ANALOG DEVICES

AN-767
APPLICATION NOTE

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106 • Tel: 781/329-4700 • Fax: 781/326-8703 • www.analog.com

Using Absolute Output *i*MEMS® Gyroscopes with Ratiometric ADCs

by Harvey Weinberg

*i*MEMS gyroscopes are often used with low cost ratiometric ADCs integral to many microcontrollers. This application note outlines how to interface a gyro's absolute (invariant with supply voltage variations) output with a ratiometric ADC.

GENERAL CONCEPTS

Ratiometric ADCs return a numeric value that corresponds to the ratio of the input voltage to the supply voltage. For example, an 8-bit ratiometric ADC that has a supply voltage of 5.00 V and 1.99 V at its input would return a value (in bits) of

$$Output = 2^8 \times (1.99\,V/5.00\,V) = 102$$

If the supply voltage changes by –5% (to 4.75 V) the converter would return a value approximately 5% greater or

$$Output = 2^8 \times (1.99\,V/4.75\,V) = 107$$

Since supply voltage can rarely be counted on to be very accurate or constant, some provision must be made for conversion errors when interfaced to transducers with absolute outputs.

USING THE GYRO'S REFERENCE OUTPUT

All Analog Devices gyros have a 2.5 V reference output that can be used to reduce conversion errors. The general idea is that by performing an A/D conversion on a known voltage (the gyro's 2.5 V reference), one can calculate what the ADC's reference voltage is and an appropriate correction factor. Since the supply voltage can vary, one should perform the 2.5 V reference and gyro rate output conversions as close to simultaneously as possible.

The ADC's transfer function when measuring the gyro's 2.5 V output is

$$A/D_{OUT} = (2.5/A/D_{REF}) \times 2^n$$

where:

n is the number of bits of the A/D converter.

A/D_{REF} is the ADC's reference voltage.

Rearranging the equation:

$$A/D_{REF} = (2.5/A/D_{OUT}) \times 2^n$$

So the correction factor is

$$CF = (A/D_{REF} / REF_{IDEAL})$$

where REF_{IDEAL} is the ideal ADC reference voltage.

For example:

$$CF = A/D_{REF} / 5 \text{ for a 5 V system.}$$

Finally the corrected A/D value is

$$A/D_{CORRECTED} = A/D_{OUT} \times CF$$

CONCLUSION

Using a ratiometric ADC with an absolute output device like *i*MEMS gyros can result in significant errors if the supply voltage can vary. The 2.5 V output on Analog Devices *i*MEMS gyros allows the user to compensate for these errors by simple calculations as presented above.

AN05353–0–2/05(0)