Agilent Technologies
Innovating the HP Way

Two Channel Optical Incremental Encoder Modules

Technical Data

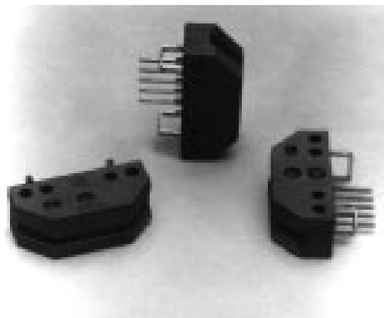
HEDS-9000
HEDS-9100

Features

- **High Performance**
- **High Resolution**
- **Low Cost**
- **Easy to Mount**
- **No Signal Adjustment Required**
- **Small Size**
- **-40°C to 100°C Operating Temperature**
- **Two Channel Quadrature Output**
- **TTL Compatible**
- **Single 5 V Supply**

Description

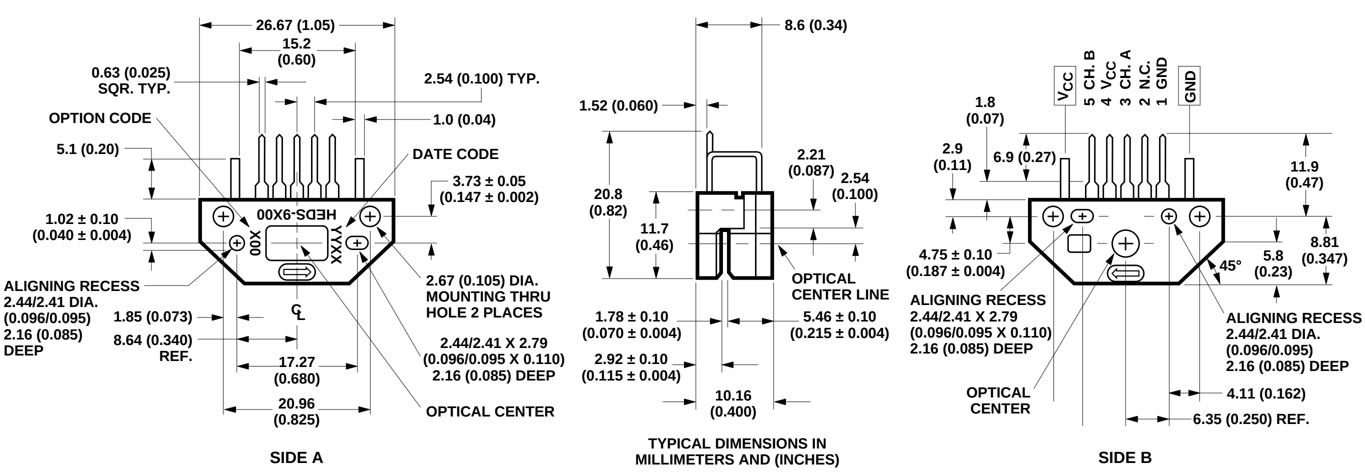
The HEDS-9000 and the HEDS-9100 series are high performance, low cost, optical incremental encoder modules. When used with a codewheel, these modules detect rotary position. The modules consist of a lensed (LED) source and a detector IC enclosed in a small C-shaped plastic package. Due to a highly collimated 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 HEDS-9000 are 500 CPR and 1000 CPR for use with a HEDS-6100 codewheel or equivalent.

Package Dimensions



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

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

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.

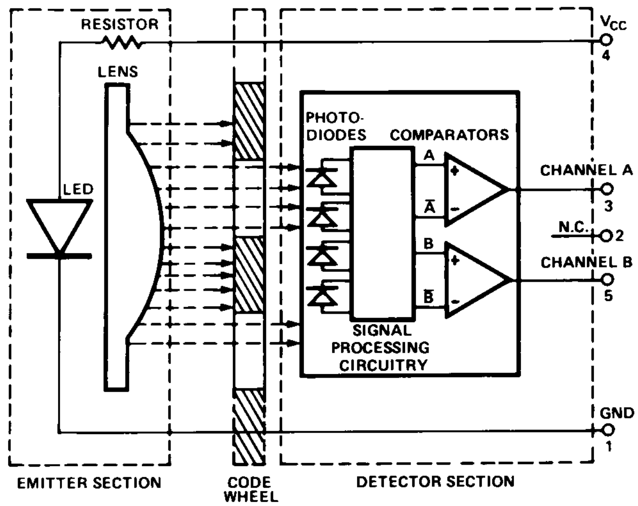
Theory of Operation

The HEDS-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.

