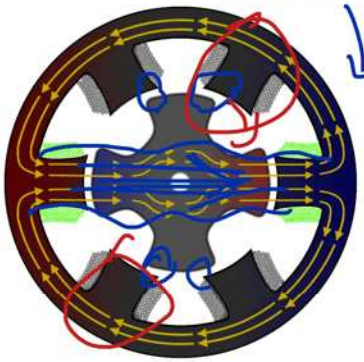
Two-Phase Permanent Magnet type Stepper

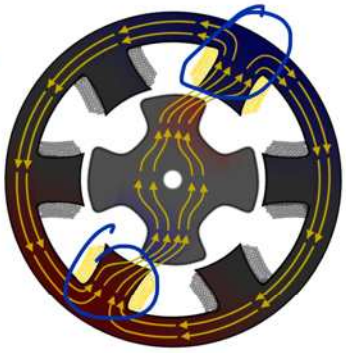


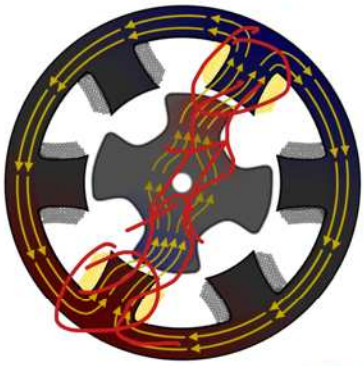


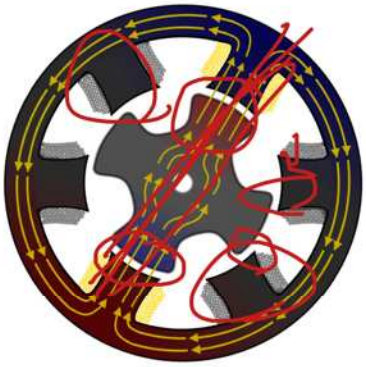


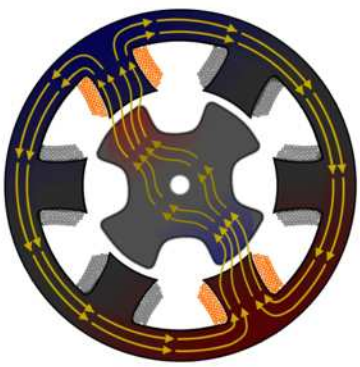
ferromagnetic

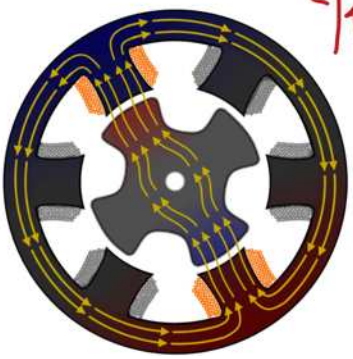


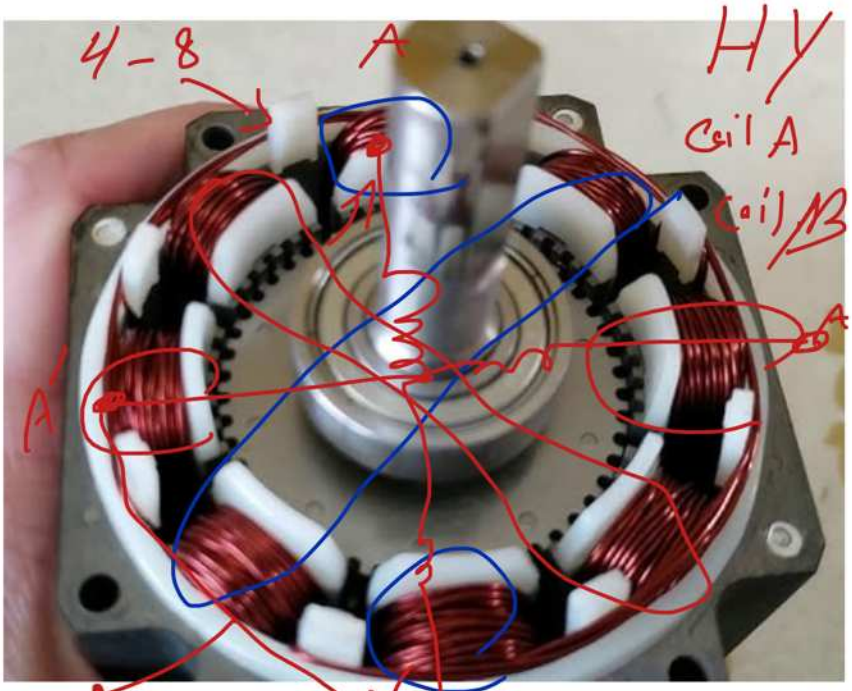


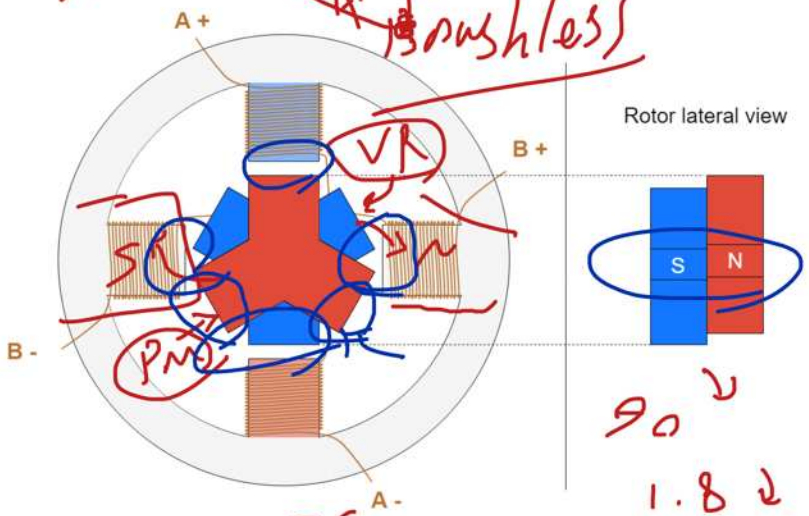


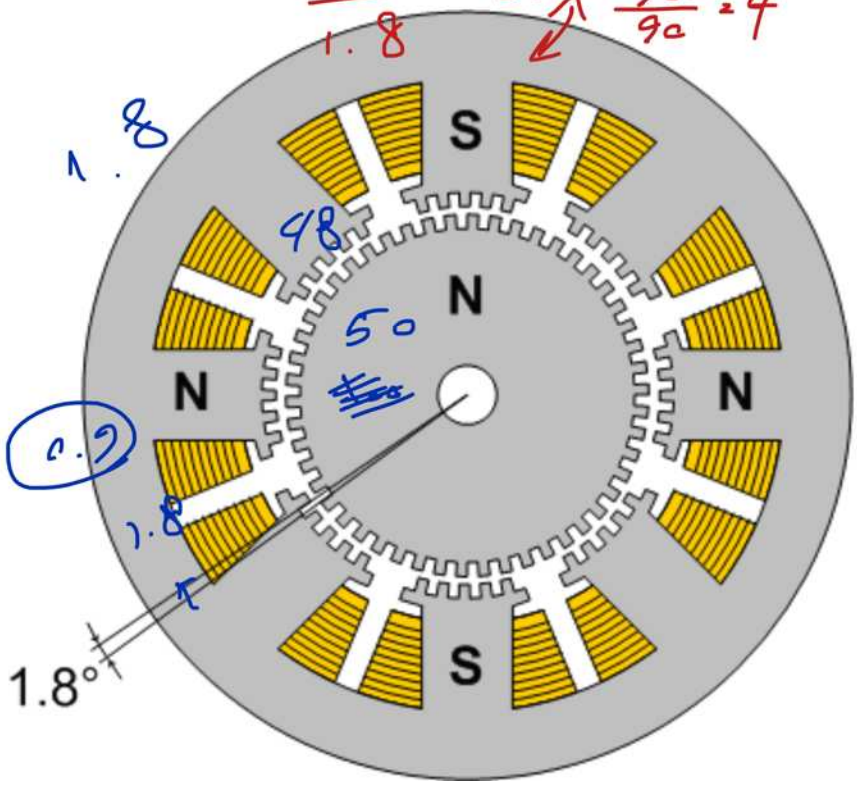








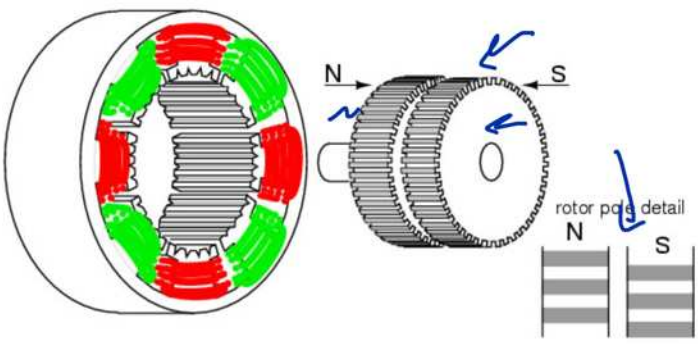




Feature	Permanent Magnet (PM)	Variable Reluctance (VR)	Hybrid (HY)
Rotor Type	Permanent magnet rotor	Soft iron rotor with salient poles	Combination of PM and VR designs
Step Angle	Typically 7.5° to 15°	Typically 15° to 30°	Typically 0.9° to 1.8°
Torque	Moderate holding torque	Low holding torque	High holding torque
Resolution	Moderate	Low	High
Efficiency	Moderate	High	Moderate to High
Construction Complexity	Simple	Simplest	Complex
Cost	Moderate	Low	High
Application Suitability	General purpose	Low-cost applications	Precision and high-performance tasks
Noise and Vibration	Moderate	High	Low
Operating Speed	Low to moderate	Moderate to high	Moderate
Magnetic Field Usage	Utilizes permanent magnet rotor	Uses changes in reluctance	Combines magnetic and reluctance forces
Control Requirements	Requires simple control logic	Requires simple control logic	Requires more complex control logic
Common Applications	Printers, toys, scanners	Indicators, low-precision drives	CNC machines, robotics, medical devices

Summary

- **Permanent Magnet (PM):** Balanced performance, suitable for moderate-precision applications.
- **Variable Reluctance (VR):** Low cost and simple, ideal for non-critical, low-resolution tasks.
- **Hybrid (HY):** Best choice for high precision and torque-intensive applications but comes with higher complexity and cost.

