

## HEDT-9000/9100

High Temperature 125°C Two Channel  
Optical Incremental Encoder Modules



## Data Sheet



### Description

The HEDT-9000 and the HEDT-9100 series are high performance, low cost, optical incremental encoder modules that operate to 125°C. When used with a codewheel, these modules detect rotary position. The modules consist of a lensed (LED) source and a detector IC enclosed in a small C-shaped plastic package. Due to a highly collimated light source and unique photodetector array, these modules are extremely tolerant to mounting misalignment.

The two channel digital outputs and the single 5 V supply input are accessed through five 0.025 inch square pins located on 0.1 inch centers.

Standard resolutions for the HEDT-9000 are 500 CPR and 1000 CPR for use with a HEDS-6100 codewheel or equivalent. For the HEDT-9100, standard resolutions between 96 CPR and 512 CPR are available for use with a HEDS-5120 codewheel or equivalent.

**Note:** Avago Technologies encoders are not recommended for use in safety critical applications. Eg. ABS braking systems, power steering, life support systems and critical care medical equipment. Please contact sales representative if more clarification is needed.

### Features

- High performance
- High resolution
- Low cost
- Easy to mount
- No signal adjustment required
- Insensitive to radial and axial play
- Small size
- -40°C to 125°C operating temperature
- Two channel quadrature output
- TTL compatible
- Single 5 V supply

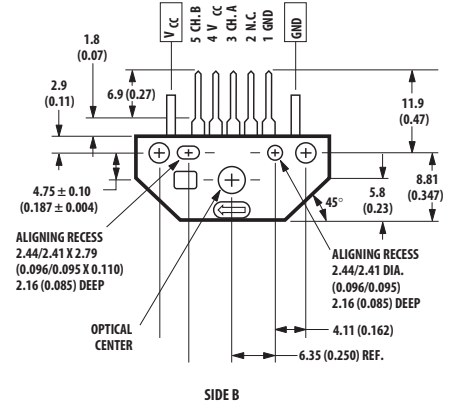
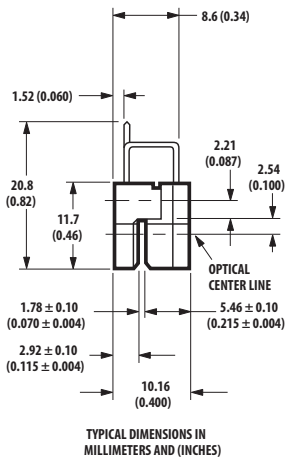
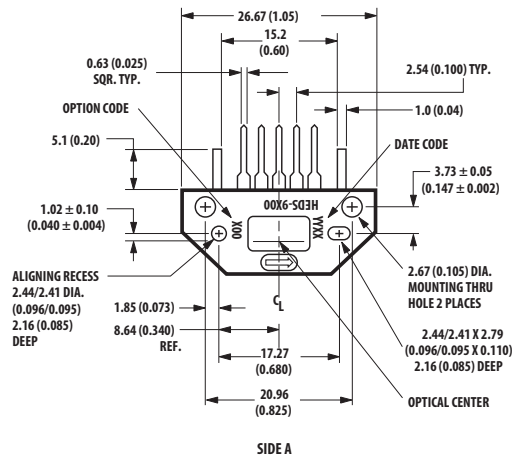
### Applications

The HEDT-9000 and 9100 provide sophisticated motion detection at a low cost, at temperatures to 125°C, making them ideal for high volume automotive applications.