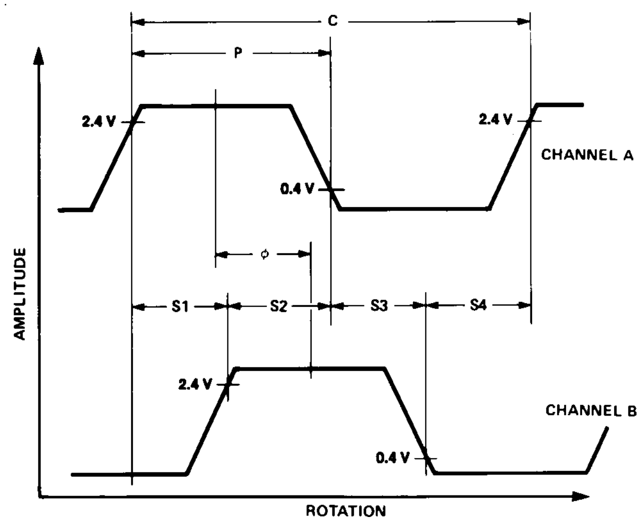
As seen in the block diagram, each module contains a single Light Emitting Diode (LED) as its light source. The light is collimated into a parallel beam by means of a single polycarbonate lens located directly over the LED. Opposite the emitter is the integrated detector circuit. This IC consists of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

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 odewheel. 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, A, B, and 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).

Block Diagram



Output Waveforms



Definitions

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

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 4 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.

Absolute Maximum Ratings

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 7 V
Output Voltage, V_O .... -0.5 V to V_{CC}
Output Current per Channel, I_{out} .... -1.0 mA to 5 mA

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 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.

Recommended Operating Conditions

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

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 contribution.

Description	Sym.	Typ.	Case 1 Max.	Case 2 Max.	Units	Notes
Pulse Width Error	ΔP	30	40	°e		
Logic State Width Error	ΔS	30	40	°e		
Phase Error	Δϕ	2	10	105	°e	

Case 1: Module mounted on tolerance circle of ± 0.13 mm (± 0.005 in.).
Case 2: HEDS-9000 mounted on tolerances of ± 0.50 mm (0.020").
HEDS-9100 mounted ontolerances of ± 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 µA 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 R_L = 11 kΩ pull-up
Fall Time	t_f		50		ns	