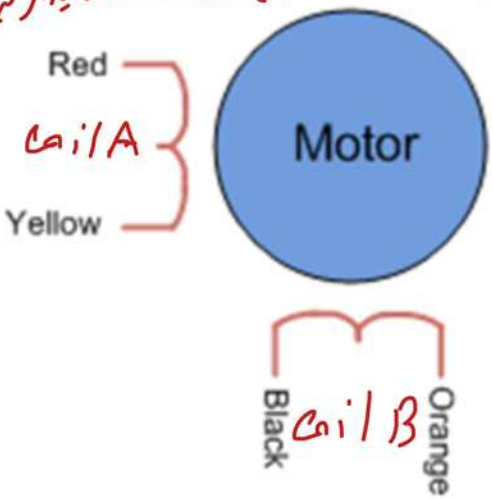


NEMA 17

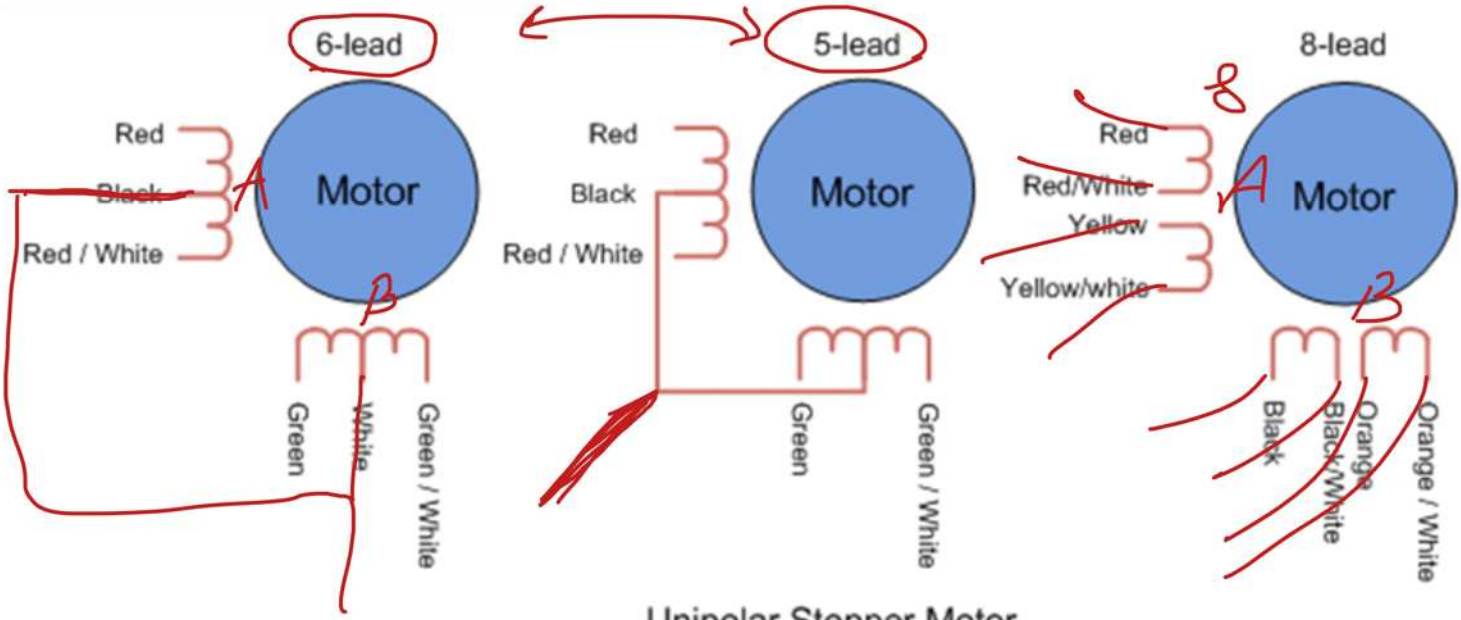
Specification	Value
Frame Size	1.7 inches (43.2 mm) square
Step Angle	1.8° (200 steps per revolution)
Holding Torque	40 to 50 N·cm (varies by model)
Current per Phase	1.2 to 2.5 A (varies by model)
Voltage	3.5 to 12 V (varies by model)
Resistance per Phase	1.4 to 3.5 Ω
Inductance per Phase	1.5 to 3.0 mH
Rotor Inertia	34 to 68 g·cm²
Weight	250 to 300 g
Number of Wires	4, 6, or 8 (depends on bipolar or unipolar)
Max RPM	Typically 2000 to 3000 RPM
Operating Temperature	-20°C to +50°C
Shaft Diameter	5 mm

Key Notes

- NEMA 17 specifies the frame size (43.2 mm square) but not other characteristics, which can vary by manufacturer and model.
- It is widely used in **3D printers**, **CNC machines**, and **robotics** due to its balanced performance and moderate size.
- The step angle of **1.8°** provides good precision, with smaller angles achievable using microstepping.
- Pay attention to **current and voltage ratings** to avoid overheating or damage when selecting a motor driver.

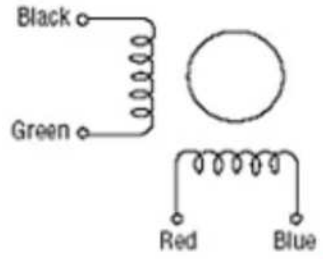
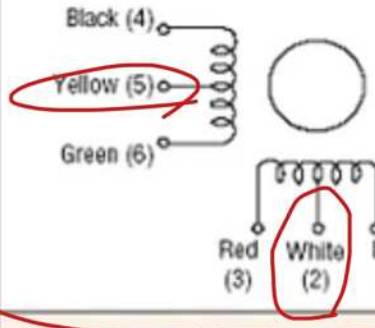
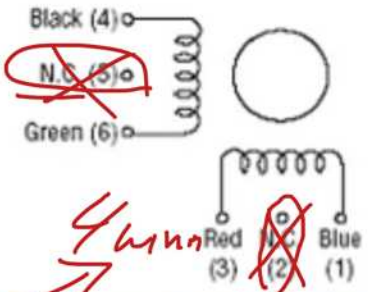
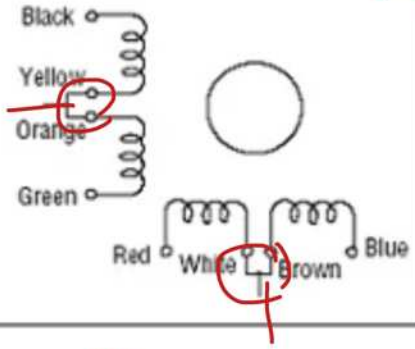
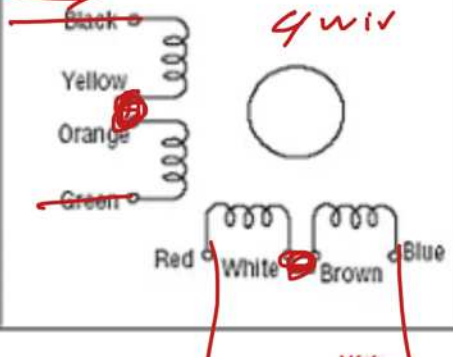
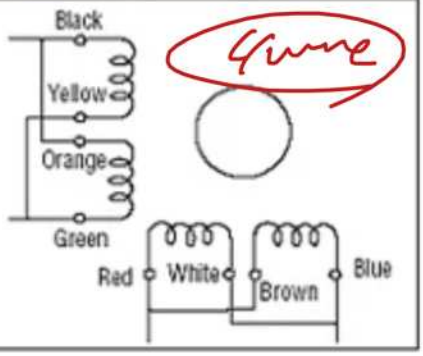