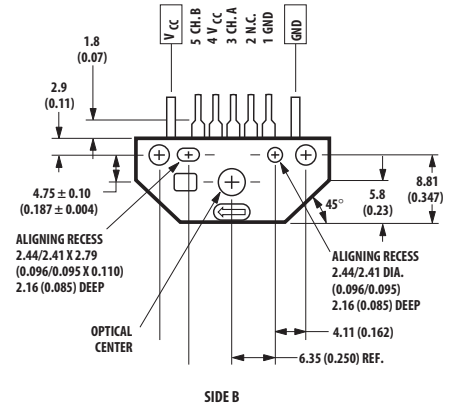
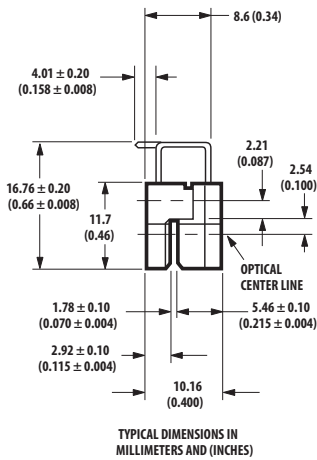
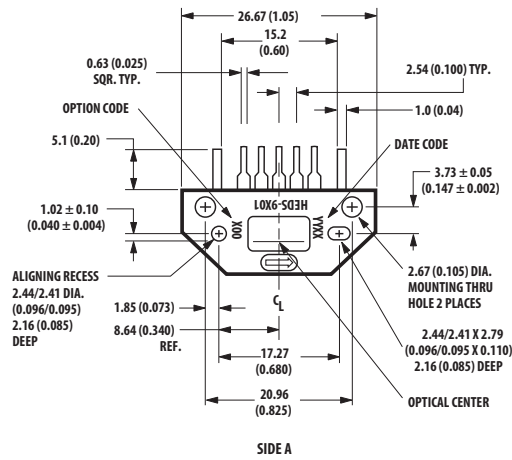
**ESD WARNING: NORMAL HANDLING PRECAUTIONS SHOULD BE TAKEN TO AVOID STATIC DISCHARGE.**

# Package Dimensions

## HEDx-9xx0 Option



## HEDx-9xx1 Option

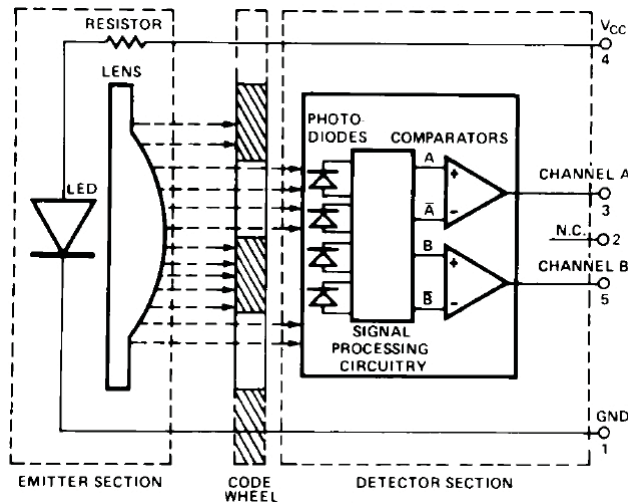


## Theory of Operation

The HEDT-9000 and 9100 are C-shaped emitter/detector modules. Coupled with a codewheel, they translate the rotary motion of a shaft into a two-channel digital output.

As seen in the block diagram, each module contains a single Light Emitting Diode (LED) as its light source. The light is collimated into a parallel beam by means of a single polyetherimide lens located directly over the LED. Opposite the emitter is the integrated detector circuit. This IC consists of multiple sets of photodetectors and the signal processing circuitry necessary to product the digital waveforms.

## Block Diagram



The codewheel rotates between the emitter and detector, causing the light beam to be interrupted by the pattern of spaces and bars on the codewheel. The photodiodes which detect these interruptions are arranged in a pattern that corresponds to the radius and design of the codewheel. These detectors are also spaced such that a light period on one pair of detectors corresponds to a dark period on the adjacent pair of detectors. The photodiode outputs are then fed through the signal processing circuitry resulting in A,  $\bar{A}$ , B, and  $\bar{B}$ . Two comparators receive these signals and produce the final outputs for channels A and B. Due to this integrated phasing technique, the digital output of channel A is in quadrature with that of channel B (90 degrees out of phase).

## Definitions

**Count (N):** The number of bar and window pairs or counts per revolution (CPR) of the codewheel.

$$1 \text{ Shaft Rotation} = 360 \text{ mechanical degrees,} \\ = N \text{ cycles.}$$

$$1 \text{ cycle (C)} = 360 \text{ electrical degrees (}^\circ\text{e),} \\ = 1 \text{ bar and window pair.}$$

**Pulse Width (P):** The number of electrical degrees that an output is high during 1 cycle. This value is nominally 180°e or 1/2 cycle.

