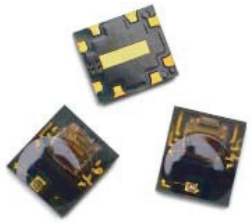
BROADCOM®

Data Sheet

# AEDR-8600

## Two-Channel Reflective Incremental Encoder



## Description

The Broadcom® AEDR-8600 is a small two-channel optical encoder with digital outputs. It uses reflective technology for motion control purposes.

The AEDR-8600 offers two-channel quadrature digital outputs. Being TTL compatible, the outputs of the AEDR-8600 encoder can be interfaced directly with most of the signal processing circuitries. Therefore, the encoder provides easy integration and flexible design-in into existing systems.

The AEDR-8600 encoder is designed to operate over –20°C to +85°C temperature range and is suitable for commercial and industrial end applications.

The encoder houses an LED light source and photo-detecting circuitry in a single package. The small size of 3.95 mm (L) x 3.4 mm (W) x 0.9562 mm (H) allows it to be used in a wide range of miniature commercial applications, where size and space are primary concerns.

## Features

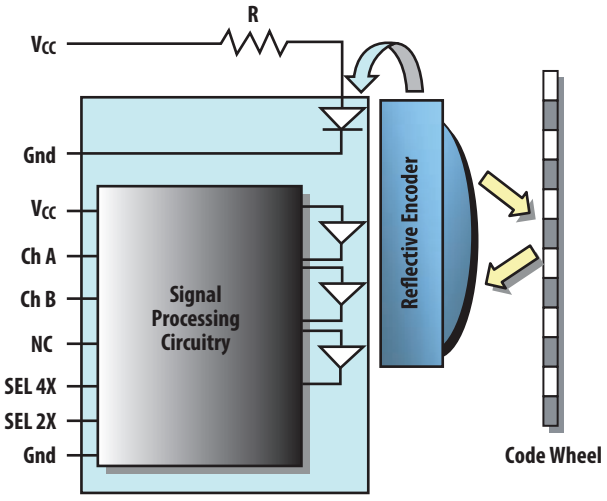
- Two-channel quadrature digital outputs for direction sensing
- Surface-mount leadless package:
  3.95 mm (L) × 3.4 mm (W) × 0.9562 mm (H)
- Built-in interpolator with 1x, 2x, and 4x, selectable via external pinouts
- TTL compatible
- Single 5.0V supply
- –20°C to +85°C absolute operating temperature
- Encoding resolution: 294 LPI (lines per in.) to 304 LPI

## Applications

- Ideal for high-volume applications
- Closed-loop stepper motors
- Miniature motors
- Printers
- Copiers
- Card readers
- Scanners
- Projectors
- Consumer and industrial product applications

# Product Overview

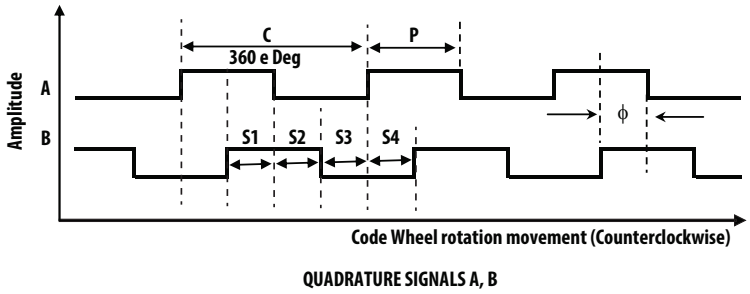
**Figure 1: Signal Processing Circuitry**

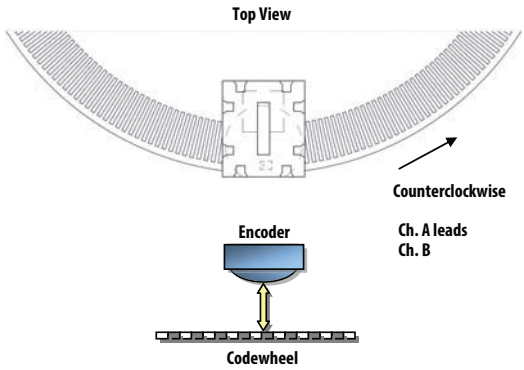



Note: Drawing not to scale.

# Output Waveform

**Figure 2: Sample of Output Waveforms**




Note: Drawing not to scale.