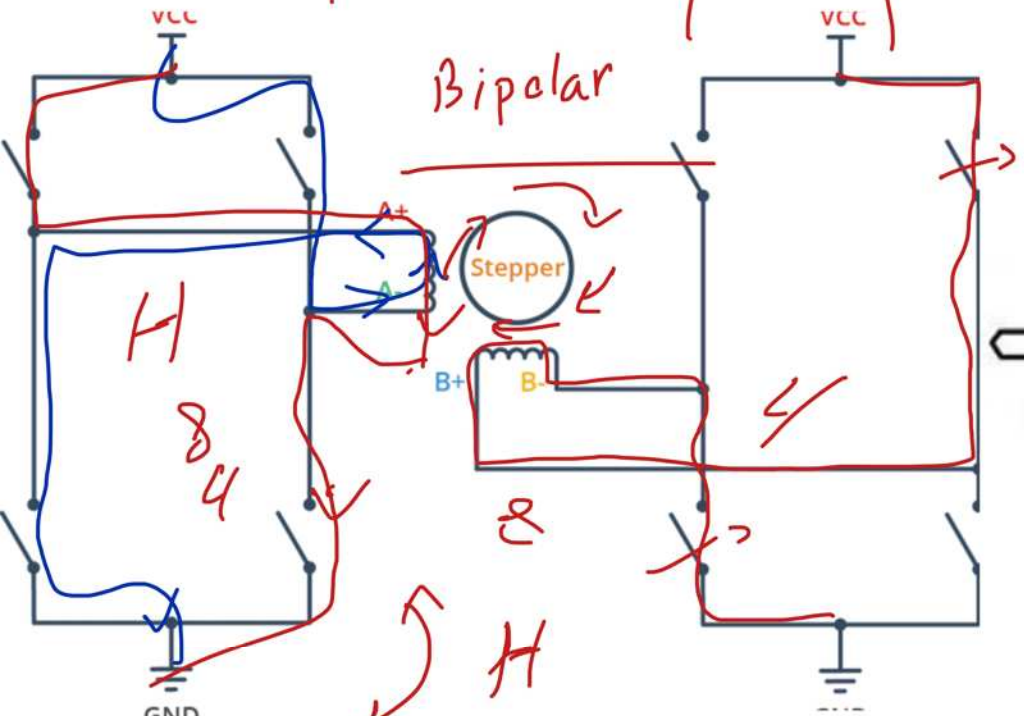
Bipolar Stepper Motor

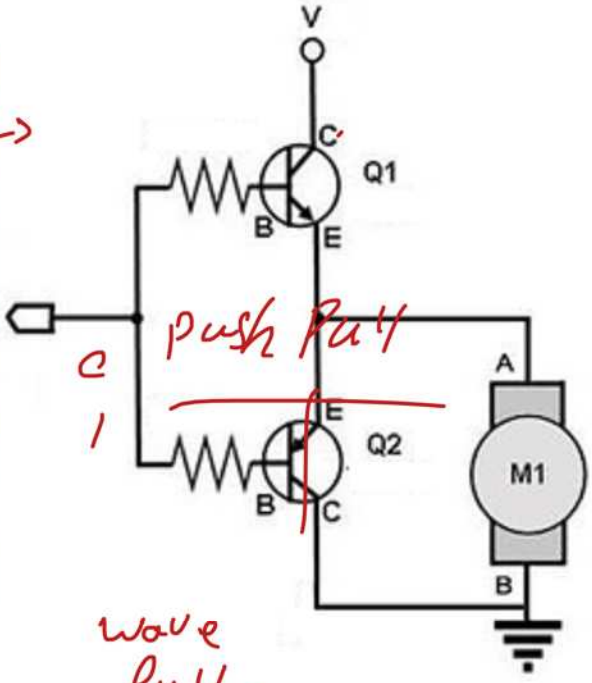


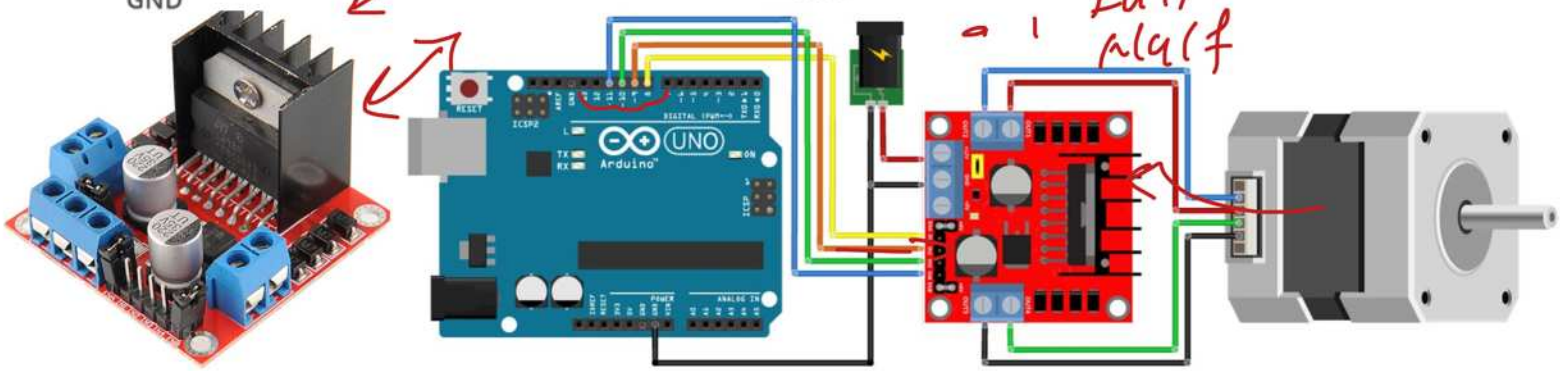
Unipolar Stepper Motor

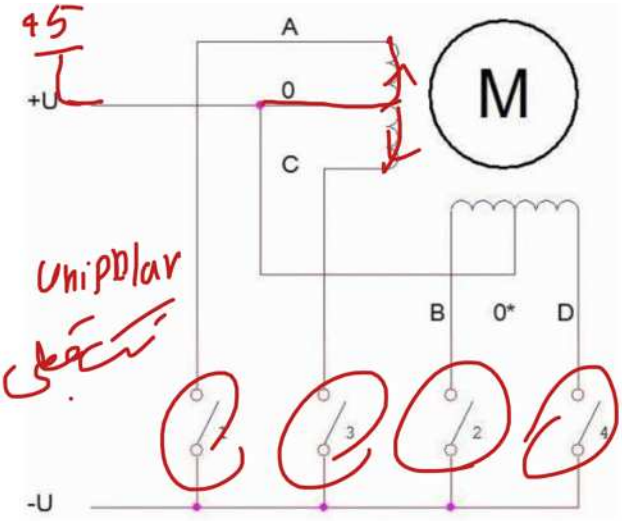
Wire Connection Diagrams

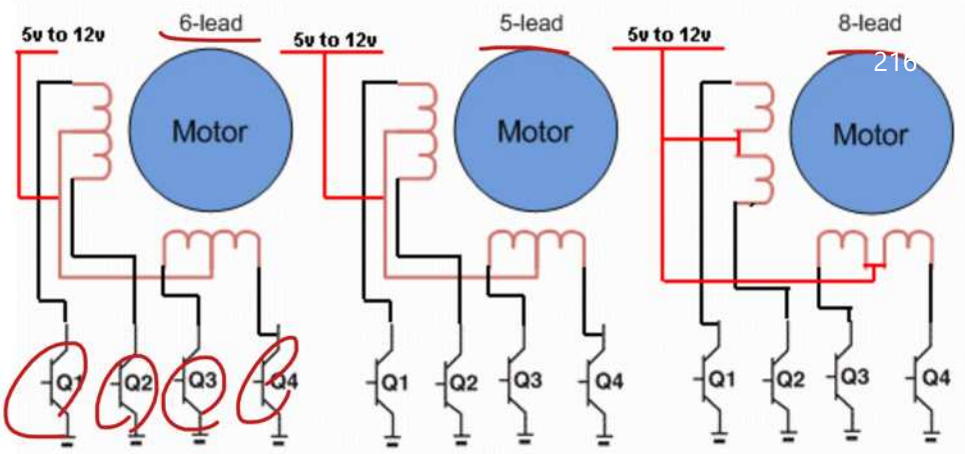
4 Lead Bipolar Connection	6 Lead Unipolar Connection	6 Lead Bipolar (Series) Connection
		