**Pulse Width Error ( $\Delta P$ ):** The deviation, in electrical degrees of the pulse width from its ideal value of 180°e.

**State Width (S):** The number of electrical degrees between a transition in the output of channel A and the neighboring transition in the output of channel B. There are 4 states per cycle, each nominally 90°e.

**State Width Error ( $\Delta S$ ):** The deviation, in electrical degrees, of each state width from its ideal value of 90°e.

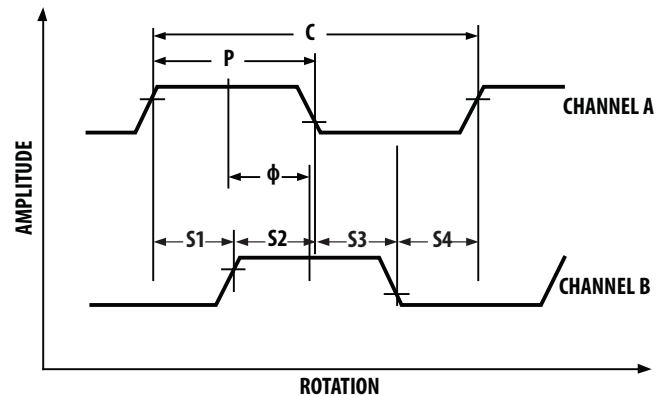
**Phase ( $\phi$ ):** The number of electrical degrees between the center of the high state of channel A and the center of the high state of channel B. This value is nominally 90°e for quadrature output.

**Phase Error ( $\Delta\phi$ ):** The deviation of the phase from its ideal value of 90°e.

**Direction of Rotation:** When the codewheel rotates in the direction of the arrow on top of the module, channel A will lead channel B. If the codewheel rotates in the opposite direction, channel B will lead channel A.

**Optical Radius ( $R_{op}$ ):** The distance from the codewheel's center of rotation to the optical center (O.C.) of the encoder module.

## Output Waveforms



## Absolute Maximum Ratings

|                                       |                    |
|---------------------------------------|--------------------|
| Storage Temperature, $T_s$            | -40°C to 125°C     |
| Operating Temperature, $T_A$          | -40°C to 125°C     |
| Supply Voltage, $V_{CC}$              | -0.5 V to 7 V      |
| Output Voltage, $V_O$                 | -0.5 V to $V_{CC}$ |
| Output Current per Channel, $I_{out}$ | -1.0 mA to 5 mA    |

## Recommended Operating Conditions

| Parameter        | Symbol   | Min. | Typ. | Max. | Units | Notes                                       |
|------------------|----------|------|------|------|-------|---|
| Temperature      | T        | -40  |      | 125  | °C    |   |
| Supply Voltage   | $V_{CC}$ | 4.5  |      | 5.5  | Volts | Ripple < 100 mV <sub>p-p</sub>              |
| Load Capacitance | $C_L$    |      |      | 100  | pF    | 3.3 kΩ pull-up resistor                     |
| Count Frequency  | f        |      |      | 100  | kHz   | $\frac{\text{Velocity (rpm)} \times N}{60}$ |

**Note:** The module performance is guaranteed to 100 kHz but can operate at higher frequencies.

## Encoding Characteristics

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances. These Characteristics do not include codewheel/codestrip contributions.

| Description             | Sym.          | Typ. | Case 1 Max. | Case 2 Max. | Units | Notes |
|-------------------------|---------------|------|-------------|-------------|-------|-------|
| Pulse Width Error       | $\Delta P$    | 7    | 35          | 45          | °e    |       |
| Logic State Width Error | $\Delta S$    | 5    | 35          | 45          | °e    |       |
| Phase Error             | $\Delta \phi$ | 2    | 15          | 20          | °e    |       |

Case 1: Module mounted on tolerance circle of  $\pm 0.13$  mm ( $\pm 0.005$  in.).