Recommended Codewheel Characteristics

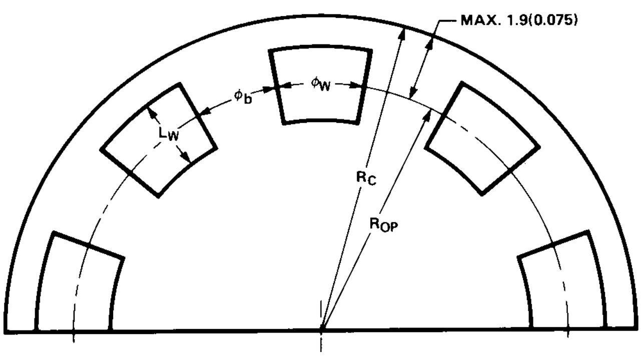


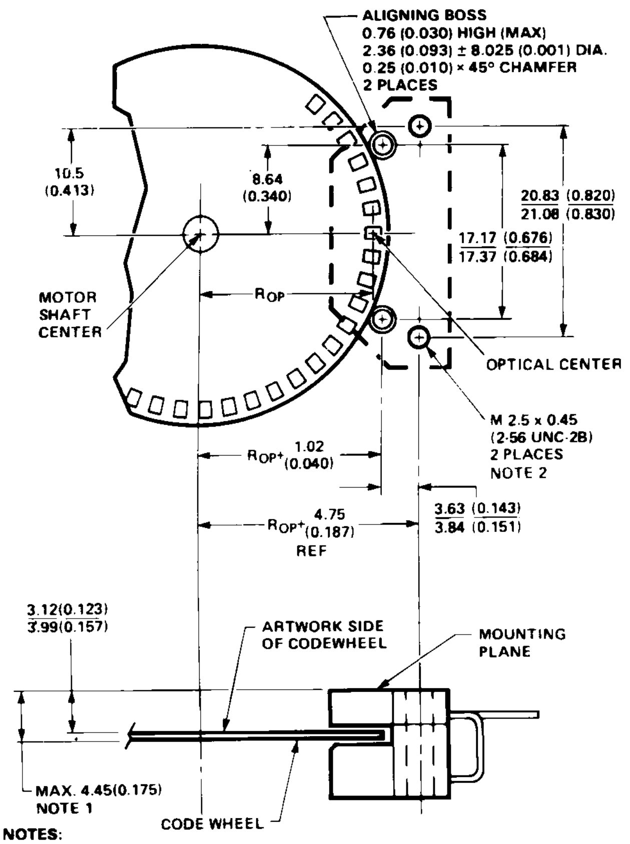
Figure 1. Codestrip Design

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)

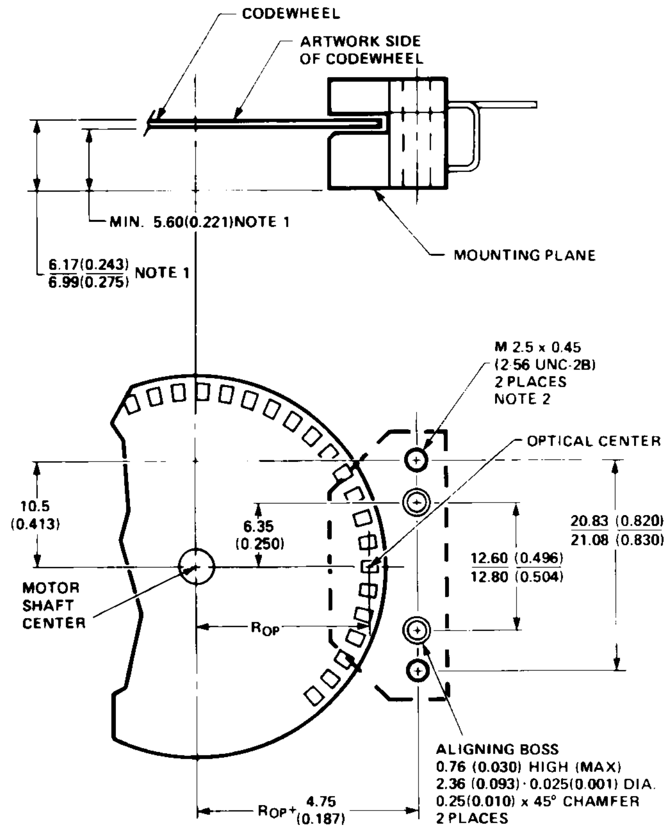
Parameter	Symbol	Minimum	Maximum	Units	Notes
Window/Bar Ratio	ϕ_w/ϕ_b	0.7	1.4		
Window Length	L_W	1.8 (0.071)	2.3 (0.09)	mm (inch)	
Absolute Maximum Codewheel Radius	R_C		R_{OP} + 1.9 (0.0075)	mm (inch)	Includes eccentricity errors

Mounting Considerations



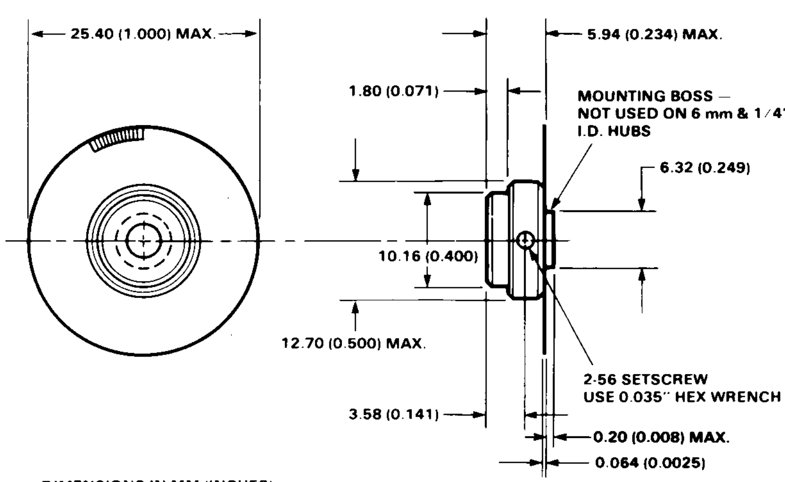
NOTES:
1. THESE DIMENSIONS INCLUDE SHAFT END PLAY, AND CODEWHEEL WARP.
2. MAXIMUM RECOMMENDED MOUNTING SCREW TORQUE IS 4 kg-cm (3.5 in-lbs).

