Practical 5: Stepper motors and Arduino

What is it about?

During this lab, you will learn how to control a stepper motor with the Arduino Uno and the Arduino motor shield.

Aims

At the end of the lab, you should:

- Know how to wire a bipolar or an unipolar stepper motor
- Know the different operation modes of a stepper motor and their main characteristics
- Program a stepper motor controller for the Arduino

Specific Challenges

- This lab mostly involve coding; the coding is a bit more involved than for the previous labs. A pencil and a piece of paper will prove useful.

Note

As usual, **document in your lab journal your findings**. Add **code snippets**, **screenshots**, **pictures** and link to **videos** as needed.

And do not forget: **write your lab journal as a text file using the Markdown syntax** and **push your journal and the pictures on GitHub**.

Preliminary steps

Step 1 – Sign-out an Arduino + motor shield kit and a stepper motor

If you have not done so already, sign-out and collect from SMB310 an Arduino Uno Kit (Arduino Uno, power supply, motor shield) **and a stepper motor**.

You can keep it for as long as you need to finish all the laboratory sessions.

Return the kit (before the end of term!) when you are done.

Important

If you have not finished your DC motor lab, you still have until January to complete it: I will not mark the journals before then.

Part I

Stepper motors: background

The aim of the lab is to program an Arduino Uno in conjunction with a motor shield to control a hybrid stepper motor (see Figure 1).

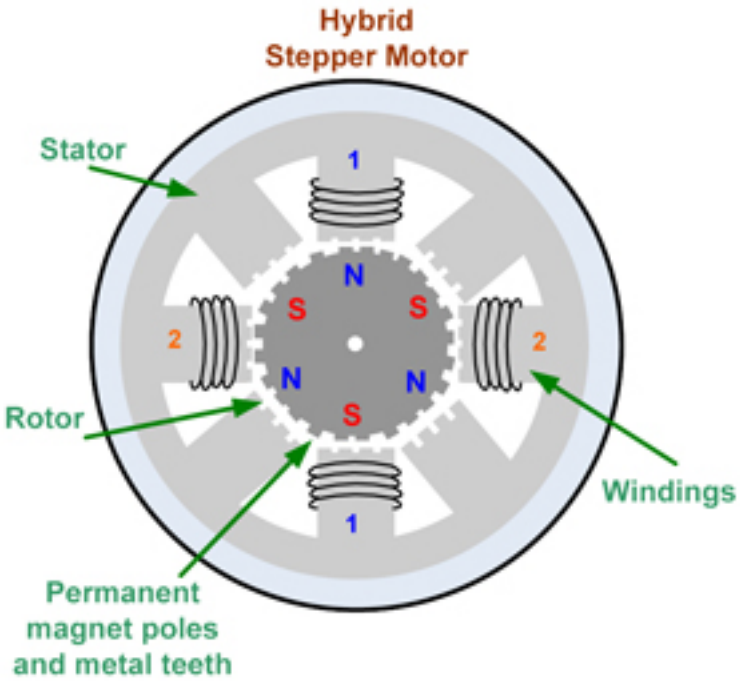


Figure 1: An hybrid stepper motor

- A hybrid stepper motor uses the same control method as a permanent magnet stepping motor
- When a winding is energized, a north and south pole are created
- The generated poles attract the permanent poles of the rotor on the fine metal rotor teeth.
- The rotor moves one step to align magnetized rotor teeth to the corresponding windings.
- A bipolar motor has four wires. There is no common centre connection and it has two independent sets of coils (see Figure 2). In this case an H-bridge channel on the Arduino motor shield can directly control each coil.
- A unipolar motor has five or six wires. The four coils have a common centre connection (see Figure3. The common connection(s) need to be connected to ground and the other coil connections connected to the H-bridge channel on the Arduino motor shield.

