Agilent Technologies

Quick Assembly Two and Three Channel Optical Encoders

Technical Data

HEDM-550x/560x
HEDS-550x/554x
HEDS-560x/564x

Features

- **Two Channel Quadrature Output with Optional Index Pulse**
- **Quick and Easy Assembly**
- **No Signal Adjustment Required**
- **External Mounting Ears Available**
- **Low Cost**
- **Resolutions Up to 1024 Counts Per Revolution**
- **Small Size**
- **-40°C to 100°C Operating Temperature**
- **TTL Compatible**
- **Single 5 V Supply**

Description

The HEDS-5500/5540, HEDS-5600/5640, and HEDM-5500/5600 are high performance, low cost, two and three channel optical incremental encoders. These encoders emphasize high reliability, high resolution, and easy assembly.

Each encoder contains a lensed LED source, an integrated circuit with detectors and output circuitry, and a codewheel which rotates between the emitter and detector IC. The outputs of the HEDS-5500/5600 and HEDM-5500/ 5600 are two square waves in quadrature. The HEDS-5540 and 5640 also have a third channel index output in addition to the two channel quadrature. This index output is a 90 electrical degree, high true index pulse which is generated once for each full rotation of the codewheel.

The HEDS series utilizes metal codewheels, while the HEDM series utilizes a film codewheel allowing for resolutions to 1024 CPR. The HEDM series is nont available with a third channel index.

These encoders may be quickly and easily mounted to a motor. For larger diameter motors, the HEDM-5600, and HEDS-5600/ 5640 feature external mounting ears.

The quadrature signals and the index pulse are accessed through five 0.025 inch square pins located on 0.1 inch centers.

Standard resolutions between 96 and 1024 counts per revolution are presently available. Consult local Agilent sales representatives for other resolutions.

Applications

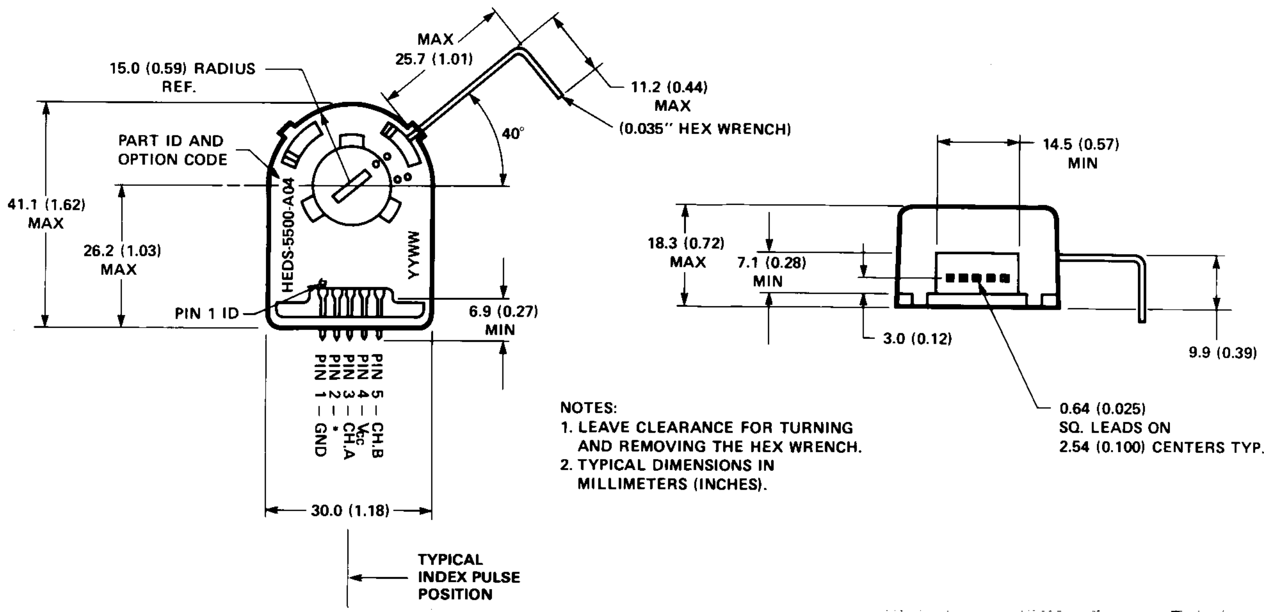
The HEDS-5500, 5540, 5600, 5640, and the HEDM-5500, 5600 provide motion detection at a low cost, making them ideal for high volume applications. Typical applications include printers, plotters, tape drives, positioning tables, and automatic handlers.

Note: Agilent 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.

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

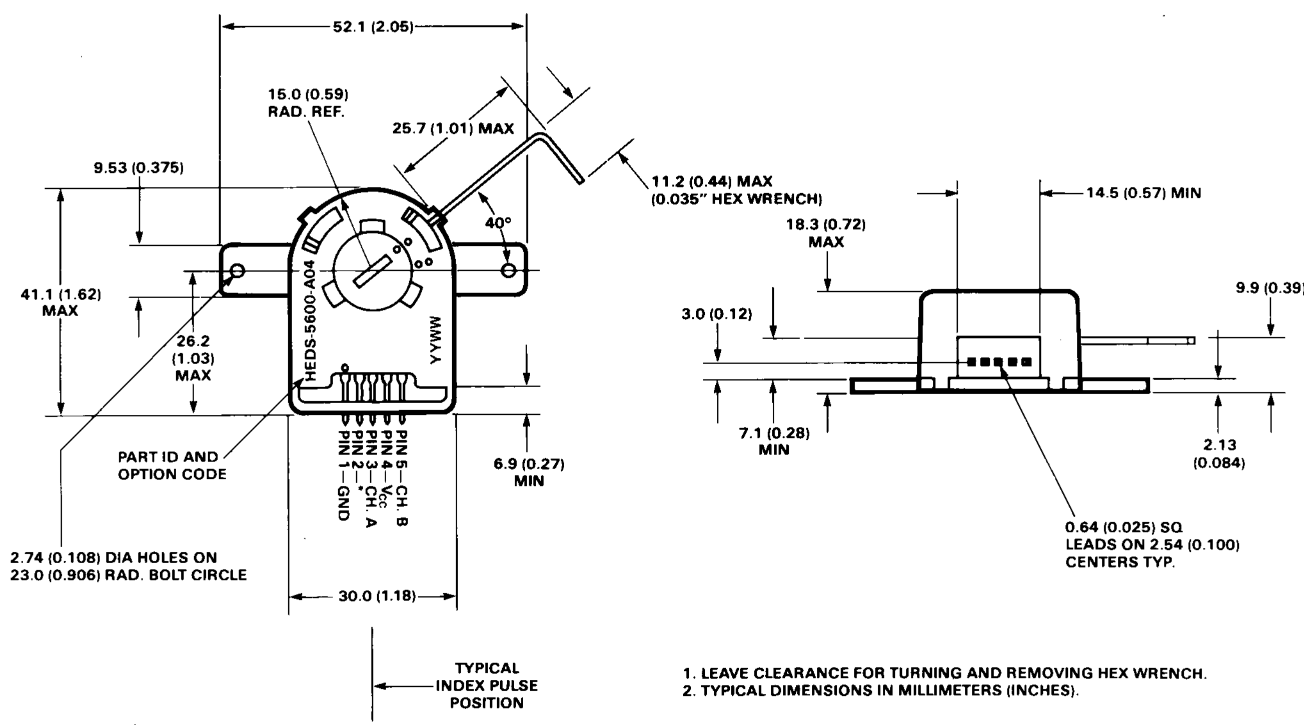
Package Dimensions

HEDS-5500/5540, HEDM-5500



***Note:** For the HEDS-5500 and HEDM-5500, Pin #2 is a No Connect. For the HEDS-5540, Pin #2 is CH. I, the index output.

HEDS-5600/5640, HEDM-5600



***Note:** For the HEDS-5600 and HEDM-5600, Pin #2 is a No Connect. For the HEDS-5640, Pin #2 is CH. I, the index output.

Theory of Operation

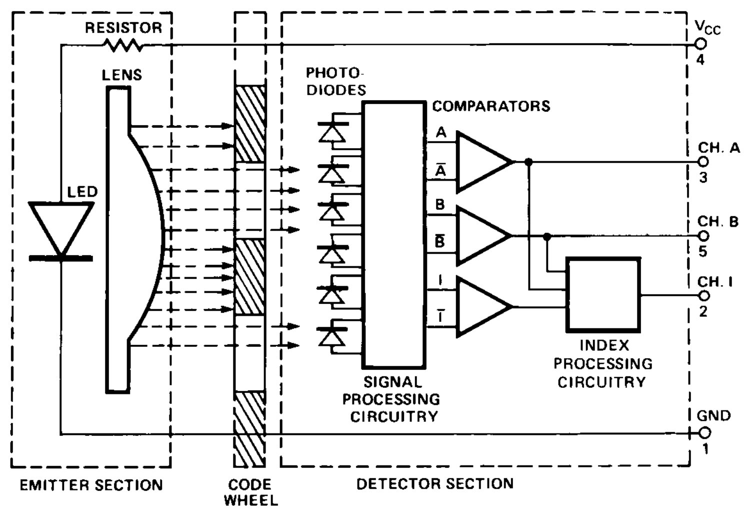
The HEDS-5500, 5540, 5600, 5640, and HEDM-5500, 5600 translate the rotary motion of a shaft into either a two- or a three-channel digital output.

As seen in the block diagram, these encoders contain 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 produce 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 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 $\bar{B}$ (also I and $\bar{I}$ in the HEDS-5540 and 5640). 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).

In the HEDS-5540 and 5640, the output of the comparator for I and $\bar{I}$ is sent to the index processing circuitry along with the outputs of channels A and B.

Block Diagram



NOTE: CIRCUITRY FOR CH. I IS ONLY IN HEDS-5540 AND 5640 THREE CHANNEL ENCODERS.

The final output of channel I is an index pulse P_O which is generated once for each full rotation of the codewheel. This output P_O is a one state width (nominally 90 electrical degrees), high true index pulse which is coincident with the low states of channels A and B.

Definitions

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

One Cycle (C): 360 electrical degrees (°e), 1 bar and window pair.

One Shaft Rotation: 360 mechanical degrees, N cycles.

Position Error (ΔΘ): The normalized angular difference between the actual shaft position and the position indicated by the encoder cycle count.

Cycle Error (ΔC): An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

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.

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.

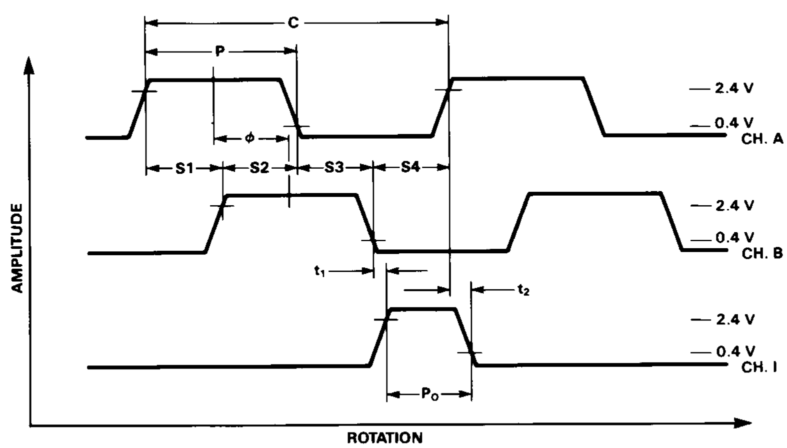
Absolute Maximum Ratings

Parameter	HEDS-55XX/56XX	HEDM-550X/560X
Storage Temperature, T_S	-40°C to 100°C	-40°C to +70°C
Operating Temperature, T_A	-40°C to 100°C	-40°C to +70°C
Supply Voltage, V_{CC}	-0.5 V to 7 V	-0.5 V to 7 V
Output Voltage, V_O	-0.5 V to V_{CC}	-0.5 V to V_{CC}
Output Current per Channel, I_{OUT}	-1.0 mA to 5 mA	-1.0 mA to 5 mA
Vibration	20 g, 5 to 1000 Hz	20 g, 5 to 1000 Hz
Shaft Axial Play	± 0.25 mm (± 0.010 in.)	± 0.175 mm (± 0.007 in.)
Shaft Eccentricity Plus Radial Play	0.1 mm (0.004 in.) TIR	0.04 mm (0.0015 in.) TIR
Velocity	30,000 RPM	30,000 RPM
Acceleration	250,000 rad/sec^2	250,000 rad/sec^2

Direction of Rotation: When the codewheel rotates in the counter-clockwise direction (as viewed from the encoder end of the motor), channel A will lead channel B. If the codewheel rotates in the clockwise direction, channel B will lead channel A.

Index Pulse Width (P_O): The number of electrical degrees that an index output is high during one full shaft rotation. This value is nominally 90°e or 1/4 cycle.

Output Waveforms



Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Temperature HEDS Series	T_A	-40		100	°C	
Temperature HEDM Series	T_A	-40		70	°C	non-condensing atmosphere
Supply Voltage	V_{CC}	4.5	5.0	5.5	Volts	Ripple < 100 mV_{p-p}
Load Capacitance	C_L			100	pF	2.7 kΩ pull-up
Count Frequency	f			100	kHz	Velocity (rpm) x N/60
Shaft Perpendicularity Plus Axial Play (HEDS Series)				± 0.25 (± 0.010)	mm (in.)	6.9 mm (0.27 in.) from mounting surface
Shaft Eccentricity Plus Radial Play (HEDS Series)				0.04 (0.0015)	mm (in.) TIR	6.9 mm (0.27 in.) from mounting surface
Shaft Perpendicularity Plus Axial Play (HEDM Series)				± 0.175 (± 0.007)	mm (in.)	6.9 mm (0.27 in.) from mounting surface
Shaft Eccentricity Plus Radial Play(HEDM Series)				0.04 (0.0015)	mm (in.) TIR	6.9 mm (0.27 in.) from mounting surface

Note: The module performance is guaranteed to 100 kHz but can operate at higher frequencies. 2.7 kΩ pull-up resistors required for HEDS-5540 and 5640.

Encoding Characteristics

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances unless otherwise specified. Values are for the worst error over the full rotation.

Part No.	Description		Sym.	Min.	Typ.*	Max.	Units
HEDS-5500 HEDS-5600 (Two Channel)	Pulse Width Error		ΔP		7	45	°e
	Logic State Width Error		ΔS		5	45	°e
	Phase Error		$\Delta\phi$		2	20	°e
	Position Error		$\Delta\Theta$		10	40	min. of arc
	Cycle Error		ΔC		3	5.5	°e
HEDM-5500 HEDM-5600 (Two Channel)	Pulse Width Error		ΔP		10	45	°e
	Logic State Width Error		ΔS		10	45	°e
	Phase Error		$\Delta\phi$		2	15	°e
	Position Error		$\Delta\Theta$		10	40	min. of arc
	Cycle Error		ΔC		3	7.5	°e
HEDS-5540 HEDS-5640 (Three Channel)	Pulse Width Error		ΔP		5	35	°e
	Logic State Width Error		ΔS		5	35	°e
	Phase Error		$\Delta\phi$		2	15	°e
	Position Error		$\Delta\Theta$		10	40	min. of arc
	Cycle Error		ΔC		3	5.5	°e
	Index Pulse Width		P_O	55	90	125	°e
	CH. I rise after CH. A or CH. B fall	-40°C to +100°C	t_2	-300	100	250	ns
	CH. I fall after CH. B or CH. A rise	-40°C to +100°C	t_2	70	150	1000	ns

Note: See Mechanical Characteristics for mounting tolerances.
*Typical values specified at V_{CC} = 5.0 V and 25°C.

Electrical Characteristics

Electrical Characteristics over Recommended Operating Range.

Part No.	Parameter	Sym.	Min.	Typ.*	Max.	Units	Notes
HEDS-5500 HEDS-5600	Supply Current High Level Output Voltage Low Level Output Voltage	I_{CC} V_{OH} V_{OL}	 2.4 	17 	40 0.4	mA V V	 I_{OH} = -40 µA max. I_{OL} = 3.2 mA
	Rise Time Fall Time	t_r t_f		200 50		ns ns	C_L = 25 pF R_L = 11 kΩ pull-up
HEDS-5540 HEDS-5640 HEDM-5500 HEDM-5600	Supply Current High Level Output Voltage Low Level Output Voltage	I_{CC} V_{OH} V_{OL}	30 2.4 	57 	85 0.4	mA V V	 I_{OH} = -200 µA max. I_{OL} = 3.86 mA
	Rise Time Fall Time	t_r t_f		180 40		ns ns	C_L = 25 pF R_L = 2.7 kΩ pull-up
HEDM-5500 HEDM-5600	Supply Current High Level Output Voltage Low Level Output Voltage	I_{CC} V_{OH} V_{OL}	30 2.4 	57 	85 0.4	mA V V	 I_{OH} = -40 µA max. I_{OL} = 3.86 mA
	Rise Time Fall Time	t_r t_f		180 40		ns ns	C_L = 25 pF R_L = 3.2 kΩ pull-up

*Typical values specified at V_{CC} = 5.0 V and 25°C.

Mechanical Characteristics

Parameter	Symbol	Dimension	Tolerance[1]	Units
Codewheel Fits These Standard Shaft Diameters		2 3 4 5 6 8	+0.000 -0.015	mm
		5/32 1/8 3/16 1/4	+0.0000 -0.0007	in
Moment of Inertia	J	0.6 (8.0 x 10^{-6})		g-cm^2 (oz-in-s^2)
Required Shaft Length[2]		14.0 (0.55)	± 0.5 (± 0.02)	mm (in.)
Bolt Circle[3]	2 screw mounting	19.05 (0.750)	± 0.13 (± 0.005)	mm (in.)
	3 screw mounting	20.90 (0.823)	± 0.13 (± 0.005)	mm (in.)
	external mounting ears	46.0 (1.811)	± 0.13 (± 0.005)	mm (in.)
Mounting Screw Size[4]	2 screw mounting	M 2.5 or (2-56)		mm (in.)
	3 screw mounting	M 1.6 or (0-80)		mm (in.)
	external mounting ears	M 2.5 or (2-56)		mm (in.)
Encoder Base Plate Thickness		0.33 (0.130)		mm (in.)
Hub Set Screw		(2-56)		(in.)

Notes:
1. These are tolerances required of the user.
2. The HEDS-55X5 and 56X5, HEDM-5505, 5605 provide an 8.9 mm (0.35 inch) diameter hole through the housing for longer motor shafts. See Ordering Information.
3. The HEDS-5540 and 5640 must be aligned using the aligning pins as specified in Figure 3, or using the alignment tool as shown in "Encoder Mounting and Assembly". See also "Mounting Considerations."
4. The recommended mounting screw torque for 2 screw and external ear mounting is 1.0 kg-cm (0.88 in-lbs). The recommended mounting screw torque for 3 screw mounting is 0.50 kg-cm (0.43 in-lbs).

Electrical Interface

To insure reliable encoding performance, the HEDS-5540 and 5640 three channel encoders require 2.7 kΩ (± 10%) pull-up resistors on output pins 2, 3, and 5 (Channels I, A, and B) as shown in Figure 1. These pull-up resistors should be located as close to the encoder as possible (within 4 feet). Each of the three encoder outputs can drive a single TTL load in this configuration.

The HEDS-5500, 5600, and HEDM-5500, 5600 two channel encoders do not normally require pull-up resistors. However, 3.2 kΩ pull-up resistors on output pins 3 and 5 (Channels A and B) are recommended to improve rise times, especially when operating above 100 kHz frequencies.

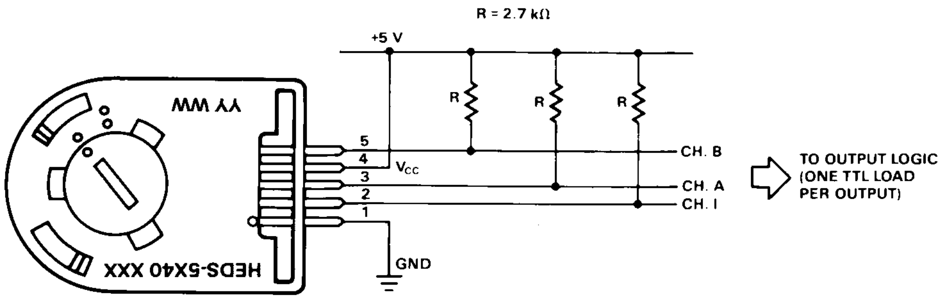


Figure 1. Pull-up Resistors on HEDS-5X40 Encoder Outputs.

Mounting Considerations

The HEDS-5540 and 5640 three channel encoders and the HEDM Series high resolution encoders must be aligned using the aligning pins as specified in Figure 3, or using the HEDS-8910 Alignment Tool as shown in Encoder Mounting and Assembly.

The use of aligning pins or alignment tool is recommended but not required to mount the HEDS-5500 and 5600. If these two channel encoders are attached to a motor with the screw sizes and mounting tolerances specified in the mechanical characteristics section without any additional mounting bosses, the encoder output errors will be within the maximums specified in the encoding characteristics section.

The HEDS-5500 and 5540 can be mounted to a motor using either the two screw or three screw mounting option as shown in Figure 2. The optional aligning pins shown in Figure 3 can be used with either mounting option.

The HEDS-5600, 5640, and HEDM-5600 have external mounting ears which may be used for mounting to larger motor base plates. Figure 4 shows the necessary mounting holes with optional aligning pins and motor boss.

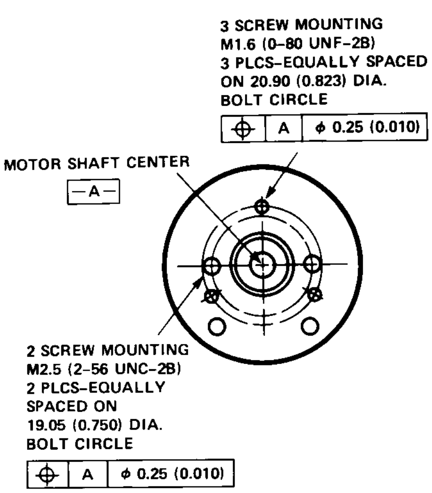


Figure 2. Mounting Holes.

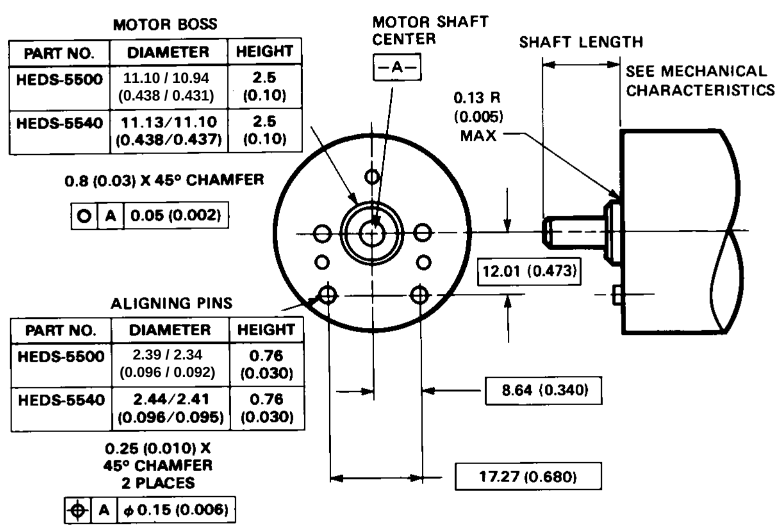


Figure 3. Optional Mounting Aids.

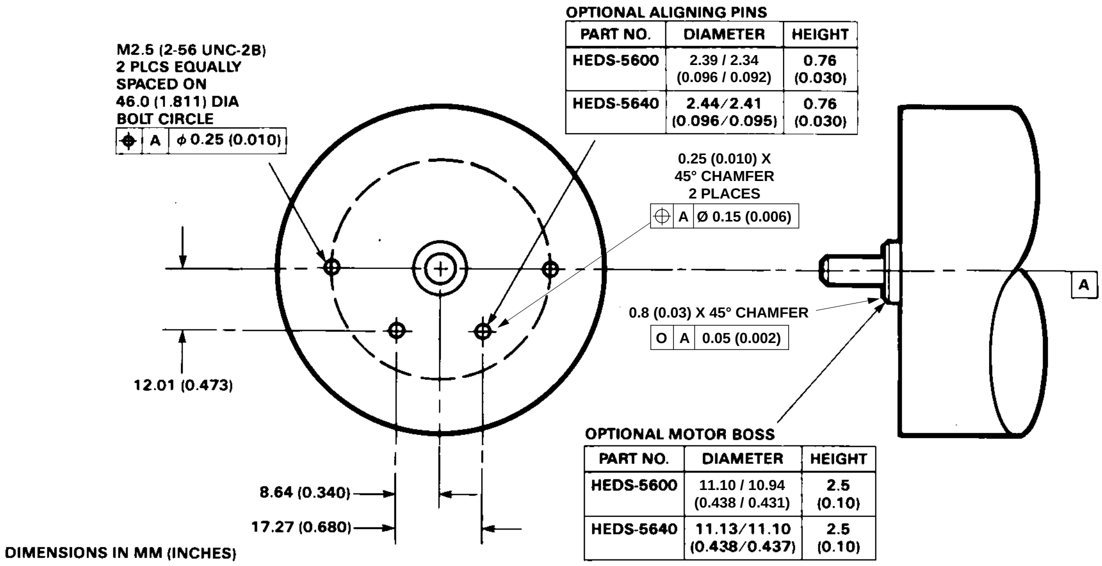
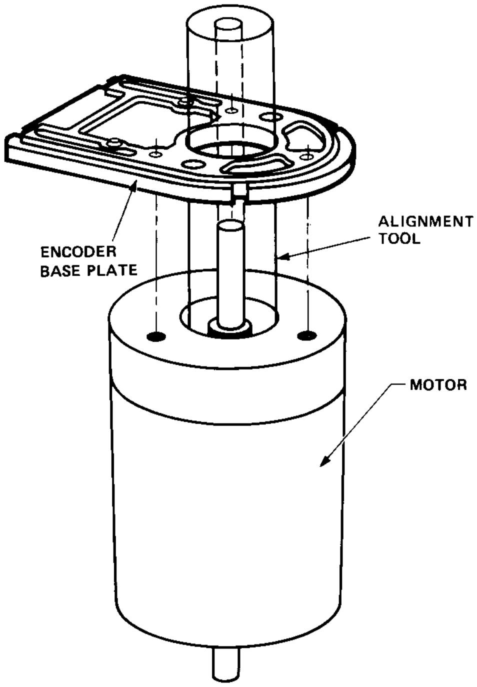


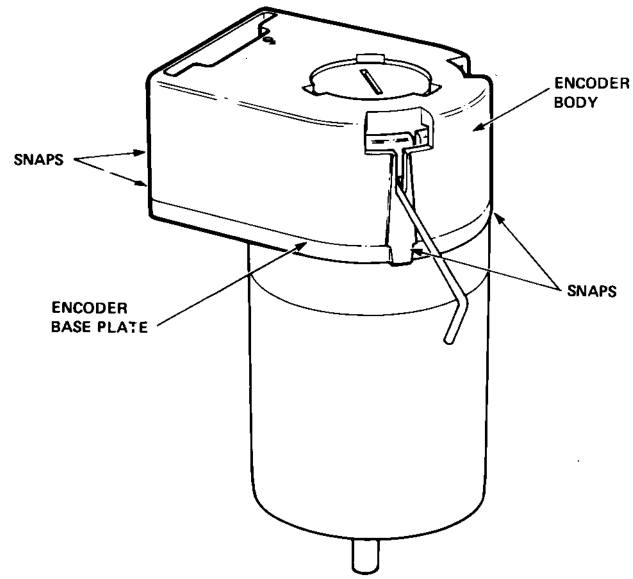
Figure 4. Mounting with External Ears.

