NI Developer Zone

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Stepper Motor Switching Sequence

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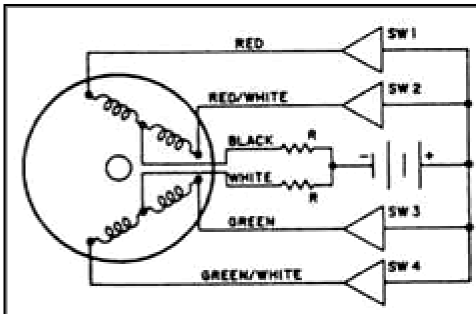
Overview

This document describes the switching sequences for stepper motors: full-step, half-step, and micro-step.

Full-Step

The stepper motor uses a four-step switching sequence, which is called a full-step switching sequence. Figure 11-59 shows a switching diagram and a table that indicates the sequence for the four switches used to control the stepper motor. The diagram shows four switches with four separate amplifiers. The diagram for the motor shows the same four windings that were discussed in the theory of operation the previous section. Each of the windings is tapped at one end and they are connected through a resistor to the negative terminal of the power supply.



(a)

FOUR STEP INPUT SEQUENCE (FULL-STEP MODE)*

STEP	SW1	SW2	SW3	SW4
1	ON	OFF	ON	OFF
2	ON	OFF	OFF	ON
3	OFF	ON	OFF	ON
4	OFF	ON	ON	OFF
1	ON	OFF	ON	OFF

(b)

FIGURE 11-59 (a) Diagram of switching circuits for stepper motor. (b) The switching sequence for a four-step (full-step) switching mode. (Courtesy of Superior Eletric, Warner Electric.)

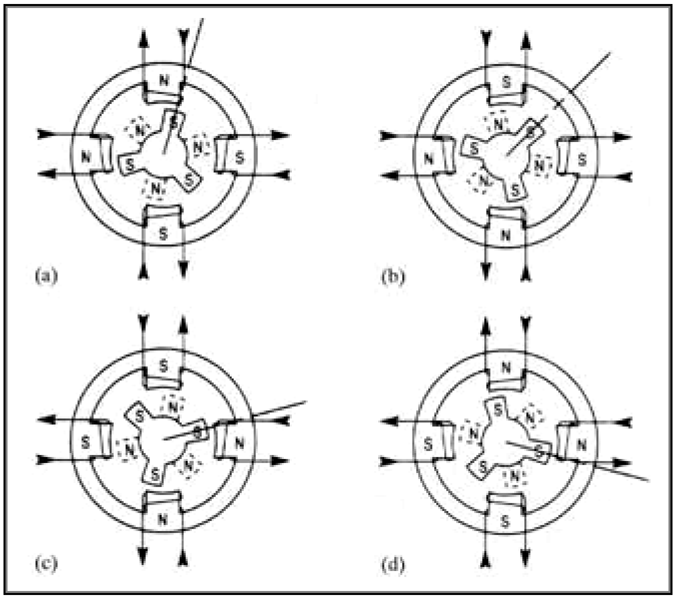
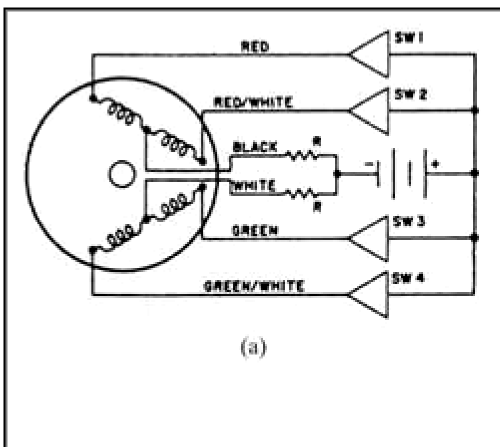


FIGURE 11-60 The diagrams that show the position of each pole while the motor is in full-step mode. The diagrams a, b, c, and d show the movement of the rotor in sequence. (Courtesy of Parker Compumotor Division.)

