Data Sheet

HEDS-9000/9100

Two-Channel Optical Incremental Encoder Modules

Description

The Broadcom® HEDS-9000 and the HEDS-9100 series are high-performance, low-cost, optical incremental encoder modules. When used with a code wheel, 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 5V supply input are accessed through five 0.025-inch square pins located on 0.1-inch centers.

Standard resolutions for the HEDS-9000 are 500 CPR and 1000 CPR for use with a HEDS-6100 code wheel or equivalent.

For the HEDS-9100, standard resolutions between 96 CPR and 512 CPR are available for use with a HEDS-5120 code wheel or equivalent.

Features

- High performance
- High resolution
- Low cost
- Easy to mount
- No signal adjustment required
- Small size
- Operating temperature: –40°C to 100°C
- Two-channel quadrature output
- TTL compatible
- Single 5V supply

Applications

The HEDS-9000 and 9100 provide sophisticated motion detection at a low cost, making them ideal for high-volume applications. Typical applications include printers, plotters, tape drives, and factory automation equipment.

NOTE: Broadcom encoders are not recommended for use in safety-critical applications: for example, ABS braking systems, power steering, life-support systems, and critical-care medical equipment. Please contact a sales representative if more clarification is needed.

WARNING! Normal handling precautions should be taken to avoid static discharge.

Theory of Operation

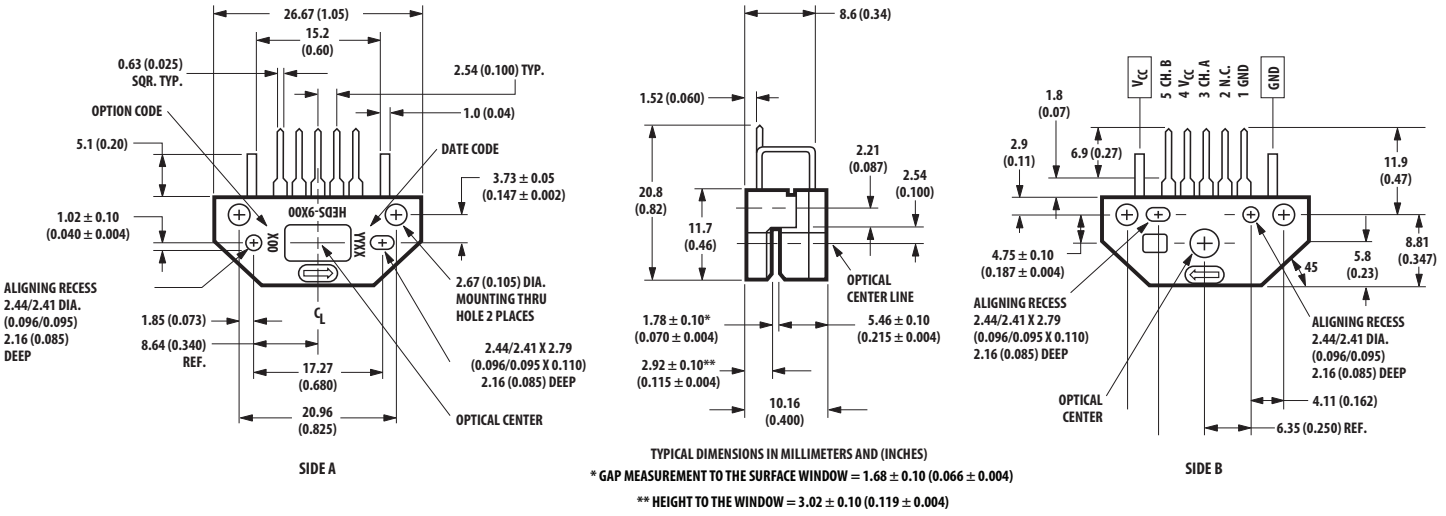
The HEDS-9000 and 9100 are C-shaped emitter/detector modules. Coupled with a code wheel, they translate the rotary motion of a shaft into a two-channel digital output.

