BROADCOM®

Application Note

AEDR-9820E/9820EA, AEDR-9830E/9830EA

Three-Channel Reflective Incremental Encoder with Analog or Digital Differential Output

Introduction

The Broadcom® AEDR-98x0E series is a three-channel reflective optical encoder. It can be configured to analog or digital outputs employing reflective technology for motion-control purposes. The selectable options available are a two-channel differential analog with a third channel differential digital or analog index output or a three-channel digital differential A, B, and I output.

The AEDR-98x0E series in analog encoder modes, with a two-channel differential analog output (Sin, /Sin, Cos, /Cos), can be interfaced directly with available external interpolators.

The AEDR-98x0E series in digital encoder mode offers two-channel (AB) quadrature digital outputs and a third channel digital index output. Being TTL compatible, the outputs of the encoder can be interfaced with most of the signal processing circuitry. Therefore, the encoder provides easy integration and flexible design-in into existing systems.

The AEDR-98x0E series encoder is designed to operate over a –40°C to 115°C temperature range and is suitable for commercial, industrial, and automotive end applications.

Features

- Analog output option: 2-channel differential analog output and differential or analog index output
- Digital output option: 3-channel differential or TTL compatible; 2-channel quadrature (AB) digital outputs for direction sensing and a third digital index channel
- Built-in interpolator for 1x, 2x, 4x, 8x, 16x, and 32x interpolation
- Surface-mount leadless package: 4.0 mm (L) × 4.0 mm (W) × 1.05 mm (H)
- Operating voltage of 3.3V and 5.0V supply
- Built-in LED current regulation
- Wide operating temperature range: –40°C to 115°C
- High encoding resolution:
  - AEDR-9820E: 225 LPI (lines per inch) or 8.86 LPmm (lines per mm)
  - AEDR-9830E: 318 LPI (lines per inch) or 12.52 LPmm (lines per mm)
- Enhanced compatibility with a wider range of code-wheel and code-strip material

Applications

- Closed-loop stepper motors
- Small motors, actuators
- Industrial printers
- Robotics
- Card readers
- Pan-tilt-zoom (PTZ) cameras
- Portable medical equipment
- Optometric equipment
- Linear stages
- Light detection and ranging (LiDAR)
- Automated guided vehicles (AGVs)
- Autonomous mobile robots (AMRs)