Case 2: HEDT-9000 mounted on tolerances of  $\pm 0.50$  mm (0.020").  
HEDT-9100 mounted on tolerances of  $\pm 0.38$  mm (0.015").

## Electrical Characteristics

Electrical Characteristics over Recommended Operating Range, typical at 25°C.

| Parameter                 | Symbol   | Min. | Typical | Max. | Units | Notes                     |
|---------------------------|----------|------|---------|------|-------|---------------------------|
| Supply Current            | $I_{CC}$ |      | 17      | 40   | mA    |                           |
| High Level Output Voltage | $V_{OH}$ | 2.4  |         |      | Volts | $I_{OH} = -40 \mu A$ max. |
| Low Level Output Voltage  | $V_{OL}$ |      |         | 0.4  | Volts | $I_{OL} = 3.2$ mA         |
| Rise Time                 | $t_r$    |      | 200     |      | ns    | $C_L = 25$ pF             |
| Fall Time                 | $t_f$    |      | 50      |      | ns    | $R_L = 11$ kΩ pull-up     |

## Recommended Codewheel Characteristics

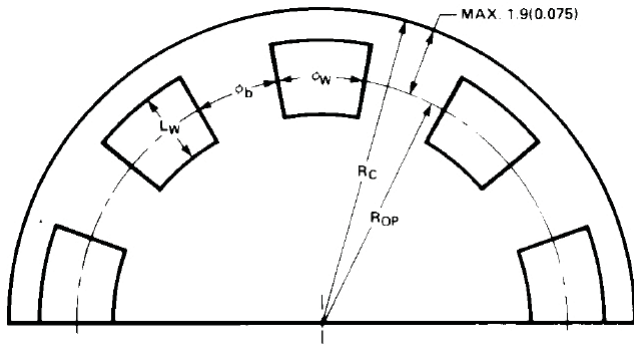


Figure 1. Codestrip Design.

## Codewheel Options

| HEDS Series | CPR (N) | Option | Optical Radius mm (in.) |
|-------------|---------|--------|-------------------------|
| 5120        | 96      | K      | 11.00 (0.433)           |
| 5120        | 100     | C      | 11.00 (0.433)           |
| 5120        | 192     | D      | 11.00 (0.433)           |
| 5120        | 200     | E      | 11.00 (0.433)           |
| 5120        | 256     | F      | 11.00 (0.433)           |
| 5120        | 360     | G      | 11.00 (0.433)           |
| 5120        | 400     | H      | 11.00 (0.433)           |
| 5120        | 500     | A      | 11.00 (0.433)           |
| 5120        | 512     | I      | 11.00 (0.433)           |
| 6100        | 500     | A      | 23.36 (0.920)           |
| 6100        | 1000    | B      | 23.36 (0.920)           |

| Parameter                         | Symbol          | Minimum    | Maximum                | Units     | Notes                        |
|-----------------------------------|-----------------|------------|------------------------|-----------|------------------------------|
| Window/Bar Ratio                  | $\phi_w/\phi_b$ | 0.7        | 1.4                    |           |                              |
| Window Length                     | L               | 1.8 (0.07) | 2.3 (0.09)             | mm (inch) |                              |
| Absolute Maximum Codewheel Radius | $R_C$           |            | $R_{OP} + 1.9 (0.075)$ | mm (inch) | Includes eccentricity errors |