Encoder Mounting and Assembly

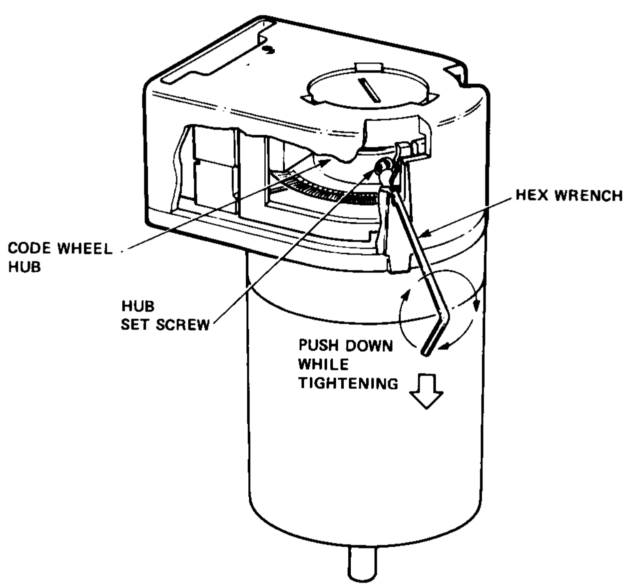


1. For HEDS-5500 and 5600: Mount encoder base plate onto motor. Tighten screws. Go on to step 2.

1a. For HEDS-5540, 5640 and HEDM-5500, 5600: Slip alignment tool onto motor shaft. With alignment tool in place, mount encoder baseplate onto motor as shown above. Tighten screws. Remove alignment tool.



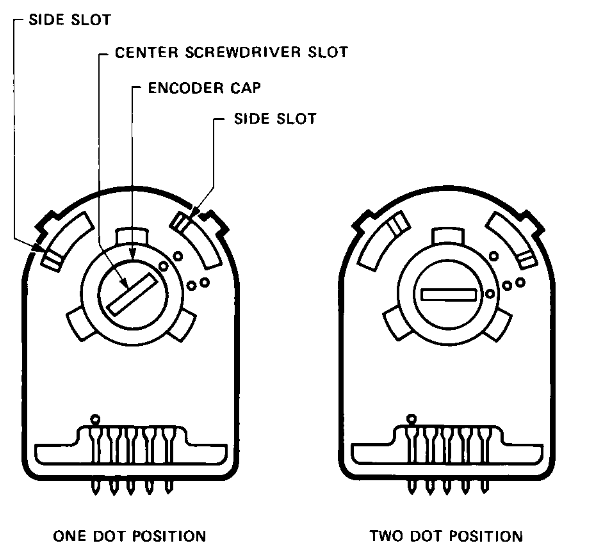
2. Snap encoder body onto base plate locking all 4 snaps.



3a. Push the hex wrench into the body of the encoder to ensure that it is properly seated into the code wheel hub set screws. Then apply a downward force on the end of the hex wrench. This sets the code wheel gap by levering the code wheel hub to its upper position.

3b. While continuing to apply a downward force, rotate the hex wrench in the clockwise direction until the hub set screw is tight against the motor shaft. The hub set screw attaches the code wheel to the motor's shaft.

3c. Remove the hex wrench by pulling it straight out of the encoder body.

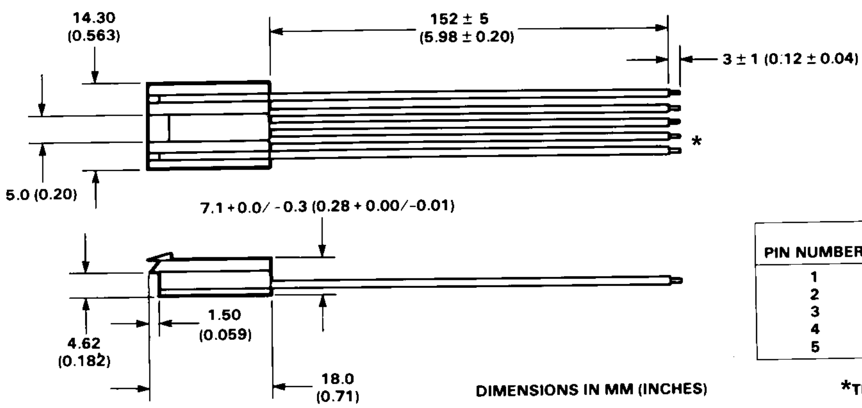


4. Use the center screwdriver slot, or either of the two side slots, to rotate the encoder cap dot clockwise from the one dot position to the two dot position. Do not rotate the encoder cap counterclockwise beyond the one dot position.

The encoder is ready for use!

Connectors

Manufacturer	Part Number
AMP	103686-4 640442-5
Dupont/Berg	65039-032 with 4825X-000 term.
Agilent (designed to mechanically lock into the HEDS-5XXX, HEDM-5X0X Series)	HEDS-8902 (2 ch.) with 4-wire leads HEDS-8903 (3 ch.) with 5-wire leads
Molex	2695 series with 2759 series term.

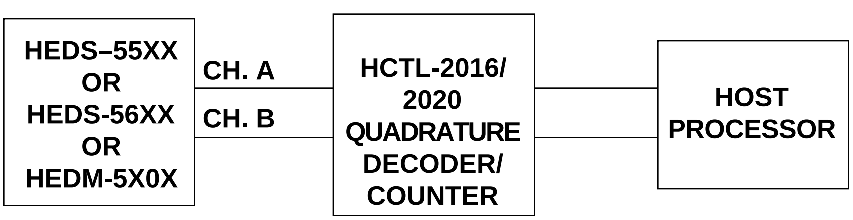


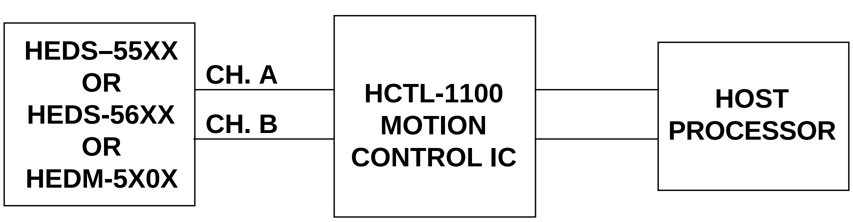
PIN NUMBER	PARAMETER	HEDS-8902 COLORS	HEDS-8903 COLORS
1	GROUND	BLACK	BLACK
2	CH. I	N/A*	BLUE
3	CH. A	WHITE	WHITE
4	V_{CC}	RED	RED
5	CH. B	BROWN	BROWN

*THIS WIRE IS NOT ON HEDS-8902.

Figure 5. HEDS-8902 and 8903 Connectors.

Typical Interfaces





Ordering Information

Encoders with Film Codewheels

HEDM-5 □ 0 □ Option □ □□

Mounting Type	Outputs	Through Hole	Resolution (Cycles/Rev)	Shaft Diameter	
5 - Standard	0 - 2 Channel	0 - None	B - 1000 CPR	01 - 2 mm	06 - 1/4 in.
6 - External Mounting Ears		5 - 8.9 mm (0.35 in.)	J - 1024 CPR	02 - 3 mm	11 - 4 mm
				03 - 1/8 in.	14 - 5 mm
				04 - 5/32 in.	12 - 6 mm
				05 - 3/16 in.	13 - 8 mm

HEDS-8910 0 □□ Alignment Tool

(Included with each order of HEDM-550X/560X two channel encoders)

Encoders with Metal Codewheels

HEDS-5 □□□ Option □ □□

Mounting Type	Outputs	Through Hole	Resolution (Cycles/Rev)		Shaft Diameter	
5 - Standard	0 - 2 Channel	0 - None	(HEDS-550X, 560X 2 Channel)		01 - 2 mm	06 - 1/4 in.
6 - External Mounting Ears	4 - 3 Channel	5 - 8.9 mm (0.35 in.)	S - 50 CPR	F - 256 CPR	02 - 3 mm	11 - 4 mm
			K - 96 CPR	G - 360 CPR	03 - 1/8 in.	14 - 5 mm
			C - 100 CPR	H - 400 CPR	04 - 5/32 in.	12 - 6 mm
			D - 192 CPR	A - 500 CPR	05 - 3/16 in.	13 - 8 mm
			E - 200 CPR	I - 512 CPR		
			(HEDS-554X, 564X 3 Channel)			
			S - 50 CPR	G - 360 CPR		
			K - 96 CPR	H - 400 CPR		
			C - 100 CPR	A - 500 CPR		
			E - 200 CPR	I - 512 CPR		
			F - 256 CPR			

HEDS-8910 0 □□ Alignment Tool

(Included with each order of HEDS-554X/564X three channel encoders)

		01	02	03	04	05	06	11	12	13	14
HEDM-5500	**B**	*	*				*	*	*	*	*
	J		*				*		*	*	*
HEDM-5505	**B**				*						
	J			*			*			*	
HEDM-5600	**B**						*			*	
	J						*				
HEDM-5605	**B**						*				
	J						*				
HEDS-5500	**A**	*	*	*	*	*	*	*	*	*	*
	C	*	*	*	*	*	*	*	*	*	*
	E		*		*	*	*	*	*		*
	F	*	*		*	*	*	*	*		*
	G		*			*	*		*		*
	H					*	*		*		*
	I	*	*	*	*	*	*	*	*	*	*
	K				*	*	*	*			
	S									*	
HEDS-5505	**A**				*		*			*	*
	C				*		*		*		*
	E				*		*				*
	F				*		*				*
	G				*		*				
	H						*				*
	I				*		*			*	
	K				*						
HEDS-5540	**A**	*	*	*	*	*	*	*	*	*	*
	C	*	*				*	*	*	*	*
	E						*	*			
	F	*						*			*
	G						*				
	H						*				*
	I	*	*				*	*	*	*	*
HEDS-5545	**A**								*		*
	C								*		
	H						*				*
	I						*				
HEDS-5600	**A**						*		*	*	*
	C						*		*		*
	E						*				
	G						*			*	
	H						*		*		
	I	*						*			

		01	02	03	40	05	06	11	12	13	14
HEDS-5605	**A**						*			*	
	C						*				
	E						*				
	F									*	
	G						*				
	H						*				*
	I						*				
HEDS-5640	**A**						*		*	*	
	E						*				
	F						*				
	H						*				
HEDS-5645	**A**						*		*	*	
	C									*	
	E									*	
	G									*	
	H						*		*		*
	I									*	

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Data subject to change.

Obsoletes 5988-2579EN
January 17, 2002
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HEDL-65xx, HEDM-65xx, HEDS-65xx Series

Large Diameter (56 mm), Housed Two and Three Channel Optical Encoders

Data Sheet

Description

The HEDS-65xx/HEDL-65xx are high performance two and three channel optical incremental encoders. These encoders emphasize high reliability, high resolution, and easy assembly. Each encoder contains a lensed LED source (emitter), an integrated circuit with detectors and output circuitry, and a codewheel which rotates between the emitter and detector integrated circuit. The outputs of the HEDS-6500 are two single ended square waves in quadrature. The HEDL-65xx outputs are differential.

The HEDS-6540 / HEDL-6540 also have a third channel index output in addition to the two quadrature outputs. This index is an active high pulse that occurs once every full rotation of the codewheel. Resolutions up to 1024 Counts Per Revolution are available in the two and three channel versions.

The line driver option offers enhanced performance when the encoder is used in noisy environments, or when it is required to drive long distances.

The line driver option utilizes an industry standard line driver IC AM26C31Q which provides complementary outputs for each encoder channel. Thus the outputs of the line driver encoder are A and $\overline{A}$, B and $\overline{B}$, and I and $\overline{I}$ for three channel versions. Suggested line receivers are 26C32 and 26C33.

The quadrature signals are accessed through a cable and 10-pin female connector. Please refer to the ordering information at the end of this data sheet for a selection matrix.

Features

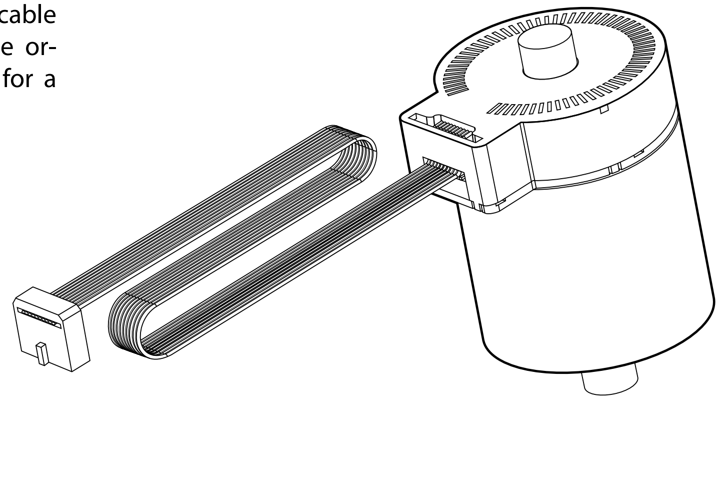
- Two channel quadrature output with optional index pulse
- TTL compatible single ended outputs on HEDS Series
- 100ºC operating temperature for metal code wheel
- 70°C operating temperature for mylar code wheel
- Industry standard AM26C31Q CMOS line driver IC on HEDL Series
- Easy assembly, no signal adjustment necessary
- Resolutions up to 2048 counts per revolution

Applications

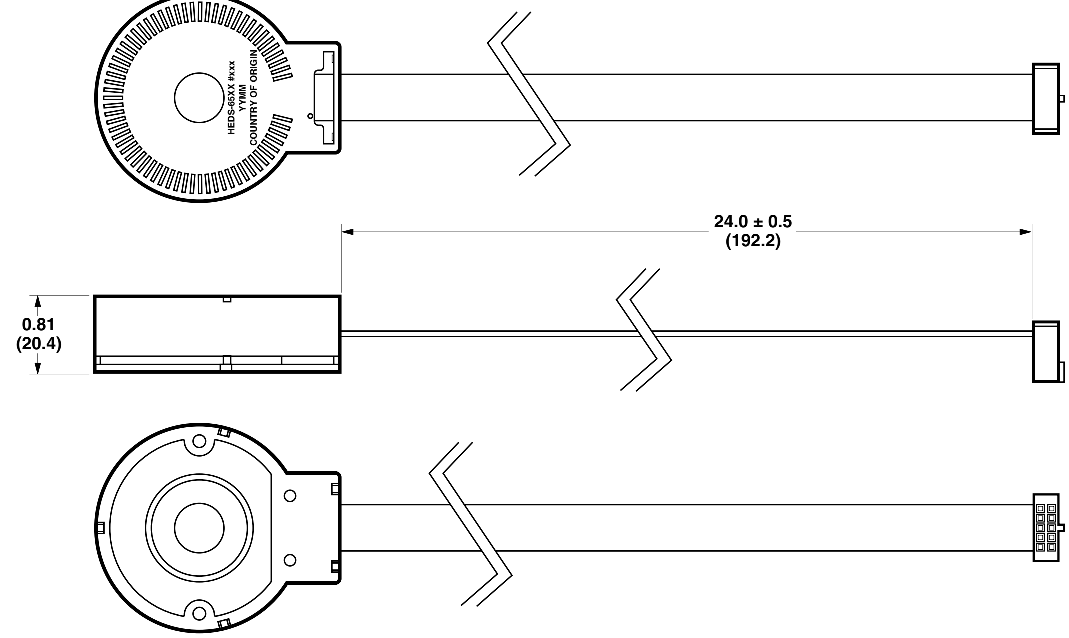
The HEDS-65xx / HEDL-65xx provide motion detection to a very high resolution and accept a variety of shaft sizes up to a maximum of 5/8 inches.

Typical applications include printers, plotters, tape drives, positioning tables, and automatic handlers.

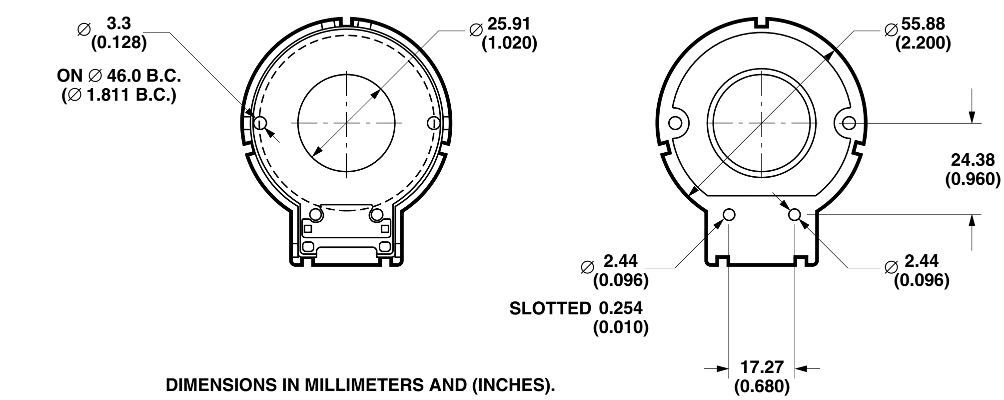
Note: Avago Technologies encoders are not recommended for use in safety critical applications. Eg. ABS braking systems, power steering, life support systems and critical care medical equipment. Please contact sales representative if more clarification is needed.



Assembled Unit

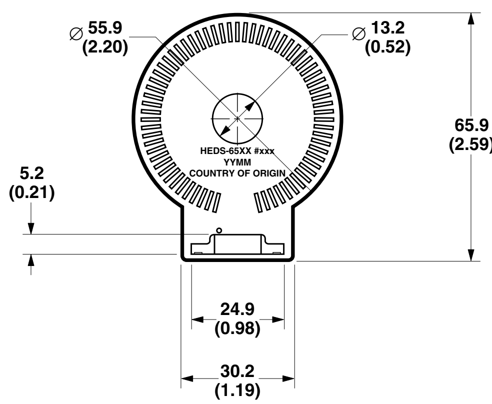


Base Plate



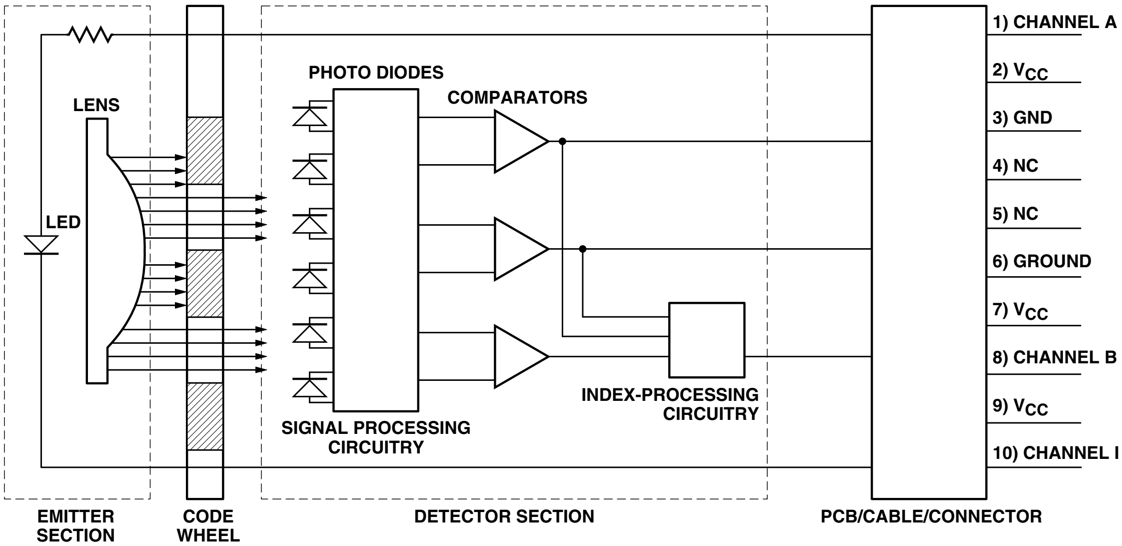
DIMENSIONS IN MILLIMETERS AND (INCHES).

Top Cover (Housing)

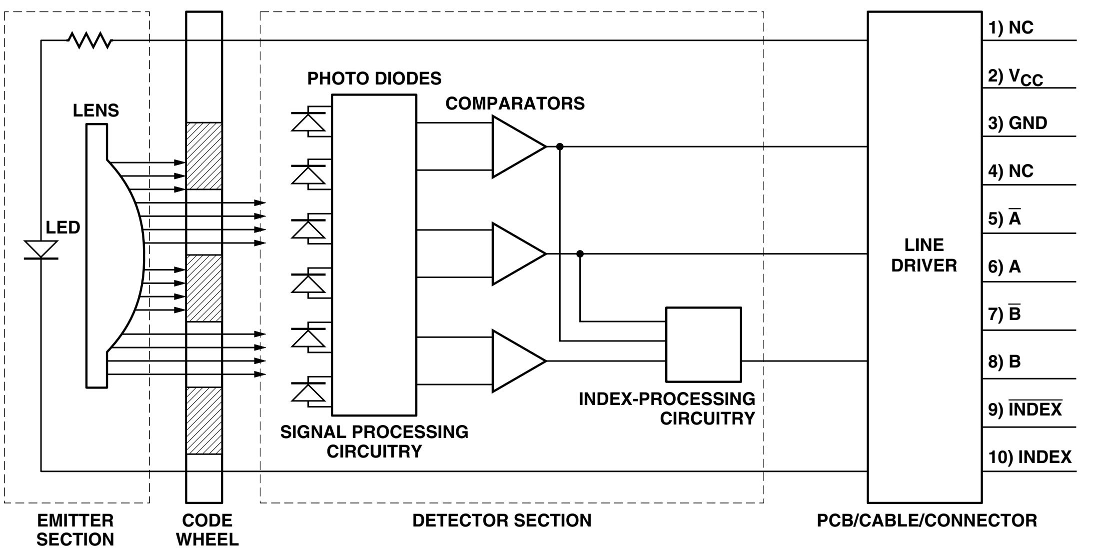


DIMENSIONS IN MILLIMETERS AND (INCHES).

Pinout A

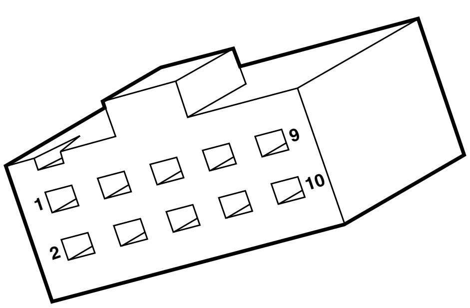


Pinout B



There are two different connector pin-out configurations used with the HEDS-65xx / HEDL-65xx series of encoders. The table below relates the part to its connector pin-out.

Connector Pin-out



Pinout A

HEDS-65xx CONNECTOR PIN OUT	
1	Channel A
2	V_{CC}
3	GND
4	NC
5	NC
6	GND
7	V_{CC}
8	Channel B
9	V_{CC}
10	Channel I

Pinout B

HEDL-65xx CONNECTOR PIN OUT	
1	NC
2	V_{CC}
3	GND
4	NC
5	$\overline{A}$
6	A
7	$\overline{B}$
8	B
9	I (INDEX)
10	$\overline{\text{I (INDEX)}}$

Theory of Operation

The HEDS-65xx / HEDL-65xx translate the rotary motion of a shaft into either a two or three channel digital output.

The HEDS-65xx uses one of the standard HEDS-9000 or HEDS-9040 modules for encoding purposes. The HEDL-654x uses the standard HEDL-9040 for encoding purposes.

As seen in the block diagram, these modules contain a single Light Emitting Diode (LED) as their light source (emitter). The light is collimated into a single parallel beam by means of a plastic lens located directly over the LED. Opposite the emitter is the integrated detector circuit (detector). This circuit consists of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The codewheel rotates between the emitter and detector, causing the light beam to be interrupted by a 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 into the signal processing circuitry resulting in A, $\overline{A}$, B, and $\overline{B}$ (I and $\overline{I}$ also in the three channel encoders). 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).

In the HEDS-6540 / HEDL-6540 the output of the comparator for the index pulse is combined with that of the outputs of channel A and channel B to produce the final index pulse. The index pulse is generated once every rotation of the codewheel and is a one state width (nominally 90 electrical degrees), true high index pulse. It is coincident with the low states on channels A and B.

Definitions

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

One Cycle (C): 360 electrical degrees (e), 1 bar and window pair.

One Shaft Rotation: 360 mechanical degrees, N cycles.

Position Error ($\Delta\Theta$): The normalized angular difference between the actual shaft position and the position indicated by the encoder cycle count.

Cycle Error (ΔC): An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

Pulse Width (P): The number of electrical degrees that an output is high during one 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.