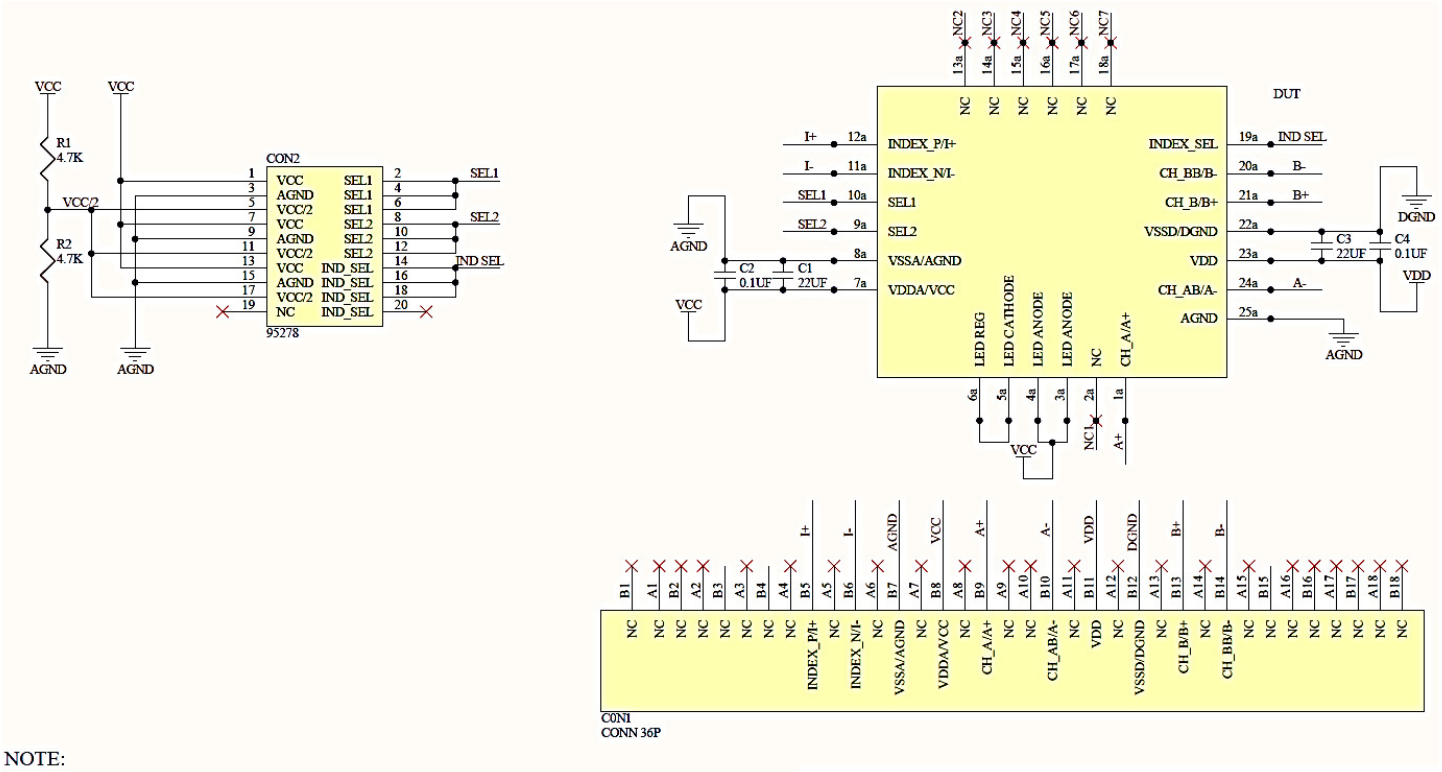
Related Part Ordering Information

Ordering Information	Type
AEDR-9820E-100	AEDR-9820E, 225-LPI incremental encoder, 1000 pieces
AEDR-9820E-102	AEDR-9820E, 225-LPI incremental encoder, 100 pieces
AEDR-9830E-100	AEDR-9830E, 318-LPI incremental encoder, 1000 pieces
AEDR-9830E-102	AEDR-9830E, 318-LPI incremental encoder, 100 pieces
HEDS-9820EEVB	AEDR-9820E evaluation board, 225-LPI encoder, and code wheel
HEDS-9830EEVB	AEDR-9830E evaluation board, 318-LPI encoder, and code wheel

Reference Schematic Design

Both the AEDR-9820E and the AEDR-9830E share the same schematic design. The following figure shows an example of the schematic diagram used in the evaluation PCB example shown later in this application note.

Figure 1: Reference Schematic Diagram for AEDR-9820E/9830E



NOTE:
1. CAPACITOR PAIR 22UF AND 0.1UF PLACE AS CLOSE AS POSSIBLE TO UNIT
2. AVOID ROUTING INDEX TRACE IN PARELLEL AND CLOSE TO ANALOG SIGNAL
3. MINIMIZE TRACE LENGTH IF POSSIBLE
4. UNIT PIN 1 ORIENTATION PLACE AT BOTTOM RIGHT

AEDR-9820E/9820EA Select Options – Encoder Built-in Interpolation

SEL 1[a]	SEL 2[a]	INDEX SEL	Interpolation Factor	Index	Max. Output Frequency	CPR at ROP 4.6 mm	CPR at ROP 11 mm
Open	Open	Low	1X	Gated 90°e	200 kHz	256	612
		High		Gated 180°e			
		Open		Ungated Raw			
Open	Low	Low	2X	Gated 90°e	400 kHz	512	1224
		High		Gated 180°e			
		Open		Gated 360°e			
High	High	Low	4X	Gated 90°e	800 kHz	1024	2448
		High		Gated 180°e			
		Open		Gated 360°e			
Low	Low	Low	8X	Gated 90°e	1.6 MHz	2048	4896
		High		Gated 180°e			
		Open		Gated 360°e			
High	Low	Low	16X	Gated 90°e	3.2 MHz	4096	9792
		High		Gated 180°e			
		Open		Gated 360°e			
High	Open	Low	32X	Gated 90°e	4.0 MHz	8192	19,584
		High		Gated 180°e			
		Open		Gated 360°e			
Open	High	N/A	Analog (500 mVpp)	Analog	200 kHz	N/A	N/A
Low	High	N/A	Analog 1 Vpp	Ungated Digital			
Low	Open	N/A	Analog 1 Vpp	Analog			

a. Open selection must be connected to the middle of a voltage divider circuit.

AEDR-9830E/9830EA Select Options – Encoder Built-in Interpolation

SEL 1[a]	SEL 2[a]	INDEX SEL	Interpolation Factor	Index	Max. Output Frequency	CPR at ROP 7.95 mm	CPR at ROP 11 mm
Open	Open	Low	1X	Gated 90°e	200 kHz	625	865
		High		Gated 180°e			
		Open		Ungated Raw			
Open	Low	Low	2X	Gated 90°e	400 kHz	1250	1730
		High		Gated 180°e			
		Open		Gated 360°e			
High	High	Low	4X	Gated 90°e	800 kHz	2500	3460
		High		Gated 180°e			
		Open		Gated 360°e			
Low	Low	Low	8X	Gated 90°e	1.6 MHz	5000	6920
		High		Gated 180°e			
		Open		Gated 360°e			
High	Low	Low	16X	Gated 90°e	3.2 MHz	10,000	13,840
		High		Gated 180°e			
		Open		Gated 360°e			
High	Open	Low	32X	Gated 90°e	4.0 MHz	20,000	27,680
		High		Gated 180°e			
		Open		Gated 360°e			
Open	High	N/A	Analog (500 mVpp)	Analog	200 kHz	N/A	N/A
Low	High	N/A	Analog 1 Vpp	Ungated Digital			
Low	Open	N/A	Analog 1 Vpp	Analog			

a. Open selection must be connected to the middle of a voltage divider circuit.

The preceding digital interpolation factor can be used in conjunction with the following equations to cater to various rotational speed (RPM) and counts per revolution (CPR).

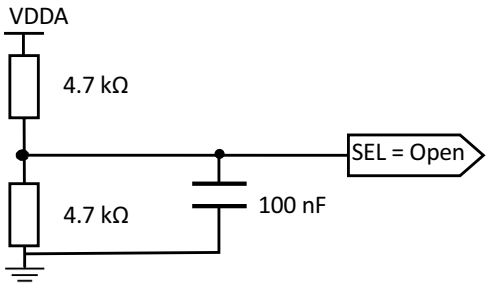
RPM = (Count Frequency × 60) / CPR

The CPR (@ 1X interpolation) is based on the following equation, which is dependent on the radius of operation (ROP).

