Neither excitation of the motor nor mechanical brushes is necessary.

Tachometers Derived From a Brushless DC Motor

Neither excitation of the motor nor mechanical brushes is necessary.

Marshall Space Flight Center, Alabama

The upper part of the figure illustrates the major functional blocks of a direction-sensitive analog tachometer circuit based on the use of an unexcited two-phase brushless dc motor as a rotation transducer. The primary advantages of this circuit over many older tachometer circuits include the following:

- Its output inherently varies linearly with the rate of rotation of the shaft.
- Unlike some tachometer circuits that rely on differentiation of voltages with respect to time, this circuit relies on integration, which results in signals that are less noisy.
- There is no need for an additional shaft-angle sensor, nor is there any need to supply electrical excitation to a shaft-angle sensor.
- There is no need for mechanical brushes (which tend to act as sources of electrical noise).
- The underlying concept and electrical design are relatively simple.

This circuit processes the back-electromagnetic force (back-emf) outputs of the two motor phases into a voltage directly proportional to the instantaneous rate (sign · magnitude) of rotation. Integration of these signals, which results in signals that are almost linear with respect to time, this circuit relies on integration, which results in signals that are less noisy.

These Analog Tachometer Circuits perform straightforward operations on the back-emf outputs of a brushless dc motor to generate voltages proportional to the rate of rotation of the shaft.

https://ntrs.nasa.gov/search.jsp?R=20100011218 2019-03-17T02:44:55+00:00Z
tion of the shaft. The processing in this circuit effects a straightforward combination of mathematical operations leading to a final operation based on the well-known trigonometric identity \((\sin x)^2 + (\cos x)^2 = 1\) for any value of \(x\). The principle of operation of this circuit is closely related to that of the tachometer circuit described in “Tachometer Derived From Brushless Shaft-Angle Resolver” (MFS-28845), NASA Tech Briefs, Vol. 19, No. 3 (March 1995), page 39. However, the present circuit is simpler in some respects because there is no need for sinusoidal excitation of shaft-angle-resolver windings.

The two back-emf signals are \(k_\theta \sin \theta\) for phase A and \(k_\theta \cos \theta\) for phase B, where \(k_\theta\) is a constant that depends on the electromagnetic characteristics of the motor. In the present case, the quantity that one seeks to measure is \(\theta\).

Each back-emf signal is fed to a dedicated squaring circuit. The outputs of the squaring circuits for phases A and B are thus proportional to \((\theta \sin \theta)^2\) and \((\theta \cos \theta)^2\). The outputs of the squaring circuits are fed to an adder. By virtue of the identity \((\sin \theta)^2 + (\cos \theta)^2 = 1\), the output of the adder is simply \(k_\theta \theta\).

This work was done by David E. Howard and Dennis A. Smith of Marshall Space Flight Center. Further information is contained in a TSP (see page 1). This invention has been patented by NASA (U.S. Patent No. 6,084,398). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31142/3.