White Paper

AS20 Encoder

Miniaturization of Energy Harvesting Magnetic Encoder: Compact Designs for Mini Motors

Abstract

Traditional encoders often present challenges in space-constrained, weight-sensitive, or high-precision applications due to their size, complexity, and installation requirements. This white paper introduces the miniature energy harvesting multi-turn (EHMT) magnetic encoder, a revolutionary solution designed to overcome these limitations. Combining an exceptionally compact-size and lightweight design with remarkably high accuracy, this encoder enables precise motion feedback where it was previously impossible or impractical. Furthermore, its innovative magnetic sensing principle and simplified mechanical interface ensure easy assembly and integration, significantly reducing installation time and complexity.

Introduction

The Broadcom® AS20 Encoder offers high performance in a miniature EHMT magnetic encoder. It features an *automatic offset and gain calibration across operating temperature*. This technology actively nullifies Hall sensor offset drift, ensuring that high accuracy is maintained immediately upon first power-on and across the full operating temperature range, eliminating a major source of system variability.

Unlike conventional counterparts, the magnetic technology demonstrates exceptional immunity to current drift throughout its operational lifetime, providing designers with confidence in stability and precision.

Its lightweight rotational magnetic source drastically reduces moment of inertia. This is transformative for applications sensitive to small starting torques, including micro-drives, portable surgical tools, and miniature robotic joints, where every milligram and mili-Newton-meter counts. Combined with its inherent small size and ease of assembly, the EHMT encoder sets a new standard for reliable, precise motion feedback in the most demanding compact applications.

Applications

- Robotics
- Medical application
- Brushless DC motor and stepper motor
- Resolver and potentiometer replacement
- Industrial automation

Where to find Broadcom encoder products:

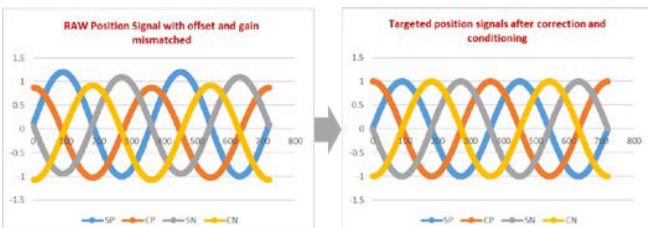
Easy access to Broadcom encoder product details and description can be found at:

https://www.broadcom.com/products/motion-control-encoders/

Core Technology: Automatic Offset and Gain Calibration across Operating Temperature

Traditional magnetic encoders relying on Hall-effect sensors are fundamentally susceptible to offset and gain drift caused by temperature variations (Figure 1). This drift manifests as significant first-power-on accuracy errors (often several percent) when the encoder is powered at a temperature different from its last calibration point. Manual calibration or complex compensation circuits are typically required to mitigate this.

Figure 1: Drifted Signal across Temperature and Targeted Signals after Correction



During manufacturing, each EHMT encoder is programmed with the default temperature value of specified operating temperature range. The optimized default offset and gain calibration values are preloaded for four key temperature points (P0-Value D, P1-Value A, P2-Value B, P3-Value C) in the internal memory, spaced at precise 32°C intervals. Point P1 is typically set at a standard room temperature (for example, 25°C). See Figure 2.

Figure 2: Memory Settings Illustration of Calibration Values

		Memory Group	Factory Default	Post calibration
P3	Room Temp +64°C	1	Value C	Value C+
P2	Room Temp +32°C	2	Value B	Value B+
P1	Room Temp	3	Value A	Value A+
P0	Room Temp -32°C	4	Value D	Value D+

Intelligent Runtime Learning:

During normal operation, when the encoder operates at a temperature close to P0 (P1 – 32°C), the system automatically performs a calibration cycle and stores the optimized offset/gain values for P0.

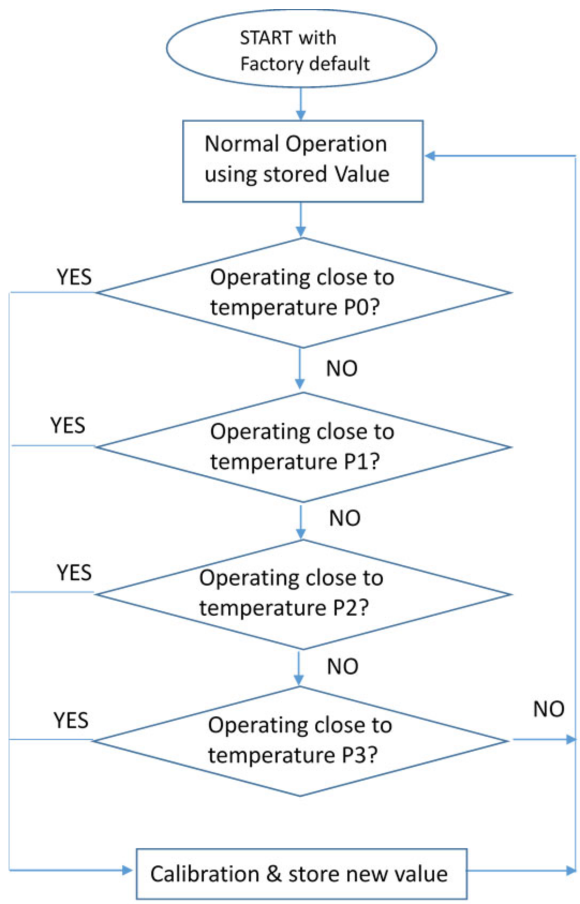
Similarly, when operating near P2 (P1 + 32°C) and P3 (P1 + 64°C), the encoder automatically calibrates and stores values for these points.