CPR = LPI × 2π × ROP (inch) or
CPR = LPmm × 2π × ROP (mm)

NOTE: LPmm (lines per mm) = LPI (lines per inch) / 25.4

Figure 2: Example of a Voltage Divider Circuit



NOTE: It is recommended to use 2 × 4.7-kΩ resistors (VDDA-GND).

Figure 3: Example of a Hi and Lo Selection Circuit



NOTE: It is recommended to include capacitors at the SEL pins to prevent or eliminate any unwanted disturbance or signal coupling that could potentially impact the mode of AEDR-9830E selection and lead to unwanted behavior of the device.

Evaluation Board with Physical Alignment Guide Lines

1. Place the mounting plate on the motor base.
2. Place the set-height jig on the motor base.
3. With the aid of the set-height jig, install the code-wheel hub assembly into the motor shaft between the motor base and the hub's bottom surface. Secure the hub with an M3x3 set screw. (The recommended tightening torque is 0.15 Nm for an M3x3 set screw.)
4. Position the PCBA on the mounting plate guided by the guide pins. Align to the code wheel by using the silk-screen-printed guide lines to the code-wheel hub assembly.
5. Secure the position with mounting screws. (The recommended tightening torque is 0.15 Nm for an M2x6 cap screw.)

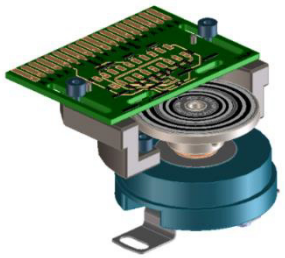
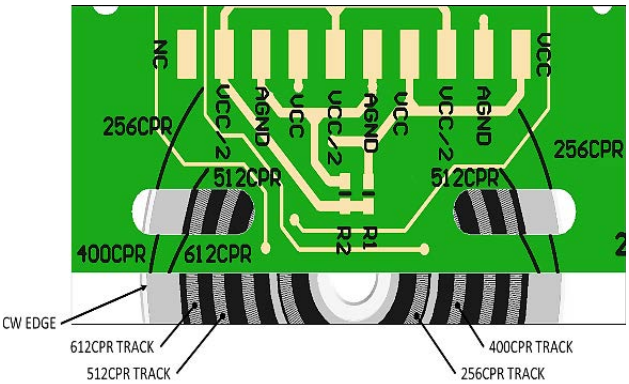