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 a single polycarbonate 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 produce the digital waveforms.

The code wheel rotates between the emitter and detector, causing the light beam to be interrupted by the pattern of spaces and bars on the code wheel. The photodiodes that detect these interruptions are arranged in a pattern that corresponds to the radius and design of the code wheel. 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, $\overline{A}$, B, and $\overline{B}$. Two comparators receive these signals and produce the final outputs for channels $\overline{A}$ and $\overline{B}$. 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).

Package Dimensions

Figure 1: HEDS-9x00

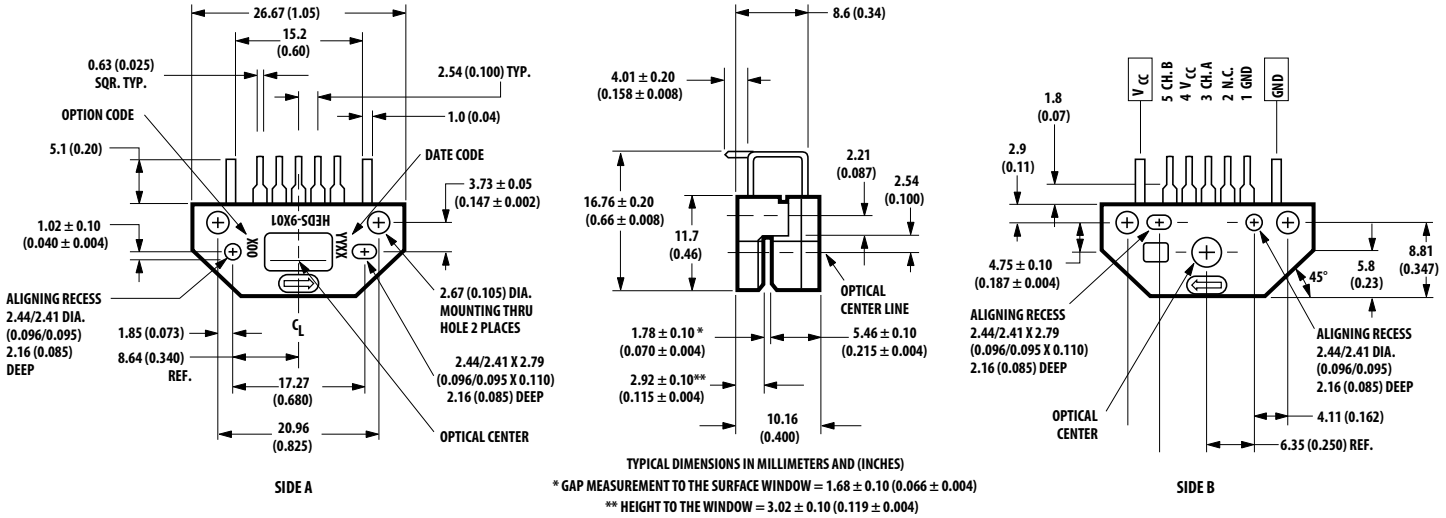


TYPICAL DIMENSIONS IN MILLIMETERS AND (INCHES)

* GAP MEASUREMENT TO THE SURFACE WINDOW = 1.68 ± 0.10 (0.066 ± 0.004)