# Mounting Considerations

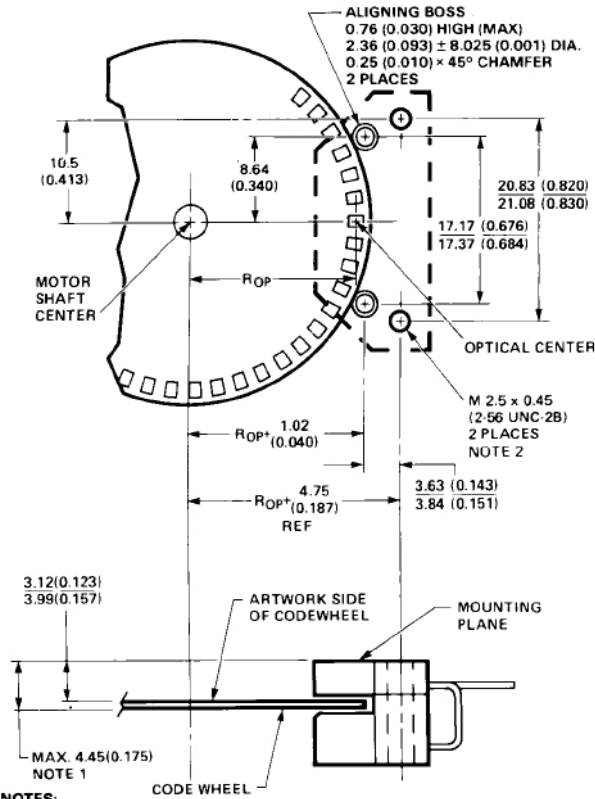


Figure 2. Mounting Plane Side A.

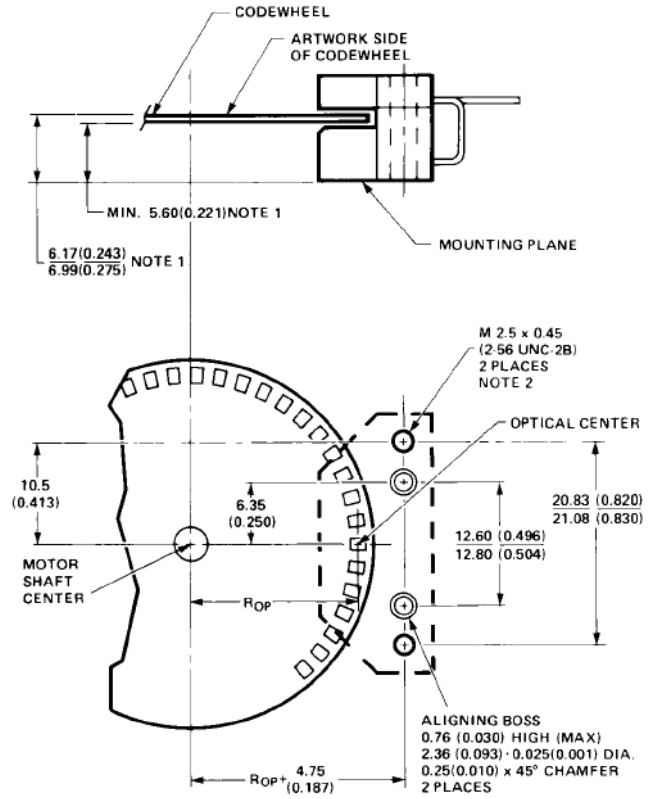


Figure 3. Mounting Plane Side B.

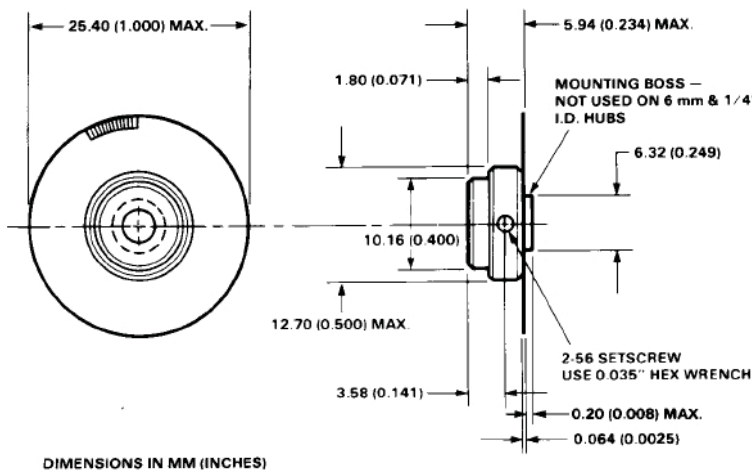


Figure 4. HEDS-5120 Codewheel.

