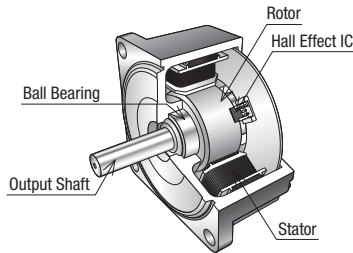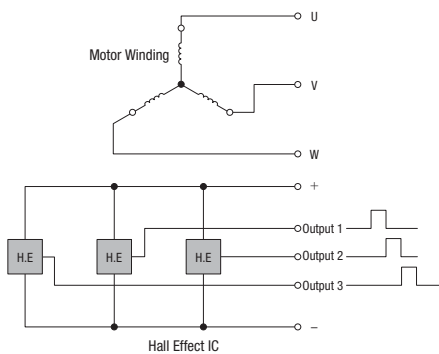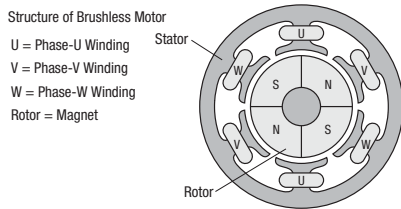# Brushless Motors/AC Speed Control Motors

■ Brushless Motor Structure and Operating Principles

● Structure of Brushless Motor

Rotor
Hall Effect IC
Ball Bearing
Output Shaft
Stator

The brushless motor has a built-in magnetic component or optical encoder for the detection of rotor position. The position detectors send signals to the drive circuit. The brushless motor uses three-phase windings in a "star" connection. A permanent magnet is used in the rotor.

Structure of Brushless Motor
U = Phase-U Winding
V = Phase-V Winding
W = Phase-W Winding
Rotor = Magnet
Stator
Rotor

Motor Winding
U
V
W
+
Output 1
Output 2
Output 3
−
H.E H.E H.E
Hall Effect IC

A hall effect IC is used for the sensor's magnetic component. 3 hall effect ICs are placed within the stator and output digital signals as the rotor rotates.

● Drive Method of Brushless Motors

The motor windings are connected to switching transistors, 6 of which make up the inverter. The top and bottom transistors turn ON and OFF according to a predetermined sequence to change the direction of current flow in the windings. The mechanism of brushless motor rotation can be described as follows:
In step ① of the transistor's switching sequence, as shown in the following figure, transistors Tr1 and Tr6 are in the ON state. At this time the winding current flows from phase U to phase W, and excites U and W to N and S poles, respectively. This causes the rotor to turn 30˚. Repeating this motion 12 times thereby facilitates rotation of the motor.
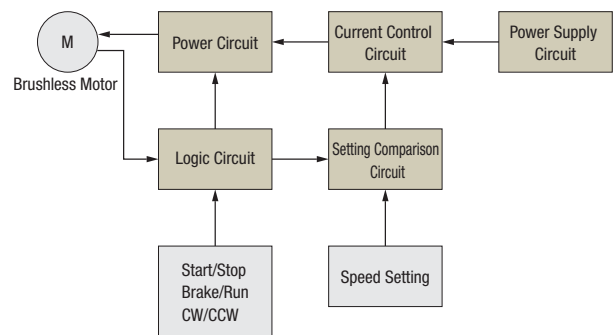

Motor Winding   Power Circuit
U   +
Tr1 Tr2 Tr3
V
①
③
W
②
Tr4 Tr5 Tr6
−
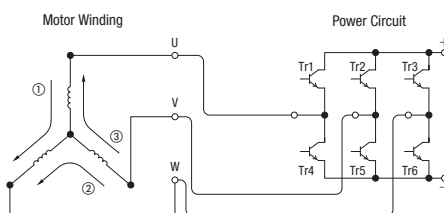
Switching Sequences of Individual Transistors

Transistor \ Step	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬
Tr1	ON					ON	ON					ON	ON
Tr2		ON	ON					ON	ON				
Tr3				ON	ON					ON	ON		
Tr4			ON	ON					ON	ON			
Tr5					ON	ON					ON	ON	
Tr6	ON	ON					ON	ON					ON
Phase U	N	—	S	S	—	N	N	—	S	S	—	N	N
Phase V	—	N	N	—	S	S	—	N	N	—	S	S	—
Phase W	S	S	—	N	N	—	S	S	—	N	N	—	S

● Control Method of Brushless Motors

The drive circuit of the brushless motor is connected in the configuration shown in the figure below and is comprised of 5 main blocks.
- Power circuit
- Current control circuit
- Logic circuit
- Setting comparison circuit
- Power supply circuit

M
Brushless Motor
Power Circuit
Current Control Circuit
Power Supply Circuit
Logic Circuit
Setting Comparison Circuit
Start/Stop Brake/Run CW/CCW
Speed Setting

◇ Power Circuit

This circuit uses transistors to control the current flow in the motor windings. 6 transistors are used.
The transistors provided at the top and bottom turn ON and OFF repeatedly according to a predetermined sequence, thereby supplying current flow to the motor windings.

◇ Current Control Circuit

The current flow to the motor varies according to the load. It is constantly detected and controlled so that the speed will not deviate from the set speed.

◇ Logic Circuit

The logic circuit detects the rotor position by receiving feedback signals from the motor's hall effect IC and determines the excitation sequence of motor windings. The circuit signal is connected to each transistor base in the power circuit, driving the transistors according to a predetermined sequence. It also detects the motor's speed.
The logic circuit is also used to control commands to the motor, including start/stop, brake/run and CW/CCW.

◇ Setting Comparison Circuit

This circuit compares the motor speed signal against the speed setting signal. The result is used to determine whether the motor speed is higher or lower than the set speed. The input to the motor is lowered if the motor speed is higher than the set speed, but the input is raised if it is lower than the set speed. In this manner, the motor speed is returned to the set speed.

◇ Power Supply Circuit

This circuit converts a commercial power supply into the voltage necessary to drive the motor and control circuits.

■Structure and Speed Control Methods of AC Speed Control Motors

● **Structure**

AC speed control motors are AC motors with a tachogenerator (speed detection sensor) installed on the back side.
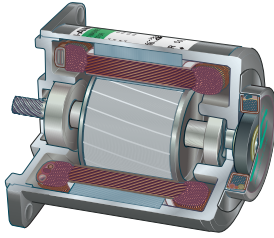
● **Speed Control Methods of AC Speed Control Motors**

The basic block diagrams and outline of the control methods are shown below.

AC speed control motors employ a closed-loop speed control method.

① The speed setting voltage is supplied via a speed potentiometer.
② The motor speed is detected by a tachogenerator and the difference in speed signal voltage is output.
③ The difference between the speed setting voltage and speed signal voltage is output.
④ A voltage determined by the output from the comparator is supplied to the motor so that it will reach the set voltage.