# Absolute Maximum Ratings

| Parameter | Symbol | Value |
|---|---|---|
| Storage Temperature | $T_S$ | –40°C to 125°C |
| Operating Temperature | $T_A$ | –40°C to 115°C |
| Supply Voltage | $V_{CC}$ | 7V |
| Output Voltage | $V_O$ | $V_{CC}$ |

**NOTE:**

1. Proper operation of the encoder cannot be guaranteed if the maximum ratings are exceeded.
2. Exposure to extreme light intensity (such as from flashbulbs or spotlights) can cause permanent damage to the device.

**CAUTION!** Take anti-static discharge precautions when handling the encoder in order to avoid damage, degradation, or both, induced by ESD.

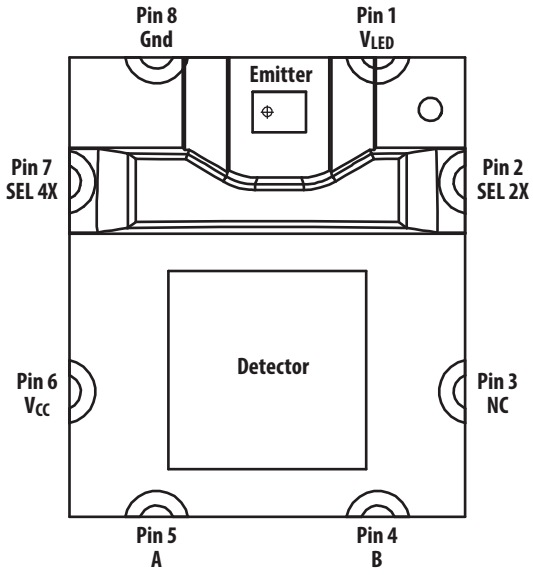
# Recommended Operating Conditions (Code Wheel of $R_{OP}$ at 11.38 mm)

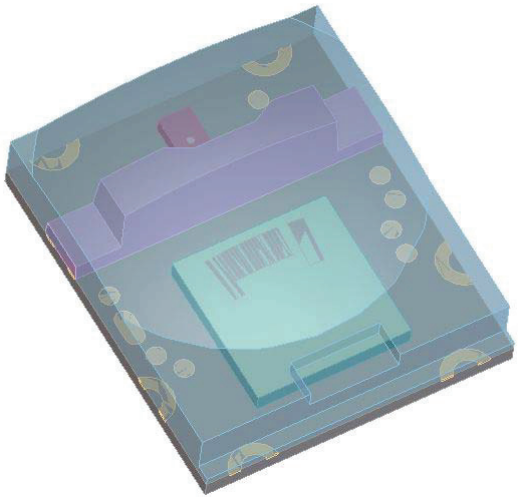
| Parameter | Sym. | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| Operating Temperature | $T_A$ | –20 | 25 | 85 | °C | |
| Supply Voltage | $V_{CC}$ | 4.5 | 5 | 5.5 | V | Ripple < 100 $mV_{p-p}$ |
| LED Current | $I_{LED}$ | — | 15 | — | mA | Use an 180Ω(±1%) LED current-limiting resistor |
| Count Frequency[a] | F | — | 55 | — | kHz | 1x interpolation factor |
| Radial Misalignment | $E_R$ | — | — | ±0.2 | mm | |
| Tangential Misalignment | $E_T$ | — | — | ±0.2 | mm | |
| Code Wheel Gap | G | 0.5 | 1.0 | 1.25 | mm | 1.0 mm nominal gap |

a. Count frequency = velocity (rpm) x CPR / 60.

# Encoder Pinout

**Figure 3: Pin Configuration, Top View**



# AEDR-8600 Built-in Interpolation

| Pin (Interpolation) | | Interpolation Factor | CPR ($R_{OP}$ = 11.38mm) | Count Frequency |
|---|---|---|---|---|
| SEL4X | SEL2X | | | |
| Low[a] | Low | 1X | 828 | 55 kHz |
| Low | High | 2X | 1656 | 110 kHz |
| High[b] | Low | 4X | 3312 | 220 kHz |
| High | High | Factory use | — | — |

a. Low logic level

b. High logic level

The digital interpolation factor above is used with the following equations to cater to various rotational speed (RPM) and count per revolution (CPR).