8 Lead Unipolar Connection	**8 Lead Bipolar (Series) Connection**	**8 Lead Bipolar (Parallel) Connection**
		

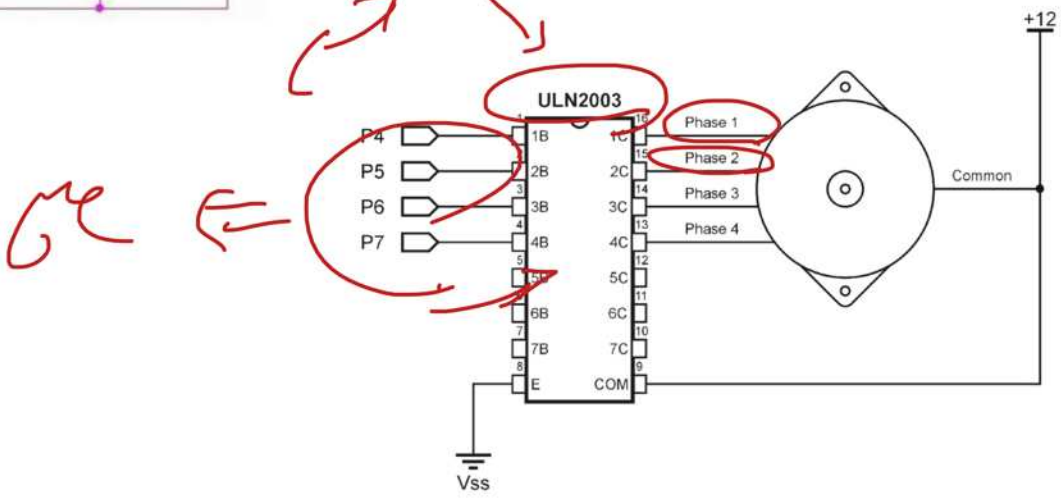


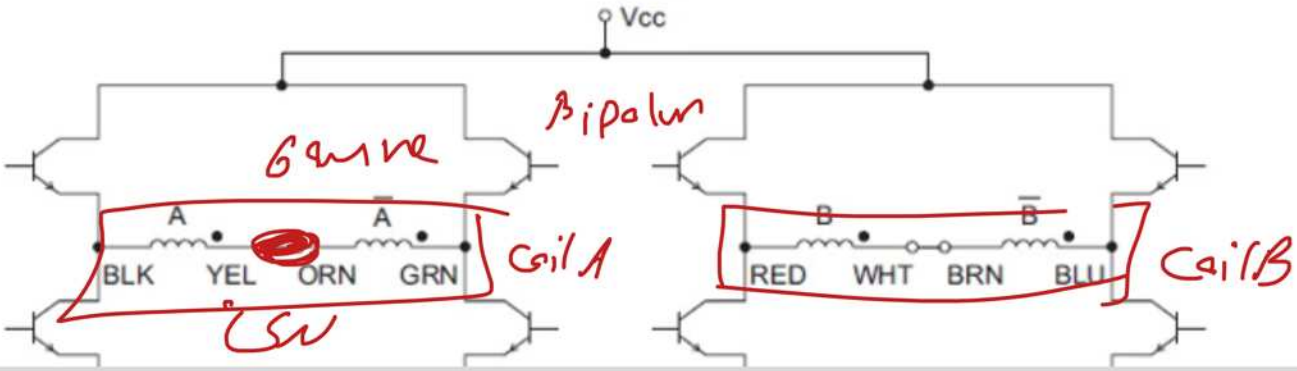


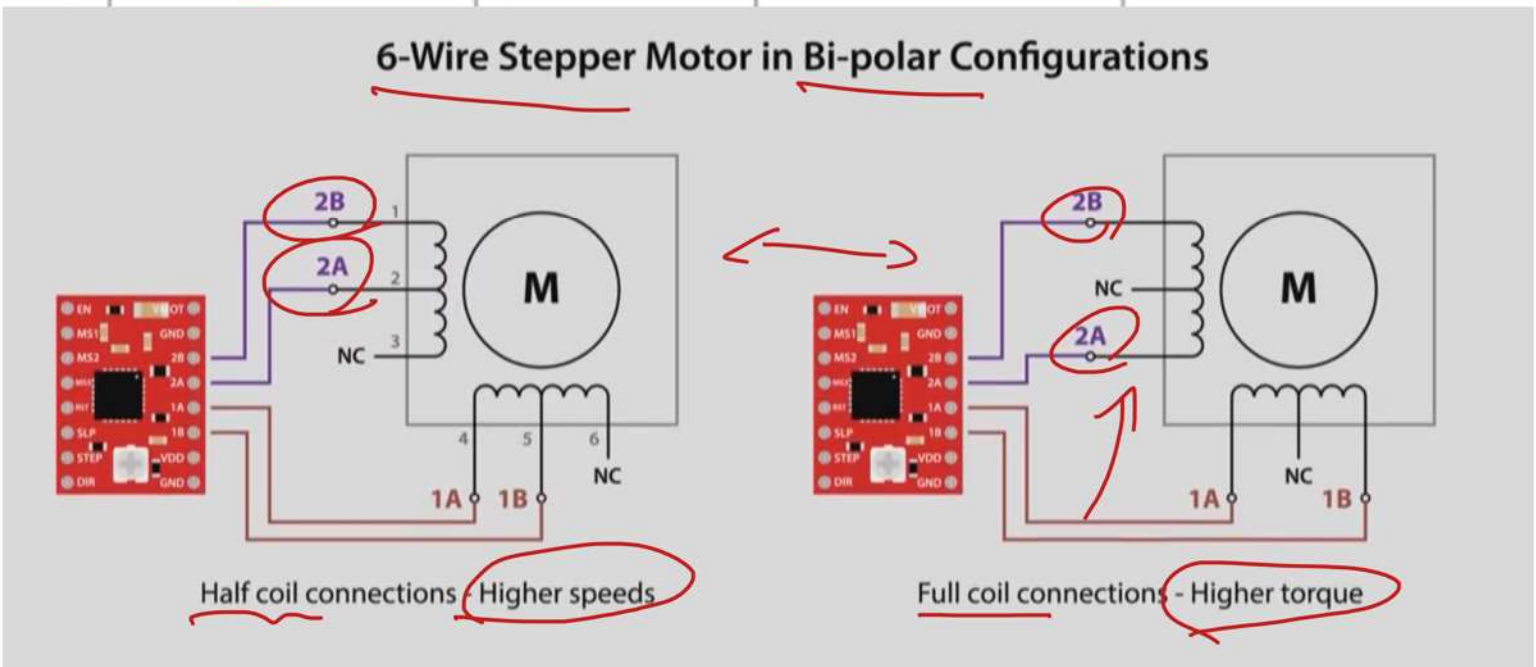



A
0
C
M
B
0*
D
+U
-U


5v to 12v
6-lead
Motor
5v to 12v
5-lead
Motor
5v to 12v
8-lead
Motor
Q1
Q2
Q3
Q4


ULN2003
P4
P5
P6
P7
1B
2B
3B
4B
5B
6B
7B
E
1C
2C
3C
4C
5C
6C
7C
COM
Phase 1
Phase 2
Phase 3
Phase 4
Common
+12
Vss


Vcc
A
A
BLK
YEL
ORN
GRN
B
B
RED
WHT
BRN
BLU

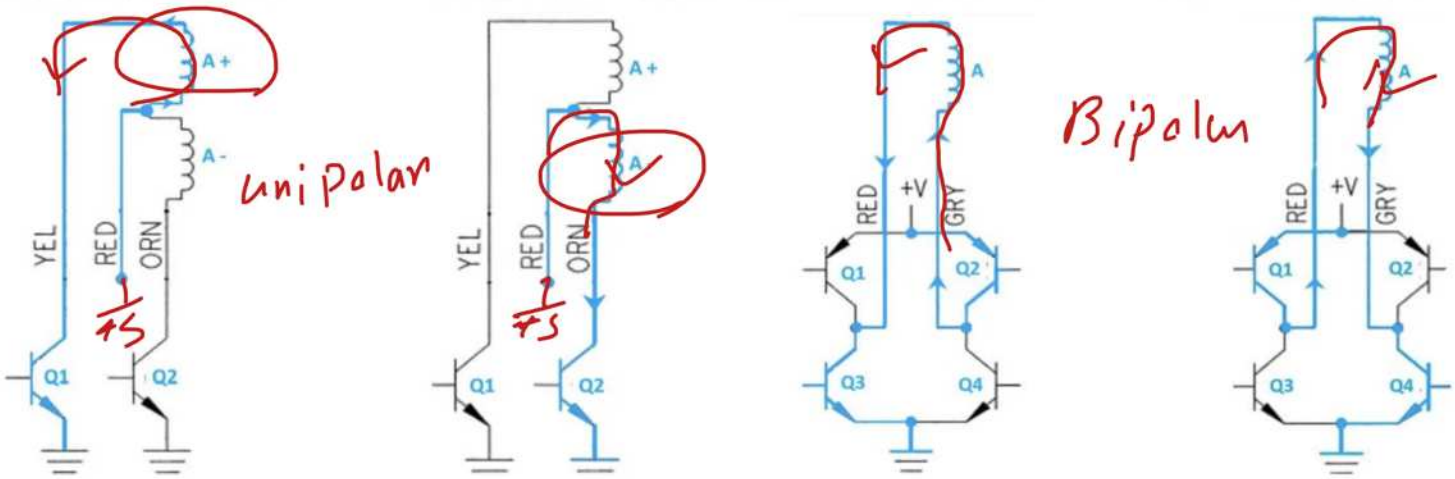

6-Wire Stepper Motor in Bi-polar Configurations
2B
2A
NC
M
1A
1B
Half coil connections - Higher speeds
Full coil connections - Higher torque