During operation at room temperature, P1 value also will be updated similar to the three other temperature points.

Calibration Storage:

All relearned calibration values (P0, P1, P2, and P3) are stored in the encoder's internal nonvolatile memory. See Figure 3.

Figure 3: Automatic Temperature Calibration Flow

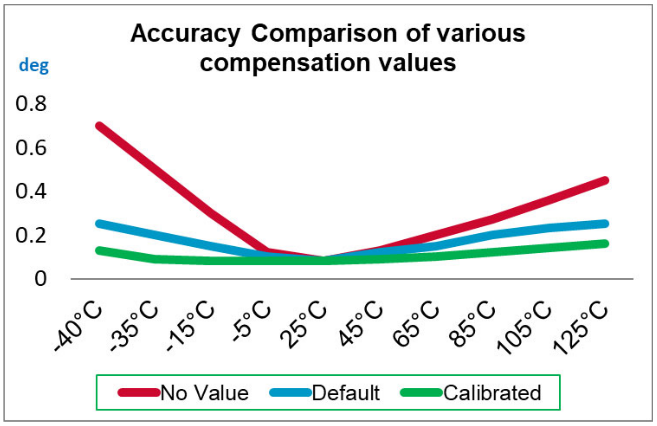


On subsequent power cycles, regardless of the ambient temperature, the encoder instantly recalls the *previously learned and stored* calibration values for the temperature point closest to the current ambient. This dramatically reduces initial accuracy drift. Figure 4 shows an accuracy comparison of various compensation values across a range of temperatures, specifically from –40°C to 125°C. The vertical axis represents accuracy error in degrees (deg), while the horizontal axis represents temperature.

Legend:

- Red line (No Value): With no compensation applied, startup accuracy error could be as worse as 0.7 deg.
- Blue line (Default): Default compensation is used. The startup accuracy is improved with the average settings.
- Green line (Calibrated): Calibrated (optimized) compensation used. The calibrated value is optimized for the particular unit where <0.2 deg is achievable.

Figure 4: Comparison of Uncelebrated, Default, and Calibrated Power on Accuracy Temperature Performance



Moment of Inertia by Modulation Element

The encoder employs a 12-mm × 2-mm permanent magnet (Figure 5) as the modulation element, embedded directly in an aluminum hub. This configuration eliminates the need for a traditional code wheel, significantly reducing the moment of inertia to 51.8 g.mm^2, which is multiple times less than the optical encoder counterparts. Position is sensed through magnetic field variation, enabling a compact form factor. For applications requiring energy harvesting, an additional magnet can be incorporated without affecting the primary sensing mechanism.

Figure 5: Modulation Element 12-mm × 2-mm Neodymium Magnet Mounted in an Aluminium Hub

Stable Power Characteristics across Lifespan and Mounting Tolerance

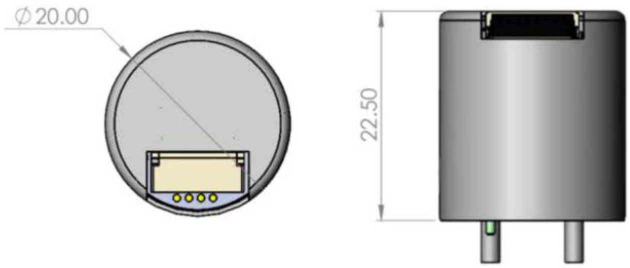
One of the key advantages of this encoder is its ability to maintain a consistent operating current of 30 mA at 5V (35 mA for differential protocols with termination resistors), regardless of its spatial orientation or age. This contrasts sharply with optical encoders, which rely on light sources such as LEDs that require precise current regulation and are sensitive to alignment and aging.

In optical encoders, even minor misalignments or degradation of the light source over time can lead to fluctuations in power consumption, signal integrity issues, and eventual performance degradation. These limitations often necessitate additional circuitry or feedback mechanisms to ensure reliable operation, increasing both system complexity and cost.

By comparison, the AS20 encoder's stable electrical characteristics reduce design overhead, simplify power budgeting, and enhance long-term reliability. This makes it especially well-suited for industrial and embedded applications where consistent performance and low maintenance are critical.

Conclusion

Figure 6: AS20 Encoder Outer Dimensions



At only 20-mm wide and 22.5-mm tall (Figure 6), the Broadcom AS20 ranks among the smallest EHMT encoders available today.

The AS20 EHMT encoder sets a new standard for compact, precision feedback systems. Its intelligent calibration, minimal inertia, and simplified assembly unlock new design possibilities in miniaturized robotics, medical tools, and industrial micro-drives.

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