RPM = (Count Frequency × 60) / CPR

The CPR (at 1X interpolation) is based on the following equation, which is dependent on radius of operation ($R_{OP}$).

CPR = LPI × 2π × $R_{OP}$ (inch) or CPR = LPmm × 2π × $R_{OP}$ (mm)

# Digital Encoder Characteristics (Code Wheel of $R_{OP}$ at 11.38 mm)

Encoding characteristics over the recommended operating condition and mounting conditions.

| Parameter | Symbol | Typical[a] | | | Unit |
|---|---|---|---|---|---|
| Interpolation Factor | | 1X | 2X | 4X | |
| Cycle Error | ΔC | 18 | 22 | 36 | °e |
| Pulse Width Error | ΔP | 15 | 20 | 30 | °e |
| Phase Error | Δϕ | 9 | 15 | 18 | °e |
| State Error | ΔS | 10 | 15 | 25 | °e |

a. Typical values represent the average value of the encoder performance at typical mounting alignment, whereas the maximum values represent the encoder performance across the range of recommended mounting tolerance.

# Electrical Characteristics

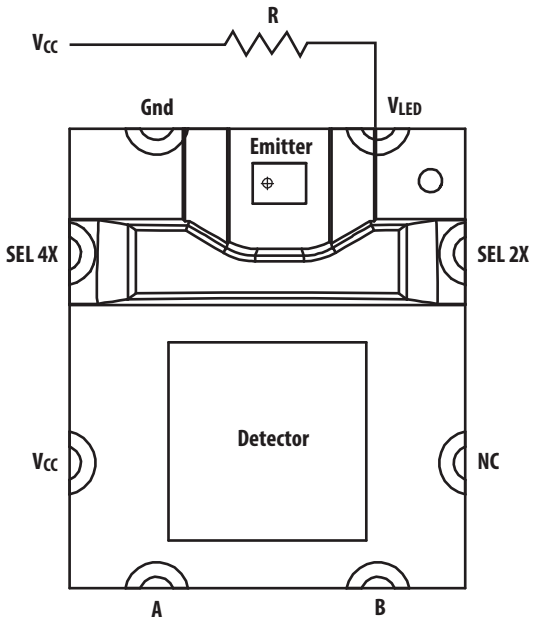
Characteristics over recommended operating conditions at 25°C.

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|
| High Level Output Voltage | $V_{OH}$ | 2.4 | — | — | V | $I_{OH}$ = –1.5 mA |
| Low Level Output Voltage | $V_{OL}$ | — | — | 0.4 | V | $I_{OH}$ = +1.5 mA |
| Output Current Per Channel, $I_{out}$ | $I_O$ | — | — | 1.5 | mA | |
| Rise Time | $t_r$ | — | <100 | — | ns | CL = 25 pF RL = 2.7 kΩ |
| Fall Time | $t_f$ | — | <100 | — | ns | |

# LED Current-Limiting Resistor

A resistor to limit the current to the LED is required. Use a 180Ω (±1%) resistor. Place it in series between the 5V supply and pin VLED of the encoder. This will result in an LED current of approximately 15 mA for optimal encoder performance.

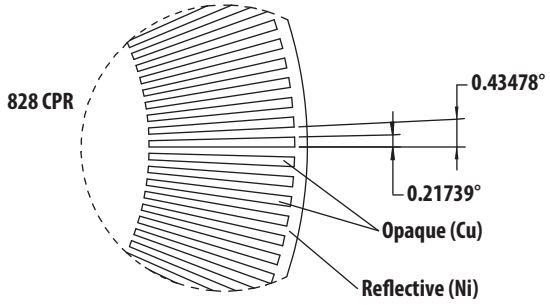
**Figure 4: Resistor Placement**



# Code Wheel Design Example

The following example demonstrates a code wheel design for a $R_{OP}$ of 11.38 mm at 828 CPR for a typical two-channel encoder.