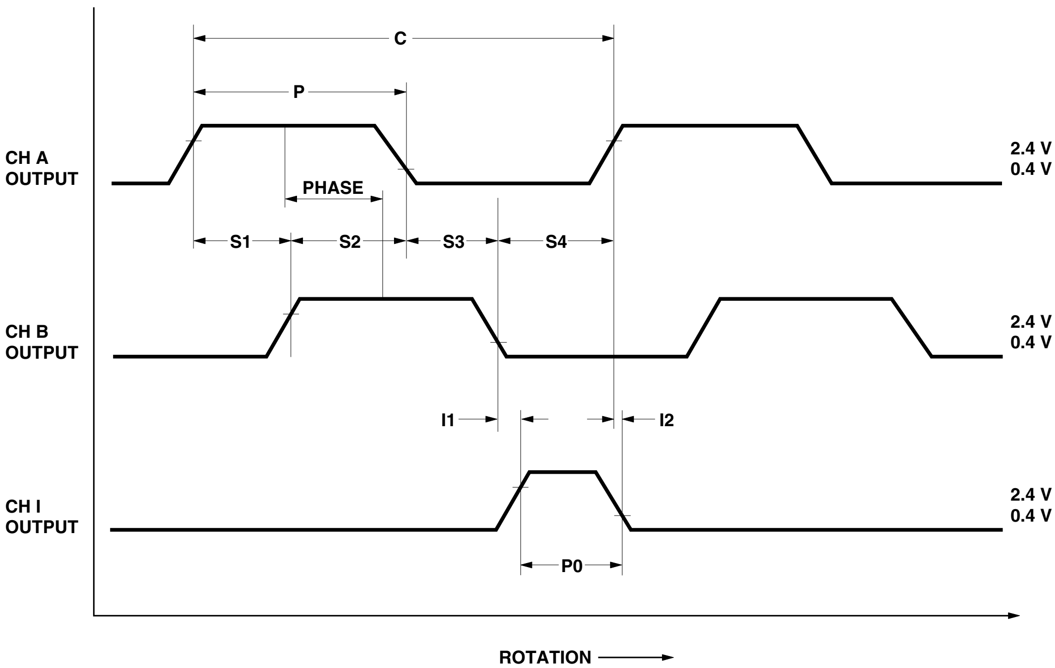
Phase (Φ): the number of electrical degrees between the center of high state on channel A and the center of the high state on channel B. This value is nominally 90 e for quadrature output.

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

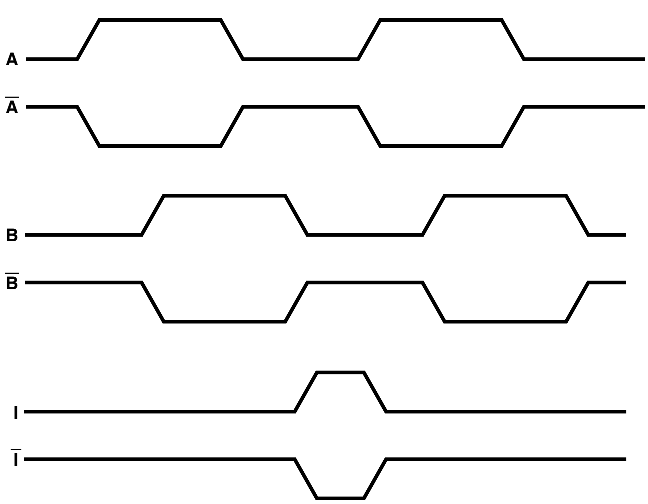
Direction of Rotation: When the codewheel rotates in a counterclockwise direction (when viewed from the encoder end of the motor) channel A will lead channel B. If the codewheel rotates in the clockwise direction channel B will lead channel A.

Index Pulse Width (P0): The number of electrical degrees that an index output is high during one full shaft rotation. This value is nominally 90 e or 1/4 cycle.

Output Waveforms



Waveforms for Encoders without Line Drivers.



Waveforms for Encoders with Line Drivers.

Absolute Maximum Ratings

Parameter	HEDS-6500	HEDS-6540	HEDL-6540	HEDL-6545	
Storage Temperature	-40 to +100	-40 to +100	-40 to +100	-40 to +100	Celsius
Operating Temperature	-40 to +100	-40 to +100	-40 to +100	-40 to +100	Celsius
Supply Voltage	-.5 to +7	-.5 to +7	-.5 to +7	-.5 to +7	Volts
Output Voltage	-.6 to Vcc	-.6 to Vcc	-.6 to Vcc	-.6 to Vcc	Volts
Output Current Per Channel	-1 to 5	-1 to 5			mA
Velocity	30,000	30,000	30,000	30,000	RPM
Vibration	20	20	20	20	Gs
Shaft Axial Play	5	5	5	5	Inch/1000
Radial Play & Eccentricity	2	2	2	2	Inch/1000

Recommended Operating Conditions

Parameter	HEDS-6500	HEDS-6540	HEDL-6540	HEDL-6545	
Temperature	-40 to +100	-40 to +100	-40 to +100	-40 to +100	Celsius
Supply Voltage	4.5 to 5.5	4.5 to 5.5	4.5 to 5.5	4.5 to 5.5	Volts
Load Capacitance	100	100	100	100	pF
Count Frequency	100	100	100	100	kHz
Shaft Eccentricity Plus Radial Play	±.05 (±.002)	±.05 (±.002)	±.05 (±.002)	±.05 (±.002)	mm (Inch/1000)

Note: The HEDS-65XX performance is guaranteed to 100 kHz but can operate at higher frequencies. For frequencies above 100 kHz it is recommended that the load capacitance not exceed 25 pF and pull up resistors of 3.3 kΩ between the output channels and Vcc are included.

Encoding Characteristics

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances unless otherwise specified. Values are for the worst error in the full rotation.

Part Number	Description	Symbol	Min.	Typ.*	Max.	Units
HEDS-6500***	Pulse Width Error	ΔP		5	35	°e
	Logic State Width Error	ΔS		5	35	°e
	Phase Error	ΔΦ		2	15	°e
	Position Error	ΔΘ		7	20	min. of arc
	Cycle Error	ΔC		5	5.5	°e
HEDS-6540**	Pulse Width Error	ΔP		5	35	°e
	Logic State Width Error	ΔS		5	35	°e
	Phase Error	ΔΦ		2	15	°e
	Position Error	ΔΘ		7	20	min. of arc
	Cycle Error	ΔC		5	5.5	°e
	Index Pulse Width	ΔP0	55	90	125	°e
	CH I fall after CH B or CH A fall					
	-25°C to +100°C	t1	10	100	250	ns
	-40°C to +100°C	t1	-300	100	250	ns
	CH I rise after CH B or CH A rise					
	-25°C to +100°C	t2	70	150	300	ns
	-40°C to +100°C	t2	70	150	1000	ns
HEDL-654x	Pulse Width Error	ΔP		5	35	°e
	Logic State Width Error	ΔS		5	35	°e
	Phase Error	ΔΦ		2	15	°e
	Position Error	ΔΘ		7	20	min. of arc
	Cycle Error	ΔC		5	5.5	°e
	Index Pulse Width	ΔP0		90		°e

*Typical values specified at Vcc = 5.0 V and 25°C.
**HEDS-6540 – Active high Index part. Pull-up of 2.7 kΩ used on all outputs of modules that do not have a line driver.
***HEDS-6500 – 3.3 kΩ pull-up resistors used on all encoder module outputs.

Electrical Characteristics

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

Part Number	Symbol*	Min.	Typ.	Max.	Units	Notes
HEDS-6500	Icc		17	40	mA	
	V_{OH}	2.4			V	I_{OH} = -40 μA max
	V_{OL}			0.4	V	I_{OL} = 3.2 mA
	tr		200		ns	C_L = 25 pF, RL = 11 kΩ pull-up.
	tf		50		ns	
HEDS-6540	Icc	30	57	85	mA	
	V_{OH}	2.4			V	I_{OH} = -200 μA max
	V_{OL}			0.4	V	I_{OL} = 3.86 mA
	tr		180		ns	C_L = 25 pF, RL = 3.3 kΩ pull-up.
	tf		40		ns	

*Explanation for symbols.

Icc – Supply current, V_{OH} – High Level Output Voltage, V_{OL} – Low Level Output Voltage, tr – Rise Time, tf – Fall Time.

Electrical Interfaces

To insure reliable encoding performance, the HEDS-6540 three channel encoder requires 2.7 kΩ pull-up resistors to the supply voltage on each of the three output lines Ch. A, Ch. B, and Ch. I located as close as possible to the encoder

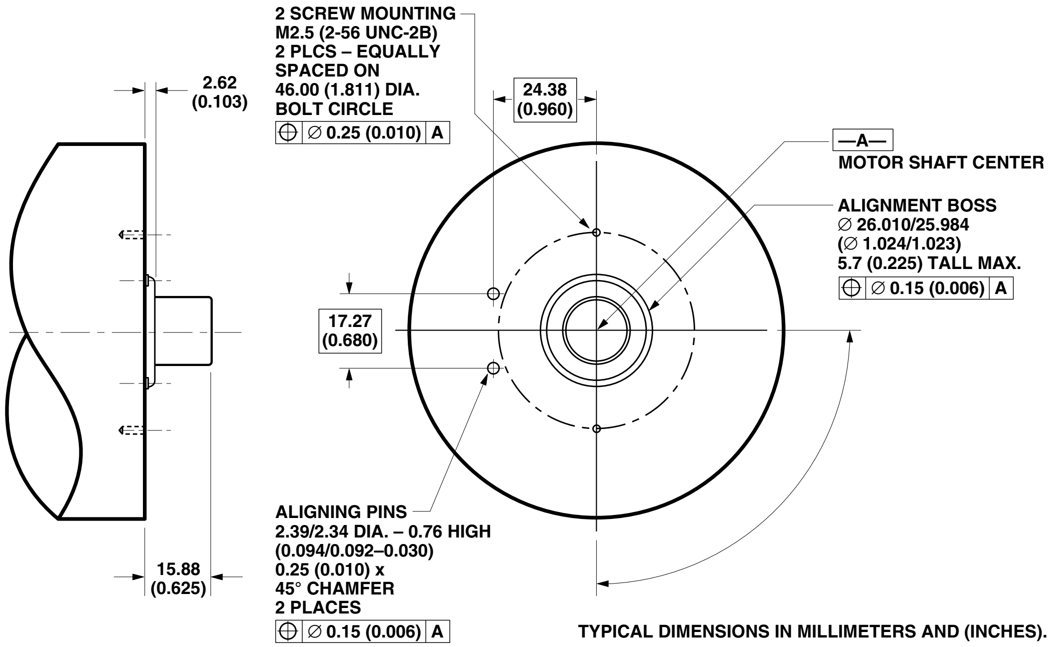
Mechanical Characteristics

Parameter	Symbol	Dimensions	Tolerances [1]	Units
Moment Of Inertia	J	7.7 (110 x 10^{-6})		gcm^2 (oz-in-s^2)
Required Shaft Length [2]		15.9 (0.625)	±0.6 (.024)	mm (inches)
Bolt Circle [3]		46.0 (1.811)	±0.13 (.005)	mm (inches)
Mounting Screw Size [4] Pan Head Style		2.5 x 0.45 x 5 #2-56 x 3/16		mm Inches
Encoder Base Plate Thickness		3.04 (120)		mm (inches)
Mounting Screw Torque		1.0 (0.88)		Kg (in-lbs)
Hub Set Screw		UNC #2-56		Hex head set screw

Notes:
1. These are tolerances required of the user.
2. Through hole in the encoder housing are also available, for longer shafts.
3. The HEDL-65X0 must be aligned using the aligning pins as specified in the section on "MOUNTING CONSIDERATIONS."
4. The recommended mounting screw torque for 2 screws is 1.0 Kg (0.88 in-lbs).

Mounting Considerations

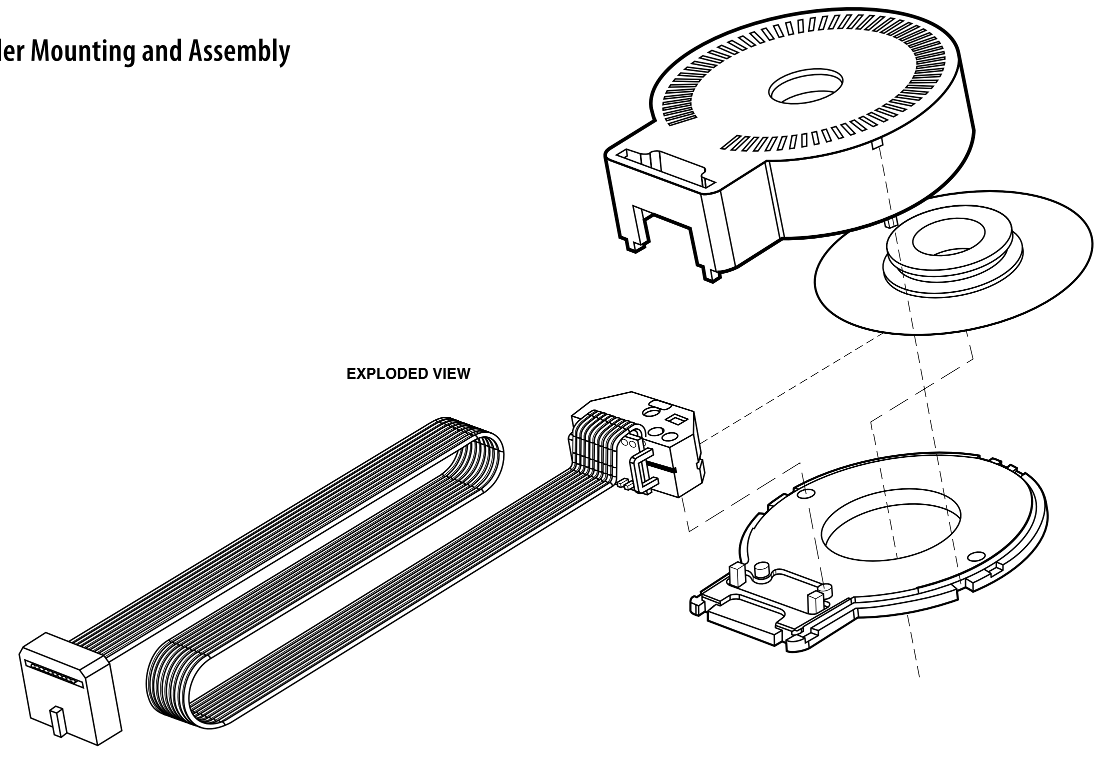
The HEDS-654x/HEDL-654x must be aligned with respect to the optical center (codewheel shaft) as indicated in the following figure.



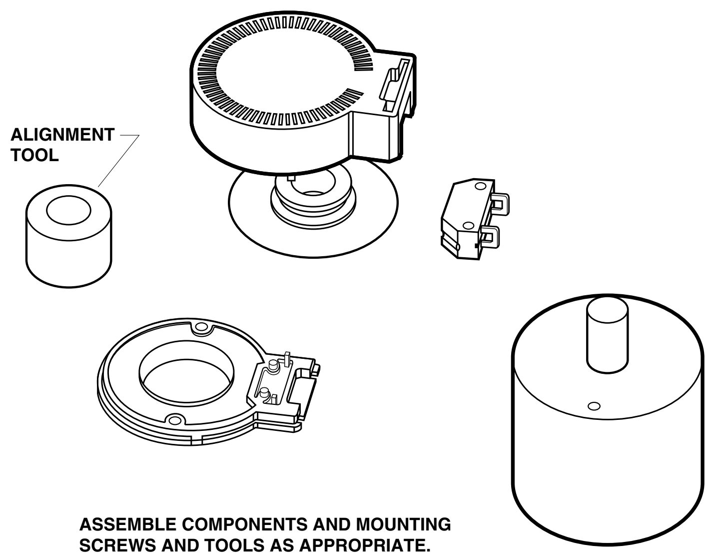
If neither locating pins nor locating boss are available, then a centering tool supplied by Avago can be used (HEDS-6510).

The following figure shows how the main encoder components are organized.

Encoder Mounting and Assembly

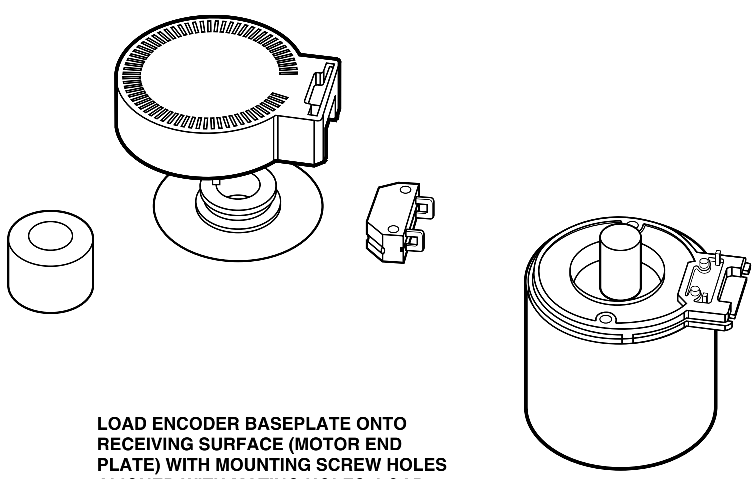


1



ASSEMBLE COMPONENTS AND MOUNTING SCREWS AND TOOLS AS APPROPRIATE.

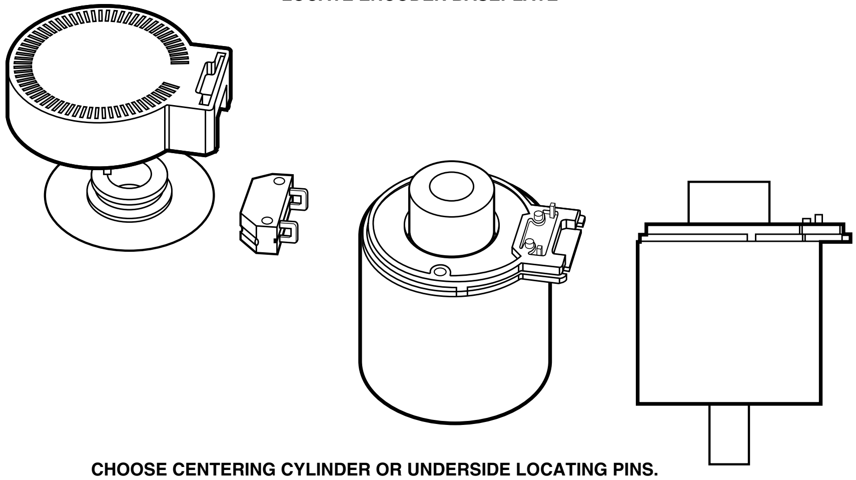
2



LOAD ENCODER BASEPLATE ONTO RECEIVING SURFACE (MOTOR END PLATE) WITH MOUNTING SCREW HOLES ALIGNED WITH MATING HOLES. LOAD MOUNTING SCREWS AND LEAVE SLIGHTLY LOOSE.

3

LOCATE ENCODER BASEPLATE



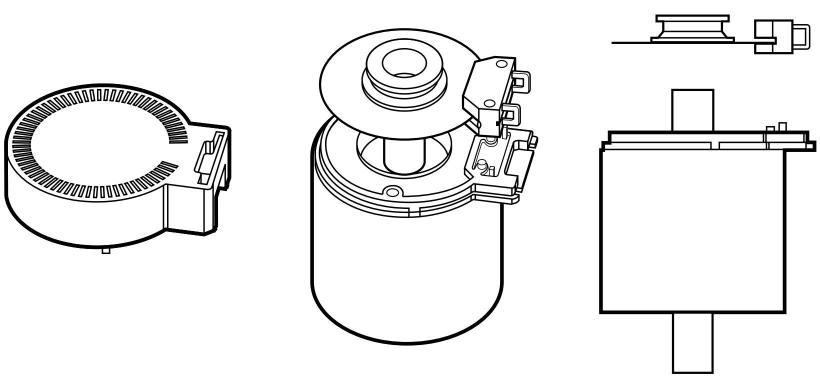
CHOOSE CENTERING CYLINDER OR UNDERSIDE LOCATING PINS.

CENTERING CYLINDER: LOCATE ENCODER BASEPLATE WITH CENTERING CYLINDER. WHEN IN PLACE, TIGHTEN MOUNTING SCREWS.

LOCATING PINS: WITH LOCATING PINS PROPERLY SEATED IN CORRESPONDING RECEIVING HOLES IN ENCODER BASEPLATE, TIGHTEN MOUNTING SCREWS.

4

LOCATE ENCODER MODULE AND CODEWHEEL

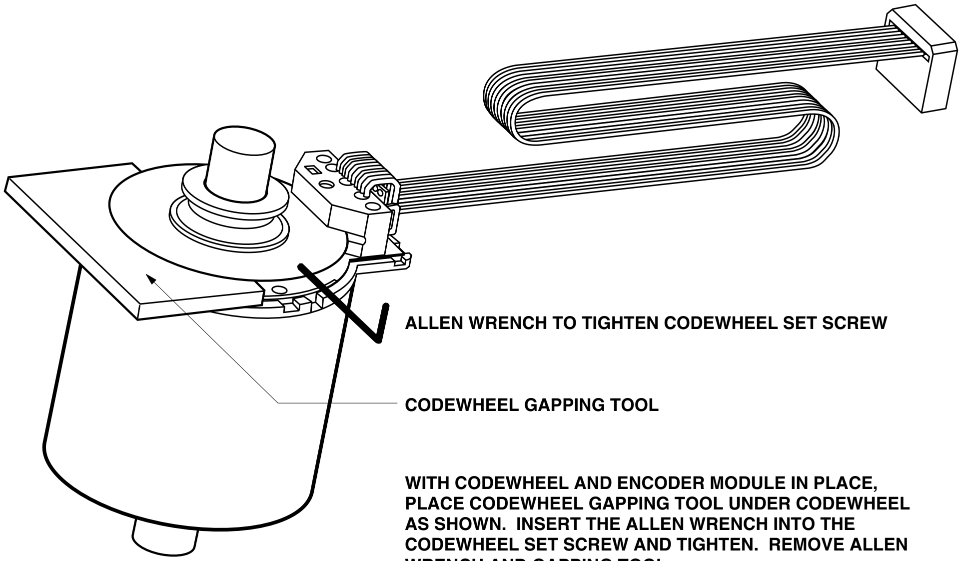


ALIGN ENCODER MODULE AND CODEWHEEL AS SHOWN.
BE CAREFUL NOT TO DAMAGE THE ENCODER INTERNAL COMPONENTS WITH THE CODEWHEEL.

BRING THE ENCODER MODULE AND CODEWHEEL DOWN SUCH THAT THE ENCODER MODULE LOCATING HOLES (ON ITS UNDERSIDE) MATE WITH THE BASEPLATE ROUND PINS. THE BASEPLATE SQUARE PINS SHOULD SEAT INTO THE ENCODER MODULE MOUNTING THRU HOLES.

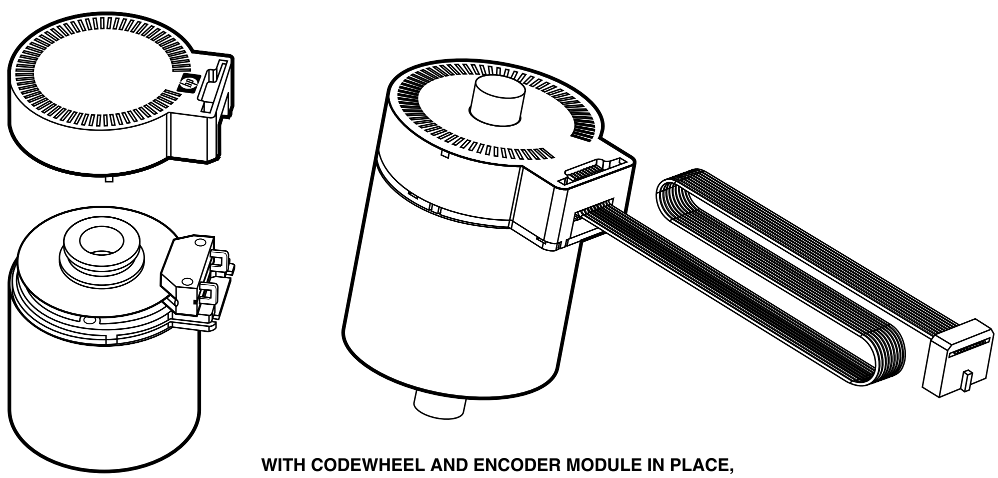
CONCURRENTLY, BRING THE CODEWHEEL DOWN ONTO THE MATING SHAFT.

5



WITH CODEWHEEL AND ENCODER MODULE IN PLACE, PLACE CODEWHEEL GAPPING TOOL UNDER CODEWHEEL AS SHOWN. INSERT THE ALLEN WRENCH INTO THE CODEWHEEL SET SCREW AND TIGHTEN. REMOVE ALLEN WRENCH AND GAPPING TOOL.

6



WITH CODEWHEEL AND ENCODER MODULE IN PLACE, LOAD ENCODER HOUSING FROM TOP INTO "SNAPPED" POSITION. INSURE THAT ANY CABLES FROM THE ENCODER MODULE ARE FOLDED DOWN SUCH THAT THEY EMERGE FROM THE BOTTOM OF THE HOUSING'S REAR RECTANGULAR PORT.

Ordering Information for 2CH and 3CH Encoder Modules

Encoders Metal Codewheel (up to 100°C)

HEDS - 65 □ □ OPTION □ □□

OUTPUTS
0 – 2 CH
4 – 3 CH

THROUGH HOLE
0 – None
5 – 13.3 mm (0.525 in.)

RESOLUTION (CYCLES/REV)
A = 500
B = 1000
J = 1024

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

		05	06	08	09	10	11	12	13
HEDS-6500#	**A**	*	*	*	*	*	*	*	*
	B	*	*	*	*	*	*	*	*
	J	*	*	*	*	*	*	*	*
HEDS-6505#	**A**								
	B				*	*			
	J				*				
HEDS-6540#	**A**	*	*	*	*	*	*	*	*
	B	*	*	*	*	*	*	*	*
	J	*	*	*	*	*	*	*	*
HEDS-6545#	**A**			*		*			
	B			*					
	J		*		*				

Encoders Film Codewheel (up to 70°C)

HEDM – 65 □ □ OPTION □ □□

OUTPUTS
0 – 2 CH
4 – 3 CH

THROUGH HOLE
0 – None
5 – 13.3 mm (0.525 in)

RESOLUTION (CYCLES/REV)
T – 2000
U – 2048 2 CH only

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

		05	06	08	09	10	11	12	13
HEDM-6500#	**T**		*	*					
	U		*						*
HEDM-6505#	**T**		*	*					
	U								*
HEDM-6540#	**T**						*		*
HEDM-6545#	**T**								

Ordering Information for 2CH and 3CH Encoder Modules with Line Driver

Encoders with Metal Codewheel (up to 100°C)

HEDL - 65 ☐ ☐ OPTION ☐ ☐ ☐

OUTPUTS
0 – 2 CH
4 – 3 CH

THROUGH HOLE
0 – None
5 – 13.3 mm (0.525 in.)

