Brushless DC Motors - How Do They Commutate?

March 13, 2013

To answer the question about brushless DC motor commutation, we will focus on a wye* connected brushless DC (BLDC) motor utilizing three hall switches as the feedback device. While different devices can be used for feedback like resolvers and encoders, hall switches are the simplest.

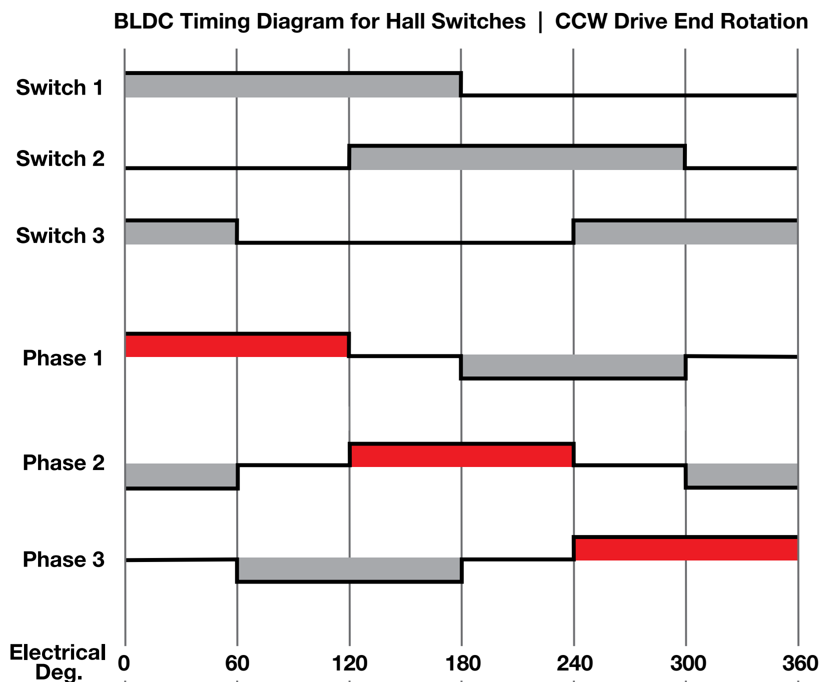
Groschopp has developed the timing diagram below to help engineers understand the commutation of our motors (this Connection Diagram is available on all of Groschopp's Brushless DC motor pages).

BLDC Timing Diagram for Hall Switches - CCW Drive End Rotation

Notice that the scale for the chart is in electrical degrees. Electrical degrees are based upon the number of poles a BLDC motor has. If the motor has 2 poles (1 north and 1 south pole); 360° electrical would be equal to 360° mechanical. If the motor has 4 poles; 360° electrical would be 180° mechanical, and so on.

We have chosen to represent our timing diagram in two different ways. The first shows a pictorial view of the commutation sequence. The second shows more of a binary type sequence. Both diagrams show the same sequence but engineers can chose which style they prefer.

The purpose of the hall switches is to tell the motor control the position of the motor by interpreting the north and south poles on the rotor. If a hall switch has a north pole in front of it, it will turn on and if it has a south pole in front of it, it will turn off. With only six different states per electrical cycle the feed back is a little coarse, however for most applications that run above 600 RPM on a 4 pole motor, this will work just fine.



Switch 1	1	1	1	0	0	0
Switch 2	0	0	1	1	1	0
Switch 3	1	0	0	0	1	1
Phase 1	+	+	0	-	-	0
Phase 2	-	0	+	+	0	-
Phase 3	0	-	-	0	+	+

Brushless DC Motor Commutation

Commutation is done by determining the angular position and then applying current to the stator which creates a magnetic field that attracts the rotor to a new position. For instance, if we start at the beginning of the timing diagram the hall switches would read; 1 on, 2 off, and 3 on. The motor control interpreting this would apply a positive current into the phase 1 lead and the current would return to the control through the phase 2 lead. This would cause the rotor to rotate and the state of the hall switches would change to; 1 on, 2 off, 3 off. Current would still flow into phase 1 but instead it would return through phase 3. This sequence would continue through the next four states and then start again at the first, giving us constant rotation.

Importance of Timing Diagrams

The timing diagram is important because not all motor and drive manufacturers label their switches and phases the same. By matching up the sequences of two data sheets, engineers are able to determine the correct connection of the motor to the drive.

Questions? Learn more about motor temperature and insulation systems, or read more in our motor selection blog series.