A+
Q1 CLOSED, Q2 OPENED

A-
Q1 OPENED, Q2 CLOSED

A+
Q2, Q3 CLOSED, Q1, Q4 OPENED

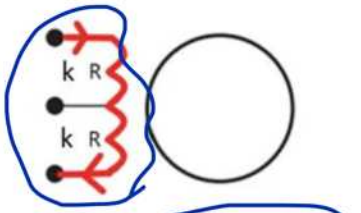
A-
Q1, Q4 CLOSED, Q2, Q3 OPENED



Unipolar

Bipolar

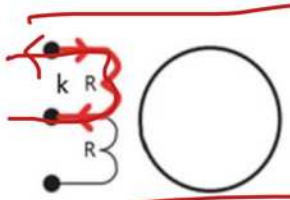
BIPOLAR



$$P_{joule\ bi} = 2 * R * i^2_{bi}$$

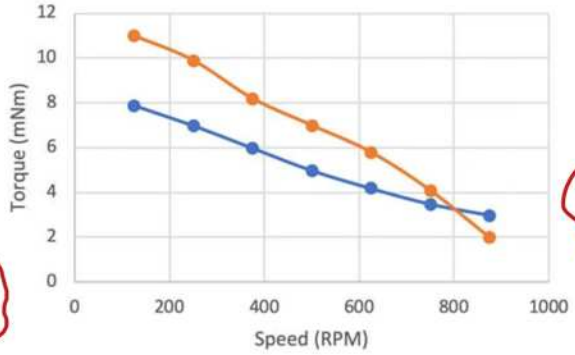
Series

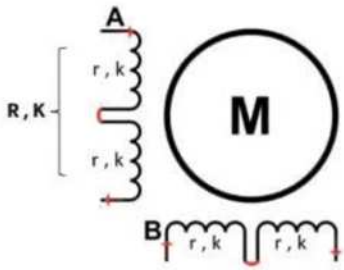
UNIPOLAR



$$P_{joule\ uni} = R * i^2_{uni}$$

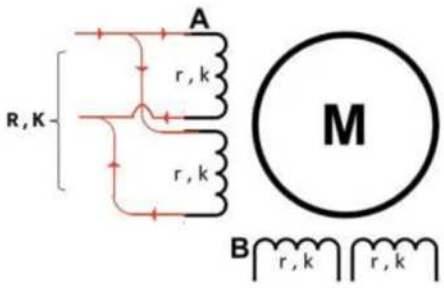
Parallel



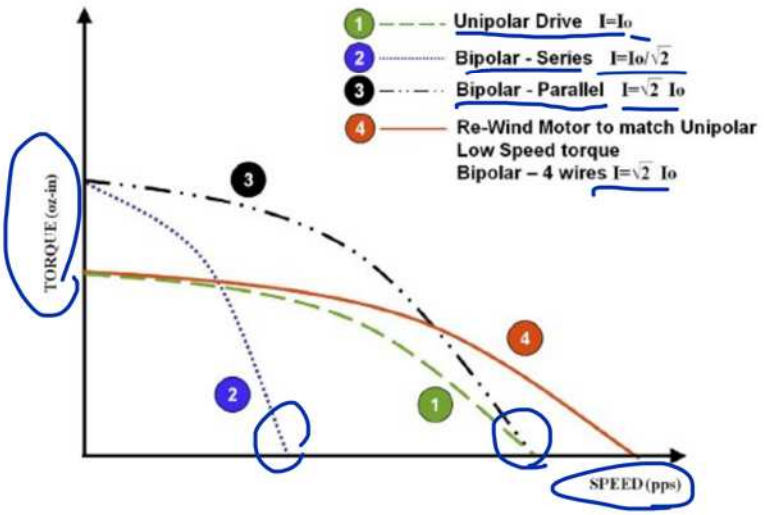


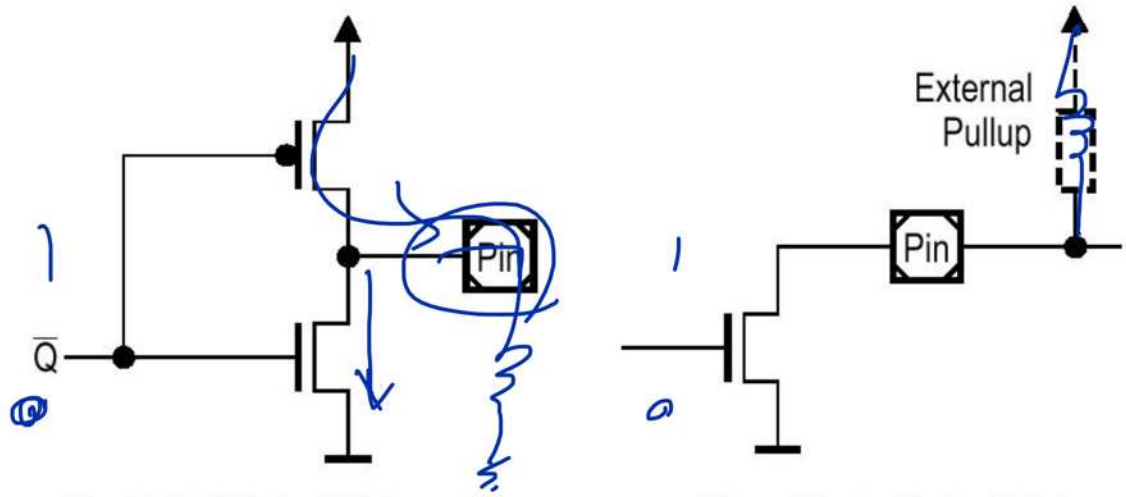
$R = r + r = 2 * r$

2r



$\frac{1}{R} = \frac{1}{r} + \frac{1}{r}$ so we have $R = \frac{r}{2}$





Push/Pull Output Driver

Open-Drain Output Driver

Bipolar

uni polar

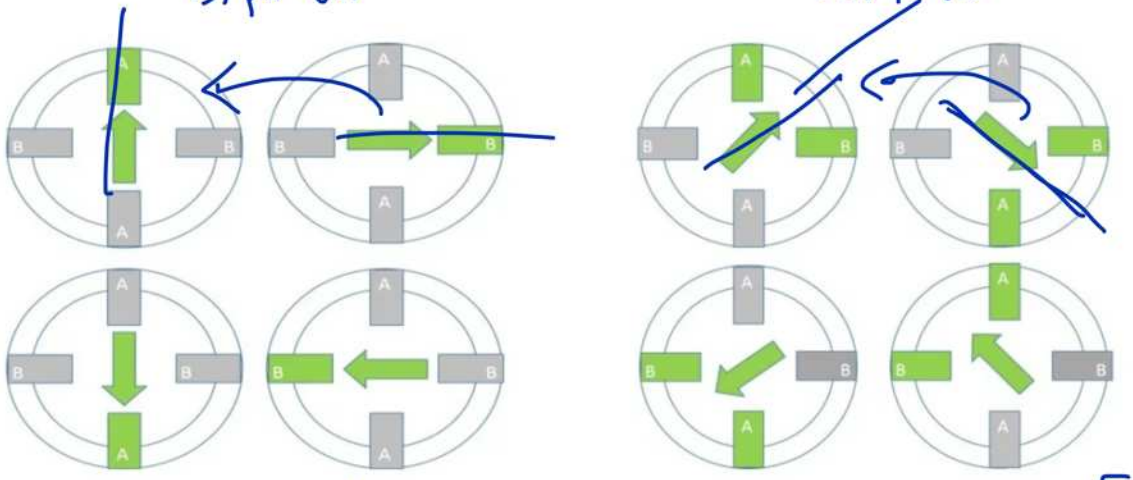


Fig 1 – One phase on – full step (wave)

Fig2 – Two phase on – full step

Step	Phase A	Phase B	Phase A'	Phase B'
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1
5	Back to Step 1			

Step	Phase A	Phase B	Phase A'	Phase B'
1	1	1	0	0
2	0	1	1	0
3	0	0	1	1
4	1	0	0	1
5	Back to Step 1			

1.8 → 0.9

200 → 400

Speed ↓

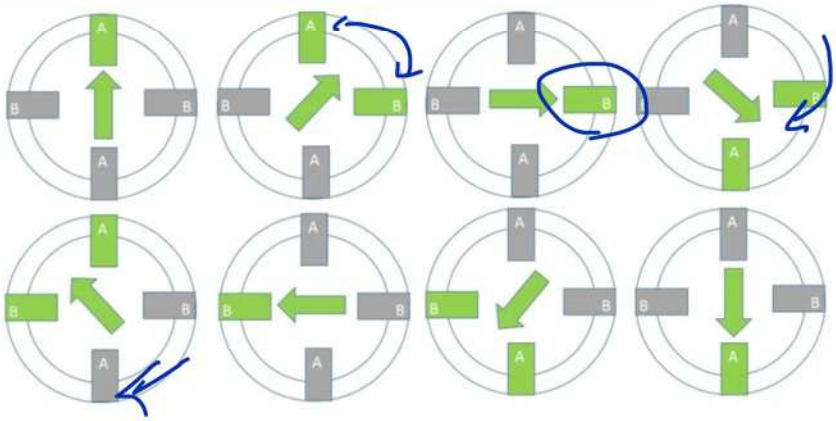
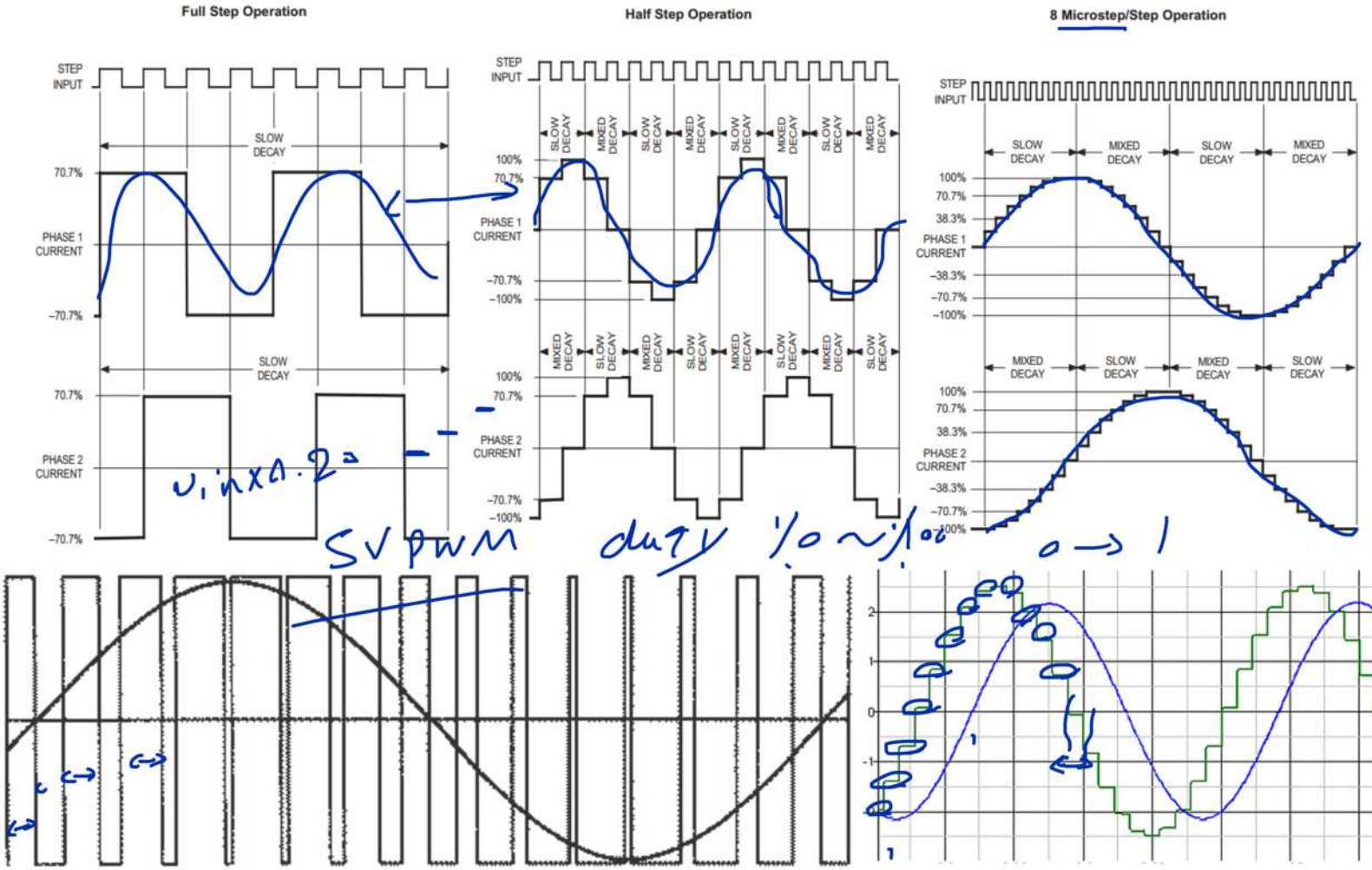
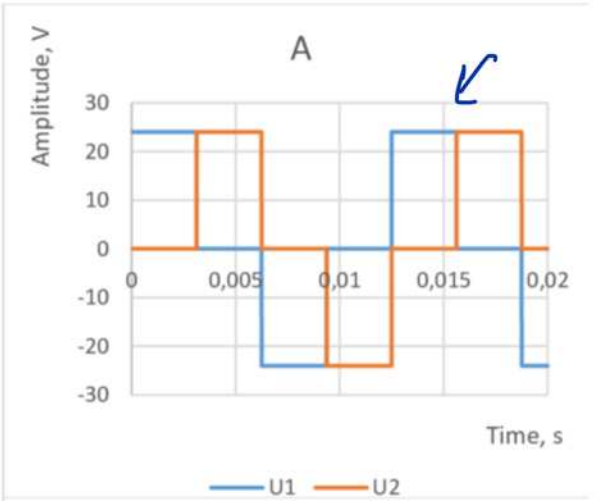
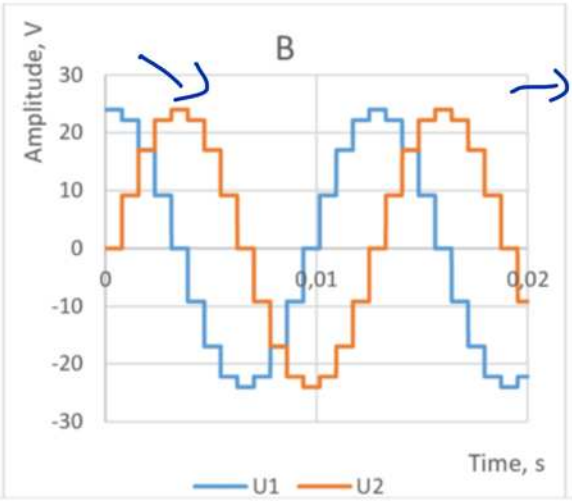