Figure 4: Evaluation Board (AEDR-9820E and AEDR-9830E) Mounting Concept

AEDR-9820E



AEDR-9830E

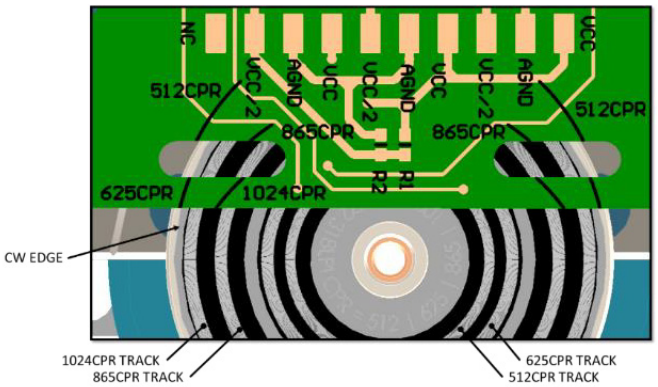


Figure 5: Evaluation Board (AEDR-9820E and AEDR-9830E) Dimensions

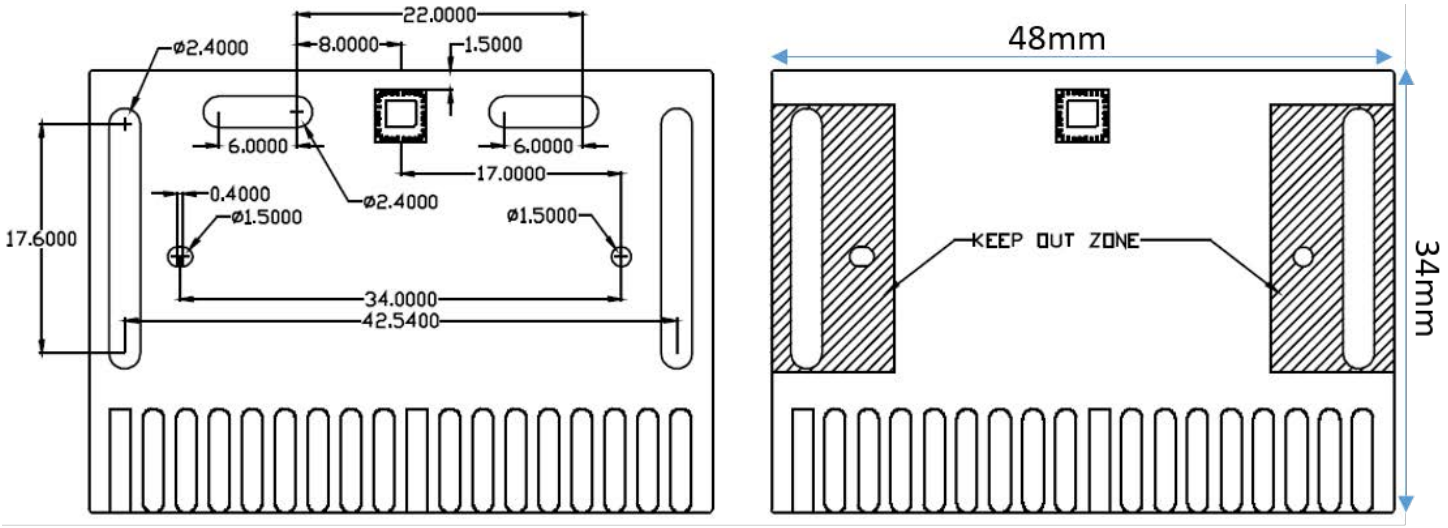
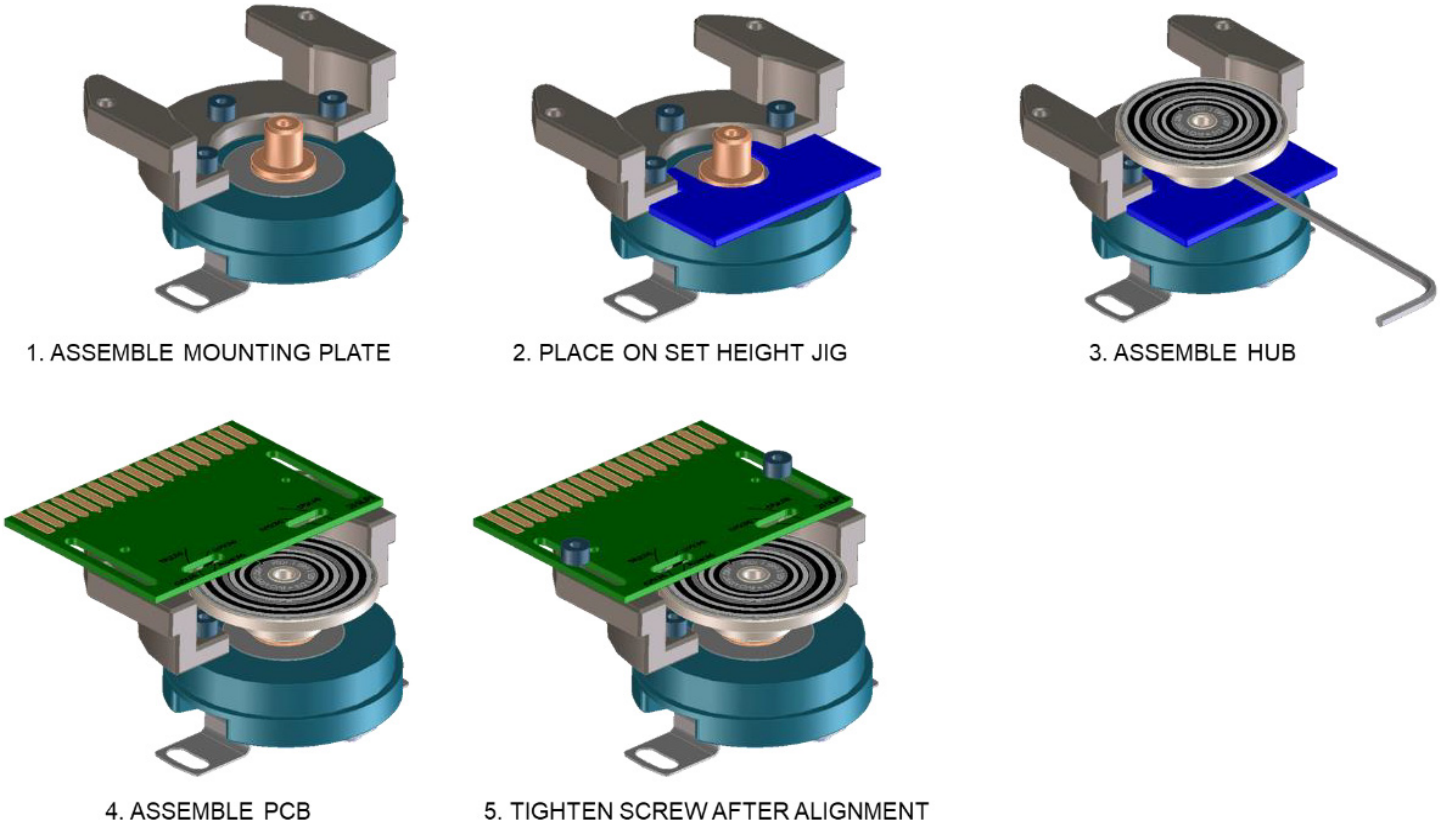


Figure 6: Evaluation Board Sample Mounting Bracket and Bearing Stage



Jig Design Concept

The jig design is based on the AEDR-98x0E series with 6-mm shaft mounting. Consult the factory for the jig design details.

