BROADCOM®

White Paper

Incremental Encoders

Achieve Higher Performance with Automatic Calibration

Abstract

Automatic calibration is a function inside incremental encoders that simplifies the calibration process and eases use on application. After the signals are calibrated to target specifications, the incremental encoders can meet high-performance outputs, such as 2-MHz or 4-MHz output frequencies, while maintaining the performance of the lower state error and duty error of the incremental outputs.

Introduction

As industries strive for higher output frequencies and cost-effective solutions, encoder technology must evolve to meet these challenges. This has given encoder makers the idea for an innovative solution. Broadcom has introduced the AEDR-99xx series high-performance reflective incremental encoders.

This series features high-resolution incremental encoders with a state-of-the-art built-in interpolator, reducing overall system costs. These encoders are suitable for both rotary and linear applications.

The AEDR-99xxA series is automotive-grade compliant with IATF-16949 and is qualified to Grade 1 AEC-Q100 automotive reliability standards, operating up to 125°C. With automatic calibration, the AEDR-99xx series delivers high-performance incremental outputs after a quick and simple setup process.

Applications

- Robotics
- Medical applications
- Brushless DC motors and stepper motors
- Resolver and potentiometer replacement
- Industrial automation
- Industrial sewing machines and textile equipment
- Light detection and ranging (LiDAR)
- Vending machines
- Liquid level monitoring

Encoder Selection Principle: Using the 4W 1H Principle to Determine Encoder Selection

Optical incremental encoders detect the light that passes through the marked disc and becomes optical pulses; the encoders convert those pulses into electrical signals and then output the signals as digital pulses A/B. From the A/B outputs, users would usually look into parameters such as output frequency, state error, duty error, interpolation factor, or resolution while selecting the encoders, together with the 4W 1H principle.

Why choose Broadcom:

Broadcom is one of the leading global encoder makers and has an extensive portfolio of encoder-related intellectual property ranging from optical encoders to magnetic encoders.

Where to find Broadcom encoder products:

Easy access to Broadcom encoder product details is available from the following web page:

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

What types of encoder to choose:

- Optical absolute encoders
- Optical incremental encoders
- Optical absolute encoders with incremental output
- Magnetic absolute encoders with incremental output

When to choose:

Choose encoders for a new project or ongoing manufacturing products that require better performance, safety requirements, a consistent supply chain, and cost savings.

How to choose:

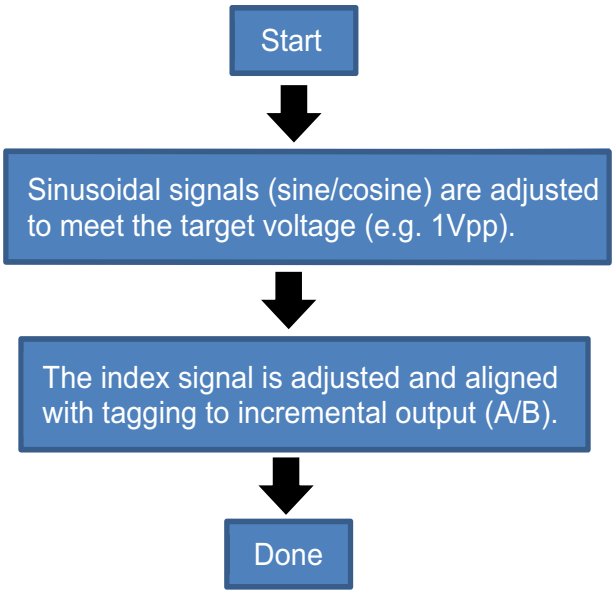
Know the design requirements and consult with a Broadcom sales representative for recommendations.

Automatic Calibration for Incremental Encoders

Automatic calibration enhances the signal performance and improves the spatial displacement during production assembly and for product reliability. Automatic calibration calibrates the analog sine/cosine, analog index, and index phase. Calibration of the analog sine/cosine improves the signal performance and LED reliability; whereas calibration of the index signal improves the spatial displacement. Without calibration, the spatial displacement tolerances are typically within 200 µm; with calibration, the spatial displacement tolerances increase up to 400 µm. Broadcom has integrated and simplified the calibration process by a single pin trigger, the encoder movement to an offscale trigger, or the SPI protocol. So to perform manual calibration, manufacturers do not need to invest in sophisticated test systems to pull out the measurement signals, largely decreasing their setup time and cost of investment.

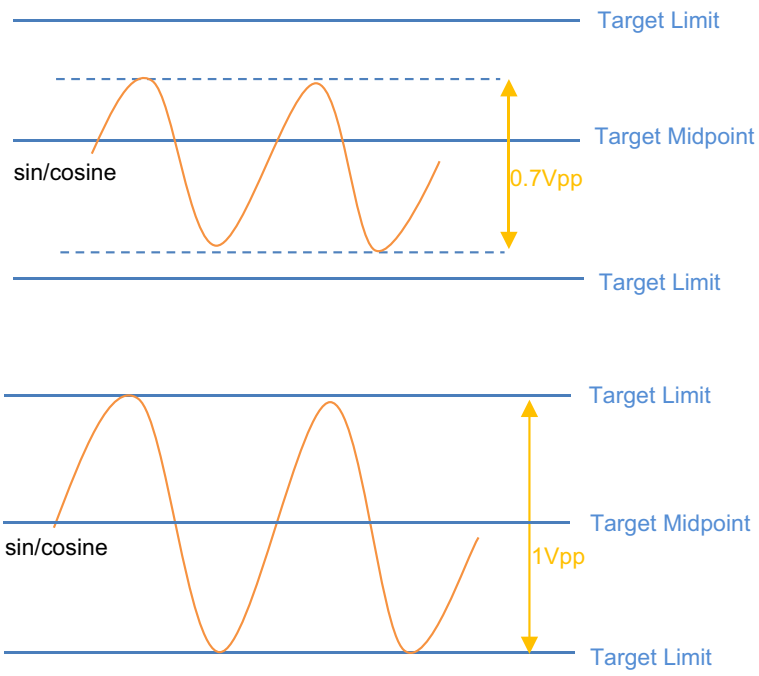
With incremental encoders, automatic calibration adjusts sinusoidal inputs to meet the target voltage, and it also adjusts and aligns index signal output tagging to incremental outputs. It can be completed by using a pad control or protocol to access the internal register to execute automatic calibration. Figure 1 shows the general flow of automatic calibration processing.