**Figure 5: Code Wheel Pattern for a Two-Channel Encoder**



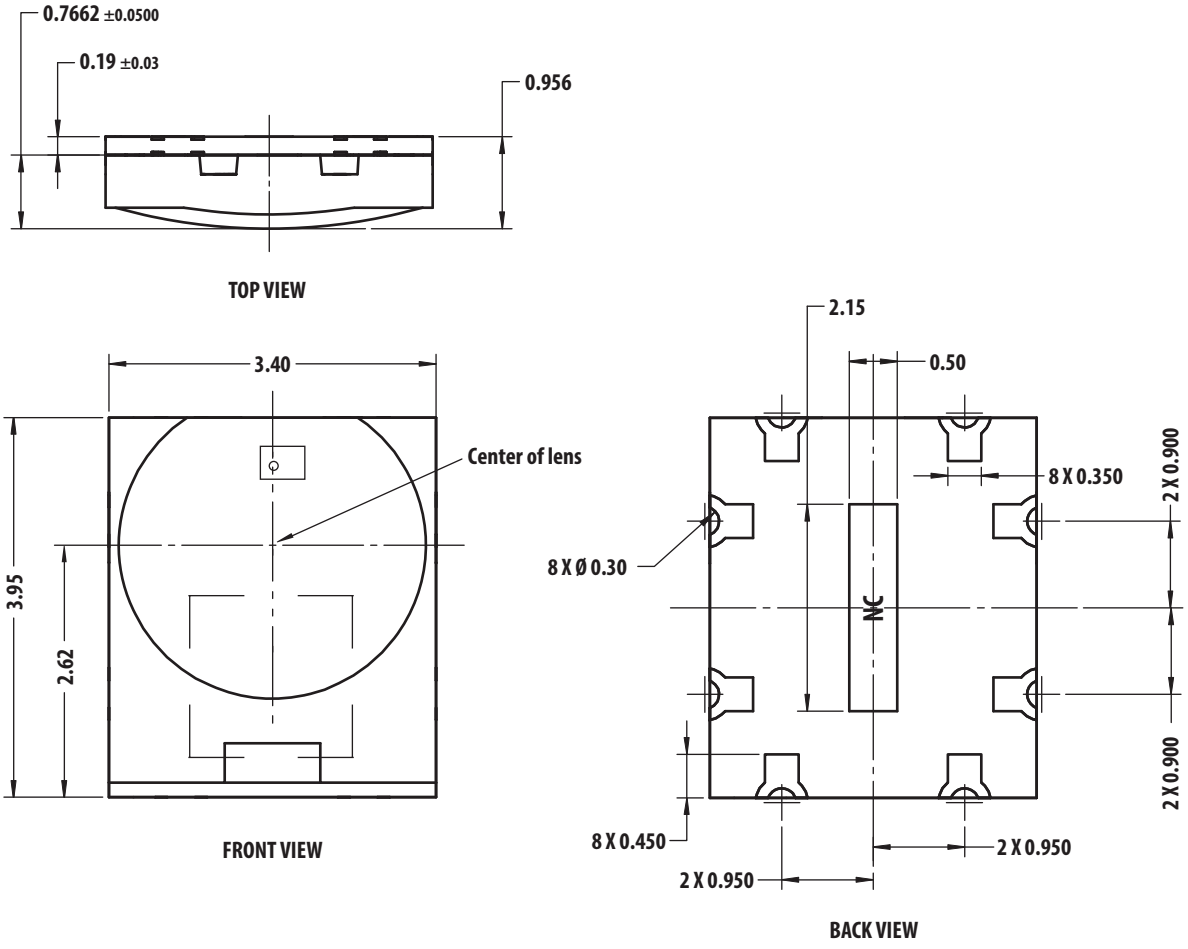

# Recommended Code Wheel Characteristics

| Parameter | Symbol | Min. | Max. | Unit | Notes |
|---|---|---|---|---|---|
| Window/Bar Ratio | $W_W/W_b$ | 0.9 | 1.1 | — | |
| Window/Bar Length | $L_W$ | 1.80 (0.071) | — | mm (in.) | |
| Specular Reflectance | $R_f$ | 60 | — | mA | Reflective area[a] |
| | | — | 10 | | Non-reflective area |
| Line Density | LPI | 294 | 304 | lines per in. | Recommended LPI = 294 |
| | LPmm | 11.575 | 11.969 | lines per mm | LPmm = CPR/ [2π.$R_{OP}$(mm)] |

a. Measurements from TMA µScan meter.

**NOTE:** The LED used in AEDR-8600 has a typical peak wavelength of 630 nm.

# Package Outline Drawing




**NOTE:**

1. All dimensions are in millimeters (mm).
2. Unless otherwise specified, tolerance is x.xx ± 0.15 mm.

# Encoder Placement Orientation, Position, and Direction of Movement

The AEDR-8600 is designed with both the emitter and detector IC placed in parallel to the code wheel window/bar orientation. The encoder package is mounted on top facing down onto the code wheel. When properly aligned, the detector side will be closer to the center of the code wheel than the emitter.