Figure 7: Mounting Jig

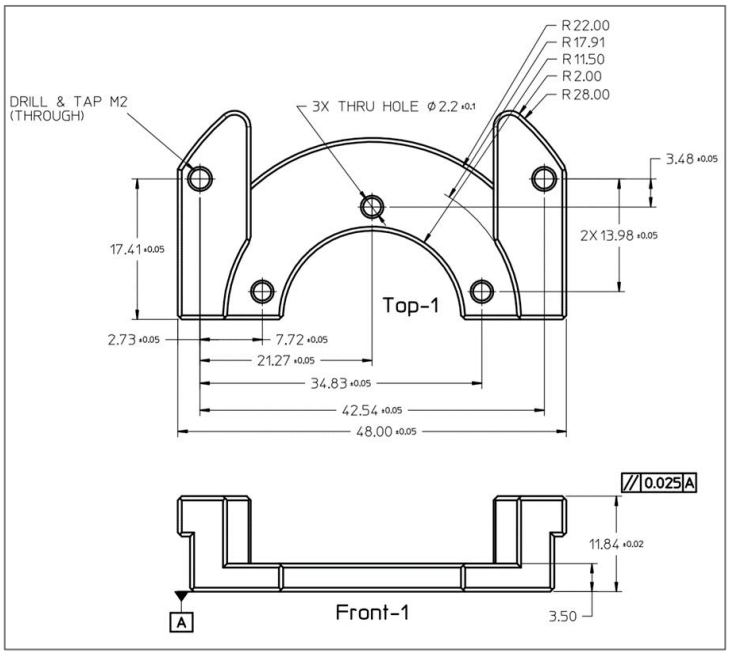
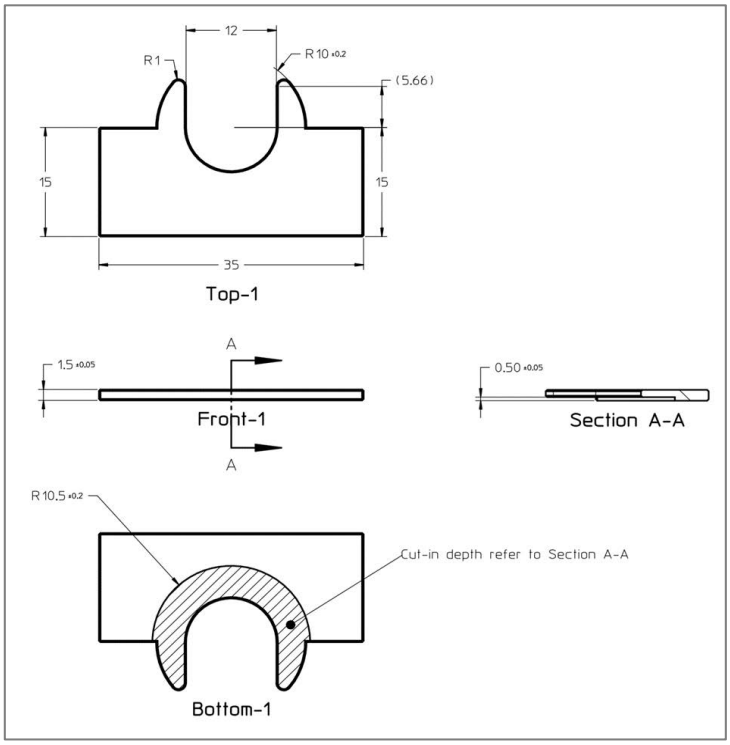


Figure 8: Set-Height Jig



Mounting Requirement

Figure 9 shows the mounting requirement to set up the encoder to the optimum position for typical encoder performance. The overall mounting requirement is applicable for the following:

- AEDR-98x0E series encoder to code-wheel operational gap
- Code-wheel placement

Figure 9: Mounting Requirement

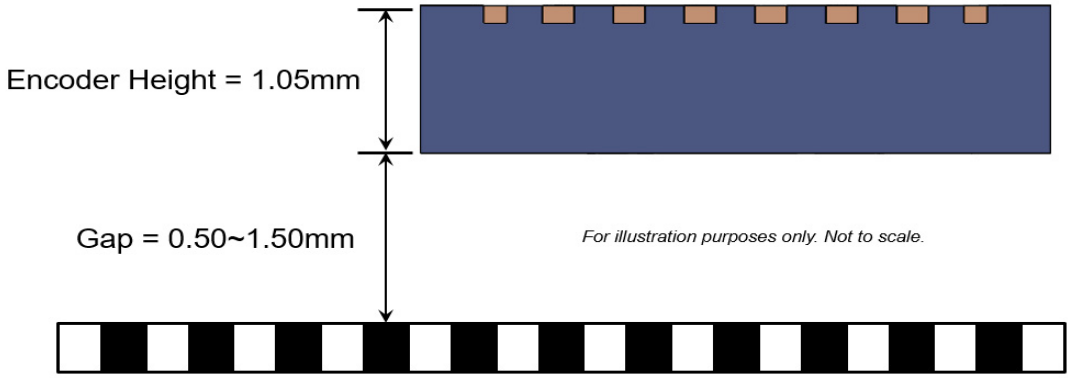
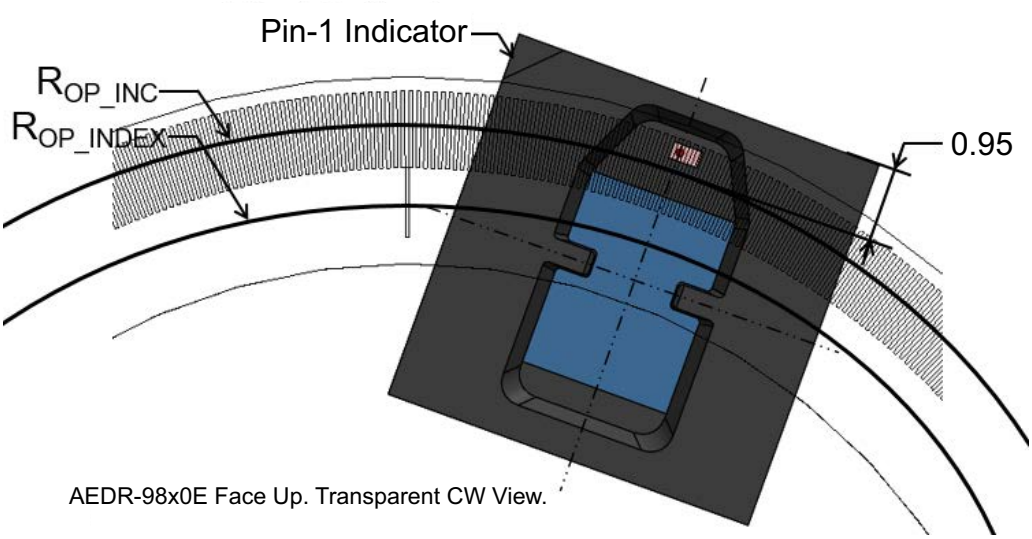
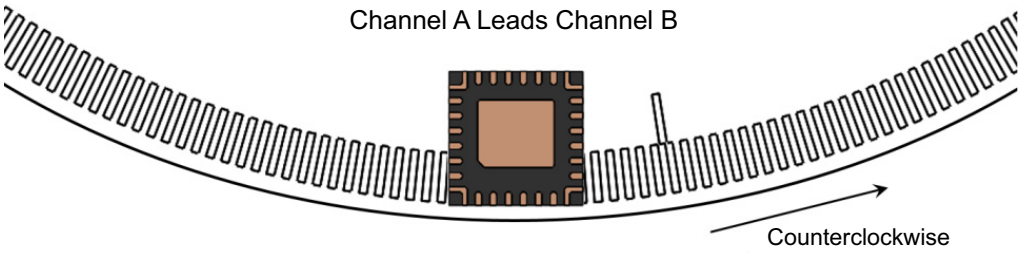