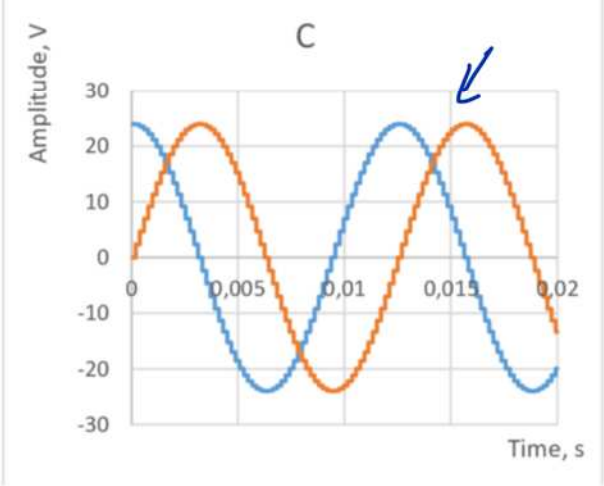
Fig3 - One-two phase on - half step

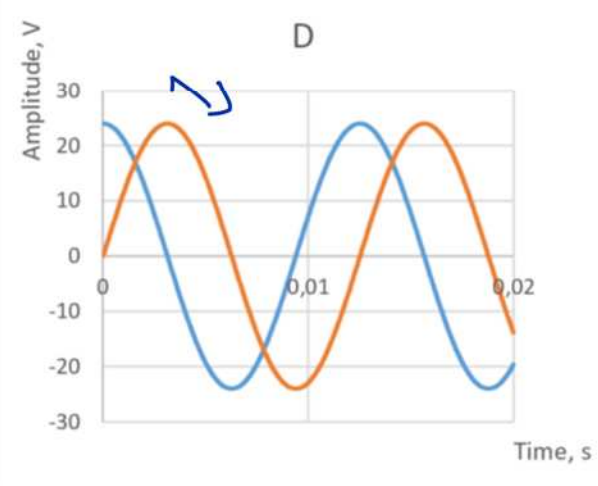
Step	Phase A	Phase B	Phase A'	Phase B'
1	1	0	0	0
2	1	1	0	0
3	0	1	0	0
4	0	1	1	0
5	0	0	1	0
6	0	0	1	1
7	0	0	0	1
8	1	0	0	1
9	Back to Step 1			


Full Step Operation
Half Step Operation
8 Microstep/Step Operation
STEP INPUT
SLOW DECAY
MIXED DECAY
70.7%
100%
38.3%
PHASE 1 CURRENT
PHASE 2 CURRENT
-70.7%
-100%
-38.3%