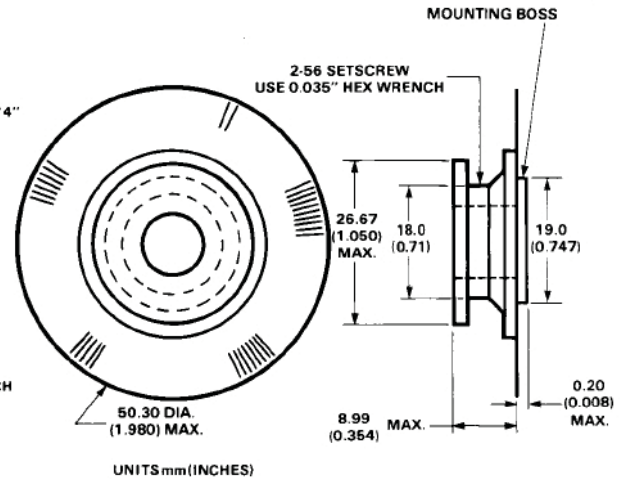


Figure 5. HEDS-6100 Codewheel.

## Ordering Information

HEDT-9001 Option

0 0

HEDS-6100 Option

| Resolution<br>(Cycles/Rev) |
|----------------------------|
| A - 500                    |

| Shaft Diameter |              |
|----------------|--------------|
| 06 - 1/4 in.   | 09 - 1/2 in. |
| 08 - 3/8 in.   | 10 - 5/8 in. |

HEDT-910

Option

0 0

HEDS-5120 Option

| Lead               |
|--------------------|
| 0 - Straight Leads |
| 1 - Bent Leads     |

| Resolution (Cycles/Rev) |             |
|-------------------------|-------------|
| C - 100 CPR             | G - 360 CPR |
| D - 192 CPR             | A - 500 CPR |
| E - 200 CPR             | I - 512 CPR |

| Shaft Diameter |           |
|----------------|-----------|
| 01 - 2 mm      | 11 - 4 mm |
| 02 - 3 mm      | 14 - 5 mm |
| 03 - 1/8 in.   | 12 - 6 mm |
| 04 - 5/32 in.  | 13 - 8 mm |
| 05 - 3/16 in.  |           |
| 06 - 1/4 in.   |           |

|           | A | C | D | E | G | I |
|-----------|---|---|---|---|---|---|
| HEDT-9001 | * |   |   |   |   |   |
| HEDT-9100 | * | * |   | * | * | * |
| HEDT-9101 | * | * | * | * | * | * |

|           |   | 01 | 02 | 03 | 04 | 05 | 06 | 08 | 09 | 10 | 11 | 12 | 13 | 14 |
|-----------|---|----|----|----|----|----|----|----|----|----|----|----|----|----|
| HEDS-6100 | A |    |    |    |    |    |    |    | *  |    |    | *  | *  |    |

|           |   | 01 | 02 | 03 | 04 | 05 | 06 | 08 | 09 | 10 | 11 | 12 | 13 | 14 |
|-----------|---|----|----|----|----|----|----|----|----|----|----|----|----|----|
| HEDS-5120 | A | *  | *  | *  | *  | *  | *  |    |    |    | *  | *  |    | *  |
|           | C |    | *  |    |    |    | *  |    |    |    | *  | *  | *  | *  |
|           | D |    |    |    |    | *  |    |    |    |    |    |    |    |    |
|           | E |    |    |    |    |    | *  |    |    |    |    | *  |    |    |
|           | F |    |    |    |    | *  |    |    |    |    |    |    |    |    |
|           | G |    | *  | *  |    | *  | *  |    |    |    | *  |    |    | *  |
|           | H |    | *  |    |    |    | *  |    |    |    | *  | *  |    | *  |
|           | I |    | *  |    |    |    |    |    |    |    |    |    |    |    |
|           | K |    | *  |    |    |    |    |    |    |    |    |    | *  |    |

For product information and a complete list of distributors, please go to our website: [www.avagotech.com](http://www.avagotech.com)

Avago, Avago Technologies, and the A logo are trademarks of Avago Technologies in the United States and other countries.  
Data subject to change. Copyright © 2005-2009 Avago Technologies. All rights reserved. Obsoletes 5988-5280EN  
AV02-1055EN - January 4, 2010

**AVAGO**  
TECHNOLOGIES