Figure 1: Automatic Calibration Flow



To further elaborate on the automatic calibration flow, Figure 2 shows the sinusoidal signal adjustment to the target specification, for example 1Vpp, and Figure 3 shows the index signal adjustment to incremental output B high.

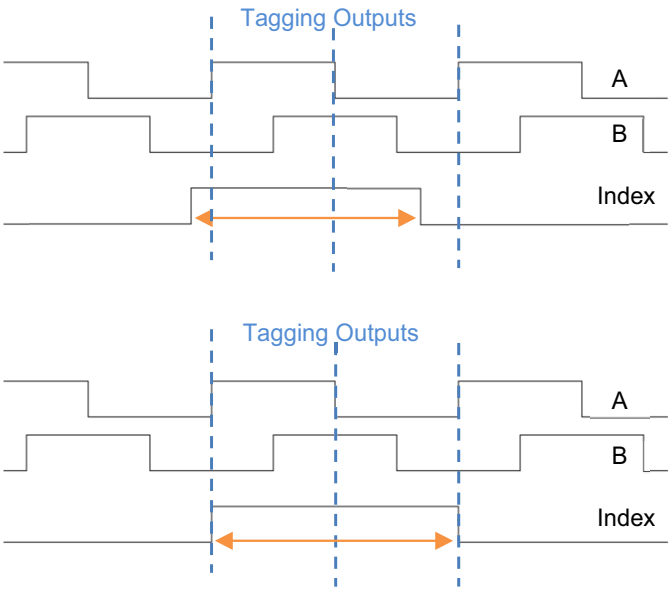
Figure 2: Adjustment of Sinusoidal Signals



Before adjustment, the sinusoidal signals are not optimized.

After automatic calibration adjustment, the sinusoidal signals are optimized to the target voltage peak-to-peak.

Figure 3: Adjustment of the Index Signal



Before adjustment, the index signal is off compared to output B.

After automatic calibration adjustment on the index signal, tagging is aligned to incremental output B high.

Product Summary



	AEDR-9930E/EA	AEDR-9930EL/ELA	AEDR-9940
Voltage	3.3V to 5V (±10%)		
Track Type	Dual Track		Dual Track
Package Size	5 mm × 5 mm		4 mm × 4 mm
LED Type	Infrared (840 nm to 860 nm)		660 nm
Automotive Ready[a]	X / √	X / √	X
Temperature Rating	–40°C to 115°C/125°C	–40°C to 115°C/125°C	–40°C to 115°C
Base/Maximum Frequency	200 kHz / 4 MHz		250 kHz / 4 MHz
Sine/Cosine Differential Output	X	X	**Output: 1Vpp** Index(Analog) Index(Ungated digital): 3.3Vpp/5Vpp **Output: 0.5Vpp** Index(Analog) Index(Ungated digital): 3.3Vpp/5Vpp
Differential ABI Output	√	√	√
Lines per Inch (LPI)	397	397	198.4
Base Cycles per Revolution (CPR)	512		256
Base Optical Radius (ROP)	5.2135		5.215
Scalability (Base CPR up to Linear)	√	√	√
Resolution	(Cycles per revolution [CPR] × Interpolation × 4)/360 = Mech deg		
Resolution Linear (Example)	16x = 1 µm; 160x = 0.1 µm		32x = 1 µm; 320x = 0.1 µm
Accuracy	Typical ± 0.1 mdeg (factory setup with motor bearing and metal code wheel)		
Latency (Typical)	7 µs		7 µs
Spatial Tolerance (Base CPR)	≥ 512 CPR ±300 µm (Auto Cal) ≥ 1000 CPR ±500 µm (Auto Cal)		128 CPR ±200 µm (Auto Cal) ≥ 512 CPR ±200 µm (No Cal) ≥ 625 CPR ±350 µm (Auto Cal)
Calibration Required	√	√	√
Maximum Digital Output(AB) Interpolation	1x to 512x Selectable		1x to 1000x Selectable
	1x to 1024x Programmable		1x to 1024x Programmable
Status Pin	√	√	√
Offscale Calibration	X	√	√

a. The manufacturing/quality management system is compliant with automotive IATF-16949. The AEDR-99xxEA/ELA (production status) are qualified to Grade 1 AEC-Q100 automotive reliability 125°C.

Conclusion

Automatic calibration inside incremental encoders provides simplified calibration for high-performance outputs. The AEDR-99xx series represents a technological advancement in encoder design, offering ease of use and robust performance for both automotive and industrial applications. With compliance to IATF-16949 and Grade 1 AEC-Q100 standards, Broadcom continues to lead the way in delivering innovative solutions for precision motion control.

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