** HEIGHT TO THE WINDOW = 3.02 ± 0.10 (0.119 ± 0.004)

Figure 2: HEDS-9x01



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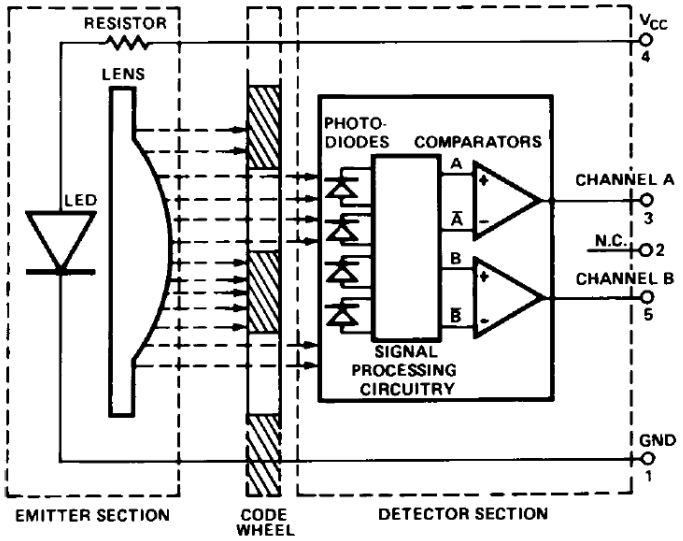
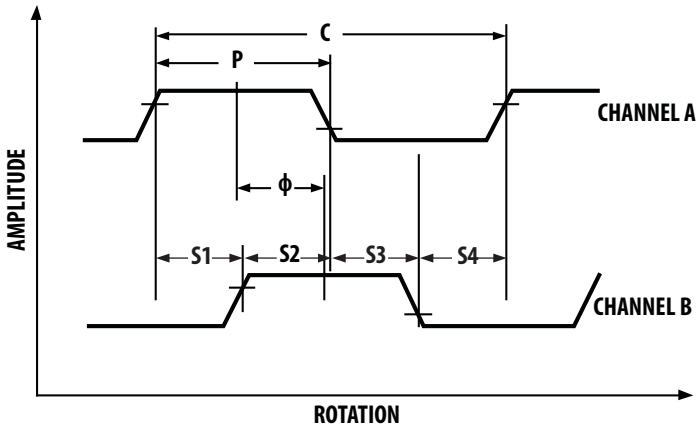
Block Diagram



Output Waveforms



Definitions

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

1 Shaft Rotation	=	360 mechanical degrees
	=	N cycles
1 cycle (C)	=	360 electrical degrees (°e)
	=	1 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 (ΔP): 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 four states per cycle, each nominally 90°e.

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

Phase (ϕ): 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 (Δϕ): The deviation of the phase from its ideal value of 90°e.

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

Optical Radius (R_{OP}): The distance from the code wheel's center of rotation to the optical center (OC) of the encoder module.

Absolute Maximum Ratings

Parameter	Value
Storage Temperature, T_S	–40°C to 100°C
Operating Temperature, T_A	–40°C to 100°C
Supply Voltage, V_{CC}	–0.5 V to 7V
Output Voltage, V_O	–0.5V 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	—	100	°C	—
Supply Voltage	V_{CC}	4.5	—	5.5	V	Ripple < 100 mV_{p-p}
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 are over the recommended operating range and recommended mounting tolerances. These characteristics do not include the code-wheel/code-strip contribution.

Description	Symbol	Typ.	Case 1 Max.[a]	Case 2 Max.[b]	Units
Pulse Width Error	ΔP	30	40	—	°e
Logic State Width Error	ΔS	30	40	—	°e
Phase Error	Δϕ	2	10	105	°e

a. Case 1: Module mounted on tolerance circle of ±0.13 mm (±0.005 in.).

b. Case 2. HEDS-9000 mounted on tolerances of ±0.50 mm (0.020 in).
HEDS-9100 mounted on tolerances of ±0.38 mm (0.015 in.).