The optical center of the encoder package must be aligned with the operating radius of the code wheel's $R_{OP}$, or rather the center point of $L_W$ (0.5 of the Length of Window). $L_W$ is to be 1.8 mm or greater.

The optimal gap setting recommended is from 0.5 mm to 1.25 mm.

Channel A leads Channel B when the code wheel rotates counterclockwise, and Channel B leads Channel A when the code wheel rotates clockwise.

**Figure 6: Placement Orientation of The Encoder on the Code Wheel, Top View**

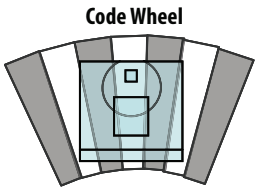



**Figure 7: Optimal Code Wheel Encoder Gap, Side View**

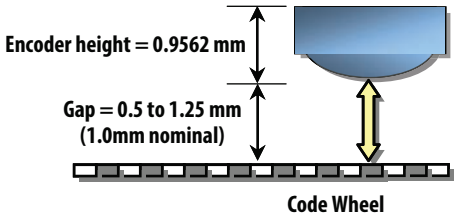
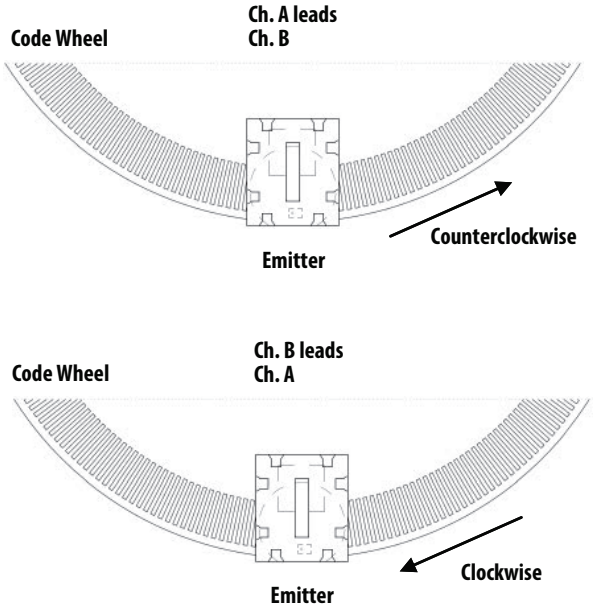



**Figure 8: Placement Orientation of The Encoder on the Code Wheel, Top View**




**NOTE:** Drawings are not to scale.

# Moisture Sensitivity Level

The AEDR-8600 package is qualified to moisture sensitive level 3 (MSL 3). Precaution is required to handle this moisture sensitive product to ensure the reliability of the product.

**Storage before use:**

- Unopened moisture barrier bag (MBB) can be stored at <40°C/90% RH for 12 months.
- Open the MBB just prior to assembly.

**Control after opening the MBB:**

- The encoder that will be subjected to SMT reflow must be mounted within 168 hours of exposure to factory conditions of <30°C/60% RH.

**Control for unfinished reel:**

- Store a sealed MBB with desiccant or desiccators at <5%RH.