RESOLUTION (CYCLES/REV)
A = 500
B = 1000
J = 1024

SHAFT DIAMETER
08 – 3/8 in.
09 – 1/2 in.
10 – 5/8 in.
11 – 4 mm
12 – 6 mm
13 – 8 mm

		05	06	08	09	10	11	12	13
HEDL-6540#	**B**						*		*
HEDL-6545#	**B**				*				
	J		*	*	*				

Ordering Information for HEDS=76XX Centering Tools

HEDS-6510 Option 0 ☐ ☐

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

		05	06	08	09	10	11	12	13
HEDS-6510	0	*	*	*	*	*	*	*	*

Ordering Information for HEDS-65XX Codewheel

Gapping Tool

HEDS-6511

AV02-0991EN January 30, 2008

Agilent Technologies
Innovating the HP Way

Two Channel High Resolution Optical Incremental Encoder Modules

Technical Data

HEDS-9000/9100/9200
Extended Resolution Series

Features

- **High Resolution: Up to 2048 Cycles per Revolution**
- **Up to 8192 Counts per Revolution with 4X Decoding**
- **Two Channel Quadrature Output**
- **Low Cost**
- **Easy to Mount**
- **No Signal Adjustment Required**
- **Small Size**
- **-40°C to 100°C Operating Temperature**
- **TTL Compatible**
- **Single 5 V Supply**

Description

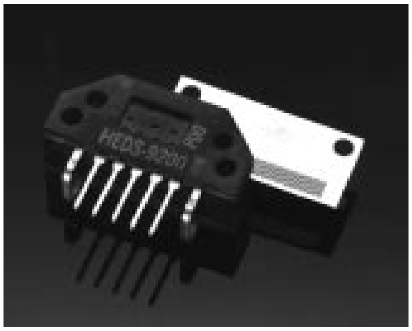
The HEDS-9000 Options T and U and the HEDS-9100 Options B and J are high resolution two channel rotary incremental encoder modules. These options are an extension of our popular HEDS-9000 and HEDS-9100 series. When used with a codewheel, these modules detect relative rotary position. The HEDS-9200 Option 300 and 360 are high resolution linear encoder modules. When used with a codestrip, these modules detect relative linear position.

These modules consist of a lensed Light Emitting Diode (LED) source and detector IC enclosed in a small C shaped plastic package. Due to a highly collimated light source and unique photodetector array, these modules provide a highly reliable quadrature output.

The HEDS-9000 and HEDS-9100 are designed for use with codewheels which have an optical radius of 23.36 mm and 11 mm respectively. The HEDS-9200 is designed for use with a linear codestrip.

These components produce a two channel quadrature output which can be accessed through five 0.025 inch square pins located on 0.1 inch centers.

The resolution of the HEDS-9000 Options T and U are 2000 and 2048 counts per revolution respectively. The HEDS-9100 Options B and J are 1000 and 1024 counts per revolution respectively. The HEDS-9200 Option 300 and 360 linear encoder modules have resolutions of 300 and 360 lines per inch.



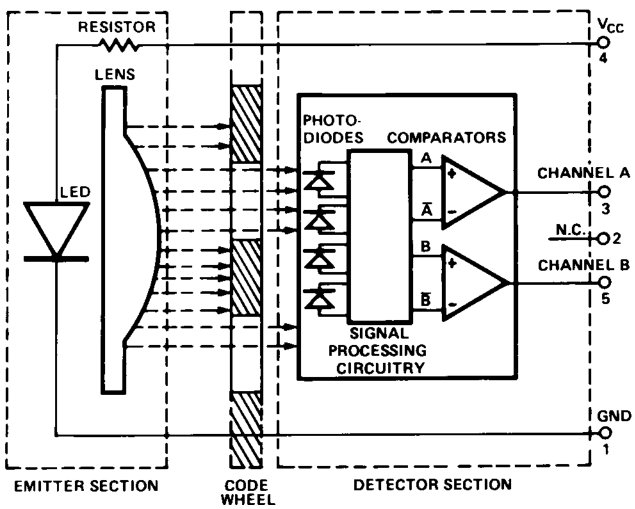
Consult local Agilent sales representatives for other resolutions.

Theory of Operation

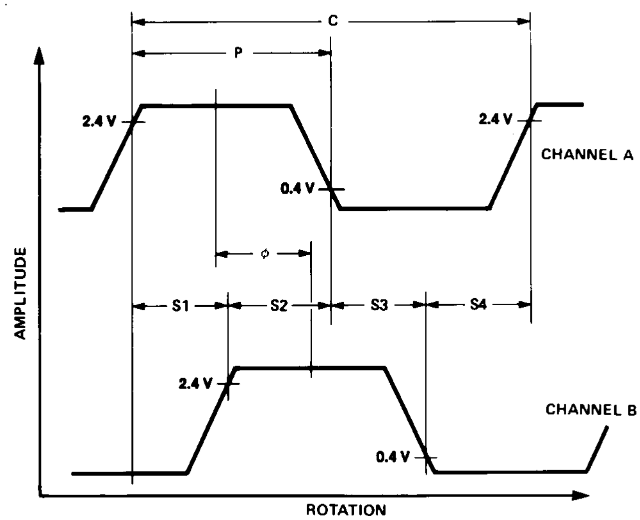
The diagram shown on the following page is a block diagram of the encoder module. As seen in this block diagram, the module contains a single LED as its light source. The light is collimated into a parallel beam by means of a single polycarbonate lens located directly over the LED. Opposite the emitter is the integrated detector circuit. This IC consists

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

Block Diagram



Output Waveforms



of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The codewheel/codestrip passes 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 codewheel/codestrip. 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 $\overline{B}$. 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 cycle (C): 360 electrical degrees (°e), 1 bar and window pair.

1 Shaft Rotation: 360 mechanical degrees, N cycles.

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.

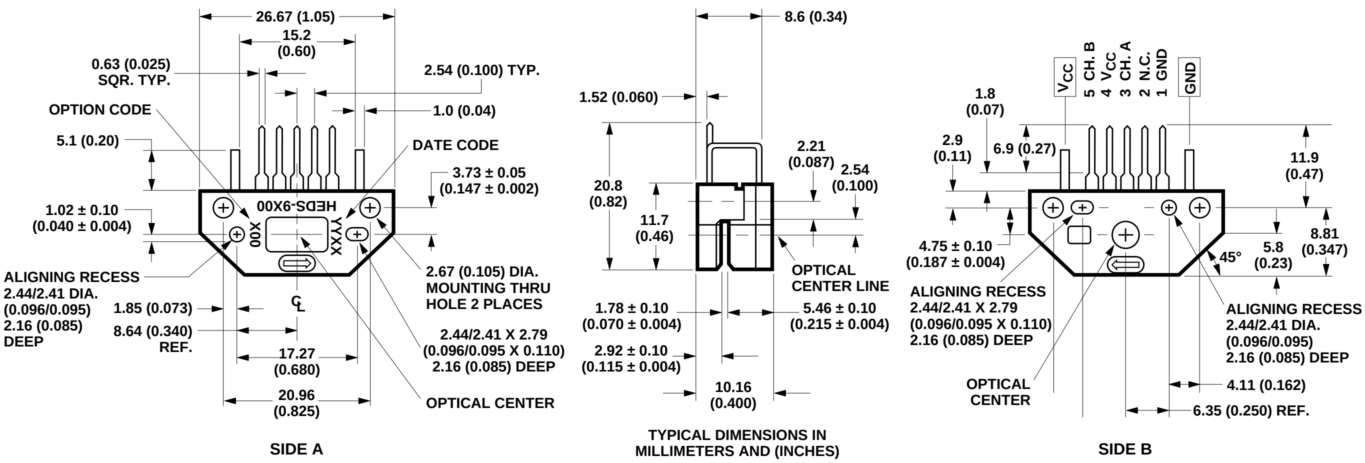
Phase (φ): The number of electrical degrees between the center of the high state of channel A and the center of the high state of channel B. This value is nominally 90°e for quadrature output.

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.

Package Dimensions



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

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Temperature	T_A	-40		100	°C	
Supply Voltage	V_{CC}	4.5	5.0	5.5	Volts	Ripple < 100 mV_{p-p}
Load Capacitance	C_L			100	pF	3.3 kΩ pull-up resistor
Count Frequency	f			100	kHz	Velocity (rpm) x N/60
Shaft Axial Play				± 0.125 ± 0.005	mm in.	

Note: The module performance is guaranteed to 100 kHz but can operate at higher frequencies. For frequencies above 100 kHz it is recommended that the load capacitance not exceed 25 pF and the pull up resistance not exceed 3.3 kΩ. For typical module performance above 100 kHz please see derating curves.

Electrical Characteristics

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

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
Supply Current	I_{CC}	30	57	85	mA	
High Level Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -200 μA max.
Low Level Output Voltage	V_{OL}			0.4	Volts	I_{OL} = 3.86 mA
Rise Time	t_r		180		ns	C_L = 25 pF R_L = 3.3 kΩ pull-up
Fall Time	t_f		40		ns	

Encoding Characteristics

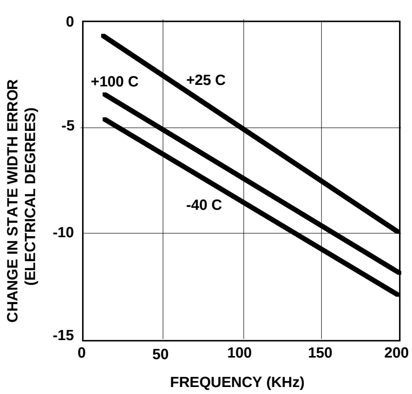
Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances. These Characteristics do not include codewheel/codestrip contribution. The Typical Values are averages over the full rotation of the codewheel. For operation above 100 kHz, see frequency derating curves.

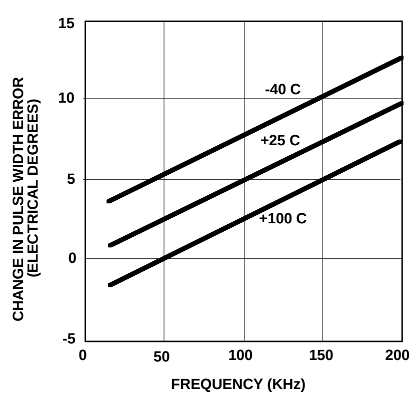
Description	Symbol	Typical	Maximum	Units
Pulse Width Error	ΔP	5	45	°e
Logic State Width Error	ΔS	3	45	°e
Phase Error	Δϕ	2	15	°e

Note: Module mounted on tolerance circle of ± 0.13 mm (± 0.005 in.) radius referenced from module Side A aligning recess centers. 3.3 kΩ pull-up resistors used on all encoder module outputs.

Frequency Derating Curves

Typical performance over extended operating range. These curves were derived using a 25 pF load with a 3.3 k pull-up resistor. Greater load capacitances will cause more error than shown in these graphs.





Gap Setting for Rotary and Linear Modules

Gap is the distance between the image side of the codewheel and the detector surface of the module. This gap dimension must always be met and codewheel warp and shaft end play must stay within this range. This dimension is shown in Figure 1.

Mounting Considerations for Rotary Modules

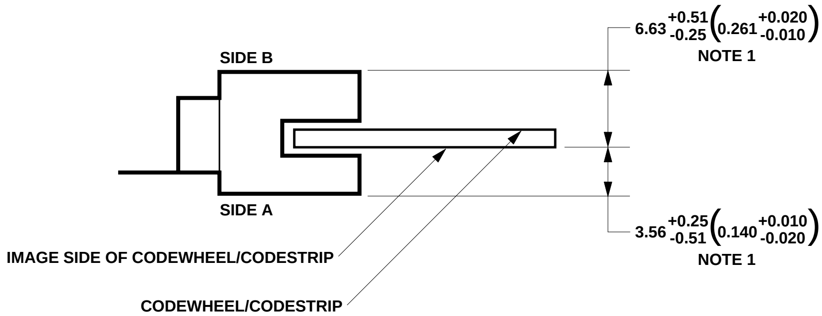
Figure 2 shows a mounting tolerance *requirement* for proper operation of the high resolution rotary encoder modules. The Aligning Recess Centers must be located within a tolerance circle of 0.13 mm (0.005 in.) radius from the nominal locations. This tolerance must be maintained whether the module is mounted with side A as the mounting plane using aligning pins (see Figure 3), or mounted with Side B as the mounting plane using an alignment tool.

Mounting with Aligning Pins

The high resolution rotary encoder modules can be mounted using aligning pins on the motor base. (Agilent does not provide aligning pins.) For this configuration, Side A *must* be used as the mounting plane. The Aligning Recess Centers must be located within the 0.13 mm (0.005 in.) R Tolerance Circle as explained above. Figure 3 shows the necessary dimensions.

Mounting with Alignment Tools

Agilent offers alignment tools for mounting Agilent encoder modules in conjunction with Agilent codewheels, using side B as the mounting plane. Please refer to the Agilent codewheel data sheet for more information.



NOTES: 1. THESE DIMENSIONS INCLUDE CODEWHEEL/CODESTRIP WARP AND SHAFT END PLAY.
2. DIMENSIONS IN MILLIMETERS AND (INCHES).

Figure 1. Module Gap Setting.

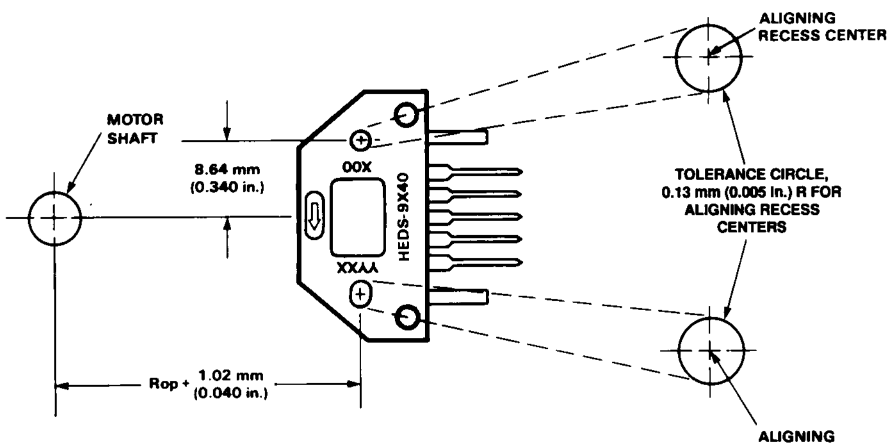
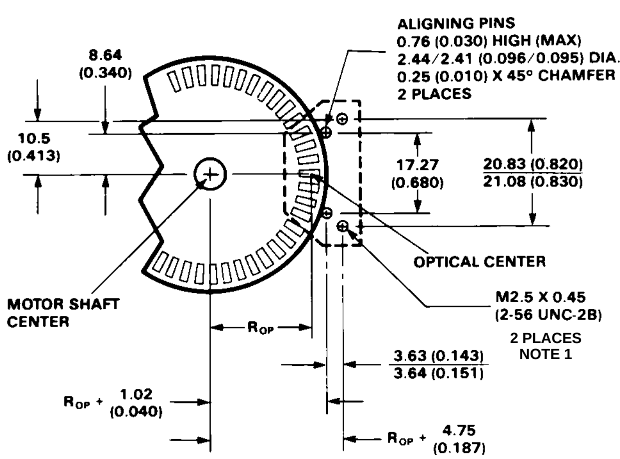


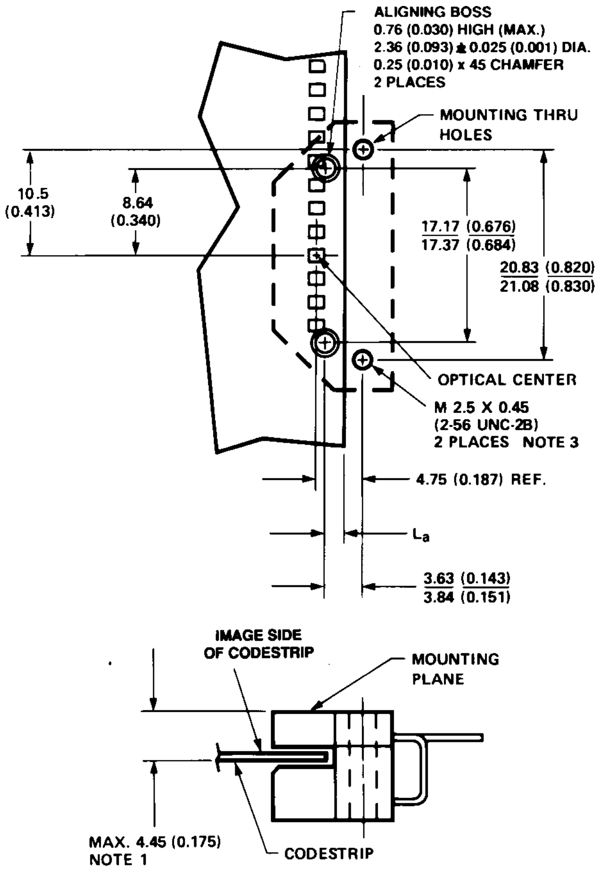
Figure 2. Rotary Module Mounting Tolerance.



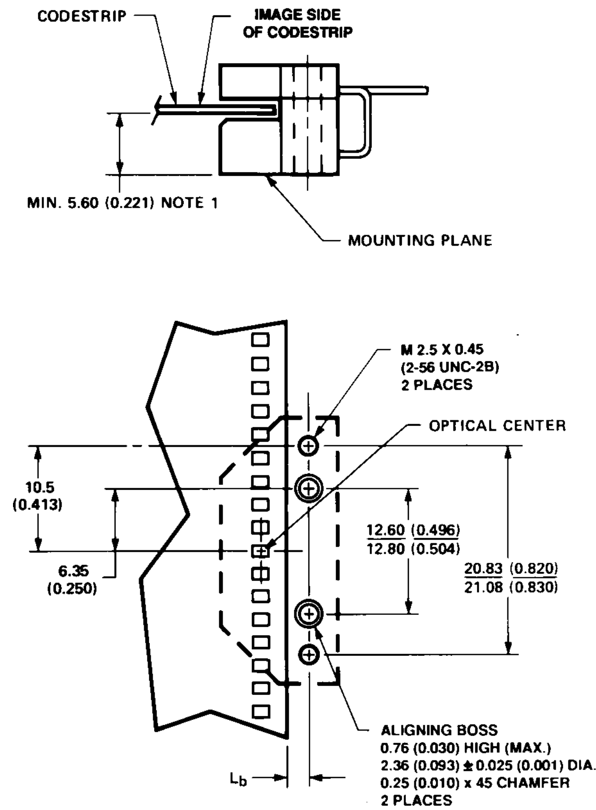
NOTE 1: RECOMMENDED MOUNTING SCREW TORQUE IS 4 KG-CM (3.5 IN-LBS).

Figure 3. Mounting Plane Side A.

Mounting Considerations for Linear Modules



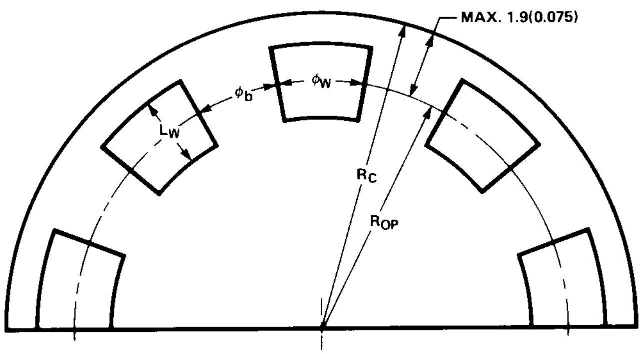
Mounting Plane Side A



Mounting Plane Side B

NOTES:
1. THESE DIMENSIONS INCLUDE CODESTRIP WARP.
2. REFERENCE DEFINITIONS OF L_a AND L_b ON THE FOLLOWING PAGE.
3. MAXIMUM RECOMMENDED MOUNTING SCREW TORQUE IS 4 kg-cm (3.5 in-lbs).

Recommended Codewheel Characteristics



Parameter	Symbol	Minimum	Maximum	Units	Notes
Window/Bar Ratio	ϕ_w/ϕ_b	0.7	1.4		
Window Length	L_w	1.8 (0.07)		mm (inch)	
Absolute Maximum Codewheel Radius	R_c		R_{op} + 1.9 (0.075)	mm (inch)	Includes eccentricity errors

Recommended Codestrip Characteristics and Alignment

Codestrip design must take into consideration mounting as referenced to either side A *or* side B (see Figure 4).

Mounting as Referenced to Side A **Mounting as Referenced to Side B**

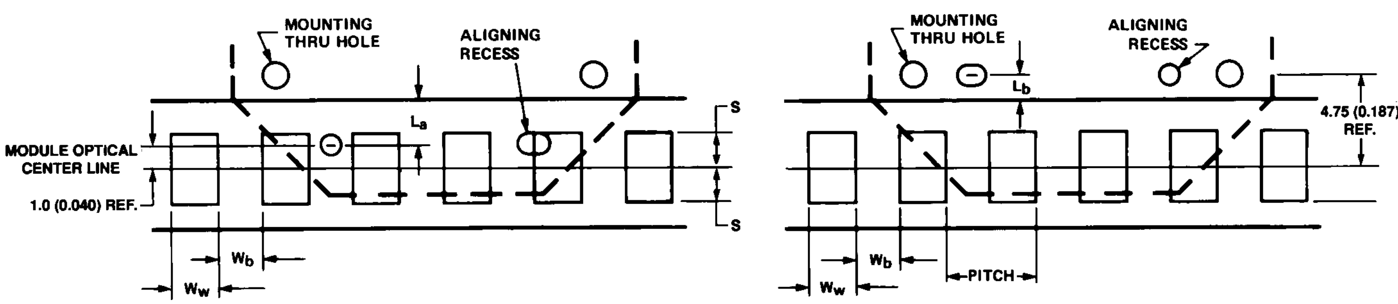


Figure 4. Codestrip Design

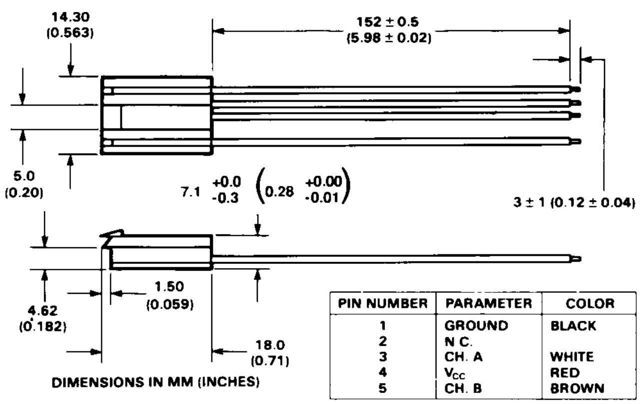
STATIC CHARGE WARNING: LARGE STATIC CHARGE ON CODESTRIP MAY HARM MODULE. PREVENT ACCUMULATION OF CHARGE.

Parameter	Symbol	Mounting Ref. Side A	Mounting Ref. Side B	Units
Window/Bar Ratio	W_w/W_b	0.7 min., 1.4 max.	0.7 min., 1.4 max.	
Window Distance	L	$L_a \leq 0.51$ (0.020)	$L_b \geq 3.23$ (0.127)	mm (inch)
Window Edge to Module Opt Center Line	S	0.90 (0.035) min.	0.90 (0.035) min.	mm (inch)
Parallelism Module to Codestrip	α	1.3 max.	1.3 max.	deg.

Note: All parameters and equations must be satisfied over the full length of codestrip travel including maximum codestrip runout.

Connectors

Manufacturer	Part Number	Mounting Surface
AMP	103686-4 640442-5	Both Side B
DuPont	65039-032 with 4825X-000 term.	Both
Agilent	HEDS-8902 with 4-wire leads	Side B (see Fig. 7)
Molex	2695 series with 2759 series term.	Side B



PIN NUMBER	PARAMETER	COLOR
1	GROUND	BLACK
2	N.C.	
3	CH. A	WHITE
4	V_{CC}	RED
5	CH. B	BROWN

Figure 7. HEDS-8902 Connector.

Ordering Information

Two Channel Encoder Modules with a 23.36 mm Optical Radius

HEDS-9000 Option ☐ **0 0** *

Resolution (Cycles/Rev)
T - 2000 CPR
U - 2048 CPR

Two Channel Encoder Modules with an 11.00 mm Optical Radius

HEDS-9100 Option ☐ **0 0** *

Resolution (Cycles/Rev)
B - 1000 CPR
J - 1024 CPR

Two Channel Linear Encoder Module

HEDS-9200 Option ☐☐☐

Resolution (Cycles/Rev)
300 - 300 LPI
360 - 360 LPI

Note: For lower resolutions, please refer to HEDS-9000/9100 and HEDS-9200 data sheets for detailed information.

*Codewheel Information

For information on matching codewheels and accessories for use with Agilent rotary encoder modules, please refer to the Agilent Codewheel Data sheet HEDS-5120/6100, HEDG-5120/6120, HEDM-5120/6120

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Data subject to change.

Obsoletes 5091-7275E (7/93)

5965-5889E (11/99)

Agilent Technologies

Two Channel Optical Incremental Encoder Modules

Technical Data

HEDS-9000
HEDS-9100

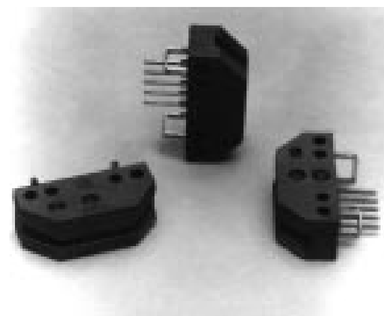
Features

- **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

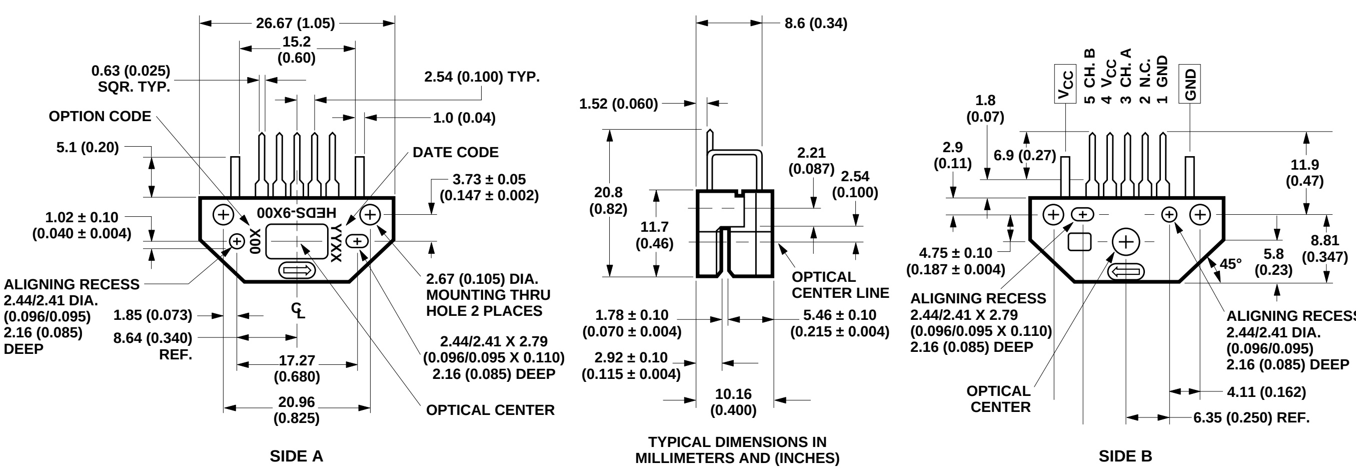
The HEDS-9000 and the HEDS-9100 series are high performance, low cost, optical incremental encoder modules. When used with a codewheel, these modules detect rotary position. The modules consist of a lensed (LED) source and a detector IC enclosed in a small C-shaped plastic package. Due to a highly collimated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

Note: Agilent 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.