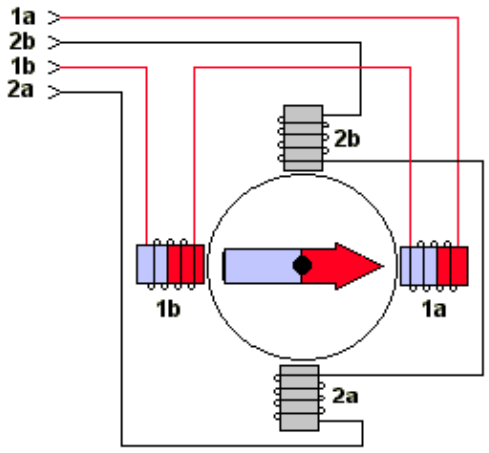


Figure 2: A bipolar stepper motor with 4 connection wires

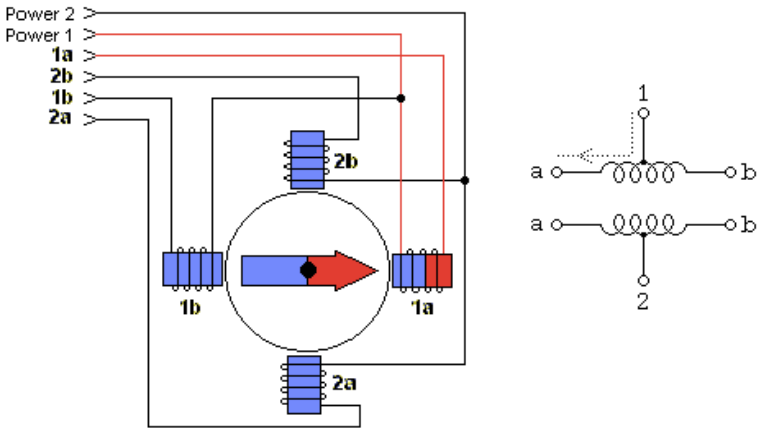


Figure 3: A unipolar stepper motor with 5 to 6 connection wires

Part II

Control a stepper motor

Step 1 – Wiring

Connect the stepper motor to the motor shield (see Figure 4 and Figure 5 for 4-wire bipolar motor). You need to wire it appropriately depending whether it has a 4 or 6 wires coil connections.

Step 2 – Initial program

Write a program for the Arduino to control its speed and rotational direction.

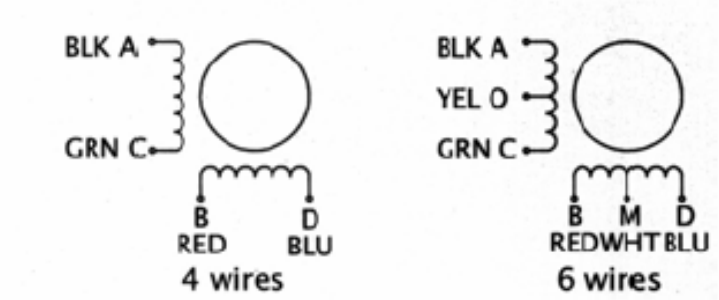


Figure 4: Wiring diagram for bipolar and unipolar stepper motors

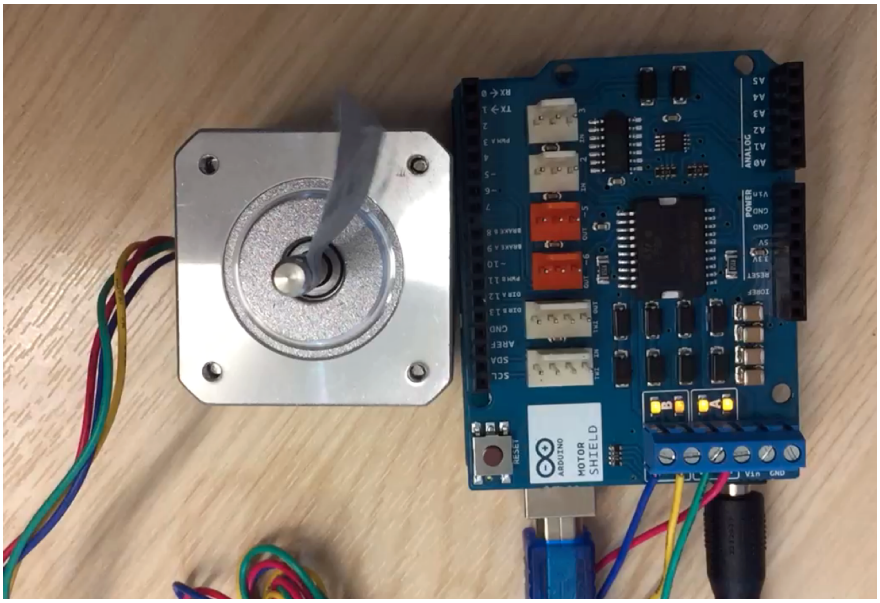


Figure 5: Connecting a bipolar motor with four wires to the motor shield

Step 3 – Programming of modes

Write four different functions to implement each of the stepper motor control strategies (see diagrams below).