A
Amplitude, V
Time, s
U1
U2

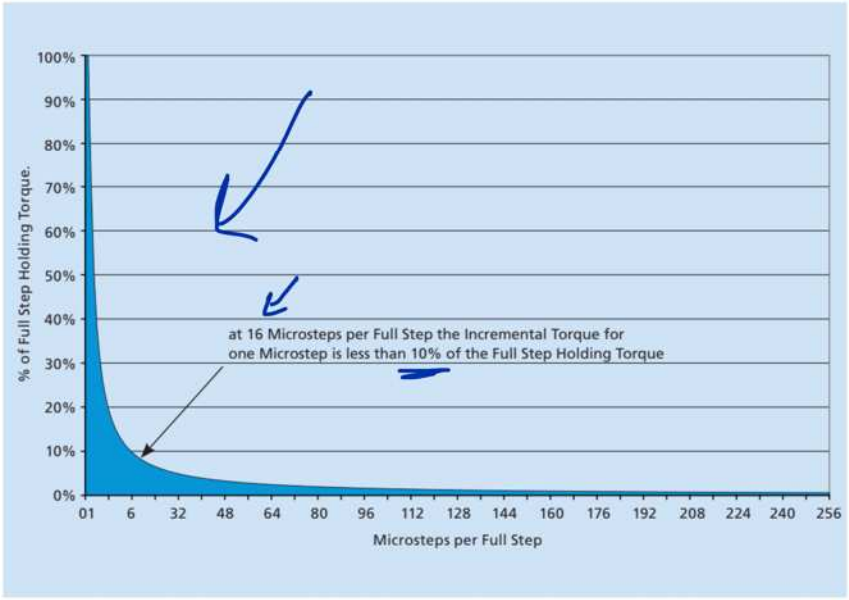

B
Amplitude, V
Time, s
U1
U2

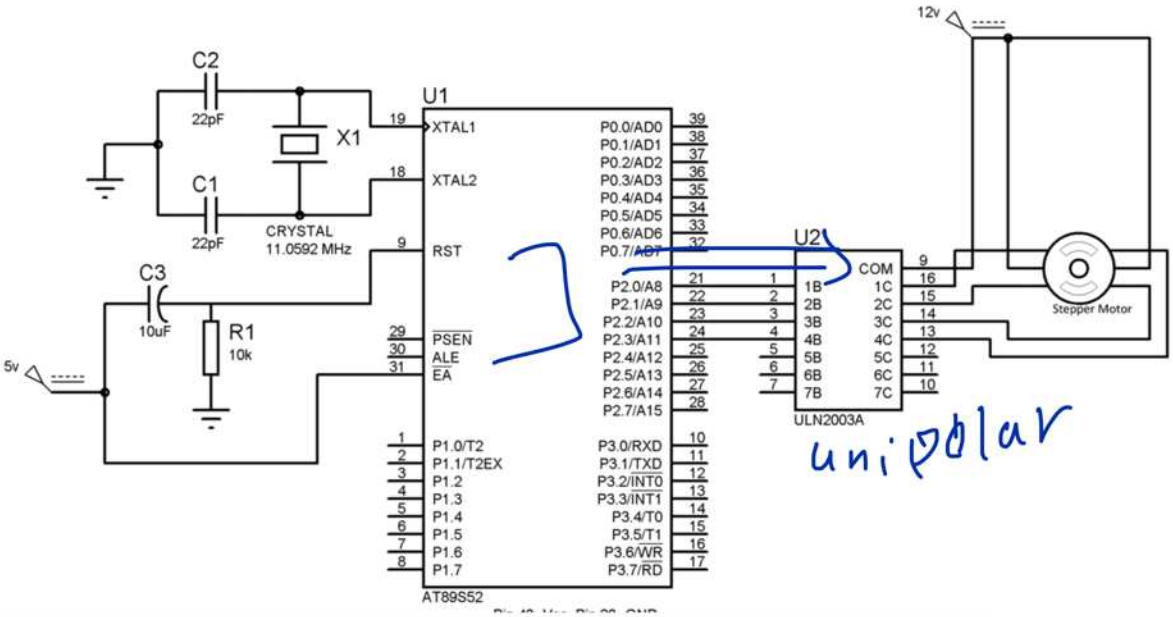

C
Amplitude, V
Time, s

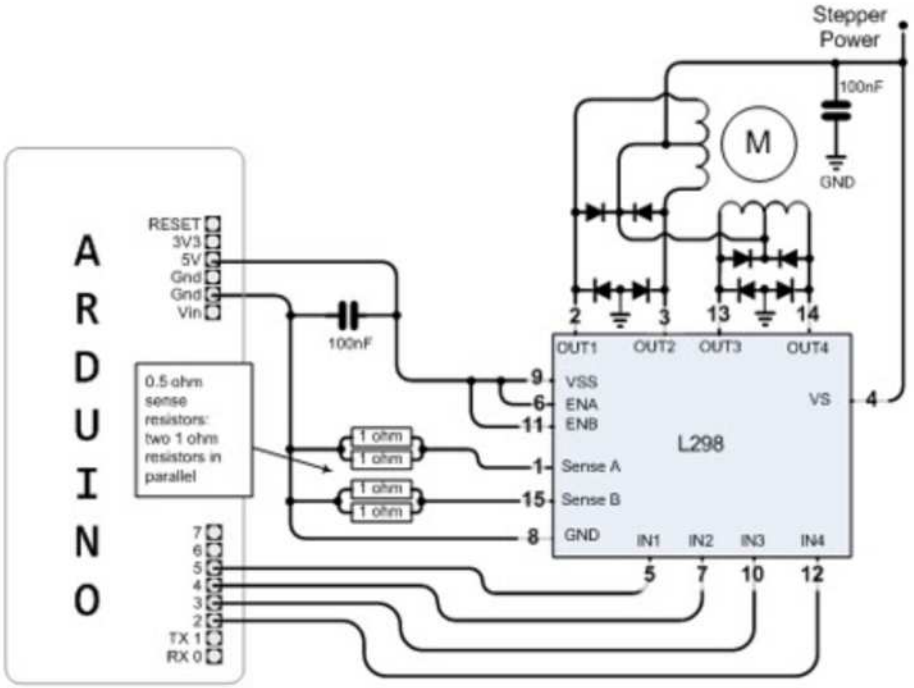

D
Amplitude, V
Time, s

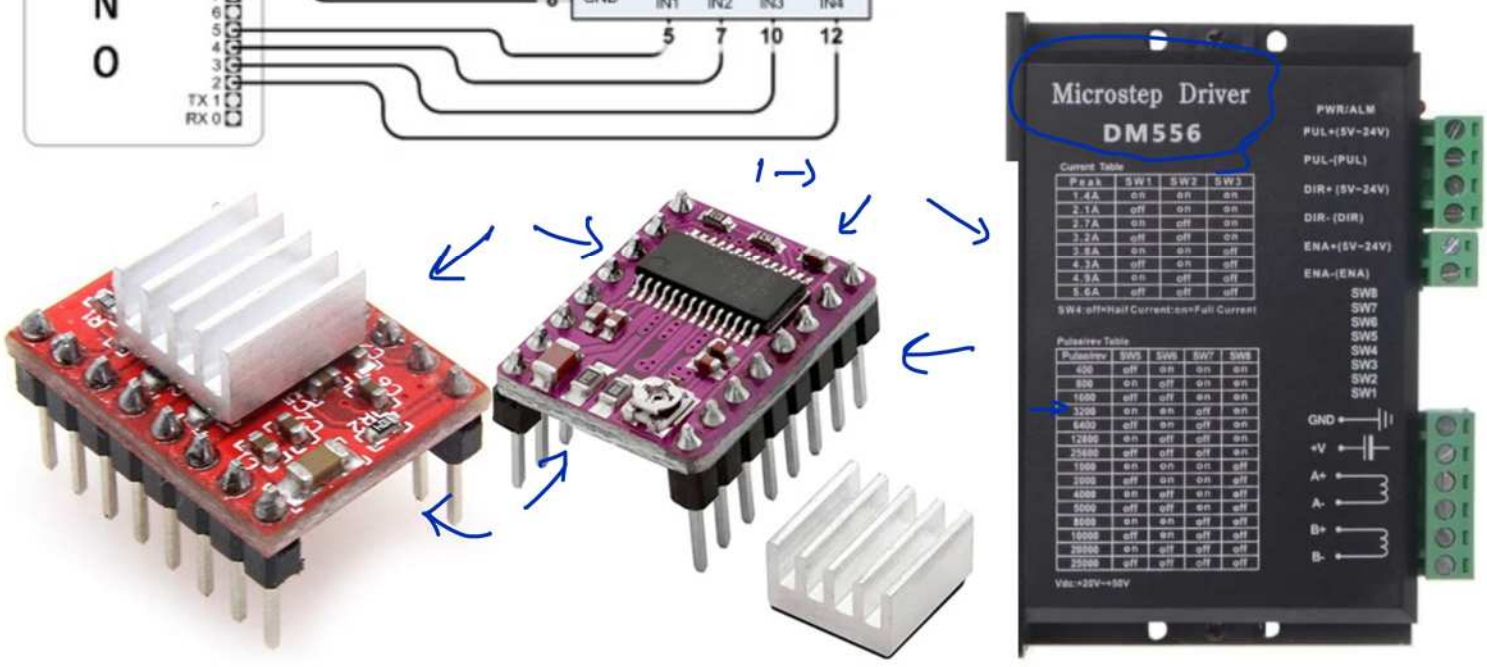
Micro-stepping level setting				
Steps/revolutions	SW5	SW6	SW7	SW8
200	on	on	on	on
400	off	on	on	on
800	on	off	on	on
1600	off	off	on	on
3200	on	on	off	on
6400	off	on	off	on
12800	on	off	off	on
25600	off	off	off	on
1000	on	on	on	off
2000	off	on	on	off
4000	on	off	on	off
5000	off	off	on	off
8000	on	on	off	off
10000	off	on	off	off
20000	on	off	off	off
25000	off	off	off	off

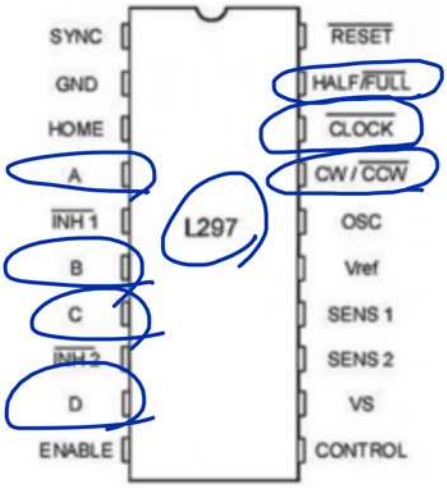
Microsteps/full step	% Holding Torque/Microstep
1	100,00%
2	70,71%
4	38,27%
8	19,51%
16	9,80%
32	4,91%
64	2,45%
128	1,23%
256	0,61%

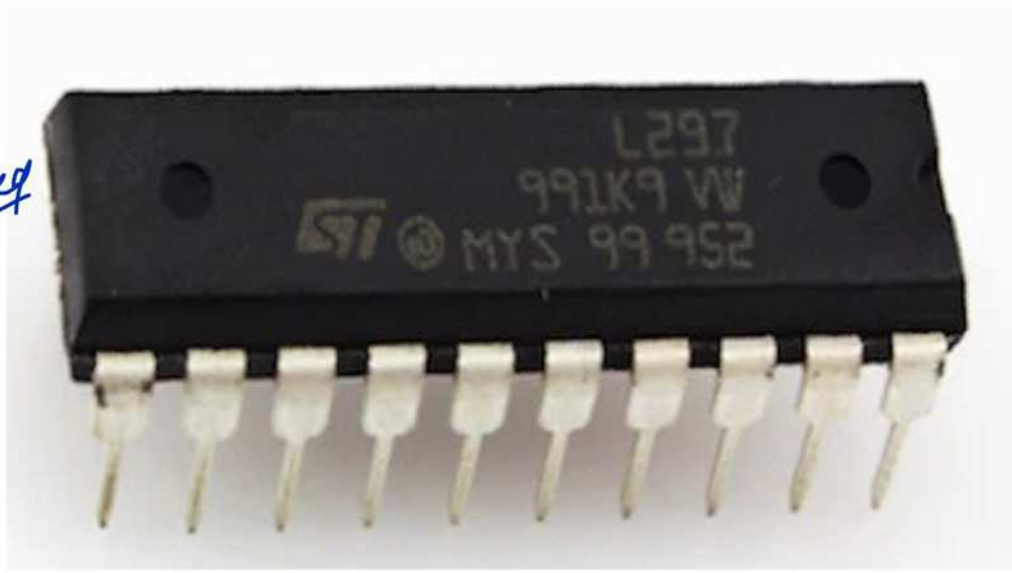



C2
22pF
X1
C1
22pF
CRYSTAL
11.0592 MHz
C3
10uF
R1
10k
5v
12v
U1
XTAL1
XTAL2
RST
PSEN
ALE
EA
P1.0/T2
P1.1/T2EX
P1.2
P1.3
P1.4
P1.5
P1.6
P1.7
P0.0/AD0
P0.1/AD1
P0.2/AD2
P0.3/AD3
P0.4/AD4
P0.5/AD5
P0.6/AD6
P0.7/AD7
P2.0/A8
P2.1/A9
P2.2/A10
P2.3/A11
P2.4/A12
P2.5/A13
P2.6/A14
P2.7/A15
P3.0/RXD
P3.1/TXD
P3.2/INT0
P3.3/INT1
P3.4/T0
P3.5/T1
P3.6/WR
P3.7/RD
AT89S52
U2
1B
2B
3B
4B
5B
6B
7B
COM
1C
2C
3C
4C
5C
6C
7C
ULN2003A
Stepper Motor
unipolar

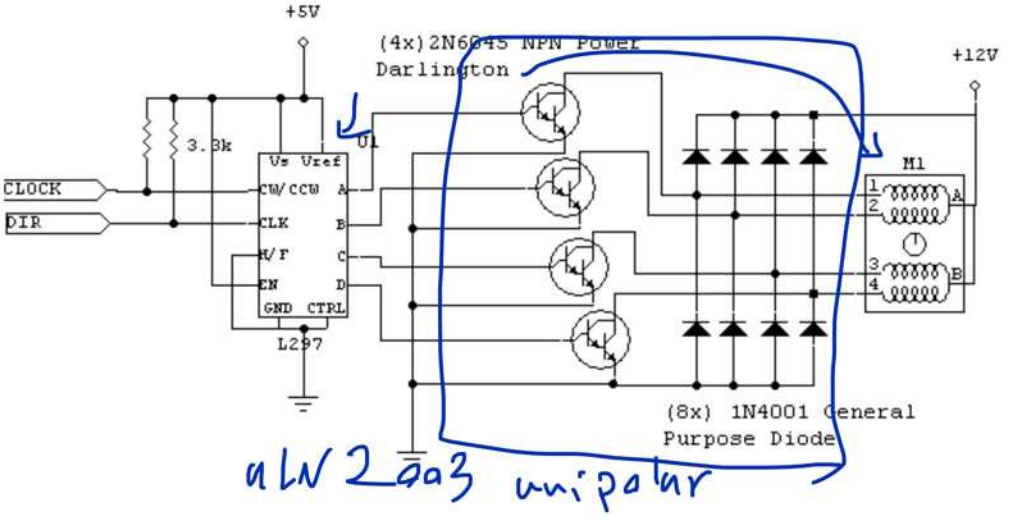

Stepper
Power
100nF
GND
M
ARDUINO
RESET
3V3
5V
Gnd
Gnd
Vin
100nF
0.5 ohm sense resistors: two 1 ohm resistors in parallel
1 ohm
1 ohm
1 ohm
1 ohm
TX 1
RX 0
OUT1
OUT2
OUT3
OUT4
VSS
ENA
ENB
Sense A
Sense B
GND
VS
L298
IN1
IN2
IN3
IN4
Bipolar

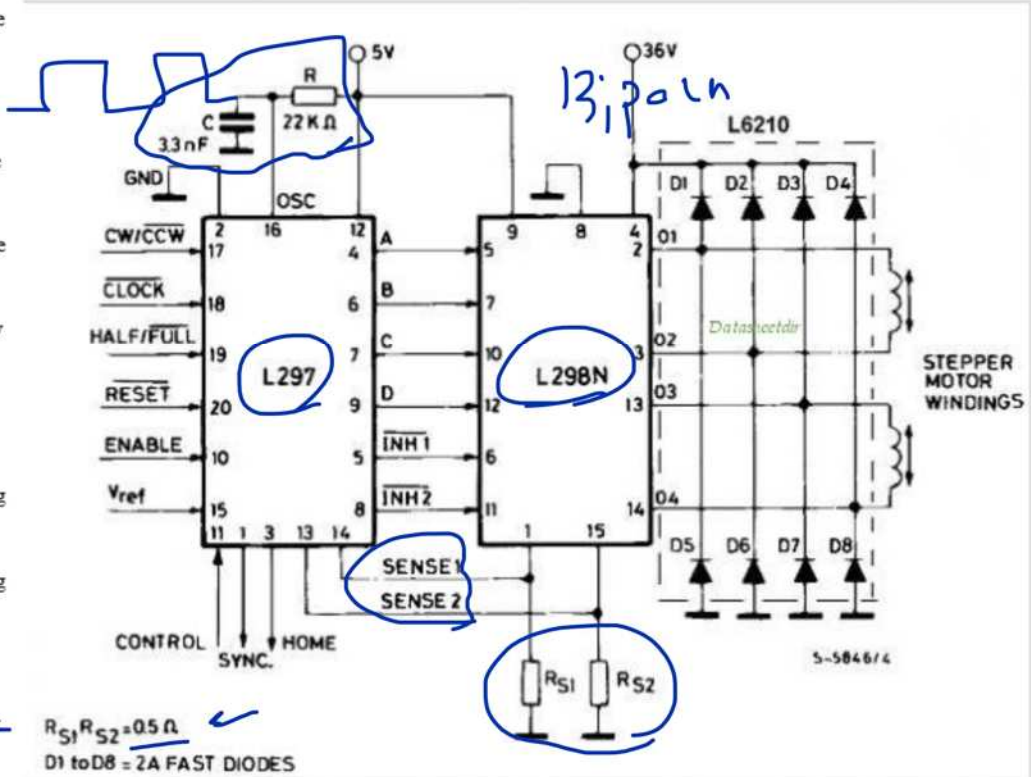

Microstep Driver
DM556
PWR/ALM
PUL+(5V-24V)
PUL-(PUL)
DIR+ (5V-24V)
DIR- (DIR)
ENA+(5V-24V)
ENA-(ENA)
GND
+V
A+
A-
B+
B-