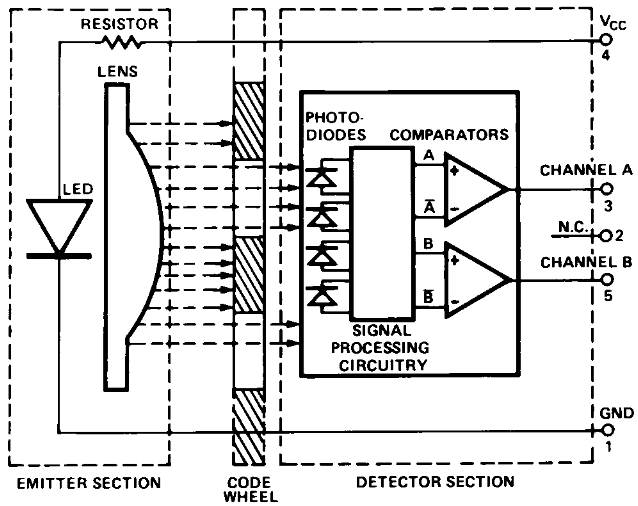
Theory of Operation

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.

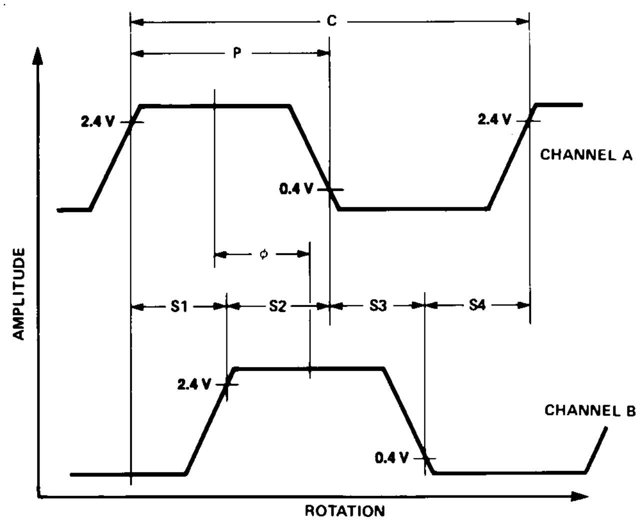
As seen in the block diagram, each module contains a single Light Emitting Diode (LED) as its light source. The light is collimated into a parallel beam by means of a single polycarbonate lens located directly over the LED. Opposite the emitter is the integrated detector circuit. This IC consists of 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 ode-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 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.

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.

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

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 kΩ pull-up resistor
Count Frequency	f			100	kHz	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").

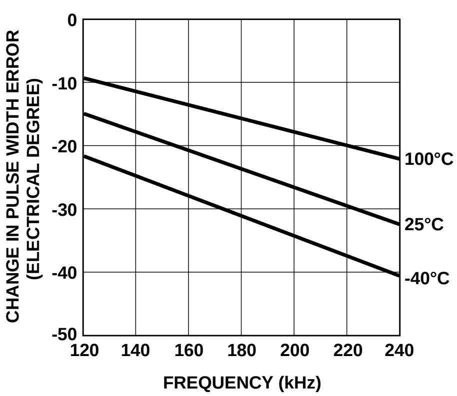
Electrical Characteristics

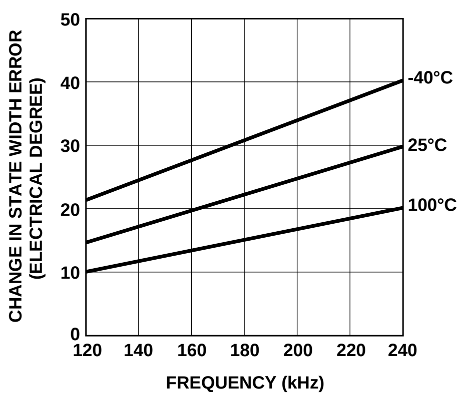
Electrical Characteristics over Recommended Operating Range, typical at 25°C.

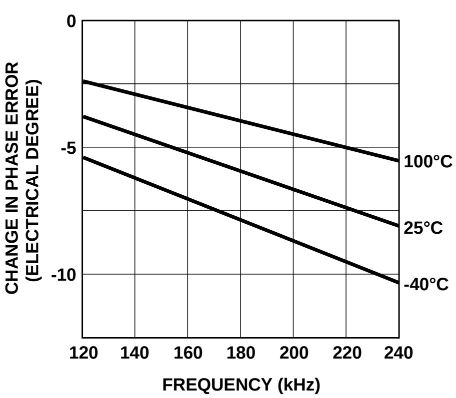
Parameter	Symbol	Min.	Typical	Max.	Units	Notes
Supply Current	I_{CC}		17	40	mA	
High Level Output Voltage	V_{OH}	2.4			Volts	I_{OH} = -40 µA max.
Low Level Output Voltage	V_{OL}			0.4	Volts	I_{OL} = 3.2 mA
Rise Time	t_r		200		ns	C_L = 25 pF R_L = 11 kΩ pull-up
Fall Time	t_f		50		ns	

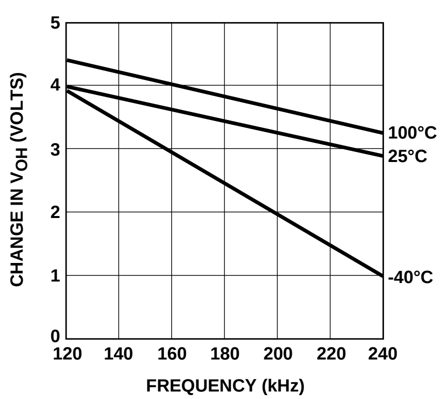
Derating Curves over Extended Operating Frequencies (HEDS-9000/9100)

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









Recommended Codewheel Characteristics

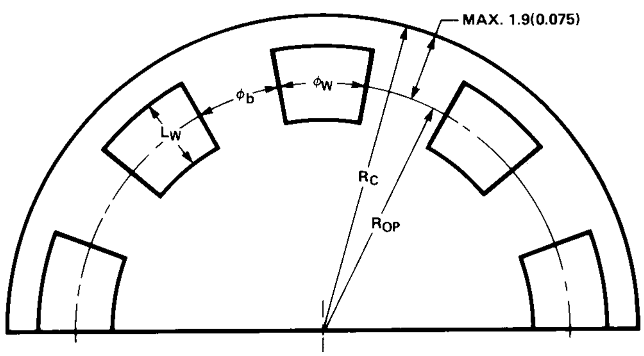


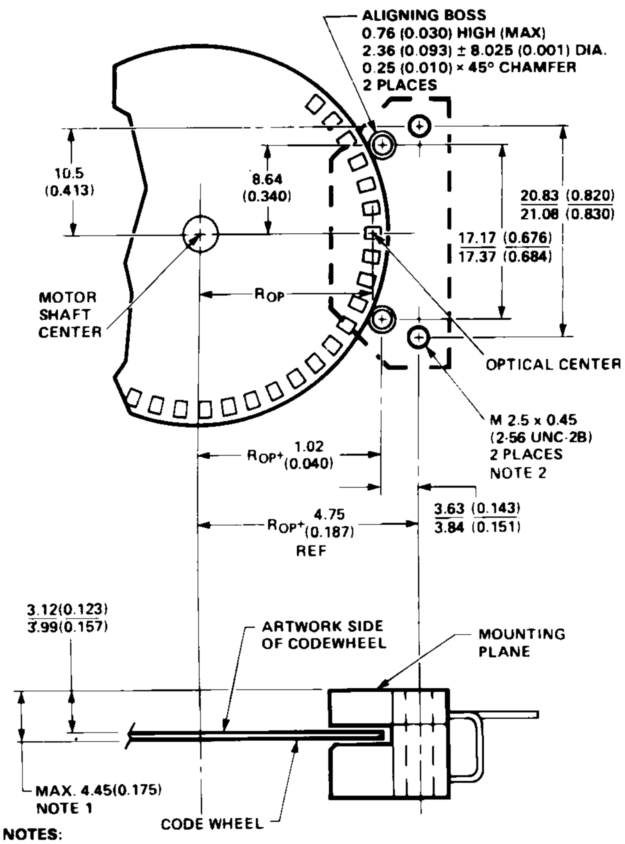
Figure 1. Codestrip Design

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)

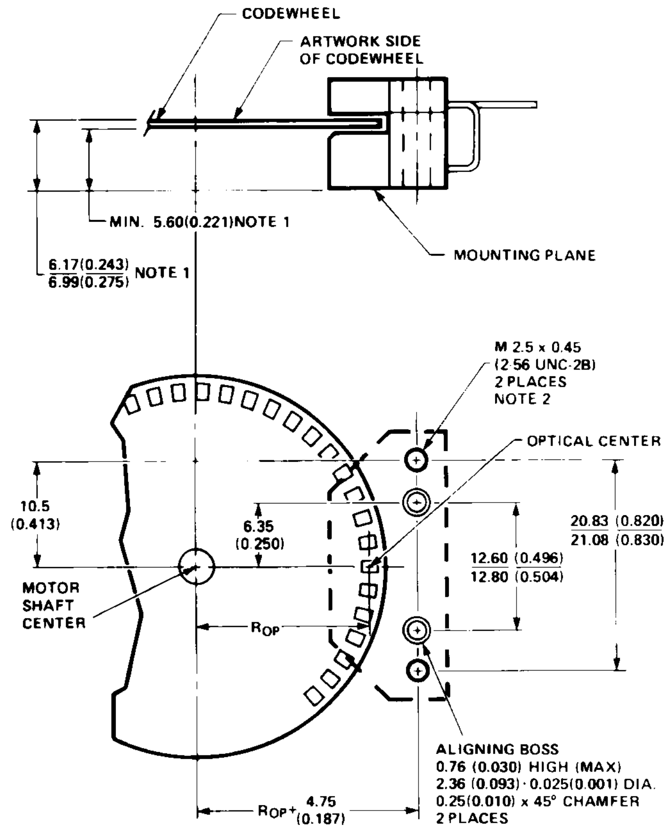
Parameter	Symbol	Minimum	Maximum	Units	Notes
Window/Bar Ratio	ϕ_w/ϕ_b	0.7	1.4		
Window Length	L_W	1.8 (0.071)	2.3 (0.09)	mm (inch)	
Absolute Maximum Codewheel Radius	R_C		R_{OP} + 1.9 (0.0075)	mm (inch)	Includes eccentricity errors

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.

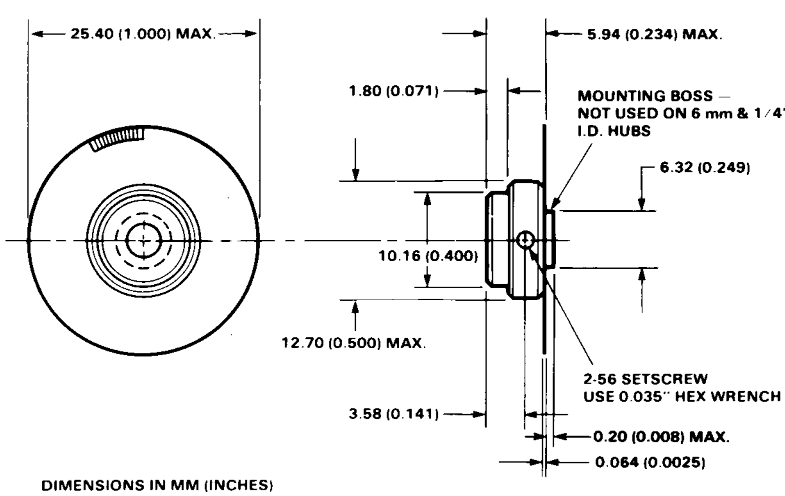


Figure 4. Mounting as Referenced to Side A.

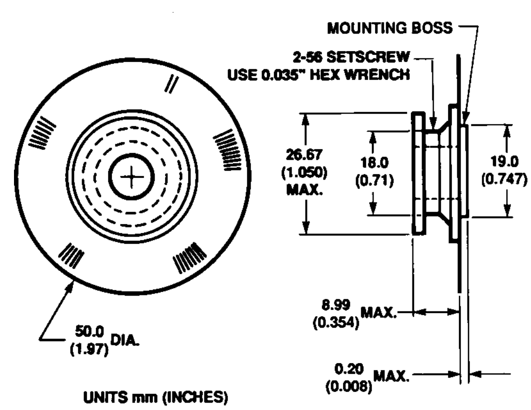


Figure 5. Mounting as Referenced to Side B.

Connectors

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

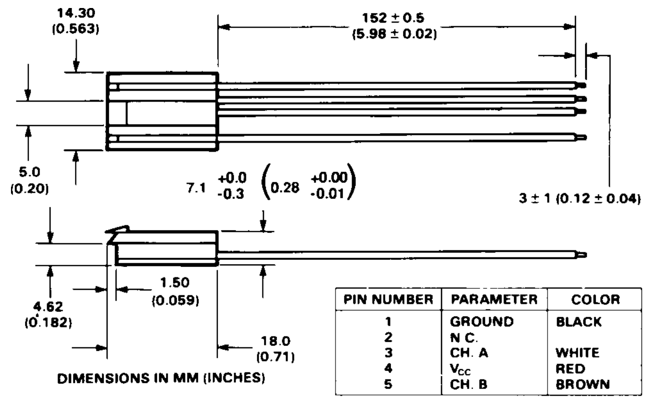


Figure 6. HEDS-8902 Connector.

Ordering Information

HEDS-9000 Option □ **0** **0**

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.
08 - 3/8 in.
09 - 1/2 in.
10 - 5/8 in.
12 - 6 mm
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						*	*	*	*				

Agilent Technologies

HEDS-910 [0] Option

Lead
0 - Straight Leads
1 - Bent Leads

HEDS-5120 Option [ ] [0] [0]

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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For product information and a complete list of distributors, please go to our web site.

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Obsoletes 5988-5857EN
May 8, 2002
5988-6712EN

Agilent Technologies

Three Channel Optical Incremental Encoder Modules

Technical Data

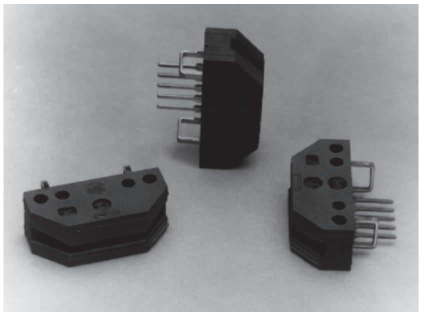
HEDS-9040
HEDS-9140

Features

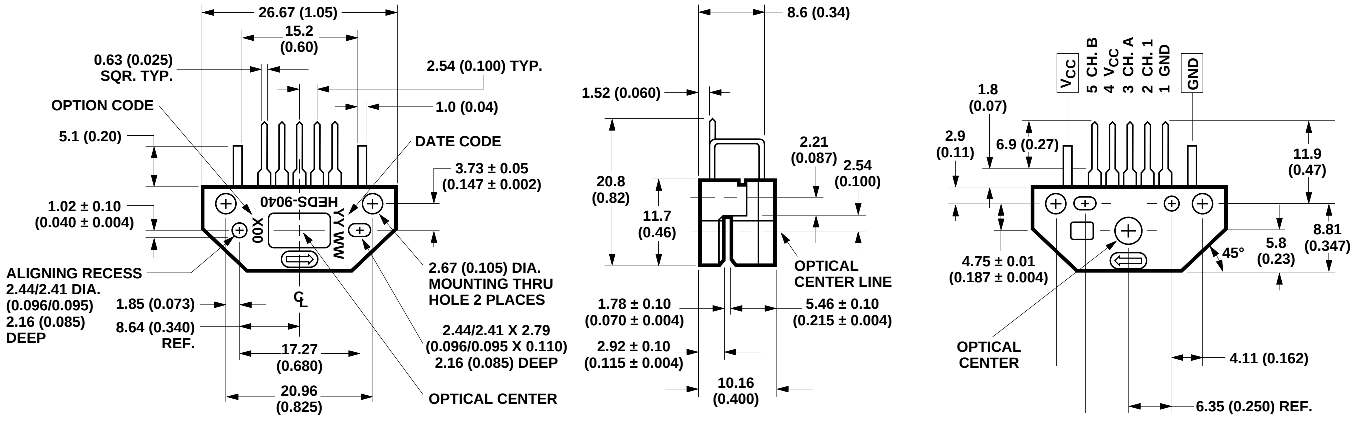
- **Two Channel Quadrature Output with Index Pulse**
- **Resolution Up to 2000 CPR Counts Per Revolution**
- **Low Cost**
- **Easy to Mount**
- **No Signal Adjustment Required**
- **Small Size**
- **-40°C to 100°C Operating Temperature**
- **TTL Compatible**
- **Single 5 V Supply**

Description

The HEDS-9040 and HEDS-9140 series are three channel optical incremental encoder modules. When used with a codewheel, these low cost modules detect rotary position. Each module consists of a lensed LED source and a detector IC enclosed in a small plastic package. Due to a highly collimated light source and a unique photodetector array, these modules provide the same high performance found in the HEDS-9000/9100 two channel encoder family.



Package Dimensions



SIDE A

TYPICAL DIMENSIONS IN MILLIMETERS AND (INCHES)

SIDE B

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

The HEDS-9040 and 9140 have two channel quadrature outputs plus a third channel index output. This index output is a 90 electrical degree high true index pulse which is generated once for each full rotation of the codewheel.

The HEDS-9040 is designed for use with a HEDX-614X codewheel which has an optical radius of 23.36 mm (0.920 inch). The HEDS-9140 is designed for use with a HEDS-5140 codewheel which has an optical radius of 11.00 mm (0.433 inch).

The quadrature signals and the index pulse are accessed through five 0.025 inch square pins located on 0.1 inch centers.

Standard resolutions between 256 and 2000 counts per revolution are available. Consult local Agilent sales representatives for other resolutions.

Applications

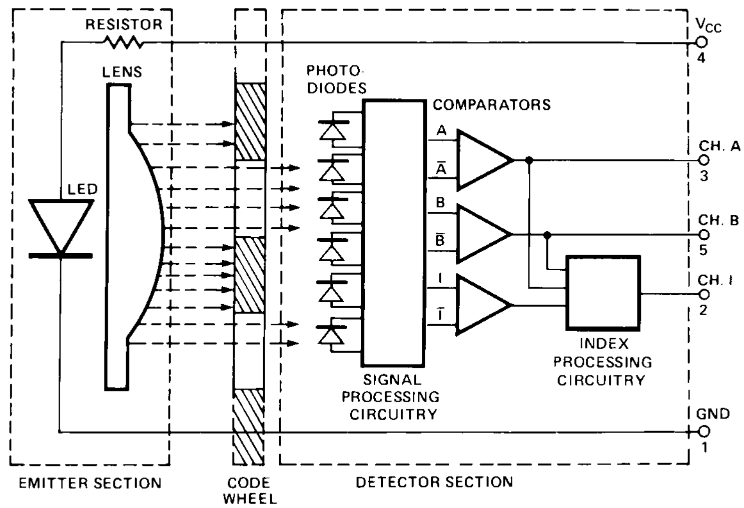
The HEDS-9040 and 9140 provide sophisticated motion control detection at a low cost, making them ideal for high volume applications. Typical applications include printers, plotters, tape drives, and industrial and factory automation equipment.

Theory of Operation

The HEDS-9040 and 9140 are emitter/detector modules. Coupled with a codewheel, these modules translate the rotary motion of a shaft into a three-channel digital output.

As seen in the block diagram, the modules contain 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 produce the digital waveforms.

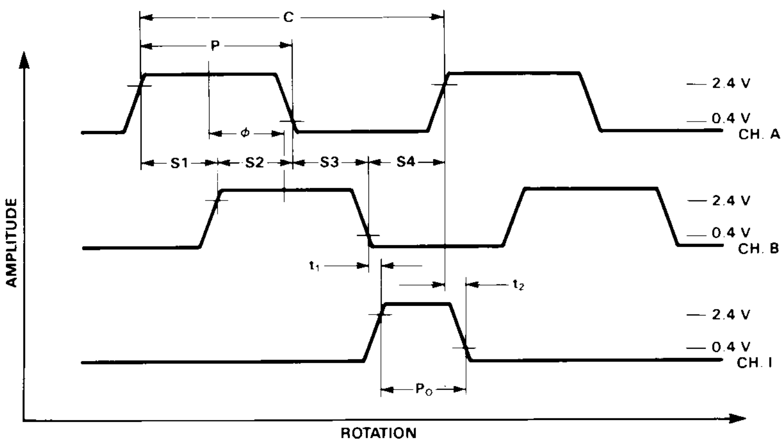
Block Diagram



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, $\overline{A}$, B, $\overline{B}$, I and $\overline{I}$. 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).

The output of the comparator for I and $\overline{I}$ is sent to the index processing circuitry along with the outputs of channels A and B. The final output of channel I is an index pulse P_O which is generated once for each full rotation of the codewheel. This output P_O is a one state width (nominally 90 electrical degrees), high true index pulse which is coincident with the low states of channels A and B.

Output Waveforms



Definitions

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

One Cycle (C): 360 electrical degrees (°e), 1 bar and window pair.

One Shaft Rotation: 360 mechanical degrees, N cycles.

Position Error (ΔΘ): The normalized angular difference between the actual shaft position and the position indicated by the encoder cycle count.

Cycle Error (ΔC): An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

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.

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.

Index Pulse Width (P_O): The number of electrical degrees that an index is high during one full shaft rotation. This value is nominally 90°e or 1/4 cycle.

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
Shaft Axial Play	± 0.25 mm (± 0.010 in.)
Shaft Eccentricity Plus Radial Play	0.1 mm (0.004 in.) TIR
Velocity	30,000 RPM[1]
Acceleration	250,000 rad/sec^2[1]

Note:

1. Absolute maximums for HEDS-5140/6140 codewheels only.

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Temperature	T_A	-40		100	°C	
Supply Voltage	V_{CC}	4.5	5.0	5.5	Volts	Ripple < 100 mV_{p-p}
Load Capacitance	C_L			100	pF	2.7 kΩ pull-up
Count Frequency	f			100	kHz	Velocity (rpm) x N/60
Shaft Perpendicularity Plus Axial Play				± 0.25 (± 0.010)	mm (in.)	6.9 mm (0.27 in.) from mounting surface
Shaft Eccentricity Plus Radial Play				0.04 (0.0015)	mm (in.) TIR	6.9 mm (0.27 in.) from mounting surface

Note: The module performance is guaranteed to 100 kHz but can operate at higher frequencies. For the HEDS-9040 #T00 for operation below 0°C and greater than 50 kHz the maximum Pulse Width and Logic State Width errors are 60°e.

Encoding Characteristics
HEDS-9040 (except #T00), HEDS-9140

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances unless otherwise specified. Values are for the worst error over the full rotation of HEDS-5140 and HEDS-6140 codewheels.

Parameter		Symbol	Min.	Typ.[1]	Max.	Units
Cycle Error		ΔC		3	5.5	°e
Pulse Width Error		ΔP		7	30	°e
Logic State Width Error		ΔS		5	30	°e
Phase Error		$\Delta\phi$		2	15	°e
Position Error		$\Delta\Theta$		10	40	min. of arc
Index Pulse Width		P_O	60	90	120	°e
CH. I rise after CH. B or CH. A fall	-25°C to +100°C	t_1	10	100	250	ns
	-40°C to +100°C	t_1	-300	100	250	ns
CH. I fall after CH. A or CH. B rise	-25°C to +100°C	t_2	70	150	300	ns
	-40°C to +100°C	t_2	70	150	1000	ns

Note:
1. Module mounted on tolerance circle of ± 0.13 mm (± 0.005 in.) radius referenced from module Side A aligning recess centers. 2.7 kΩ pull-up resistors used on all encoder module outputs.

Encoding Characteristics
HEDS-9040 #T00

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances unless otherwise specified. Values are for the worst error over the full rotation of HEDM-614X Option TXX codewheel.

Parameter		Symbol	Min.	Typ.[1]	Max.	Units
Cycle Error		ΔC		3	7.5	°e
Pulse Width Error		ΔP		7	50	°e
Logic State Width Error		ΔS		5	50	°e
Phase Error		Δϕ		2	15	°e
Position Error		ΔΘ		2	20	min. of arc
Index Pulse Width		P_O	40	90	140	°e
CH. I rise after CH. B or CH. A fall	-40°C to +100°C	t_1	10	450	1500	ns
CH. I fall after CH. A or CH. B rise	-40°C to +100°C	t_2	10	250	1500	ns

Note:
1. Module mounted on tolerance circle of ± 0.13 mm (± 0.005 in.) radius referenced from module Side A aligning recess centers. 2.7 kΩ pull-up resistors used on all encoder module outputs.

Electrical Characteristics

Electrical Characteristics over Recommended Operating Range.

Parameter	Symbol	Min.	Typ.[1]	Max.	Units	Notes
Supply Current	I_{CC}	30	57	85	mA	
High Level Output Voltage	V_{OH}	2.4			V	I_{OH} = -200 µA max.
Low Level Output Voltage	V_{OL}			0.4	V	I_{OL} = 3.86 mA
Rise Time	t_r		180[2]		ns	C_L = 25 pF R_L = 2.7 kΩ pull-up
Fall Time	t_f		49[2]		ns	

Notes:
1. Typical values specified at V_{CC} = 5.0 V and 25°C.
2. t_r and t_f 80 nsec for HEDS-9040 #T00.

Electrical Interface

To insure reliable encoding performance, the HEDS-9040 and 9140 three channel encoder modules require 2.7 kΩ (± 10%) pull-up resistors on output pins 2, 3, and 5 (Channels I, A and B) as shown in Figure 1. These pull-up resistors should be located as close to the encoder module as possible (within 4 feet). Each of the three encoder module outputs can drive a single TTL load in this configuration.

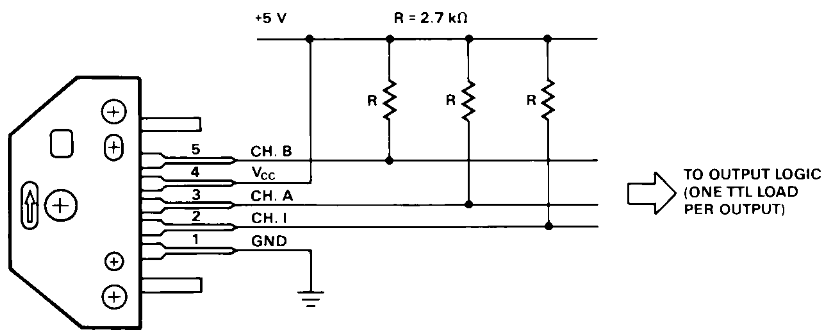


Figure 1. Pull-up Resistors on HEDS-9X40 Encoder Module Outputs.

