NASA TECH BRIEF

Hall Effect Encoding of Brushless DC Motors

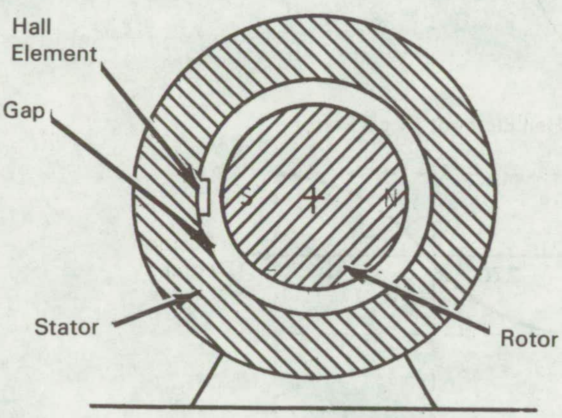

Figure 1. Element Location

To operate a brushless dc motor, an encoder and external circuitry must be employed to provide commutation of the windings. In order to eliminate the need for external devices to encode information relating the position and velocity of the rotating member, an encoding mechanism integral to the motor, and using the permanent magnets embedded in the rotor, has been developed. Brushless dc motors are constructed with the magnetic field created by permanent magnets in the rotating member (rotor) and the windings in the stationary member (stator). While a two-pole machine is described here, the scheme is useful in machines with numerous poles.

As shown in Figure 1, a Hall-effect element, attached to the stator, is mounted in the motor gap. When driven with a constant current, the output of the element is proportional to the magnetic induction, B, including both direction (or sense) and magnitude of the rotor field. Thus the output is maximum in one direction when the north pole is under the Hall element, maximum in the other direction when the south pole is under the Hall element, and at some intermediate level when the position of the rotor is in between.

For the brushless motor type having two windings in quadrature, sine and cosine driving signals are required. Two Hall elements are used to replace the sine-cosine resolver. The field of the rotor is a sinusoidal function of position. Position is described by the angle θ, where θ equals zero when Hall element #1, as shown in Figure 2 is energized by the north pole of the rotor. The sine and cosine outputs are amplified and applied to the proper motor winding by external control electronics.

For a switched-winding type motor, where the windings are energized sequentially as a function of motor rotor position, a slightly different arrangement is used. Here, one sensor is used for each pair of windings. All windings are energized sequentially over 360 electrical degrees where for multi-winding or multi-pole machines:

$$360 \text{ electrical degrees} = \frac{360 \text{ mechanical degrees of rotation}}{\text{number of pole pairs}}$$

If there are X pairs of windings, then each winding is energized for 360/2X electrical degrees. Detection of positive and negative outputs from each Hall element is performed to energize the proper windings by external commutation and control logic.

Notes:

1. In this design, the encoding function uses the permanent magnets integral to the motor so that size and weight are minimized through the elimination of conventional encoders, disks, or magnets.

(continued overleaf)

2. Requests for further information may be directed to:
Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B70-10188

Patent status:

No patent action is contemplated by NASA.

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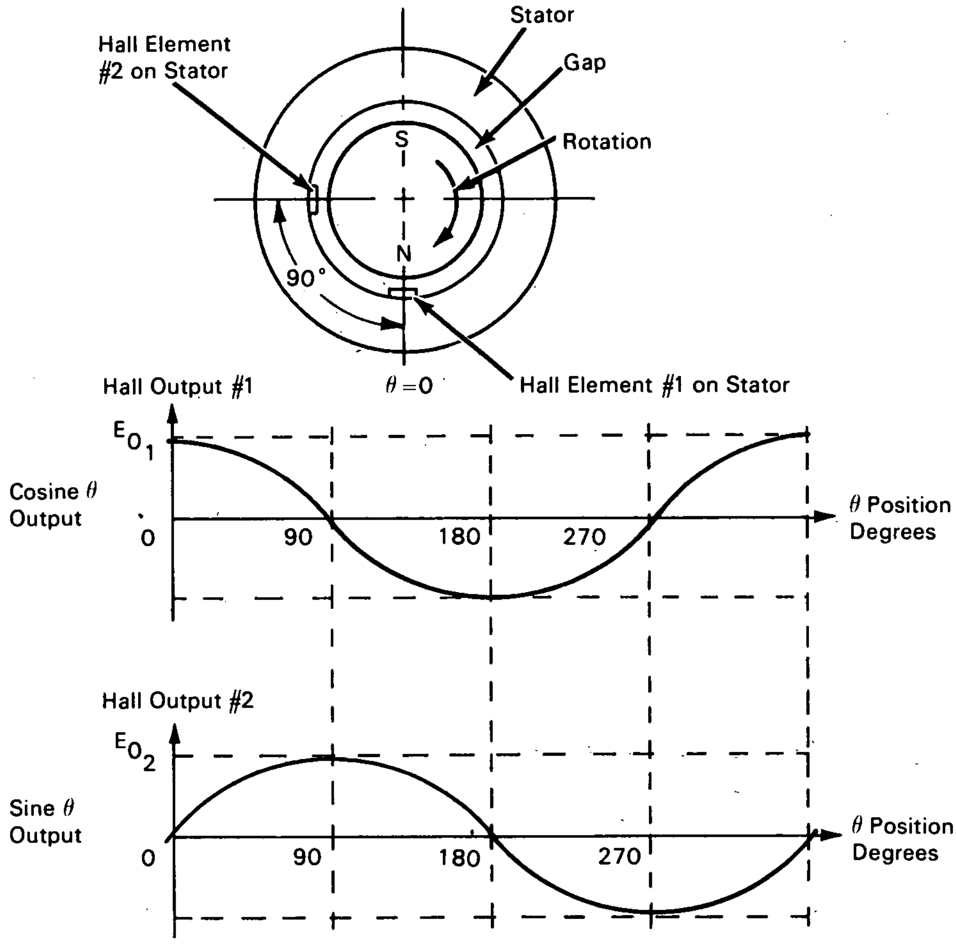

Figure 2. Sine and Cosine Outputs During Rotor Movement