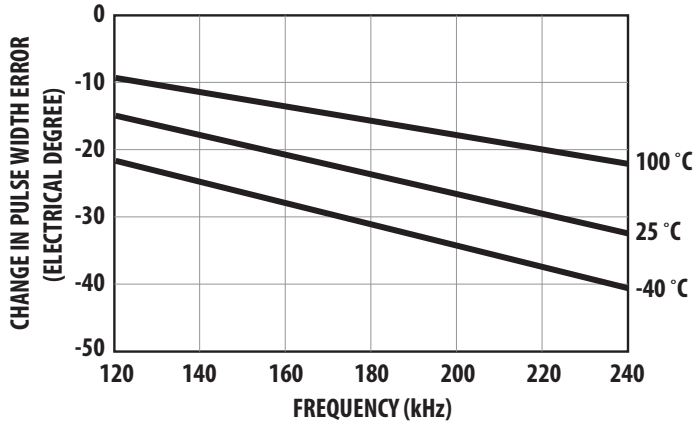
Electrical Characteristics

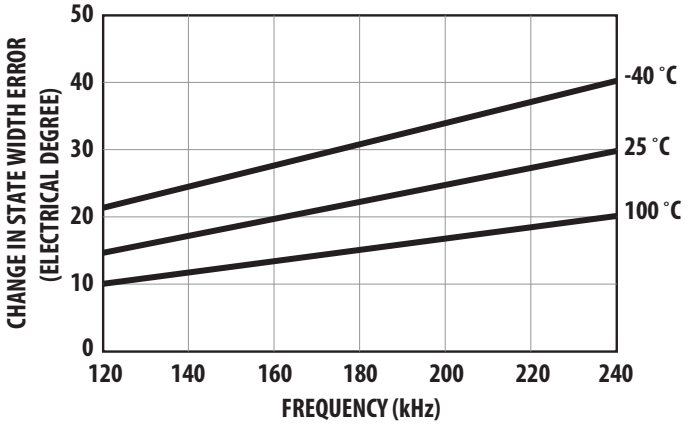
Electrical characteristics are over the recommended operating range, typically at 25°C.

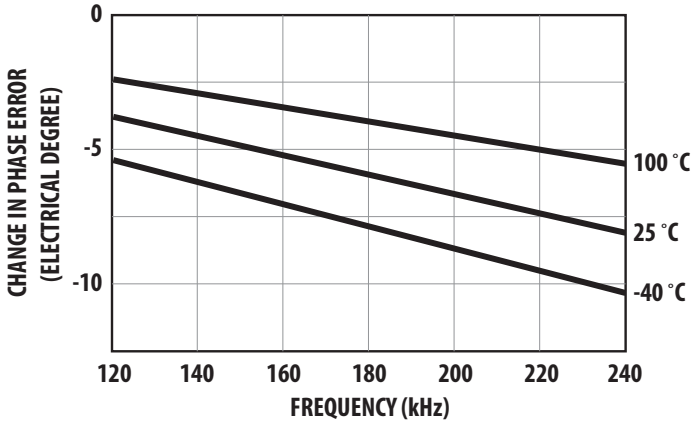
Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Current	I_{CC}	—	17	40	mA	HEDS-9100 all series, HEDS-9000#A00, and J00
Supply Current	I_{CC}	—	22	40	mA	HEDS-9000#B00
Supply Current	I_{CC}	—	51	85	mA	HEDS-9000#T00 and U00
High Level Output Voltage	V_{OH}	2.4	—	—	V	I_{OH} = –40 µA maximum
Low Level Output Voltage	V_{OL}	—	—	0.4	V	I_{OL} = 3.2 mA maximum
Rise Time	t_r	—	200	—	ns	C_L = 25 pF R_L = 11-kΩ pull-up
Fall Time	t_f	—	50	—	ns	All series except HEDS-9000#B00
Fall Time	t_f	—	125	—	ns	HEDS-9000#B00