Figure 2. Mounting Plane Side A.



NOTES:
1. THESE DIMENSIONS INCLUDE SHAFT END PLAY, AND CODEWHEEL WARP.
2. MAXIMUM RECOMMENDED MOUNTING SCREW TORQUE IS 4 kg-cm (3.5 in-lbs).

Figure 3. Mounting Plane Side B.



DIMENSIONS IN MM (INCHES)

Figure 4. Mounting as Referenced to Side A.

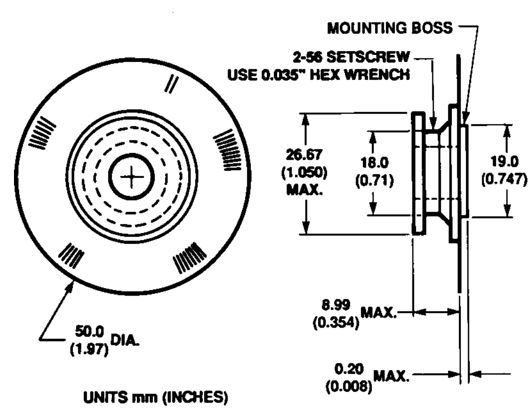


Figure 5. Mounting as Referenced to Side B.

Connectors

Manufacturer	Part Number	Mounting Surface
AMP	1203686-4 640442-5	Both Side B
DuPont	65039-032 with 4825X-000 term.	Both
Agilent	HEDS-8902 with 4-wire leads	Side B (see Fig. 6)
Molex	2695 series with 2759 series term.	Side B

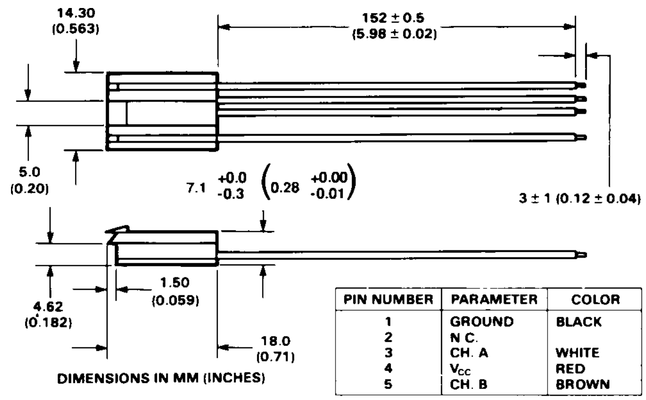


Figure 6. HEDS-8902 Connector.

Ordering Information

HEDS-9000 Option ☐ **0** **0**

Resolution (Cycles/Rev)

A - 500 CPR
B - 1000 CPR
T = 2000 CPR*
U = 2048 CPR*

HEDS-6100 Option ☐ ☐ ☐

Shaft Diameter

05 - 3/16 in.	10 - 5/8 in.
06 - 1/4 in.	11 - 4 mm
07 - 5/16 in.	12 - 6 mm
08 - 3/8 in.	13 - 8 mm
09 - 1/2 in.	

HEDS-9100 Option ☐ **0** **0**

Resolution (Cycles/Rev)

S - 50 CPR	G - 360 CPR
K - 96 CPR	H - 400 CPR
C - 100 CPR	A - 500 CPR
D - 192 CPR	I - 512 CPR
E - 200 CPR	B - 1000 CPR*
F - 256 CPR	J - 1024 CPR*

HEDS-5120 Option ☐ ☐ ☐

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.	

HEDS-91 ☐ ☐

Resolution (Cycles/Rev)

BA - 250 CPR
BB - 480 CPR
BC - 576 CPR

*Please refer to separate HEDS-9000/9100/9200 Extended Resolution series data sheet for detailed information and Codewheel selection.

www.semiconductor.agilent.com

Data subject to change.

Obsoletes 5091-8349E (7/93)

5965-5887E (11/99)