Figure 10: Channel A and B Signal Orientation vs. Mounting Position

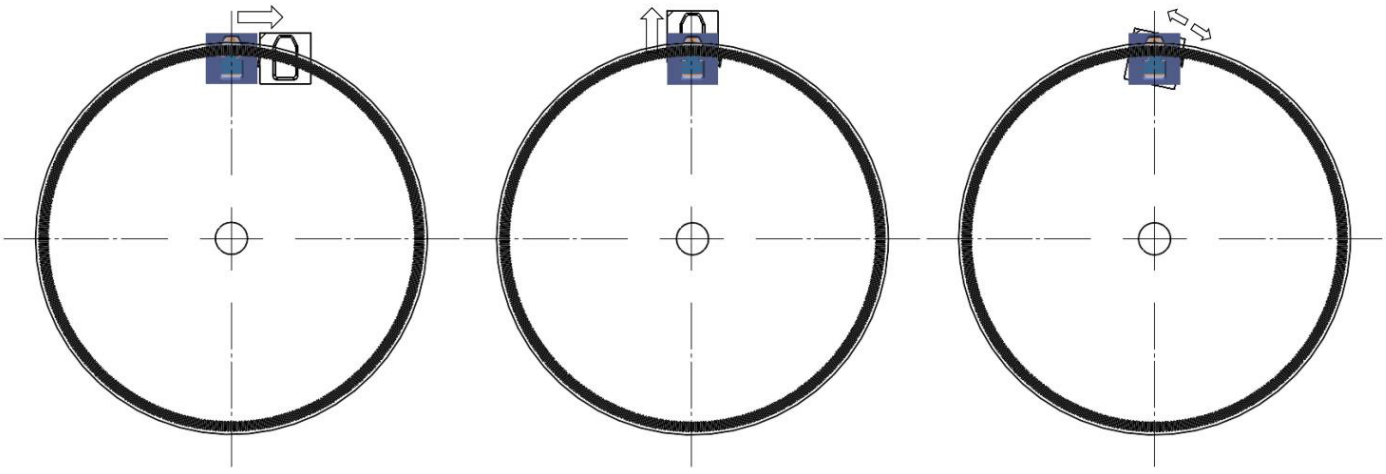




For Illustration Purposes Only. Not to Scale.

Spatial Tolerances

Figure 11: AEDR-9820E and AEDR-9830E Spatial Tolerances

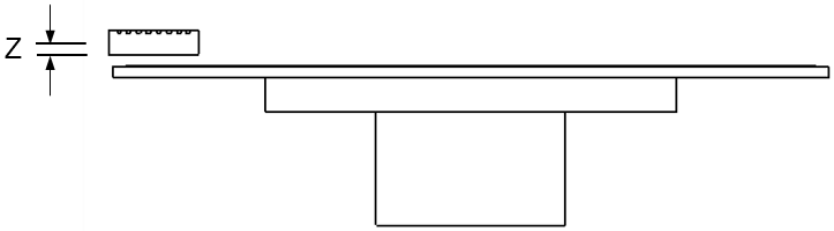


Tangential X: +/- 0.20 mm

Radial Y: +/- 0.20 mm

Tilt θ : +/- 2^0

Gap Z: 1.0 +/- 0.5 mm
(Nominal at 1.00 mm & with the range of 0.50 mm to 1.50 mm)



Notes on Assembly

1. The assembly of the encoder requires a clean-room condition, Class 100k or better.
2. The encoder must be enclosed with an IP50-rated enclosure.
3. The encoder is supplied with protective tape to prevent contamination. Remove the tape only after the surface-mount soldering-reflow process.