Mounting Considerations

Figure 2 shows a mounting tolerance *requirement* for proper operation of the HEDS-9040 and HEDS-9140. The Aligning Recess Centers must be located within a tolerance circle of 0.005 in. radius from the nominal locations. This tolerance must be maintained whether the module is mounted with side A as the mounting plane using aligning pins (see Figure 5), or mounted with Side B as the mounting plane using an alignment tool (see Figures 3 and 4).

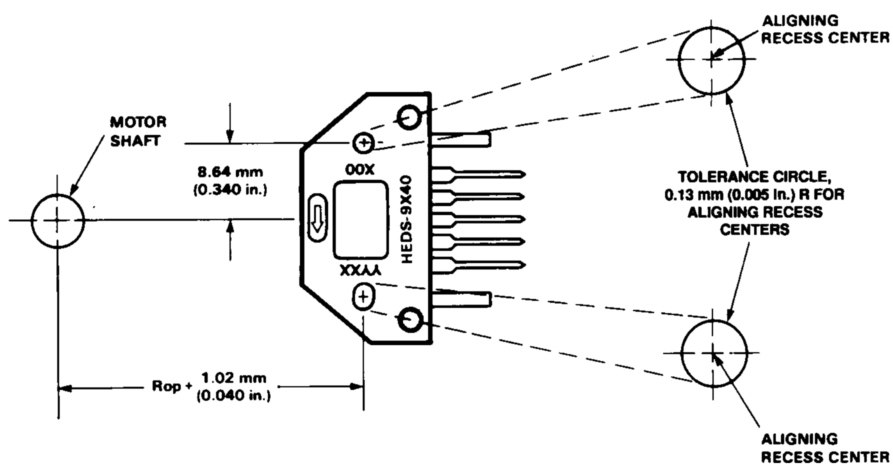


Figure 2. HEDS-9X40 Mounting Tolerance.

Mounting with an Alignment Tool

The HEDS-8905 and HEDS-8906 alignment tools are recommended for mounting the modules with Side B as the mounting plane. The HEDS-8905 is used to mount the HEDS-9140, and the HEDS-8906 is used to mount the HEDS-9040. These tools fix the module position using the codewheel hub as a reference. They will not work if Side A is used as the mounting plane.

The following assembly procedure uses the HEDS-8905/8906 alignment tool to mount a HEDS-9140/9040 module and a HEDS-5140/6140 codewheel:

Instructions:

1. Place codewheel on shaft.

2. Set codewheel height by placing alignment tool on motor base (pins facing up) flush up against the codewheel as shown in Figure 3. Tighten codewheel setscrew and remove alignment tool.

3. Insert mounting screws through module and thread into the motor base. Do not tighten screws.

4. Slide alignment tool over codewheel hub and onto module as shown in Figure 4. The pins of the alignment tool should fit snugly inside the alignment recesses of the module.

5. While holding alignment tool in place, tighten screws down to secure module.

6. Remove alignment tool.

Mounting with Aligning Pins

The HEDS-9040 and HEDS-9140 can also be mounted using aligning pins on the motor base. (Hewlett-Packard does not provide aligning pins.) For this configuration, Side A must be used as the mounting plane. The aligning recess centers must be located within the 0.005 in. R Tolerance Circle as explained above. Figure 5 shows the necessary dimensions.

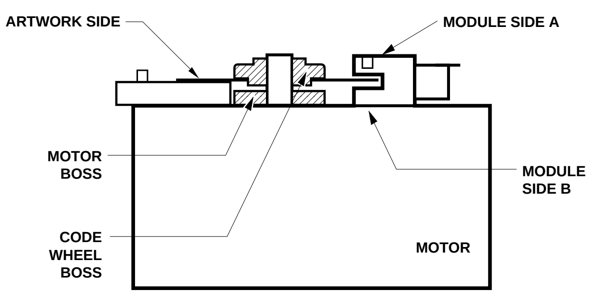


Figure 3. Alignment Tool is Used to Set Height of Codewheel.

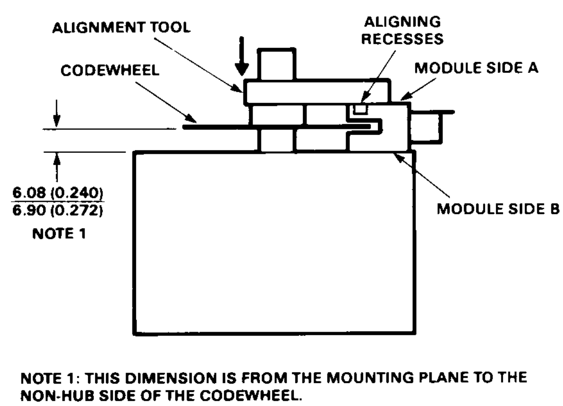


Figure 4. Alignment Tool is Placed over Shaft and onto Codewheel Hub. Alignment Tool Pins Mate with Aligning Recesses on Module.

Mounting with Aligning Pins

The HEDS-9040 and HEDS-9140 can also be mounted using aligning pins on the motor base. (Agilent does not provide aligning pins.) For this configuration, Side A *must* be used as the mounting plane. The aligning recess centers must be located within the 0.005 in. Radius Tolerance Circle as explained in "Mounting Considerations." Figure 5 shows the necessary dimensions.

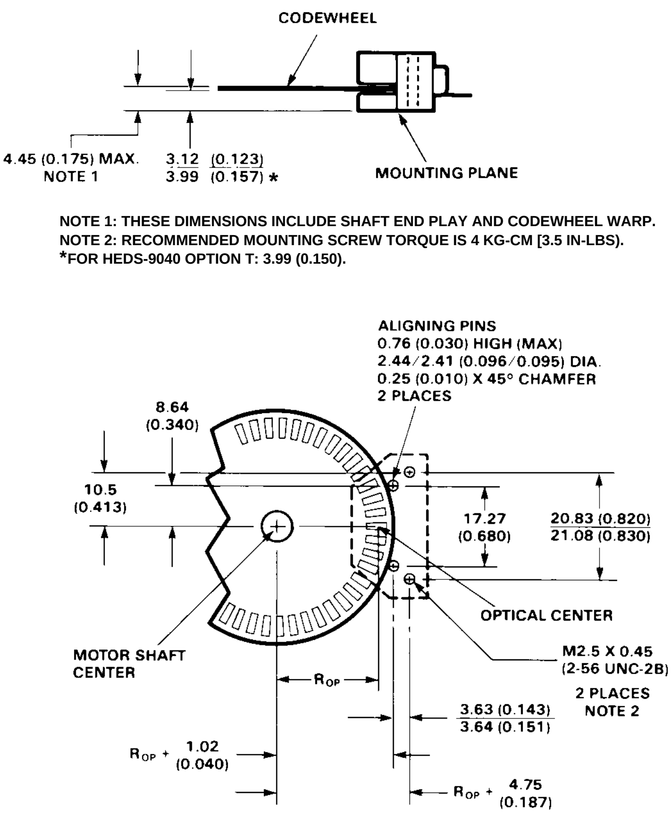


Figure 5. Mounting Plane Side A.

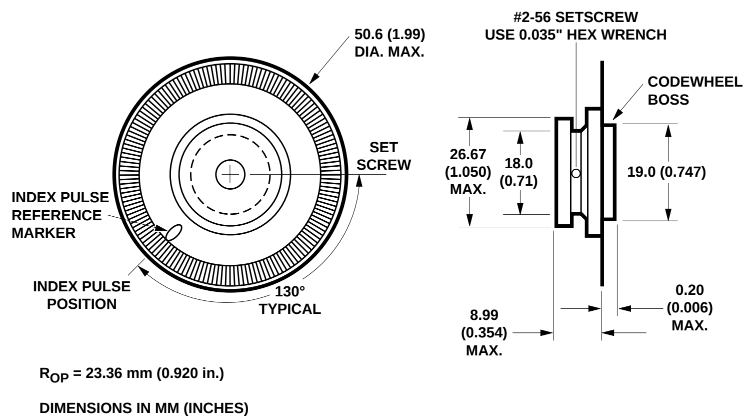


Figure 6a. HEDS-6140 Codewheel Used with HEDS-9040.

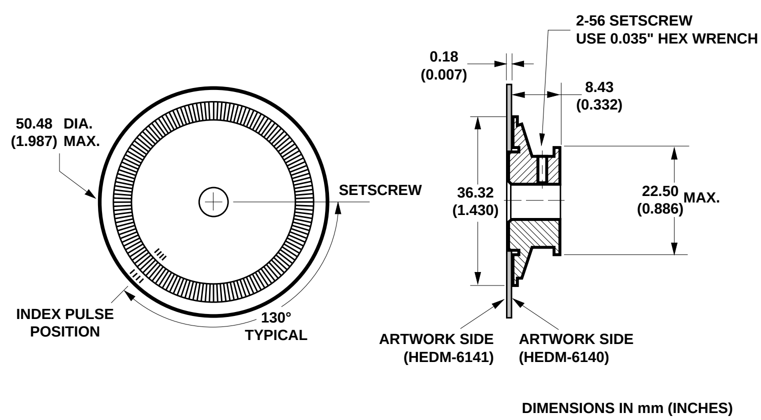


Figure 6b. HEDM-614X Series Codewheel used with HEDS-9040 #T00.

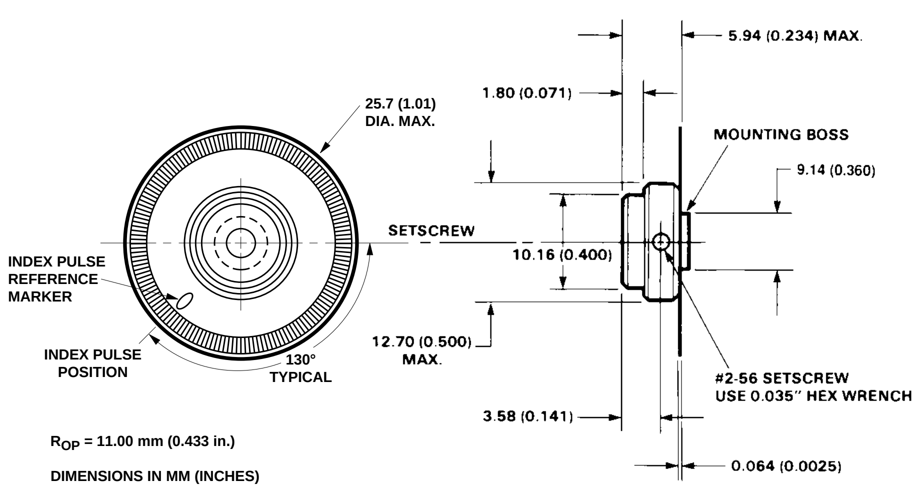


Figure 7. HEDS-5140 Codewheel Used with HEDS-9140.

Orientation of Artwork for HEDS-9040 Option T00 (2000 CPR, 23.36 mm Rop)

The Index area on the HEDS-9040 Option T00, 2000 CPR Encoder Module has a non-symmetrical pattern as does the mating Codewheel. In order for the Index to operate, the "Right-reading" side of the Codewheel disk (the “Artwork Side”) must point toward “Side A” of the Module (the side with the connecting pins).

Because the Encoder Module may be used with either “Side A” or with “Side B” toward the Mounting Surface, Agilent supplies two versions of Film Codewheels for use with the Option T00 3-channel Module: Codewheel HEDM-6140 Option TXX has the Artwork Side on the “Hub Side” of the Codewheel/hub assembly and works with “Side B” of the Module on the user’s mounting surface. Codewheel HEDM-6141 Option TXX has the Artwork Side opposite the “Hub Side” and works with “Side A” of the Module on the mounting surface. For the Index to operate, these parts must be oriented as shown in Figure 7a and 7b.

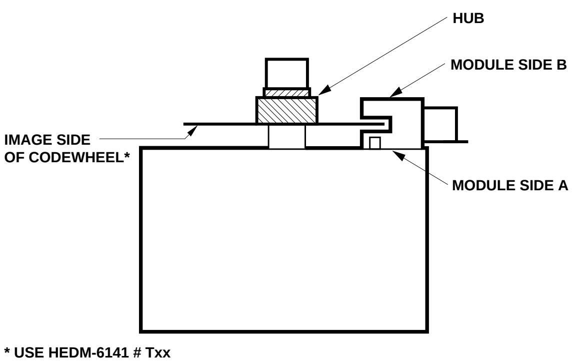


Figure 7a.

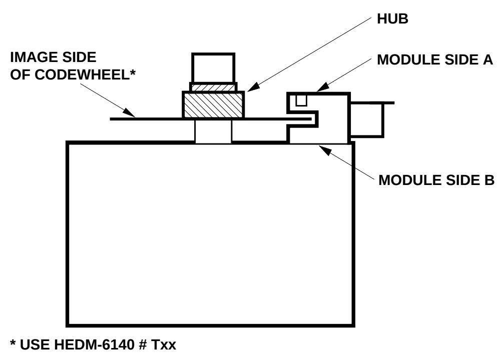


Figure 7b.

*Please note that the image side of the codewheel must always be facing the module Side A.

Connectors

Manufacturer	Part Number	Mounting Surface
AMP	103686-4	Both
	640442-5	Side B
DuPont	65039-032 with 4825X-000 term	Both
HP	HEDS-8903 with 5-wire leads	Side B (see Figure 8)
Molex	2695 series with 2759 series term	Side B

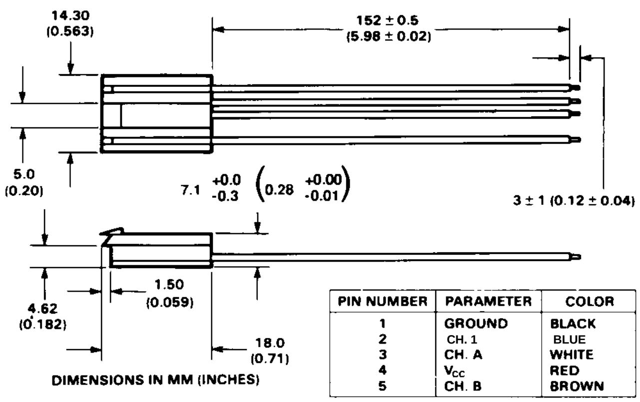
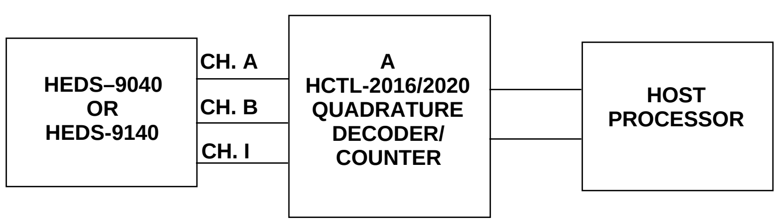
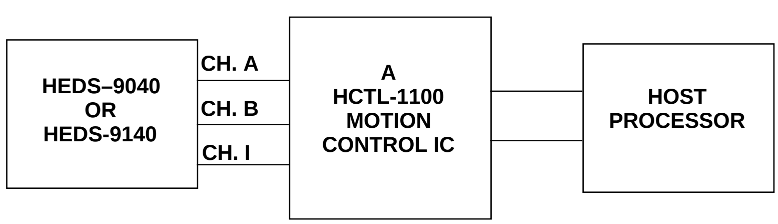


Figure 8. HEDS-8903 Connector.

Typical Interfaces





Ordering Information

Three Channel Encoder Modules and Codewheels, 23.36 mm Optical Radius.

HEDS-904 [0] Option [ ] [0] [0] HEDS-6140 Option [ ] [ ] [ ]

Assembly Tool

HEDS-8906

Lead Bend
- 0 - Straight Leads
- 1 - Bent Leads

Resolution (Cycles/Rev)
- B - 1000 CPR
- J - 1024 CPR

Shaft Diameter
- 06 - 1/4 in.
- 08 - 3/8 in.
- 09 - 1/2 in.
- 10 - 5/8 in.
- 11 - 4 mm
- 12 - 6 mm
- 13 - 8 mm

Three Channel Encoder Modules and Codewheels, 23.36 mm Optical Radius

HEDS-9040 Option [ ] [0] [0] HEDM-614 [ ] Option [ ] [ ] [ ]

Assembly Tool

HEDS-8906

Resolution (Cycles/Rev)
- T - 2000 CPR

Artwork Orientation
- 0 - Artwork on hub side (use when module Side B is down)
- 1 - Artwork opposite hub side (use when Module Side A is down)

Shaft Diameter
- 12 - 6 mm

	A	B	C	D	E	F	G	H	I	J	K	S	T	U
HEDS-9040	*									*			*	
HEDS-9041	*													

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDS-6140	B						*	*	*	*	*	*	*	
	J						*		*			*	*	
HEDM-6140	T											*		

Three Channel Encoder Modules and Codewheels, 11.00 mm Optical Radius

HEDS-914 [0] **Option [ ] [0] [0]** **HEDS-5140 Option [ ] [ ] [ ]**

Lead Bend

0 - Straight Leads
1 - Bent Leads

Resolution (Cycles/Rev)

S - 50 CPR	G - 360 CPR
C - 100 CPR	H - 4000 CPR
E - 200 CPR	A - 5000 CPR
F - 256 CPR	I - 512 CPR

Shaft Diameter

02 - 3 mm	11 - 4 mm
04 - 5/32 in.	14 - 5 mm
05 - 3/16 in.	12 - 6 mm
06 - 1/4 in.	13 - 8 mm

Assembly Tool

HEDS-8905

	A	B	C	D	E	F	G	H	I	J	K	S	T	U
HEDS-9140	*		*		*	*	*	*	*		*			
HEDS-9141	*				*	*	*							

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDS-5140	A		*		*	*	*				*	*	*	*
	C				*		*					*	*	
	E						*				*	*		*
	F				*							*		*
	G						*					*		*
	I		*		*		*				*	*	*	*

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Data subject to change.

May 8, 2001
Obsoletes 5965-5870E (11/99)
5988-2558EN

HEDS-51X0/61X0 Series, HEDG-512X/612X Series
HEDM-512X/61XX Series

Two and Three Channel Codewheels for Use with Avago Technologies Optical Encoder Modules

Technical Data

Description

Avago Technologies offers a wide variety of codewheels for use with Avago Technologies' HEDS-9000, HEDS-9100, HEDS-9040, and HEDS-9140 series Encoder Modules. Designed for many environments, applications, and budgets, Avago Technologies' codewheels are available in Glass, Film, and Metal. These codewheels are available in resolutions from 96 Counts Per Revolution (CPR) to 1024 CPR on an 11 mm optical radius and 500 to 2048 CPR on a 23.36 mm optical radius.

Each of the three codewheel materials offers a certain advantage. Metal codewheels are the most versatile, with a temperature rating up to 100°C, resolution to 512 CPR (28 mm diameter), as well as 2 and 3 channel outputs. Film codewheels offer higher resolution (up to 1024 CPR on a 28 mm diameter) with an operating temperature of 70°C. Glass codewheels combine the best of film and metal, offering a temperature rating of 100°C and resolutions to 1024 CPR on a 28 mm diameter.

In addition, each material offers a specific reliability rating. It is important to consider the specific application operating environment, long term operating conditions, and temperature ranges when choosing a codewheel material.

Also See:
- HEDS-9000/HEDS-9100 Encoder Module Data Sheet
- HEDS-9000/9100/9200 Extended Resolution Encoder Module Data Sheet
- HEDS-9040/9140 Three Channel Encoder Module Data Sheet
- HEDS-9700 Small Encoder Module Data Sheet

Features:

- Codewheels Available in Glass, Film, and Metal
- Available in Two Standard Diameters
- Cost Effective
- Resolutions from 96 CPR to 2048 CPR
- For Use with HEDS-90XX/91XX Series Two and Three Channel Encoders
- Lead Free

Absolute Maximum Ratings

It is important to consider the environment in which the codewheels will be used when selecting a codewheel material. In brief, metal codewheels are rugged, but do not offer higher resolution capabilities. Film codewheels allow higher resolution, but cannot endure the same temperatures and high humidity as metal. Glass codewheels offer both high temperature and higher resolution, but are also more expensive. Consider the following rating table when choosing a codewheel material.

Parameter	Symbol	HEDS-XXXX Metal Codewheels	HEDM-XXXX Film Codewheels	HEDG-XXXX Glass Codewheels
Storage Temperature	T_S	-40°C to +100°C	-40°C to +70°C	-40°C to +100°C
Operating Temperature	T_A	-40°C to +100°C	-40°C to +70°C	-40°C to +100°C
Humidity			non condensing	
Velocity		30,000 RPM	30,000 RPM	12,000 RPM
Shaft Axial Play		±0.25 mm (±0.010 in)	±0.175 mm (±0.007 in)	±0.175 mm (±0.007 in)
Shaft Eccentricity Plus Radial Play		±0.1 mm (±0.004 in) TIR	±0.04 mm (±0.0015 in) TIR	±0.04 mm (±0.0015 in) TIR
Acceleration		250,000 Rad/Sec^2	250,000 Rad/Sec^2	100,000 Rad/Sec^2

Recommended Operating Conditions

Parameter	HEDS-XXXX Metal Codewheels	HEDM-XXXX Film Codewheels	HEDG-XXXX Glass Codewheels
Maximum Count Frequency	100 kHz	200 kHz*	200 kHz
Shaft Perpendicularity Plus Axial Play	±0.25 mm (±0.010 in)	±0.175 mm (±0.007 in)	±0.175 mm (±0.007 in)
Shaft Eccentricity Plus Radial Play	±0.1 mm (±0.004 in) TIR	±0.04 mm (±0.0015 in) TIR	±0.04 mm (±0.0015 in) TIR

Note: Avago Technologies Encoder Modules are guaranteed to 100 kHz, but can operate at higher frequencies. See Encoder Module Data Sheet for specifications and output load recommendations.

*HEDM-6140 is guaranteed to 100 kHz with the HEDS-9040 #T00 module.

Encoding Characteristics

Encoding characteristics over recommended operating range and recommended mounting tolerances unless otherwise specified. Values are for worst error over a full rotation. Please refer to Encoder Module Data Sheet for definitions of Encoding characteristics.

Reliability

In addition to the absolute maximum specifications of codewheels, the environment characteristics of the application are also important. For example, consistent, large temperature swings over the life of the product will affect the codewheel performance characteristics depending on the material. The following reliability table shows results of lifetests under varying conditions of temperature and humidity.

Part Number	Description	Symbol	Min.	Typ.	Max.	Units
HEDS-51XX	Cycle Error	ΔC		3	5.5	°e
	Position Error	Δθ		10	40	min. of arc
HEDS-61XX	Cycle Error	ΔC		3	5.5	°e
	Position Error	Δθ		7	20	min. of arc
HEDM-512X	Cycle Error	ΔC		3	7.5	°e
	Position Error	Δθ		4	40	min. of arc
HEDM-61XX	Cycle Error	ΔC		3	7.5	°e
	Position Error	Δθ		2	20	min. of arc
HEDG-512X	Cycle Error	ΔC		3	7.5	°e
	Position Error	Δθ		4	30	min. of arc
HEDG-612X	Cycle Error	ΔC		3	7.5	°e
	Position Error	Δθ		2	15	min. of arc

Glass Codewheel Tests

Test	Duration	Number of Parts	Number of Failures
Storage at 100°C	1000 hours	44	0
Rotating at 100°C	500 hours	10	0
Temperature Cycle: -40°C to +100°C	500 cycles	98	0
Temperature/Humidity: 85°C/85% R.H.	500 hours	43	0

Film Codewheel Tests

Test	Duration	Number of Parts	Number of Failures
Storage at 70°C	1000 hours	118	0
Rotating at 70°C	500 hours	10	0
Temperature Cycle: -40°C to +70°C	500 cycles	66	0
Temperature Cycle: +20°C to +40°C	1000 cycles	64	0
Temperature Cycle: +20°C to +55°C	1000 cycles	46	0
Temperature Cycle: +20°C to +70°C	500 cycles	50	0

Mounting Rotary Encoders with Codewheels

There are two orientations for mounting the Avago Technologies encoder module and Avago Technologies codewheel. Figure 1a shows mounting the module with side A as the mounting plane. Figure 1b shows mounting the module with side B as the mounting plane. When assembling the encoder and codewheel, it is important to maintain the tolerances of Side A of the module, and the image side of the codewheel. See module Data Sheets for these tolerances.

Mounting with Module Side A as the Mounting Plane

Mounting a high resolution or three channel encoder with Module Side A as the mounting plane requires alignment pins in the motor base. These alignment pins provide the necessary centering of the module with respect to the center of the motor shaft. In addition to centering, the codewheel gap is also important. Please refer to the respective encoder data sheet for necessary mounting information.

Mounting with Module Side B as the Mounting Plane, using Avago Technologies Assembly Tools

Avago Technologies offers centering tools and gap setting tools only for the case when the module is mounted with Side B down. Please refer to the Ordering Information Table to choose the correct assembly tools.

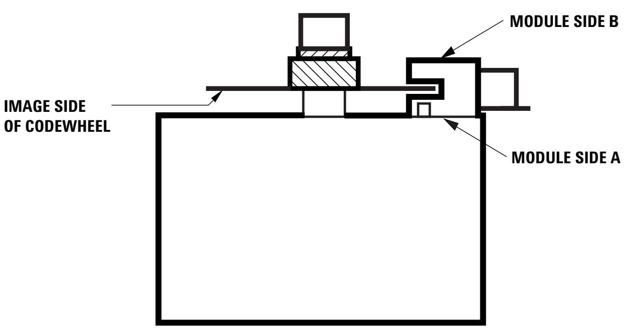


Figure 1a.

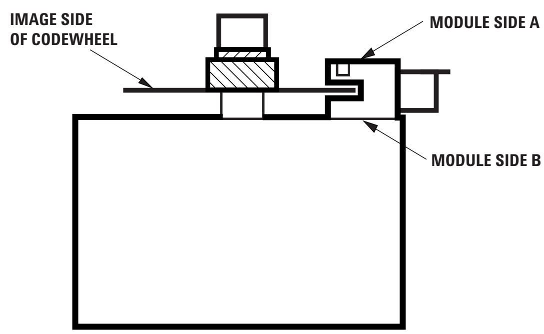


Figure 1b.

*Please note that the image side of the codewheel must always be facing the module Side A.