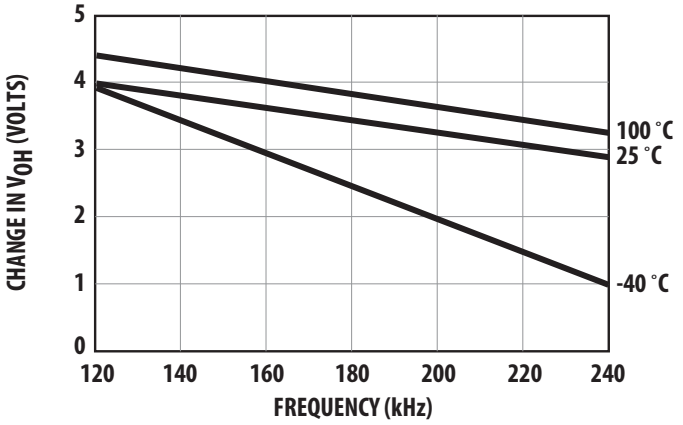
Derating Curves over Extended Operating Frequencies

The following are the derating curves for state, duty, phase, and V_{OH} over extended operating frequencies of up to 240 kHz (the recommended maximum frequency is 100 kHz). The curves were derived using a standard TTL load. Operation at –40°C is not feasible above 160 kHz because V_{OH} beyond that frequency will drop below 2.4V (the minimum TTL for logic state high).



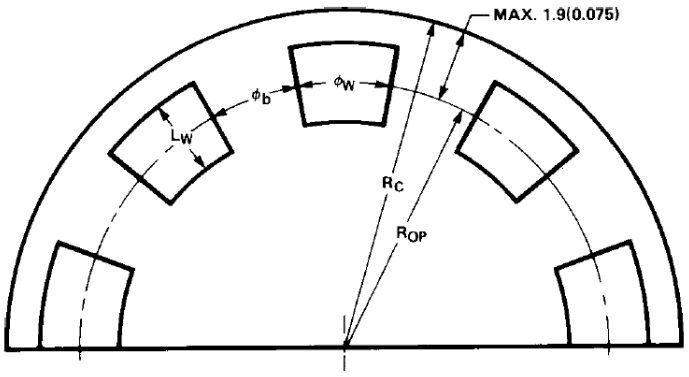






Recommended Code-Wheel Characteristics

Figure 3: Cope-Strip Design



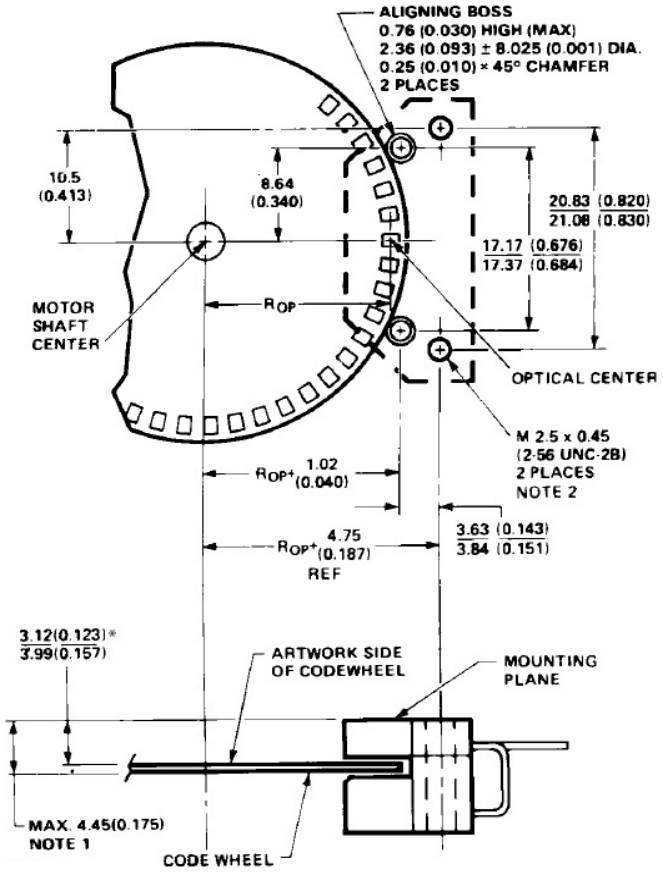
Code-Wheel Options

HEDS Series	CPR (N)	Option	Optical Radius mm (inch)
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	Min.	Max.	Units	Notes
Window/Bar Ratio	ϕ_w/ϕ_b	0.7	1.4	—	—
Window Length	L_W	1.8 (0.071)	2.3 (0.09)	mm (inch)	—
Absolute Maximum Code-Wheel Radius	R_C	—	R_{OP} + 1.9 (0.0075)	mm (inch)	Includes eccentricity errors