Recommended Shaft Tolerance

Hub ID (mm)	Hole Tolerance			Set Screw Size	Shaft OD (mm)	Shaft Tolerance		
	Lower	Upper	Hole Basis			Lower	Upper	Shaft Basis
6	0	0.008	H6	M3	6	–0.004	–0.009	g5
8	0	0.009	H6	M3	8	–0.005	–0.011	g5

Code-Wheel Handling

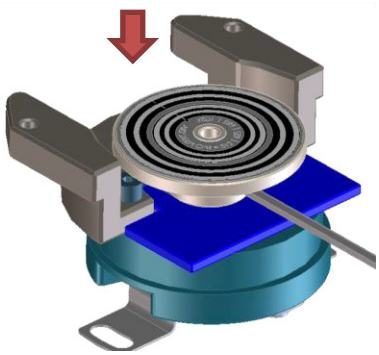
- Prevent touching the code-wheel active area by wearing a finger cot.
- Use only delicate task wipers with isopropyl alcohol to wipe the code wheel. Do not use cotton buds (non-lint-free) because they will cause scratches and will contaminate the code wheel.



Good



Contaminated

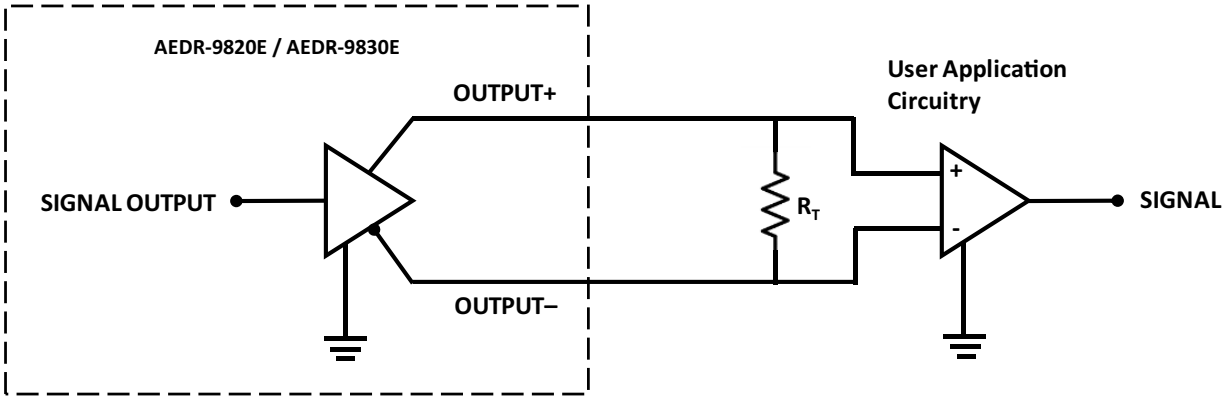


Recommended Electrical Interface

1. Provide the encoder power supply with the following values:
   – For a 5.0V supply, the Vcc must be within the range of 4.5V to 5.5V.
   – For a 3.3V supply, the Vcc must be within the range of 3.0V to 3.6V.
2. For best noise immunity, use a twisted-pair shielded cable for connection to the servo driver.
3. To prevent undesirable signal reflection, terminate with 1200Ω resistors.

Differential I/O Connection

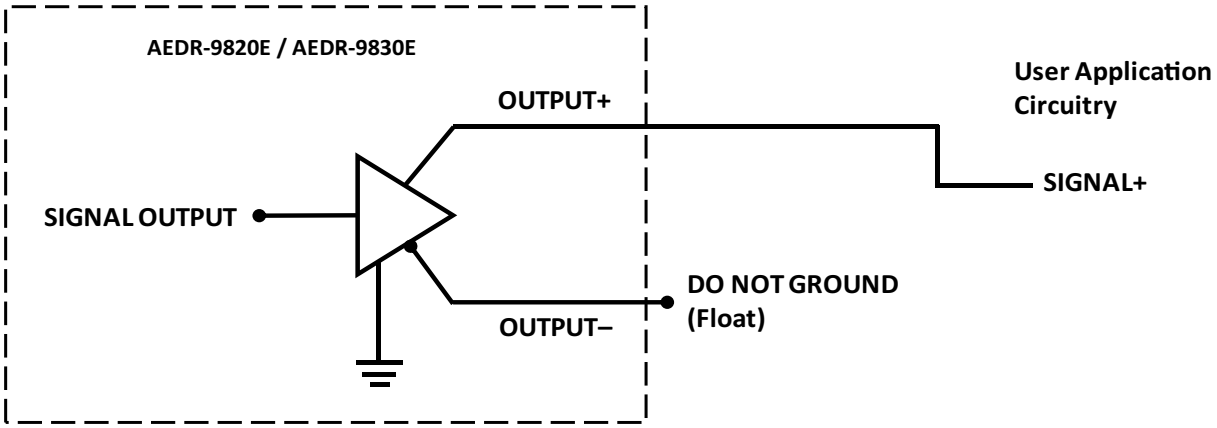
- Ground unused pins for noise reduction.
- Use a shielded cable for better noise immunity.