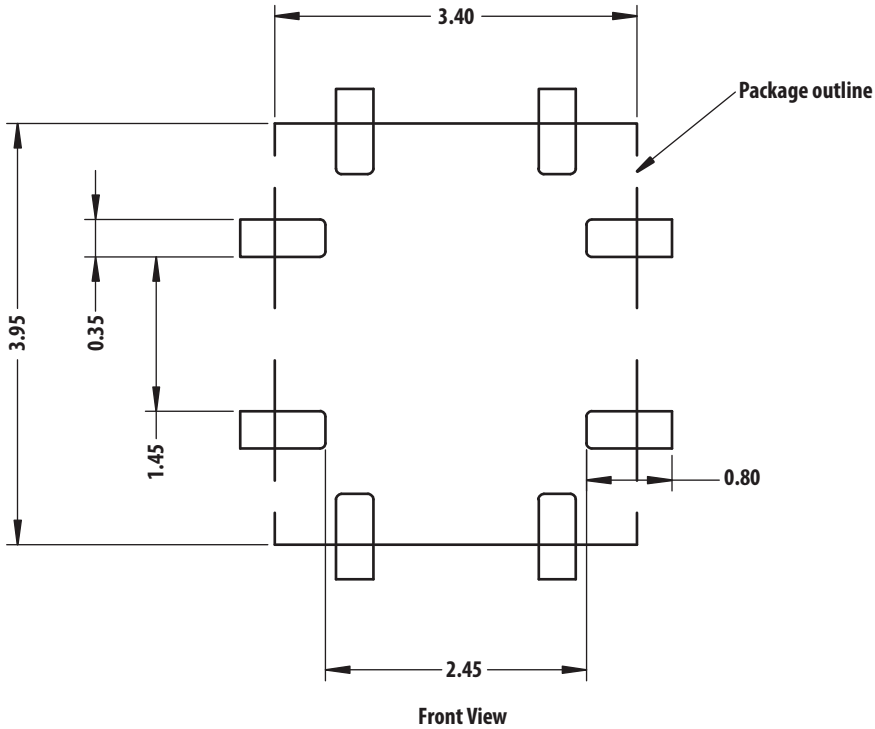
**Baking is required if:**

- The humidity indicator card (HIC) is >10% when read at 23°C ± 5°C.
- The encoder floor life exceeded 168 hours after opening the moisture barrier bag.

**Recommended baking condition:**

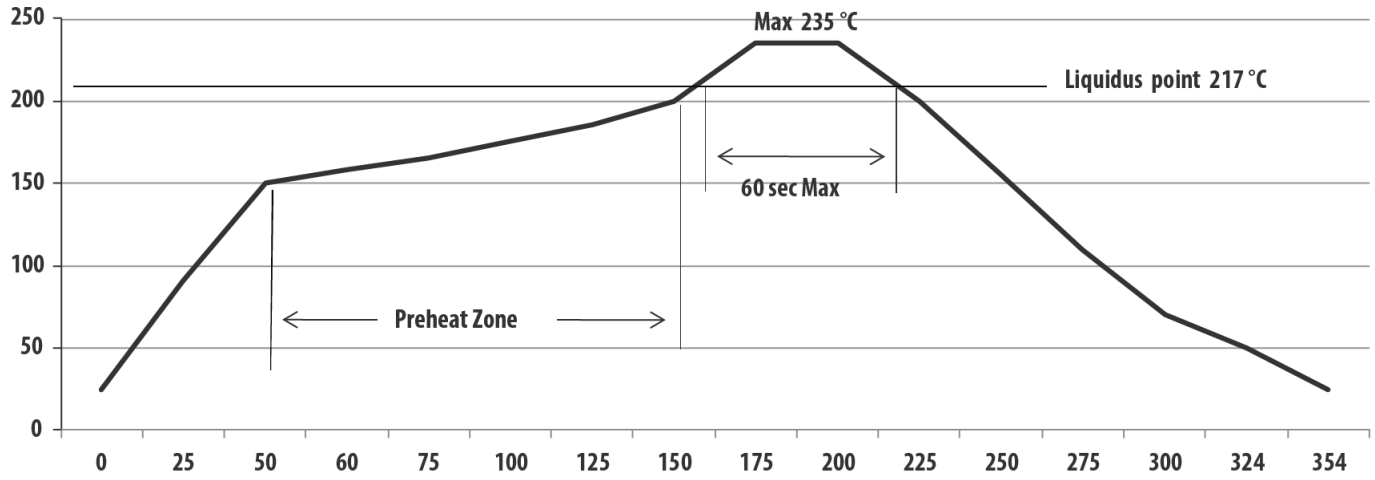
- 60°C ± 5°C for 20 hours (tape and reel) or 125°C ± 5°C for 5 hours (loose units).