Mounting Considerations

Figure 4: Mounting Plane Side A



NOTES:
1. THESE DIMENSIONS INCLUDE SHAFT END PLAY AND CODEWHEEL WARP.
2. RECOMMENDED MOUNTING SCREW TORQUE RANGES FROM MINIMUM 1 kg-cm (0.9 in-lb) TO MAXIMUM 4 kg-cm (3.5 in-lb).
3. *FOR WINDOW OPTION MEASUREMENT = 3.22 (0.127).

Figure 5: Mounting Plane Side B

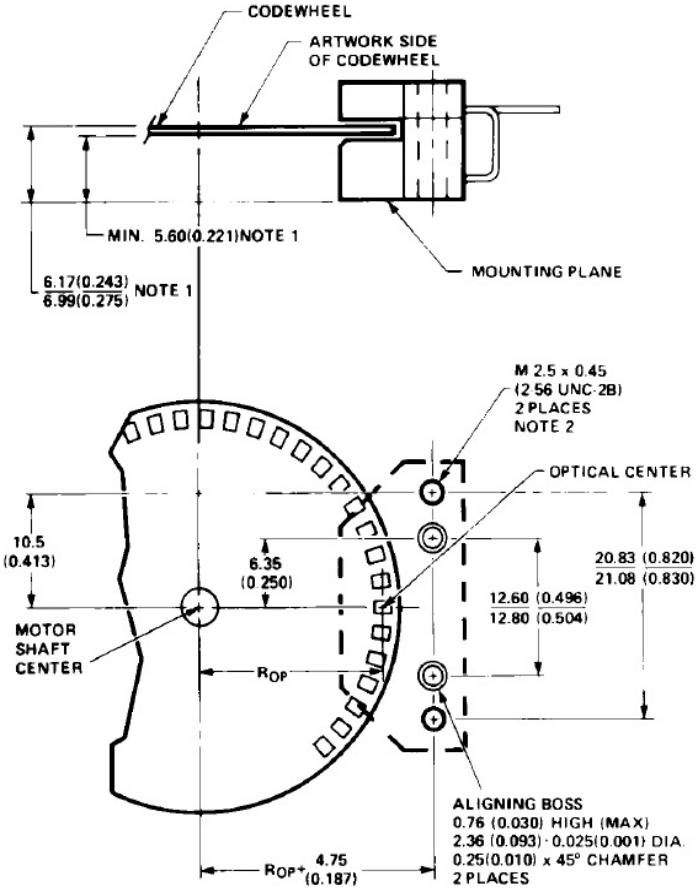


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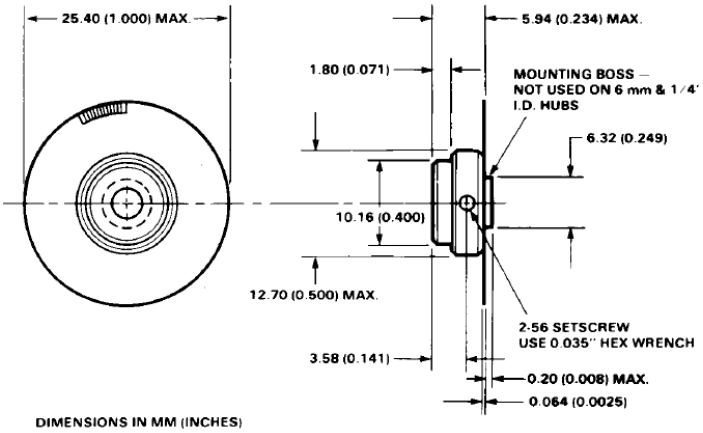
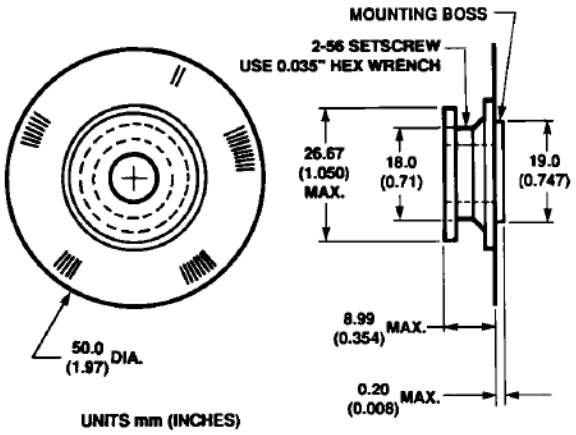
Figure 6: Mounting as Referenced to Side A



DIMENSIONS IN MM (INCHES)

Figure 7: Mounting as Referenced to Side B

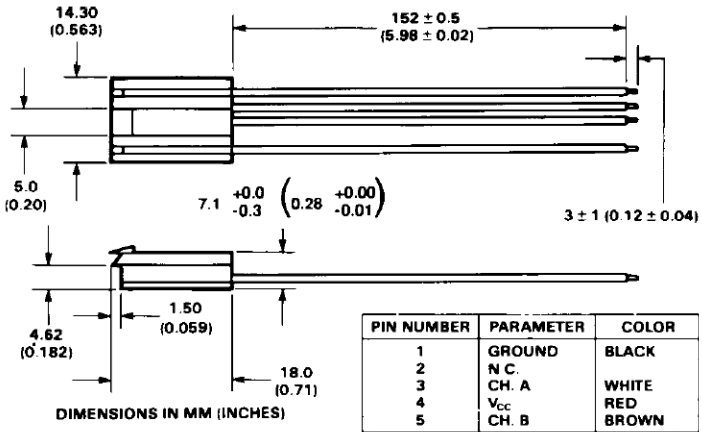


UNITS mm (INCHES)

Connectors

Mounting Manufacturer	Part Number	Surface
AMP	1203686-4 640442-5	Both Side B
DuPont	65039-032 with 4825X-000 term.	Both
HP	HEDS-8902 with 4-wire leads	Side B (see Figure 8)
Molex	2695 series with 2759 series term.	Side B

Figure 8: HEDS-8902 Connector



Ordering Information

HEDS-9000 Option □ 0 0 HEDS-6100 Option □ □ □

Resolution (Cycles/Rev)

A - 500 CPR
B - 1000 CPR
J - 1024 CPR
T - 2000 CPR*
U - 2048 CPR*

Shaft Diameter

06 - 1/4 in.	10 - 5/8 in.
08 - 3/8 in.	12 - 6 mm
09 - 1/2 in.	13 - 8 mm

	A	B	C	D	E	F	G	H	I	J	K	L	S	T	U
HEDS-9000	*	*								*				*	*

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

HEDS-910 0 Option □ 0 0 HEDS-5120 Option

Lead

0 - Straight Leads
1 - Bent Leads

Resolution (Cycles/Rev)

S - 50 CPR	H - 400 CPR
K - 96 CPR	A - 500 CPR
C - 100 CPR	I - 512 CPR
E - 200 CPR	B - 1000 CPR*
F - 256 CPR	J - 1024 CPR*
G - 360 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	B	C	D	E	F	G	H	I	J	K	S	T	U
HEDS-9100	*	*	*		*	*	*	*	*	*	*	*		
HEDS-9101	*		*		*		*							

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

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