Chapter 7: Motor Control

*Motor control which needs PWM, such as DC motor speed control and Servo Control, is discussed in a separate volume.

The most common motors in microcontroller control for robots and other motion/movement control are DC motors. They are cheap and easy to control (rotational direction, start/stop, and speed). However, for robot arm or tracking camera movement control, stepper motor is the only way to satisfy the requirement since its position is precisely controlled for a desired position. In this chapter we explore the world of DC motors and stepper motors. A similar one, servo motor, will be discussed in Chapter 13 while we discuss about the PWM (Pulse Width Modulation) module of 16F877. Therefore, any control of motors which requires PWM is not discussed here but later in Chapter 13. So the main theme of control is consistent of: (1) DC motor rotational direction control and (2) Stepper motor position control.

1. Motors

DC Motor

A DC motor usually means a permanent-magnet, direct-current (DC) motor of the sort used in toys, models, cordless tools, and robots. These motors are particularly versatile because both their speed and direction can be readily controlled; speed by the voltage or duty cycle of their power supply, and direction by its polarity.

Fig. 32 DC motor

Torque is a measurement of the motors power. The higher the torque of the motor the more weight it can move. DC motors provide different amounts of torque depending on their running speed, which is measured in RPM (revolutions per minute). At low RPM DC motors produce poor torque, and generally the higher the RPM, the better the motors torque. However, in high torque, the speed may be too high for an application. That's why we have to use gears (or geared motor) to reduce the overall speed of the motor and running at the top speed to get the most power to, say, a wheel attached to the shaft of the motor.

Stepper Motor

Stepper motors work in a similar way to dc motors, but where dc motors have 1 electromagnetic coil to produce movement, stepper motors contain many. Stepper motors are controlled by turning each coil on and off in a sequence. Every time a new coil is energized, the motor rotates a few degrees, called the step angle. Repeating the sequence causes the motor to move a few more degrees and so on, resulting in a constant rotation of the motor shaft. For example, a stepper motor with a step angle of 7.5 degrees requires 48 pulses for a complete revolution. The diagram below shows how a stepper motor works. The magnet in the middle of the arrangement is connected to the motor shaft and produces the rotation. The 4 magnets around the outside represent each coil of the stepper motor. As different coils are energized the central

magnet is pulled in different directions. By applying the correct sequence of pulses to the coils the motor can be made to rotate.

Fig. 33 Stepper Motor

This design gives stepper motors the upper hand over DC motors. Varying the speed of the input sequence can exactly control the speed of the motor. Also, by keeping count of the sequence the motor can be made to rotate any number of times to any position. The way to activate the coils determines two classes of the stepper motor: unipolar stepper motor and bipolar stepper motor. In a unipolar stepper motor the current direction in a coil is unidirectional. In other words, the polarity of the voltage across a coil is always the same or there is no voltage developed across the coil. Therefore in unipolar scheme, the motor power's positive polarity must be connected to the terminals 1 and 2 of the illustration shown below. The control of a unipolar stepper motor is, thus, to turn on and off the current flow through the four coils in a sequence for the step direction and speed. As we see a unipolar stepper motors has at least 5 external wires: 5 when terminals 1 and 2 are jointed together into one terminal, and 6 when two are left as separate terminals.

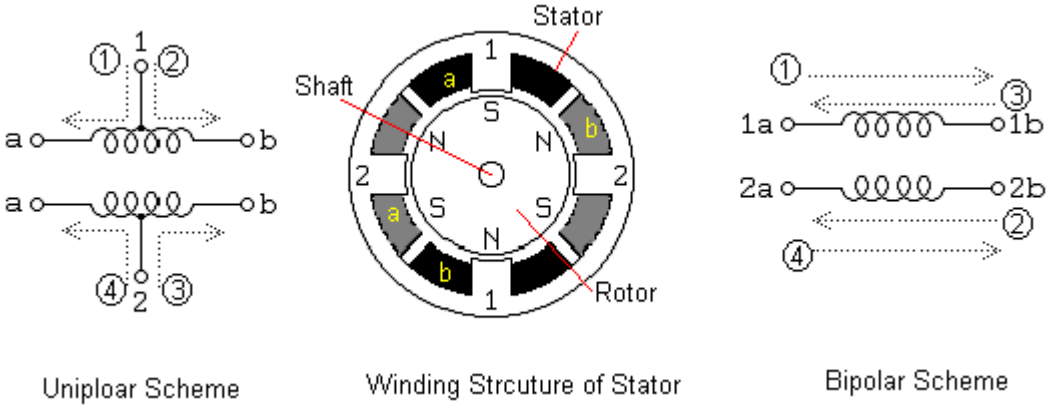

Fig. 34 How a Stepper Motor Works

In bipolar scheme, the coils can be excited by both directions. In other words, in a coil current can flow both ways. Therefore, the bipolar scheme must provide a way to apply either positive voltage to one of the coil and ground to the other end, vice versa, at a given sequence. A bipolar stepper motor therefore has only 4 external wires to excite.

Servo Motor

A Servo is a small device that has an output shaft. This shaft can be positioned to specific angular positions by sending the servo a coded signal. As long as the coded signal exists on the