**Figure 9: Recommended Land Pattern for AEDR-8600**



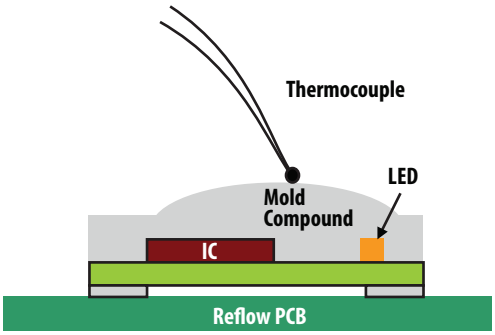
# Lead-Free Reflow Soldering

**Figure 10: Typical Lead-Free Solder Reflow Profile**




| | |
|---|---|
| Average Ramp Up Rate | 3°C per second |
| Average Ramp Down Rate | 6°C per second |
| Preheat Temperature | 150°C to 200°C |
| Preheat Time | 60 seconds to 100 seconds |
| Time Maintain Above 217°C | 40 seconds to 60 seconds |
| Peak Temperature | 235°C |
| Time Within 5°C of Peak Temperature | 20 seconds to 30 seconds |

**Figure 11: Thermocouple Placement**

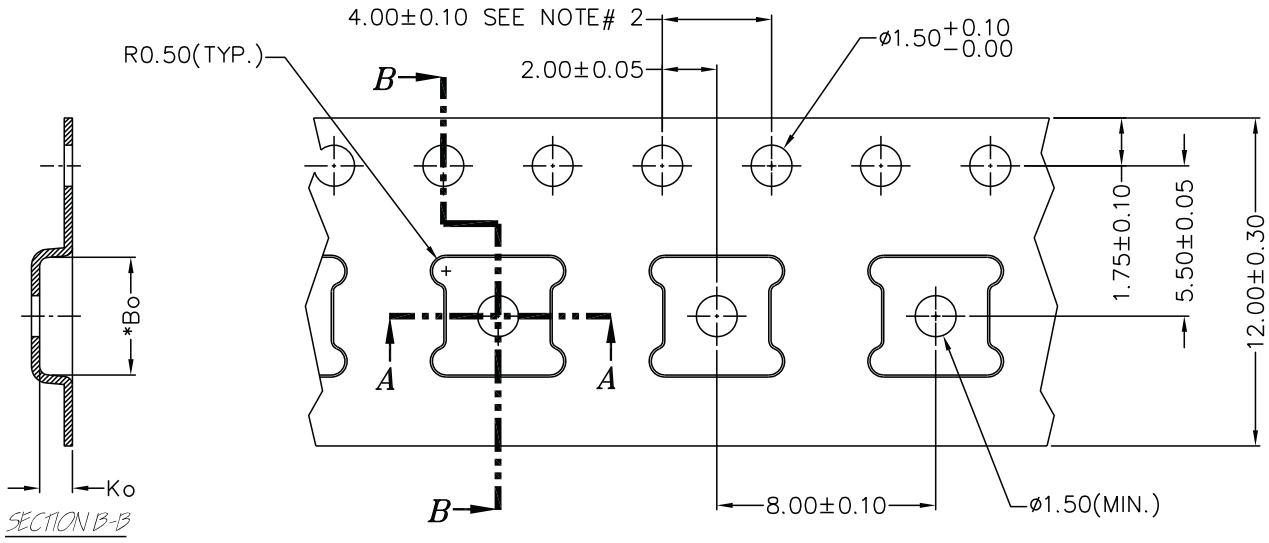


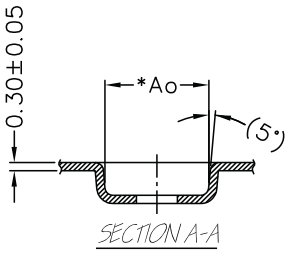

**NOTE:**

1. Reflow with a peak temperature >235°C may cause damage to the component.
2. Due to treatment of high temperature, this clear compound may turn yellow after IR reflow.
3. The profile shown here is the actual readings from the thermocouple attached to AEDR-8600 as shown in Figure 11 on the reflow board PCB.

# Tape and Reel Information

**Figure 12: AEDR-8600 Carrier Tape Dimensions**




NOTES: –
1. * Ao & Bo measured at 0.3mm above base of pocket.
2. 10 pitches cumulative tol. ±0.2mm.
3. ( ) Reference dimensions only.

| | |
|---|---|
| *Ao:* | *3.80* |
| *Bo:* | *4.30* |
| *Ko:* | *1.20* |
| *Pitch:* | *8.00* |
| *Width:* | *12.00* |

# Ordering Information

**AEDR – 8600 – x0x**

| Packaging | Shipping Units |
|---|---|
| 1 – Tape and Reel | 0 – 1000 pcs<br>2 – 100 pcs |

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