Assembly Instructions Using Avago Technologies Assembly Tools

Instructions

1. Place codewheel on shaft.
2. Set codewheel height:

(a) Place the correct gap setting tool (per Ordering Information Table) on motor base, flush up against the motor shaft as shown in Figure 2. The shim has two different size steps. Choose the one that most closely matches the width of the codewheel boss. The shim should not contact the codewheel boss.

(b) Push codewheel down against gap setting shim. The codewheel is now at the proper height.

(c) Tighten codewheel setscrew.

3. Insert mounting screws through module and thread into the motor base. Do not tighten screws.
4. Slide the HEDS-8905 or HEDS-8906 centering tool over codewheel hub and onto module as shown in Figure 3. The pins of the alignment tool should fit snugly inside the alignment recesses of the module.
5. While holding alignment tool in place, tighten screws down to secure module.
6. Remove alignment tools.

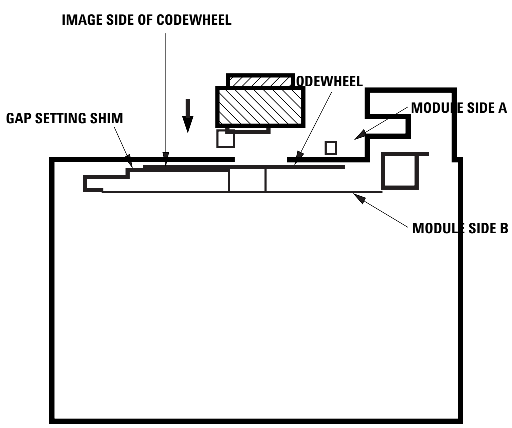


Figure 2. Alignment Tool is Used to Set Height of Codewheel.

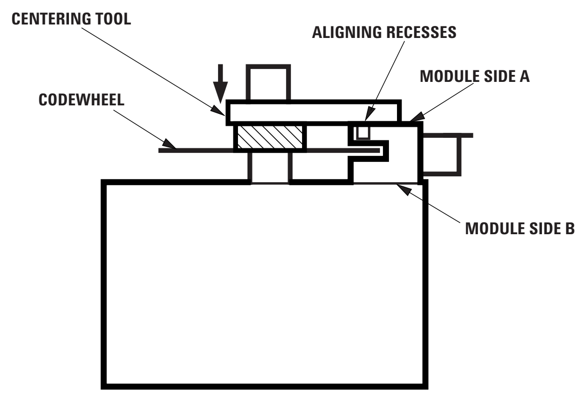


Figure 3. Alignment Tool is Placed over Shaft and onto Codewheel Hub. Alignment Tool Pins Mate with Aligning Recesses on Module.

Mechanical Drawings

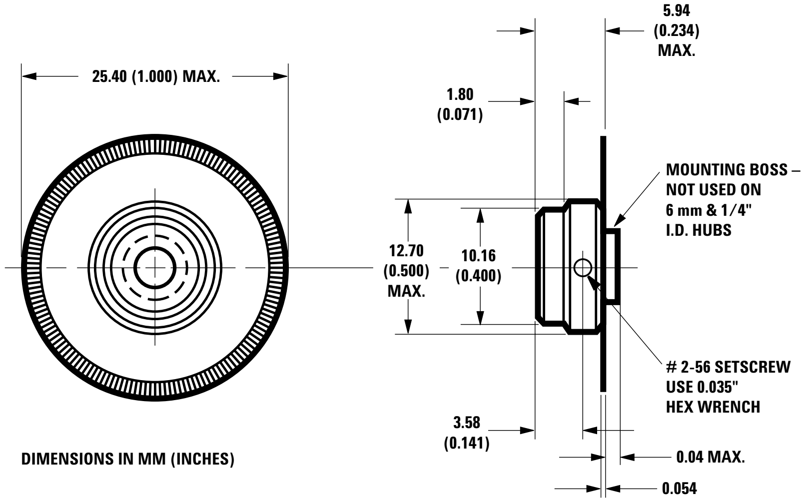


Figure 4. HEDS-5120 Codewheel.

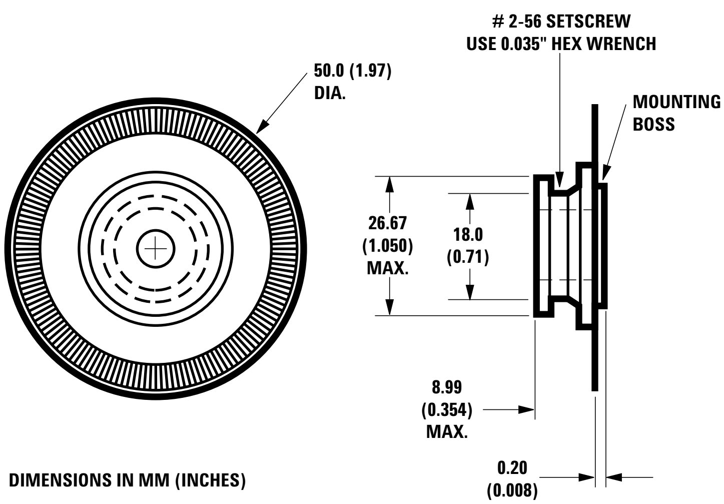


Figure 5. HEDS-6100 Codewheel.

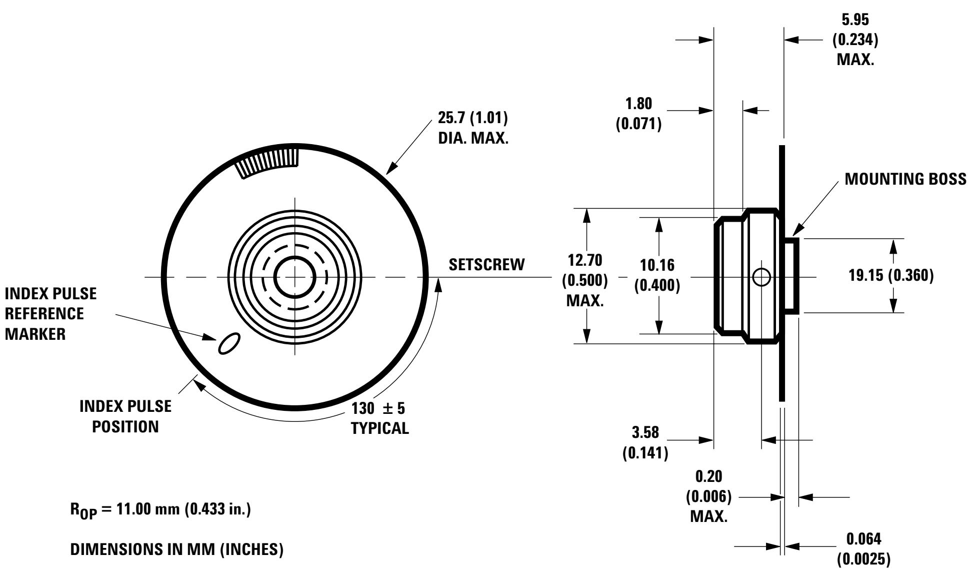
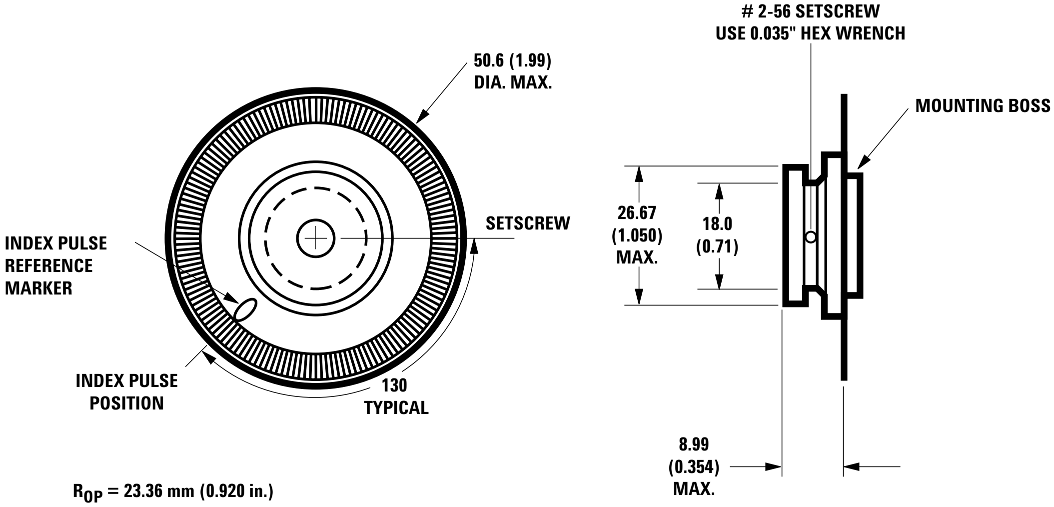


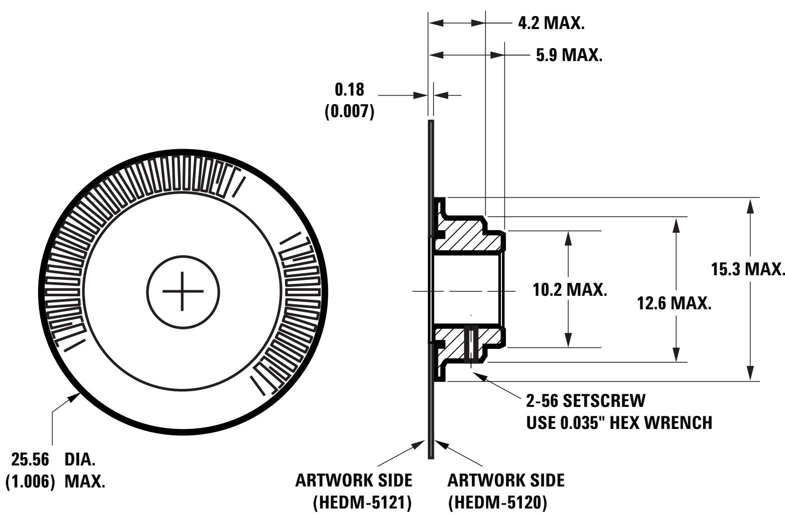
Figure 6. HEDS-5140 Codewheel Used with HEDS-9140.



R_{OP} = 23.36 mm (0.920 in.)

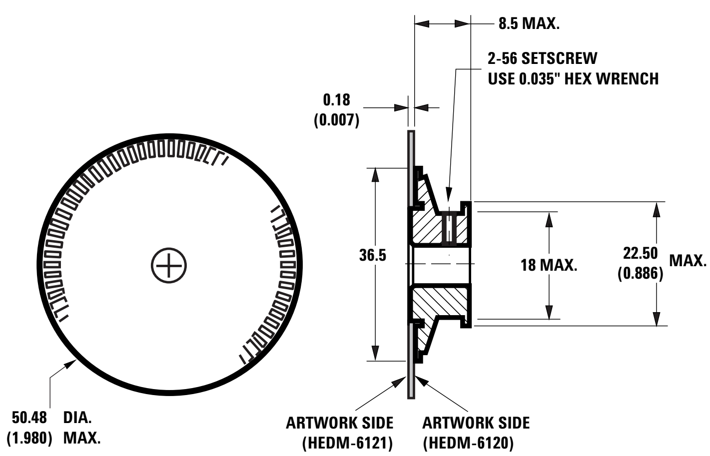
DIMENSIONS IN MM (INCHES)

Figure 7. HEDS-6140 Codewheel Used with HEDS-9040.



DIMENSIONS IN mm (INCHES)

Figure 8. HEDM-5120 Codewheel/HEDM-5121 Codewheel.



DIMENSIONS IN mm (INCHES)

Figure 9. HEDM-6120 Codewheel/HEDM-6121 Codewheel.

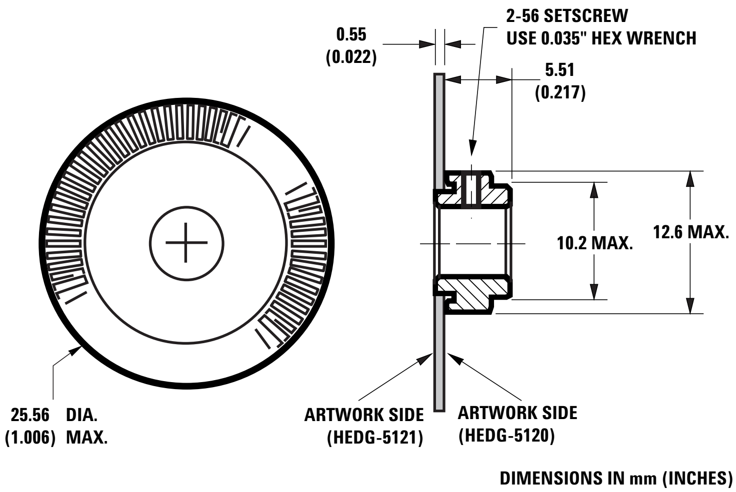


Figure 10. HEDG-5120 Codewheel/HEDG-5121 Codewheel.

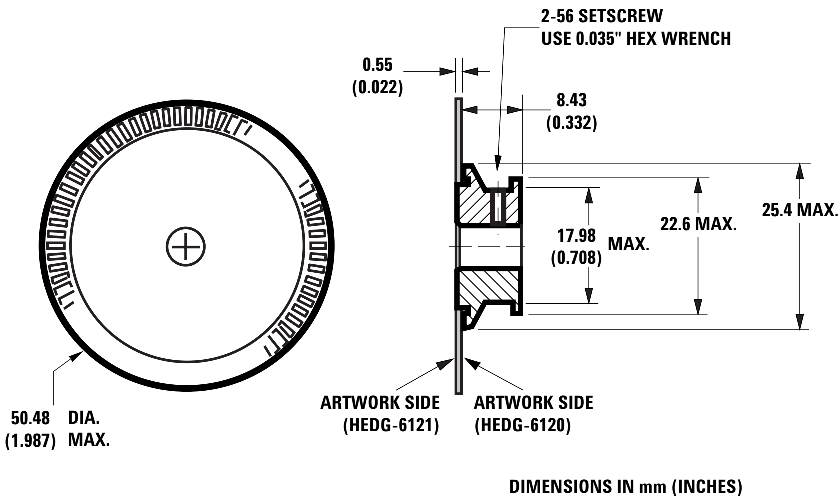


Figure 11. HEDG-6120 Codewheel/HEDG-6121 Codewheel.

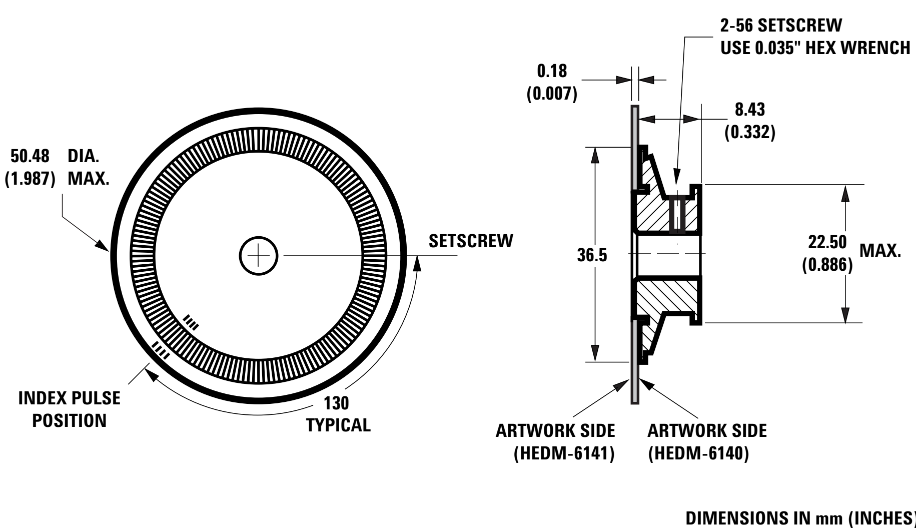


Figure 12. HEDM-6140 Codewheel/HEDM-6141 Codewheel.

Ordering Information Encoder Modules, Codewheel and Assembly Tools

Metal Codewheels

HEDS-9100 Option modules [ ] [0] [0] **HEDS-5120 codewheels** **Option** [ ] [ ][ ] **Rop = 11 mm, 2 Channels**

Resolution (Cycles/Rev)

- K - 96 CPR
- C - 100 CPR
- D - 192 CPR
- E - 200 CPR
- F - 256 CPR
- G - 360 CPR
- H - 400 CPR
- A - 500 CPR
- I - 512 CPR

Shaft Diameter

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

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8905	**HEDS-8901**

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

HEDS-9140 Option modules [ ] [0] [0] **HEDS-5140 codewheels** **Option** [ ] [ ][ ] **Rop = 11 mm, 3 Channels**

Resolution (Cycles/Rev)

- C - 100 CPR
- E - 200 CPR
- F - 256 CPR
- G - 360 CPR
- A - 500 CPR
- I - 512 CPR

Shaft Diameter

- **02 - 3 mm**
- **03 - 1/8 in.**
- **04 - 5/32 in.**
- **05 - 3/16 in.**
- **06 - 1/4 in.**
- **11 - 4 mm**
- **14 - 5 mm**
- **12 - 6 mm**
- **13 - 8 mm**

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8905	**HEDS-8905**

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDS-5140	A		*		*	*	*				*	*	*	*
	C				*		*					*	*	
	E						*				*	*		*
	F				*							*		*
	G						*					*		*
	I		*		*		*				*	*	*	*

Ordering Information (Cont'd.)

HEDS-9000 Option modules [ ] [0] [0] **HEDS-6100 codewheels** **Option** [ ] [ ][ ] **Rop = 23 mm, 2 Channels**

Resolution (Cycles/Rev)
A - 500 CPR
B - 1000 CPR

Shaft Diameter
06 - 1/4 in.
08 - 3/8 in.
09 - 1/2 in.
10 - 5/8 in.
11 - 4 mm
12 - 6 mm
13 - 8 mm

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8906	**HEDS-8901**

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

HEDS-9040 Option modules [ ] [0] [0] **HEDS-6140 codewheels** **Option** [ ] [ ][ ] **Rop = 23.36 mm, 3 Channels**

Resolution (Cycles/Rev)
B - 1000 CPR
J - 1024 CPR

Shaft Diameter
06 - 1/4 in.
08 - 3/8 in.
09 - 1/2 in.
10 - 5/8 in.
11 - 4 mm
12 - 6 mm
13 - 8 mm

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8906	**HEDS-8906**

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDS-6140#	B						*	*	*	*	*	*	*	
	J						*		*			*	*	

Note:

1. For the lower resolution, two channel encoders, (11 mm ≤ 512 CPR; 23.36 mm ≤ 1024 CPR) the centering tool and gap-setting shim are not necessary, but sometimes helpful in an assembly process.

Ordering Information (Cont'd.)

Film Codewheels

HEDS-9000 modules Option [ ] [0] [0] **HEDM-512 codewheels Option** [ ] [ ][ ] [ ]

Rop = 11 mm, 2 Channels

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8905	**HEDS-8901**

Resolution (Cycles/Rev)	Artwork Orientation	Shaft Diameter
B - 1000 CPR J - 1024 CPR	0 - Artwork on hub side (use when module side B is down) 1 - Artwork opposite hub side (use when module side A is down)	02 - 3 mm 06 - 1/4 in. 11 - 4 mm 12 - 6 mm

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDM-5120#	B		*				*				*	*		
	J						*				*			
HEDM-5121	B					*	*							
	J													

HEDS-9000 modules Option [ ] [0] [0] **HEDM-612 codewheels Option** [ ] [ ][ ] [ ]

Rop = 23.36 mm, 2 Channels

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8906	**HEDS-8906**

Resolution (Cycles/Rev)	Artwork Orientation	Shaft Diameter
T - 2000 CPR U - 2048 CPR	0 - Artwork on hub side (use when module side B is down) 1 - Artwork opposite hub side (use when module side A is down)	06 - 1/4 in. 08 - 3/8 in. 12 - 6 mm 13 - 8 mm

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDM-6120#	T						*	*				*	*	
	U								*					
HEDM-6121#	T								*					

Ordering Information (Cont'd.)

HEDS-9040 modules Option [ ] [0] [0]

HEDM-614 [ ] codewheels Option [ ] [ ][ ]

Rop = 23.36 mm, 3 Channels

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8906	**HEDS-8906**

Resolution (Cycles/Rev)
- T - 2000 CPR

Artwork Orientation*
- 0 - Artwork on hub side (use when module side B is down)
- 1 - Artwork opposite hub side (use when module side A is down)

Shaft Diameter
- 10 - 5/8 in.
- 12 - 6 mm

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDM-6140#	T											*		
HEDM-6141#	T									*				

Glass Codewheels

HEDS-9100 modules Option [ ] [0] [0]

HEDG-512 [ ] codewheels Option [ ] [ ][ ]

Rop = 11 mm, 2 Channels

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8905	**HEDS-8932**

Resolution (Cycles/Rev)
- B - 1000 CPR
- J - 1024 CPR

Artwork Orientation
- 0 - Artwork on hub side (use when module side B is down)
- 1 - Artwork opposite hub side (use when module side A is down)

Shaft Diameter
- 06 - 1/4 in.
- 14 - 5 mm

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDG-5121#	B						*					*		
	J													*

Ordering Information (Cont'd.)

HEDS-9000 modules Option ☐ **0** **0**

HEDG-612 codewheels Option ☐ ☐☐

Rop = 23.36 mm, 2 Channels

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8906	**HEDS-8932**

Resolution (Cycles/Rev)
T - 2000 CPR
U - 2048 CPR

Shaft Diameter
12 - 6 mm

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDG-6120#	U											*		

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

5989-0866EN - May 25, 2006

Agilent Technologies

Two and Three Channel Codewheels for Use with Agilent Optical Encoder Modules

Technical Data

HEDS-51X0/61X0 Series
HEDG-512X/612X Series
HEDM-512X/61XX Series

Features:

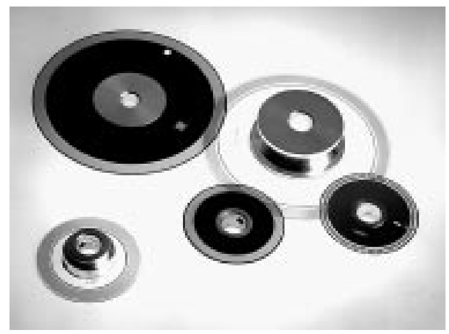
- **Codewheels Available in Glass, Film, and Metal**
- **Available in Two Standard Diameters**
- **Cost Effective**
- **Resolutions from 96 CPR to 2048 CPR**
- **For Use with HEDS-90XX/ 91XX Series Two and Three Channel Encoders**

Description

Agilent Technologies offers a wide variety of codewheels for use with Agilent's HEDS-9000, HEDS-9100, HEDS-9040, and HEDS-9140 series Encoder Modules. Designed for many environments, applications, and budgets, Agilent codewheels are available in Glass, Film, and Metal. These codewheels are available in resolutions from 96 Counts Per Revolution (CPR) to 1024 CPR on an 11 mm optical radius and 500 to 2048 CPR on a 23.36 mm optical radius.

Each of the three codewheel materials offers a certain advantage. Metal codewheels are the most versatile, with a temperature rating up to 100°C, resolution to 512 CPR (28 mm diameter), as well as 2 and 3 channel outputs. Film codewheels offer higher resolution (up to 1024 CPR on a 28 mm diameter) with an operating temperature of 70°C. Glass codewheels combine the best of film and metal, offering a temperature rating of 100°C and resolutions to 1024 CPR on a 28 mm diameter.

In addition, each material offers a specific reliability rating. It is important to consider the specific application operating environment, long term operating conditions, and temperature ranges when choosing a codewheel material.



Also See:

- HEDS-9000/HEDS-9100 Encoder Module Data Sheet
- HEDS-9000/9100/9200 Extended Resolution Encoder Module Data Sheet
- HEDS-9040/9140 Three Channel Encoder Module Data Sheet
- HEDS-9700 Small Encoder Module Data Sheet

Absolute Maximum Ratings

It is important to consider the environment in which the codewheels will be used when selecting a codewheel material. In brief, metal codewheels are rugged, but do not offer higher resolution capabilities. Film codewheels allow higher resolution, but cannot endure the same temperatures and high humidity as metal. Glass codewheels offer both high temperature and higher resolution, but are also more expensive. Consider the following rating table when choosing a codewheel material.

Parameter	Symbol	HEDS-XXXX Metal Codewheels	HEDM-XXXX Film Codewheels	HEDG-XXXX Glass Codewheels
Storage Temperature	T_S	-40°C to +100°C	-40°C to +70°C	-40°C to +100°C
Operating Temperature	T_A	-40°C to +100°C	-40°C to +70°C	-40°C to +100°C
Humidity			non condensing	
Velocity		30,000 RPM	30,000 RPM	12,000 RPM
Shaft Axial Play		± 0.25 mm (± 0.010 in)	± 0.175 mm (± 0.007 in)	± 0.175 mm (± 0.007 in)
Shaft Eccentricity Plus Radial Play		± 0.1 mm (± 0.004 in) TIR	± 0.04 mm (± 0.0015 in) TIR	± 0.04 mm (± 0.0015 in) TIR
Acceleration		250,000 Rad/Sec^2	250,000 Rad/Sec^2	100,000 Rad/Sec^2

Recommended Operating Conditions

Parameter	HEDS-XXXX Metal Codewheels	HEDM-XXXX Film Codewheels	HEDG-XXXX Glass Codewheels
Maximum Count Frequency	100 kHz	200 kHz*	200 kHz
Shaft Perpendicularity Plus Axial Play	± 0.25 mm (± 0.010 in)	± 0.175 mm (± 0.007 in)	± 0.175 mm (± 0.007 in)
Shaft Eccentricity Plus Radial Play	± 0.1 mm (± 0.004 in) TIR	± 0.04 mm (± 0.0015 in) TIR	± 0.04 mm (± 0.0015 in) TIR

Note: Agilent Encoder Modules are guaranteed to 100 kHz, but can operate at higher frequencies. See Encoder Module Data Sheet for specifications and output load recommendations.

*HEDM-6140 is guaranteed to 100 kHz with the HEDS-9040 #T00 module.

Encoding Characteristics

Encoding characteristics over recommended operating range and recommended mounting tolerances unless otherwise specified. Values are for worst error over a full rotation. Please refer to Encoder Module Data Sheet for definitions of Encoding characteristics.