NOTE:

1. Output+ represents the A+, B+, or I+ digital output from the encoder.
2. Output– represents the A–, B–, or I– digital output from the encoder.
3. Load resistance, R_T, is optional although highly recommended to reduce reflection.
4. The differential I/O connection is applicable only for digital output. Do not use for analog output.

Single-Ended I/O Connection



NOTE:

1. Output+ represents the A+, B+, or I+ digital output from the encoder.
2. Output– represents the A–, B–, or I– digital output from the encoder.
3. Do not ground Output– from the encoder. Allow the output to float.

I/O Pins

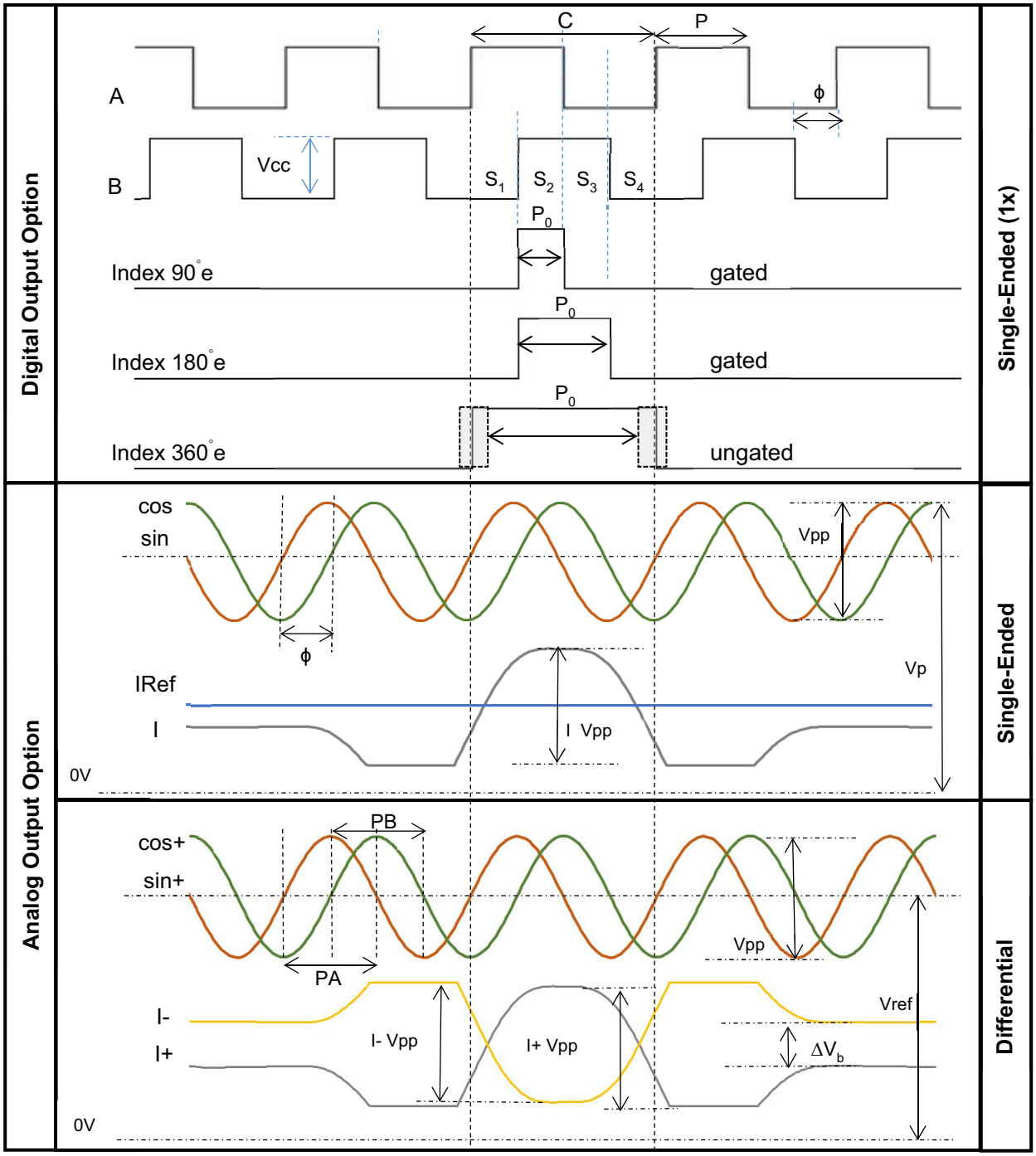
It is advisable that there be no voltage or current applied to the I/Os of the encoder before the encoder is powered up. The device pads include ESD diodes and I/O multiplexing, and any undue voltage or current going into the device can potentially partially power up the device and bring it to an unknown state or cause an undue collection of charges prior to a proper power-up. Proper power sequencing is strongly advisable to ensure proper operation of the encoder.

Output Load

It is important to note that the AEDR-98x0E series encoder is designed for a diverse type of application and, as such, provides different modes of functional selection. Careful consideration of the external load is required to prevent unwanted overshoot, ringing, and even instability of the device. It is strongly recommended to select a proper RC load at the output for the mode selected in the application. It is generally not recommended to directly drive a capacitive or inductive load.

Output Waveform

The following figure shows an example of the output waveform digital signals A and B, gated index of 90°e and 180°e, and ungated index of 360°e when the code-wheel rotation is in the counterclockwise direction. The figure also shows an additional waveform output example for the analog output option with single-ended and differential modes.



NOTE: The minimum voltage of index plus must be more than 0.8V.

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