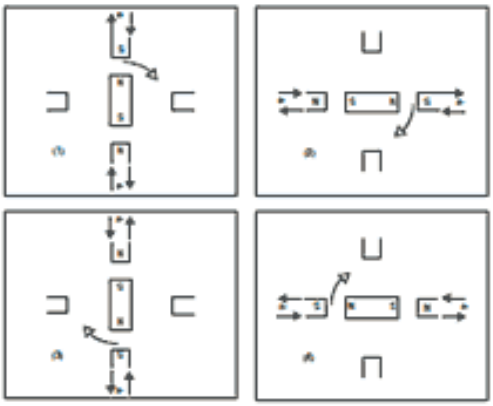
Implement the following modes:

- Full-step mode (Figure 6).
- Double-step mode (Figure 7).
- Half-step mode (Figure 8).
- Micro-step mode (Figure 9).

Step 4 – Characterisation

- Estimate the maximum angular velocity of the stepper motor in the different modes

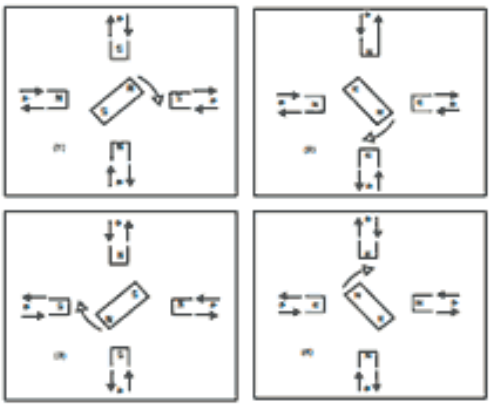
- Using your own initiative, roughtly examine the torque of the motor in the different modes (Hint: try to stop the shaft rotating by holding it with your hand, and compare this across modes).



One-Phase On, Full Step

	PHASE			
	A	B	$\overline{A}$	$\overline{B}$
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1

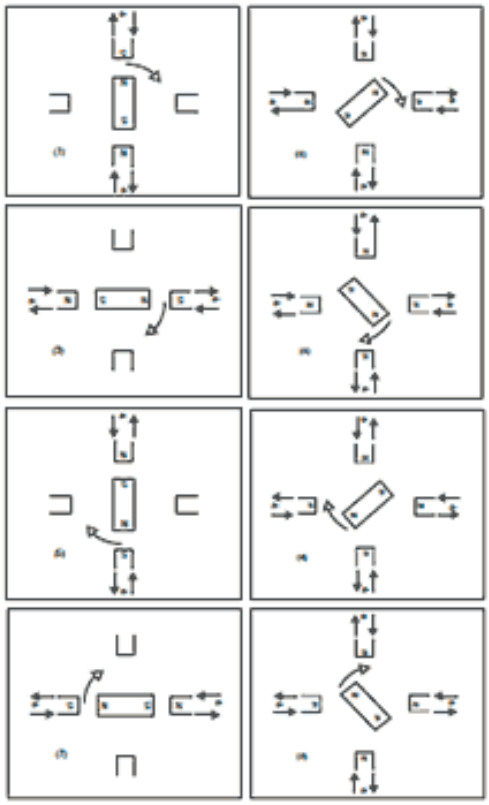
Figure 6: Full step mode. Only a single phase is activated at a time. As the full step drive, but the motor will have significantly less than rated torque



Two-Phase On, Full Step

	PHASE			
	A	B	$\overline{A}$	$\overline{B}$
1	1	1	0	0
2	0	1	1	0
3	0	0	1	1
4	1	0	0	1

Figure 7: Double-step mode. Two phases are always on so the motor will provide its maximum rated torque



Half Step

	PHASE			
	A	B	$\overline{A}$	$\overline{B}$
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

Figure 8: Half-step mode. Drive alternates between two phases on and a single phase on. This increases the angular resolution.

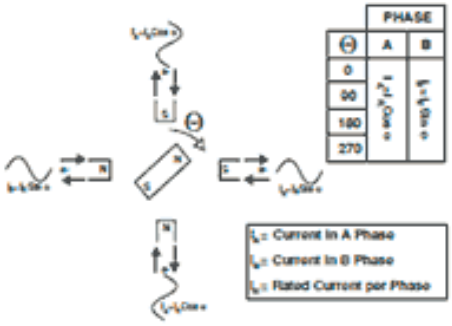


Figure 9: Microstepping. Winding current approximates a sinusoidal AC waveform. Motor operation becomes smoother