The table shows the sequence for energizing the coils. During the first step of the sequence, switches SW1 and SW3 are on and the other two are off. During the second step of the sequence, switches SW1 and SW4 are on and the other two are off. During the third step of the sequence, SW2 and SW4 are on and the other two are off. During the fourth step of the sequence, SW2 and SW3 are on and the other two are off. This sequence continues through four steps, and then the same four steps are repeated again. These steps cause the motor to rotate one *step* or *tooth* on the rotor when a pulse is applied by closing two of the switches. Figure 11-60 shows the position of the poles during each step when the motor is in full-step mode.

Half-Step

Another switching sequence for the stepper motor is called an *eight-step* or *half-step sequence.* The switching diagram for the half-step sequence is shown in Fig. 11-61. The main feature of this switching sequence is that you can double the resolution of the stepper motor by causing the rotor to move half the distance it does when the full-step switching sequence is used. This means that a 200-step motor, which has a resolution of 1.8°, will have a resolution of 400 steps and 0.9°. The half-step switching sequence requires a special stepper motor controller, but it can be used with a standard hybrid motor. The way the controller gets the motor to reach the half-step is to energize both phases at the same time with equal current.



EIGHT STEP INPUT SEQUENCE
HALF-STEP MODE*

STEP	SW1	SW2	SW3	SW4
1	ON	OFF	ON	OFF
2	ON	OFF	OFF	OFF
3	ON	OFF	OFF	ON
4	OFF	OFF	OFF	ON
5	OFF	ON	OFF	ON
6	OFF	ON	OFF	OFF
7	OFF	ON	ON	OFF
8	OFF	OFF	ON	OFF
1	ON	OFF	ON	OFF

(b)

FIGURE 11-61 (a) The stepper motor with its switches, (b) The switching sequence for the eight-step input (half-step mode). (Courtesy of Superior Electric, Warner Electric.)

In this sequence the first step has SW1 and SW3 on, and SW2 and SW4 are off. The sequence for the first step is the same as the full-step sequence. The second step has SW1 on and all of the remaining switches are off. This configuration of switches causes the rotor to move an additional half-step. The third step has SW1 and SW4 on, and SW2 and SW3 are off, which is the same as step 2 of the full-step sequence. The sequence continues for eight steps and then repeats. The main difference between this sequence and the full-step sequence is that steps 2, 4, 6, and 8 are added to the full-step sequence to create the half-step moves.

Micro Step Mode

The full-step and half-step motors tend to be slightly jerky in their operation as the motor moves from step to step.

The amount of resolution is also limited by the number of physi-cal poles that the rotor can have. The amount of resolution (number of steps) can be in-creased by manipulating the current that the controller sends to the motor during each step. The current can be adjusted so that it looks similar to a sine wave.
Figure 11-62 shows the waveform for the current to each phase. From this diagram you can see that the current sent to each of the two sets of windings is timed so that it is always *out of phase* with each other. The fact that the current to each individual phase increases and decreases like a sine wave and that is always out of time with the other phase will allow the rotor to reach hundreds of intermediate steps. In fact it is possible for the controller to reach as many as 500 microsteps for a full-step sequence, which will provide 100,000 steps for each revolution.

The voltage sent to the motor is now a sine wave. The motor for this type of application is generally a permanent magnet brushless DC motor. When the sine wave is sent to the motor at 60 Hz, it will cause the motor shaft to rotate at 72 rpm. The motor windings will require a capacitor to be wired in series for this type of application.

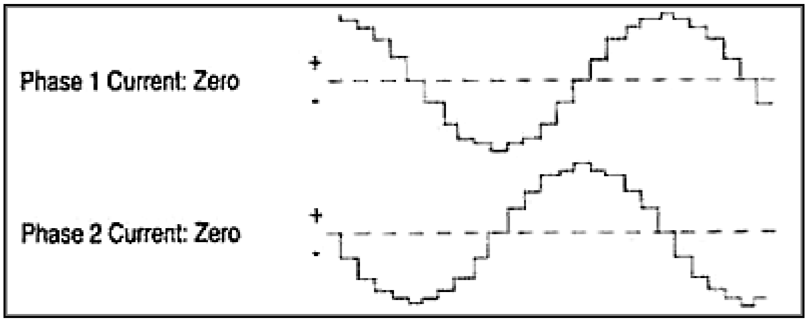


FIGURE 11-62 Phase-current diagram for a stepper motor controller in microstep mode. (Courtesy of Parker Compumotor Division.)

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