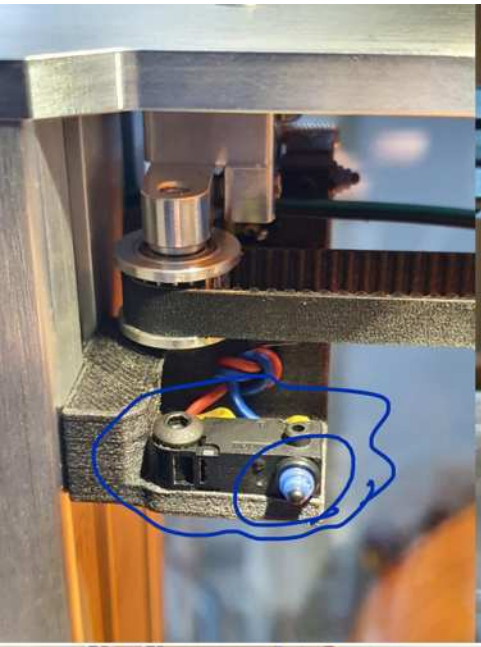


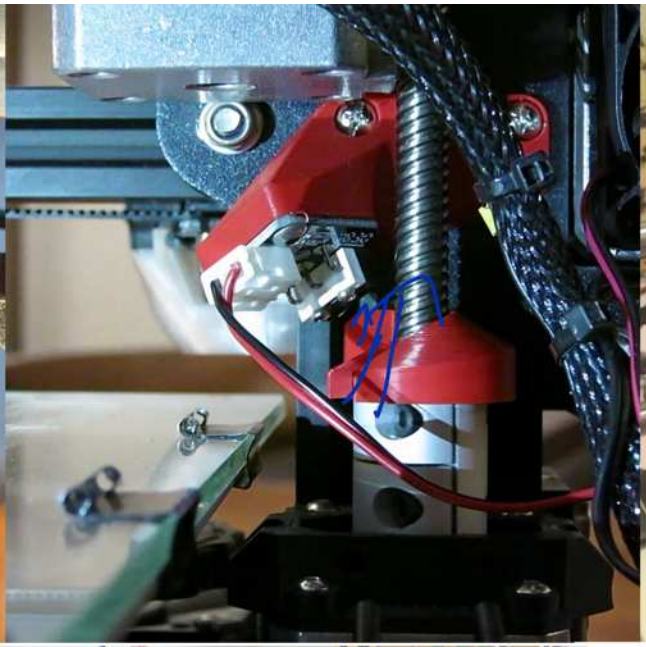


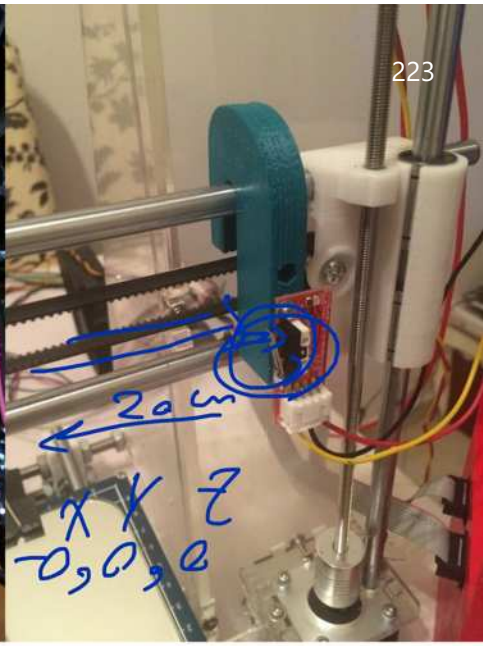
Pin Number	Pin Name	Description
1	SYNC	Synchronization output to connect multiple L297 ICs. Ensures step coordination between drivers.
2	GND	Ground connection for the logic circuit.
3	HOME	Indicates the reference position of the stepper motor. Used to track the initial step position.
4, 5, 6, 7	A, B, C, D	Outputs controlling the phases of the stepper motor. Drive the motor coils in the correct sequence.
8	INH1	Inhibit input for phases A and B. Disables these outputs when pulled LOW.
9	INH2	Inhibit input for phases C and D. Disables these outputs when pulled LOW.
10	ENABLE	Enables or disables the motor outputs. HIGH enables, and LOW disables the motor.
11	RESET	Resets the internal logic and sets the motor to its initial state. Active LOW.
12	HALF/FULL	Selects between half-step mode (HIGH) and full-step mode (LOW).
13	CLOCK	Input clock signal for stepping the motor. Each pulse advances the motor by one step.
14	CW/CCW	Direction control input. Clockwise (CW) when HIGH, counter-clockwise (CCW) when LOW.
15	OSC	External clock input for frequency control. Can be connected to an external oscillator.
16	Vref	Reference voltage input for current regulation in the motor coils.
17	SENS1	Current sense input for monitoring the current in phases A and B. Used for current regulation.
18	SENS2	Current sense input for monitoring the current in phases C and D. Used for current regulation.
19	VS	Power supply voltage for the motor driver stage.
20	CONTROL	Control input for selecting current regulation mode (chopper control).

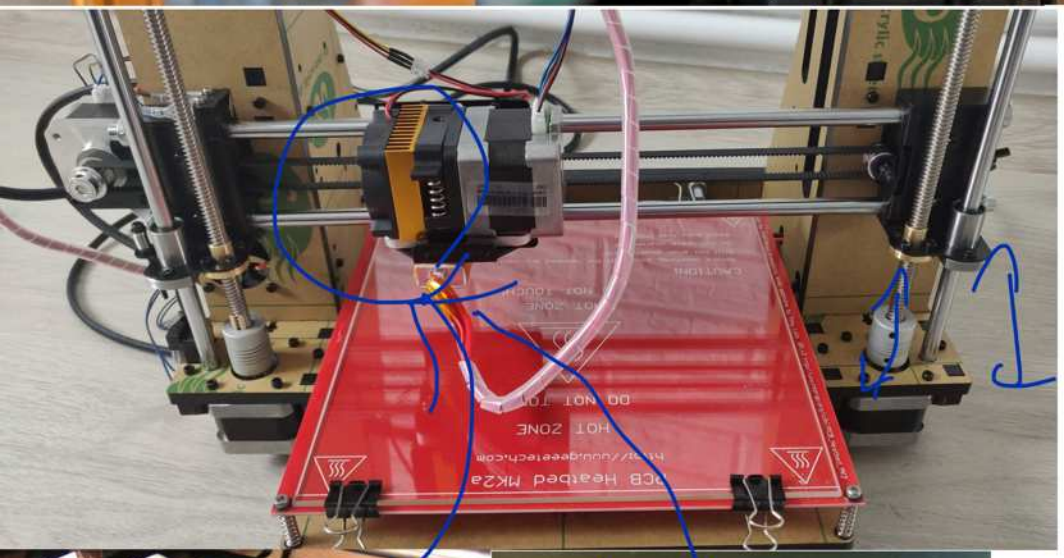


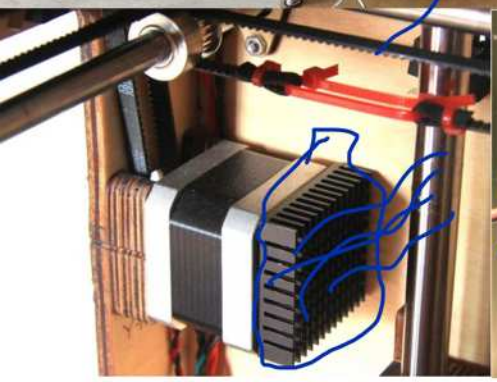


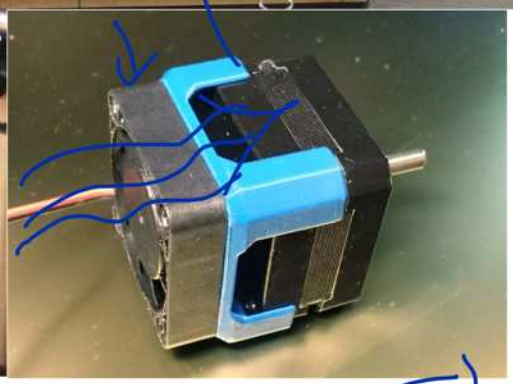


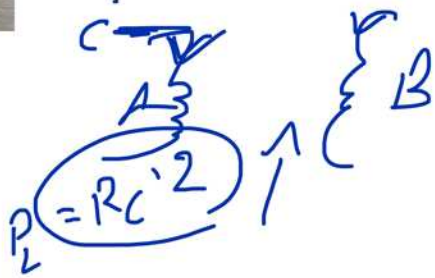












توضیحات استپ

ولتاژ (V)	6
قطر شافت (mm)	5
طول شافت (mm)	16
عرض (mm)	42
طول (mm)	43
درجه هر استپ	1.8
ارتفاع (mm)	48