Part Number	Description	Symbol	Min.	Typ.	Max.	Units
HEDS-51XX	Cycle Error Position Error	ΔC $\Delta\theta$		3 10	5.5 40	°e min. of arc
HEDS-61XX	Cycle Error Position Error	ΔC $\Delta\theta$		3 7	5.5 20	°e min. of arc
HEDM-512X	Cycle Error Position Error	ΔC $\Delta\theta$		3 4	7.5 40	°e min. of arc
HEDM-61XX	Cycle Error Position Error	ΔC $\Delta\theta$		3 2	7.5 20	°e min. of arc
HEDG-512X	Cycle Error Position Error	ΔC $\Delta\theta$		3 4	7.5 30	°e min. of arc
HEDG-612X	Cycle Error Position Error	ΔC $\Delta\theta$		3 2	7.5 15	°e min. of arc

Reliability

In addition to the absolute maximum specifications of codewheels, the environment characteristics of the application are also important. For example, consistent, large temperature swings over the life of the product will affect the codewheel performance characteristics depending on the material. The following reliability table shows results of lifetests under varying conditions of temperature and humidity.

Glass Codewheel Tests

Test	Duration	Number of Parts	Number of Failures
Storage at 100°C	1000 hours	44	0
Rotating at 100°C	500 hours	10	0
Temperature Cycle: -40°C to +100°C	500 cycles	98	0
Temperature/Humidity: 85°C/85% R.H.	500 hours	43	0

Film Codewheel Tests

Test	Duration	Number of Parts	Number of Failures
Storage at 70°C	1000 hours	118	0
Rotating at 70°C	500 hours	10	0
Temperature Cycle: -40°C to +70°C	500 cycles	66	0
Temperature Cycle: +20°C to +40°C	1000 cycles	64	0
Temperature Cycle: +20°C to +55°C	1000 cycles	46	0
Temperature Cycle: +20°C to +70°C	500 cycles	50	0

Mounting Rotary Encoders with Codewheels

There are two orientations for mounting the Agilent encoder module and Agilent codewheel. Figure 1a shows mounting the module with side A as the mounting plane. Figure 1b shows mounting the module with side B as the mounting plane. When assembling the encoder and codewheel, it is important to maintain the tolerances of Side A of the module, and the image side of the codewheel. See module Data Sheets for these tolerances.

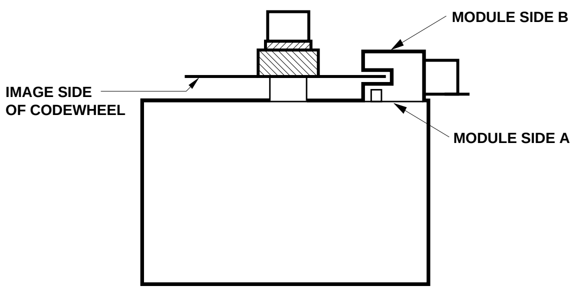


Figure 1a.

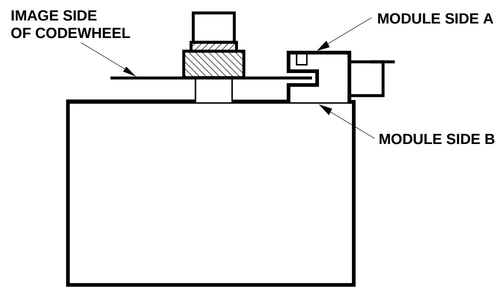


Figure 1b.

*Please note that the image side of the codewheel must always be facing the module Side A.

Mounting with Module Side A as the Mounting Plane

Mounting a high resolution or three channel encoder with Module Side A as the mounting plane requires alignment pins in the motor base. These alignment pins provide the necessary centering of the module with respect to the center of the motor shaft. In addition to centering, the codewheel gap is also important. Please refer to the respective encoder data sheet for necessary mounting information.

Mounting with Module Side B as the Mounting Plane, using Agilent Assembly Tools

Agilent offers centering tools and gap setting tools only for the case when the module is mounted with Side B down. Please refer to the Ordering Information Table to choose the correct assembly tools.

Assembly Instructions Using Agilent Assembly Tools

Instructions

1. Place codewheel on shaft.
2. Set codewheel height:
   (a) Place the correct gap setting tool (per Ordering Information Table) on motor base, flush up against the motor shaft as shown in Figure 2. The shim has two different size steps. Choose the one that most closely matches the width of the codewheel boss. The shim should not contact the codewheel boss.
   (b) Push codewheel down against gap setting shim. The codewheel is now at the proper height.
   (c) Tighten codewheel setscrew.
3. Insert mounting screws through module and thread into the motor base. Do not tighten screws.
4. Slide the HEDS-8905 or HEDS-8906 centering tool over codewheel hub and onto module as shown in Figure 3. The pins of the alignment tool should fit snugly inside the alignment recesses of the module.
5. While holding alignment tool in place, tighten screws down to secure module.
6. Remove alignment tools.

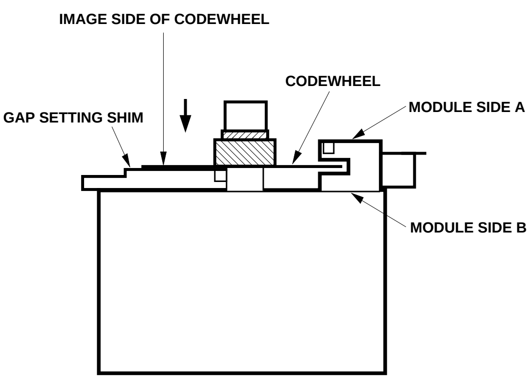


Figure 2. Alignment Tool is Used to Set Height of Codewheel.

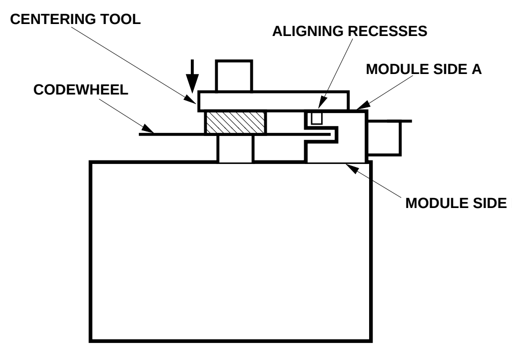


Figure 3. Alignment Tool is Placed over Shaft and onto Codewheel Hub. Alignment Tool Pins Mate with Aligning Recesses on Module.

Mechanical Drawings

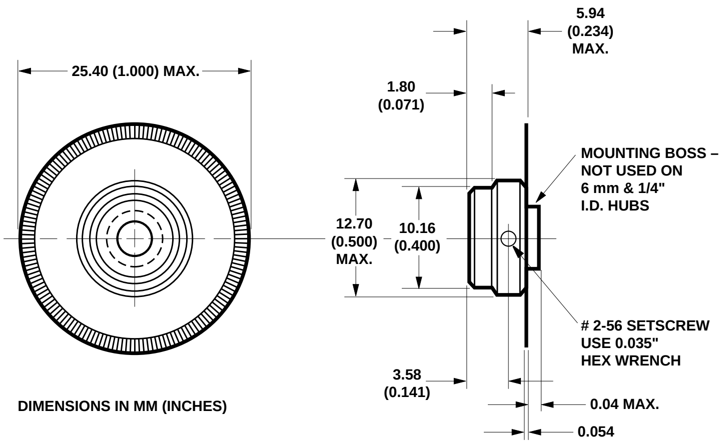


Figure 4. HEDS-5120 Codewheel.

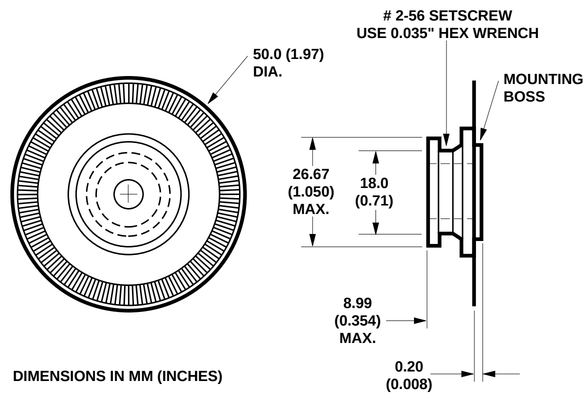


Figure 5. HEDS-6100 Codewheel.

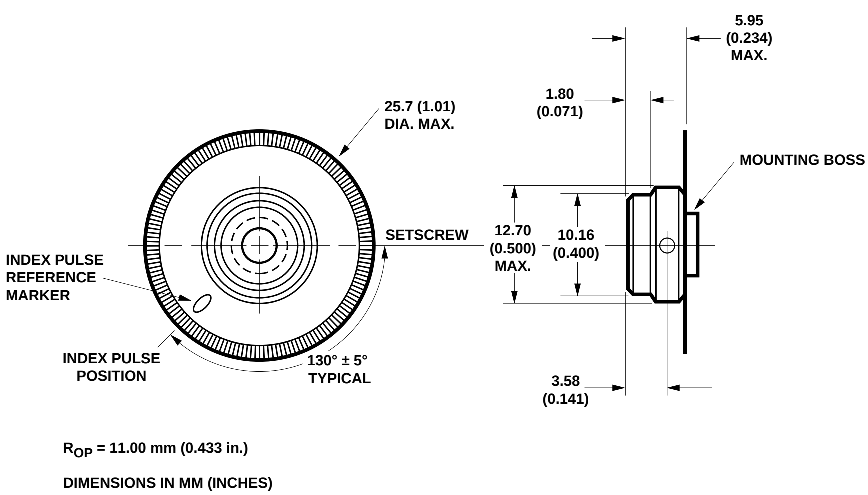


Figure 6. HEDS-5140 Codewheel Used with HEDS-9140.

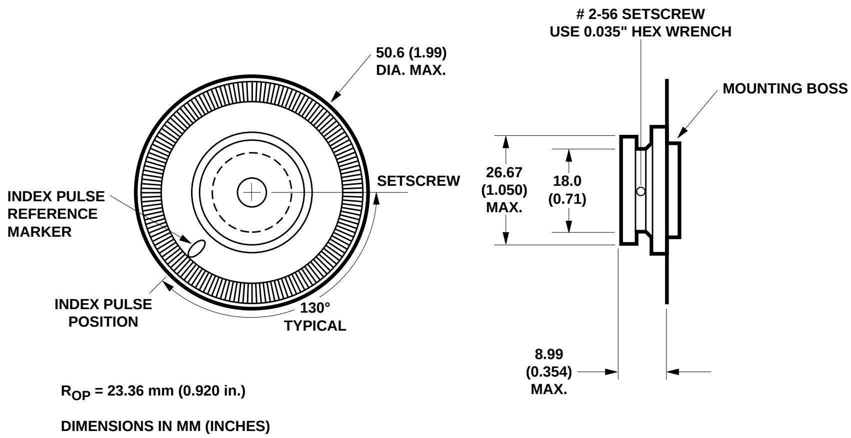


Figure 7. HEDS-6140 Codewheel Used with HEDS-9040.

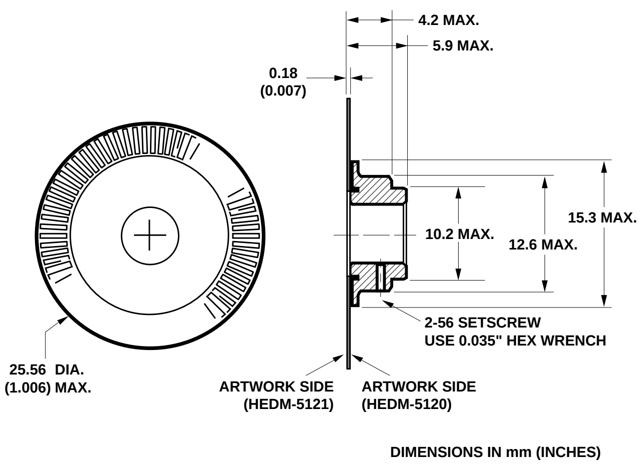


Figure 8. HEDM-5120 Codewheel/HEDM-5121 Codewheel.

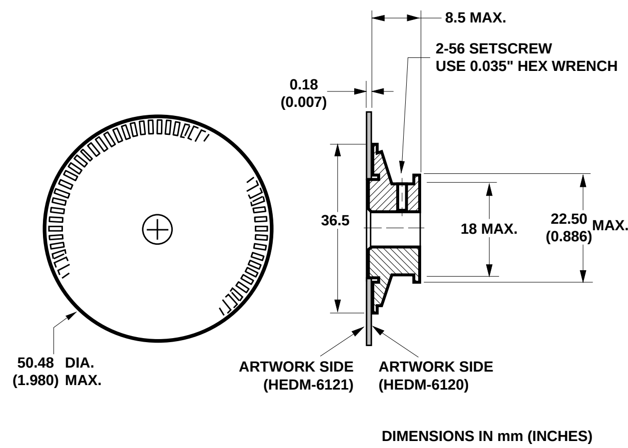


Figure 9. HEDM-6120 Codewheel/HEDM-6121 Codewheel.

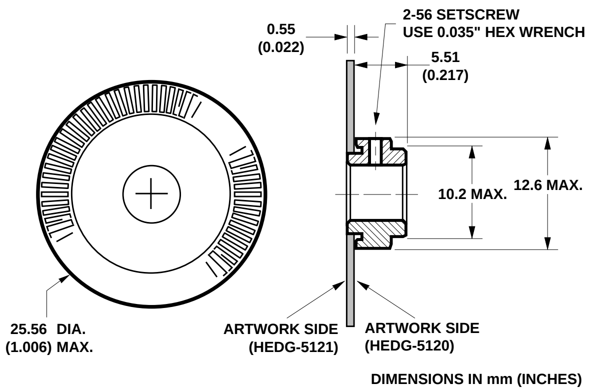


Figure 10. HEDG-5120 Codewheel/HEDG-5121 Codewheel.

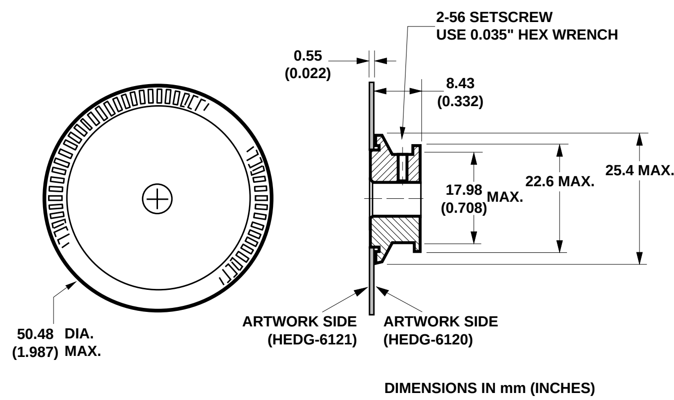


Figure 11. HEDG-6120 Codewheel/HEDG-6121 Codewheel.

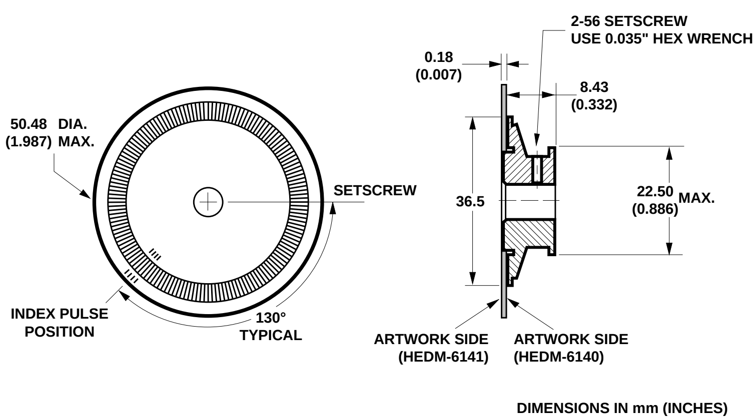


Figure 12. HEDM-6140 Codewheel/HEDM-6141 Codewheel.

Ordering Information Encoder Modules, Codewheel and Assembly Tools

Metal Codewheels

HEDS-9100 Option [ ] [0] [0] **modules**

HEDS-5120 Option [ ] [ ][ ] **codewheels**

Rop = 11 mm, 2 Channels

Resolution (Cycles/Rev)
- K - 96 CPR
- C - 100 CPR
- D - 192 CPR
- E - 200 CPR
- F - 256 CPR
- G - 360 CPR
- H - 400 CPR
- A - 500 CPR
- I - 512 CPR

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

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8905	**HEDS-8901**

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

HEDS-9140 Option [ ] [0] [0] **modules**

HEDS-5140 Option [ ] [ ][ ] **codewheels**

Rop = 11 mm, 3 Channels

Resolution (Cycles/Rev)
- C - 100 CPR
- E - 200 CPR
- F - 256 CPR
- G - 360 CPR
- A - 500 CPR
- I - 512 CPR

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

Assembly Tools	
Centering	**Gap-Setting**
HEDS-8905	**HEDS-8905**

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDS-5140	A		*		*	*	*				*	*	*	*
	C				*		*					*	*	
	E						*				*	*		*
	F				*							*		*
	G						*					*		*
	I		*		*		*				*	*	*	*

Ordering Information (Cont'd.)

HEDS-9000 Option ☐ **0** **0** **modules** — **HEDS-6100 Option** ☐ ☐☐ **codewheels** — **Rop = 23 mm, 2 Channels**

Resolution (Cycles/Rev)
- A - 500 CPR
- B - 1000 CPR

Shaft Diameter
- 06 - 1/4 in.
- 08 - 3/8 in.
- 09 - 1/2 in.
- 10 - 5/8 in.
- 11 - 4 mm
- 12 - 6 mm
- 13 - 8 mm

Assembly Tools

Centering	Gap-Setting
HEDS-8906	HEDS-8901

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

HEDS-9040 Option ☐ **0** **0** **modules** — **HEDS-6140 Option** ☐ ☐☐ **codewheels** — **Rop = 23.36 mm, 3 Channels**

Resolution (Cycles/Rev)
- B - 1000 CPR
- J - 1024 CPR

Shaft Diameter
- 06 - 1/4 in.
- 08 - 3/8 in.
- 09 - 1/2 in.
- 10 - 5/8 in.
- 11 - 4 mm
- 12 - 6 mm
- 13 - 8 mm

Assembly Tools

Centering	Gap-Setting
HEDS-8906	HEDS-8906

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDS-6140#	B						*	*	*	*	*	*	*	
	J						*		*			*	*	

Note:
1. For the lower resolution, two channel encoders, (11 mm ≤ 512 CPR; 23.36 mm ≤ 1024 CPR) the centering tool and gap-setting shim are not necessary, but sometimes helpful in an assembly process.

Ordering Information (Cont'd.)

Film Codewheels

HEDS-9000 modules Option [ ] **0 0**

HEDM-512 [ ] **codewheels Option** [ ] [ ][ ]

Rop = 11 mm, 2 Channels

Resolution (Cycles/Rev)	Artwork Orientation	Shaft Diameter
B - 1000 CPR J - 1024 CPR	0 - Artwork on hub side (use when module side B is down) 1 - Artwork opposite hub side (use when module side A is down)	02 - 3 mm 06 - 1/4 in. 11 - 4 mm 12 - 6 mm

Assembly Tools

Centering	Gap-Setting
HEDS-8905	HEDS-8901

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDM-5120#	B		*				*				*	*		
	J						*				*			
HEDM-5121	B					*	*							
	J													

HEDS-9000 modules Option [ ] **0 0**

HEDM-612 [ ] **codewheels Option** [ ] [ ][ ]

Rop = 23.36 mm, 2 Channels

Resolution (Cycles/Rev)	Artwork Orientation	Shaft Diameter
T - 2000 CPR U - 2048 CPR	0 - Artwork on hub side (use when module side B is down) 1 - Artwork opposite hub side (use when module side A is down)	06 - 1/4 in. 08 - 3/8 in. 12 - 6 mm 13 - 8 mm

Assembly Tools

Centering	Gap-Setting
HEDS-8906	HEDS-8906

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDM-6120#	T						*	*				*	*	
	U								*					
HEDM-6121#	T								*					

Ordering Information (Cont'd.)

HEDS-9040 modules
Option [ ] **0** **0**

HEDM-614 [ ]
codewheels
Option [ ] [ ][ ]

Rop = 23.36 mm, 3 Channels

Assembly Tools

Centering	**Gap-Setting**
HEDS-8906	**HEDS-8906**

Resolution (Cycles/Rev)
T - 2000 CPR

Artwork Orientation*
0 - Artwork on hub side (use when module side B is down)
1 - Artwork opposite hub side (use when module side A is down)

Shaft Diameter
10 - 5/8 in.
12 - 6 mm

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDM-6140#	T											*		
HEDM-6141#	T									*				

Glass Codewheels

HEDS-9100 modules
Option [ ] **0** **0**

HEDG-512 [ ]
codewheels
Option [ ] [ ][ ]

Rop = 11 mm, 2 Channels

Assembly Tools

Centering	**Gap-Setting**
HEDS-8905	**HEDS-8932**

Resolution (Cycles/Rev)
B - 1000 CPR
J - 1024 CPR

Artwork Orientation
0 - Artwork on hub side (use when module side B is down)
1 - Artwork opposite hub side (use when module side A is down)

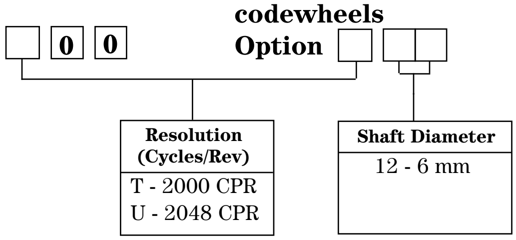
Shaft Diameter
06 - 1/4 in.
14 - 5 mm

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDG-5121#	B						*					*		
	J													*

Ordering Information (Cont'd.)

HEDS-9000 modules Option

HEDG-612 codewheels Option



Rop = 23.36 mm, 2 Channels

Assembly Tools

Centering	**Gap-Setting**
HEDS-8906	**HEDS-8932**

		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDG-6120#	U											*		

Agilent Technologies

www.semiconductor.agilent.com

Data subject to change.

April 26, 2001
Obsoletes 5965-5891E (11/99)
5988-2630EN

HEDL-65xx, HEDM-65xx, HEDS-65xx Series

Large Diameter (56 mm), Housed Two and Three Channel Optical Encoders

Data Sheet

Description

The HEDS-65xx/HEDL-65xx are high performance two and three channel optical incremental encoders. These encoders emphasize high reliability, high resolution, and easy assembly. Each encoder contains a lensed LED source (emitter), an integrated circuit with detectors and output circuitry, and a codewheel which rotates between the emitter and detector integrated circuit. The outputs of the HEDS-6500 are two single ended square waves in quadrature. The HEDL-65xx outputs are differential.

The HEDS-6540 / HEDL-6540 also have a third channel index output in addition to the two quadrature outputs. This index is an active high pulse that occurs once every full rotation of the codewheel. Resolutions up to 1024 Counts Per Revolution are available in the two and three channel versions.

The line driver option offers enhanced performance when the encoder is used in noisy environments, or when it is required to drive long distances.

The line driver option utilizes an industry standard line driver IC AM26C31Q which provides complementary outputs for each encoder channel. Thus the outputs of the line driver encoder are A and $\overline{A}$, B and $\overline{B}$, and I and $\overline{I}$ for three channel versions. Suggested line receivers are 26C32 and 26C33.

The quadrature signals are accessed through a cable and 10-pin female connector. Please refer to the ordering information at the end of this data sheet for a selection matrix.

Features

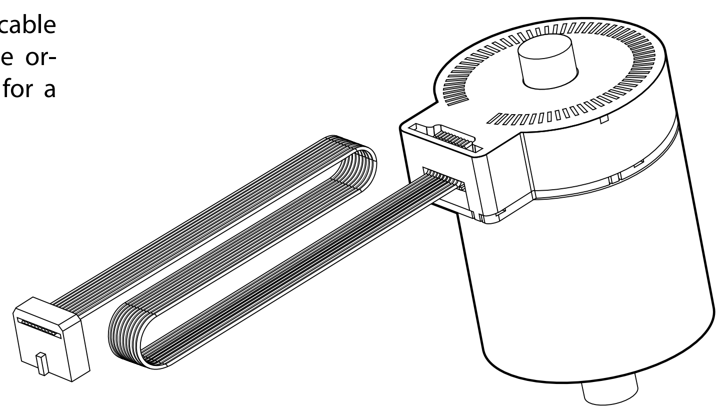
- Two channel quadrature output with optional index pulse
- TTL compatible single ended outputs on HEDS Series
- 100ºC operating temperature for metal code wheel
- 70°C operating temperature for mylar code wheel
- Industry standard AM26C31Q CMOS line driver IC on HEDL Series
- Easy assembly, no signal adjustment necessary
- Resolutions up to 2048 counts per revolution

Applications

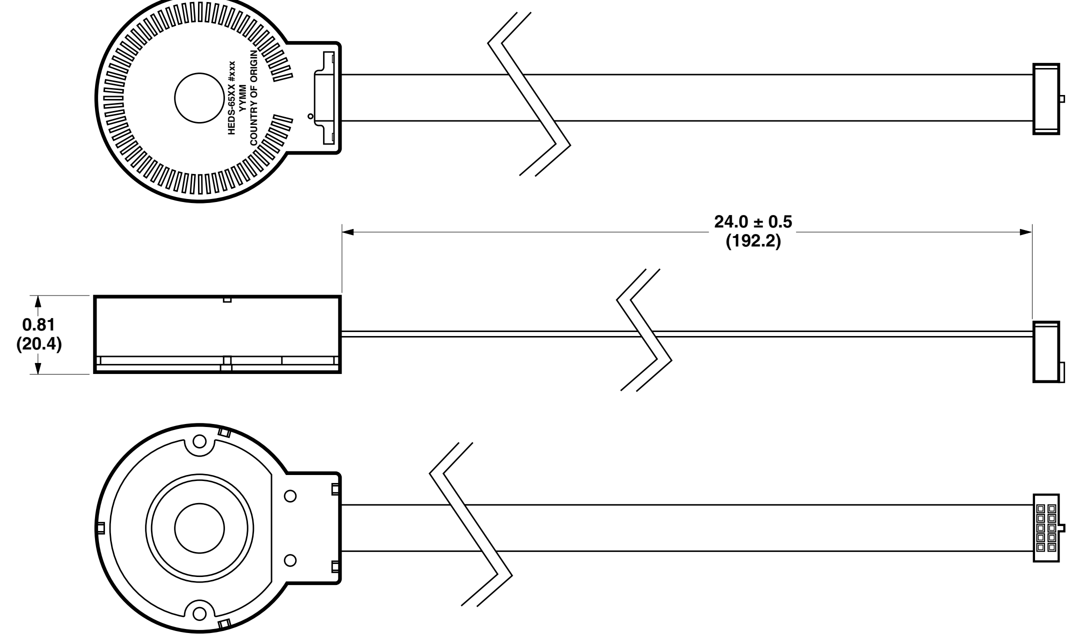
The HEDS-65xx / HEDL-65xx provide motion detection to a very high resolution and accept a variety of shaft sizes up to a maximum of 5/8 inches.

Typical applications include printers, plotters, tape drives, positioning tables, and automatic handlers.

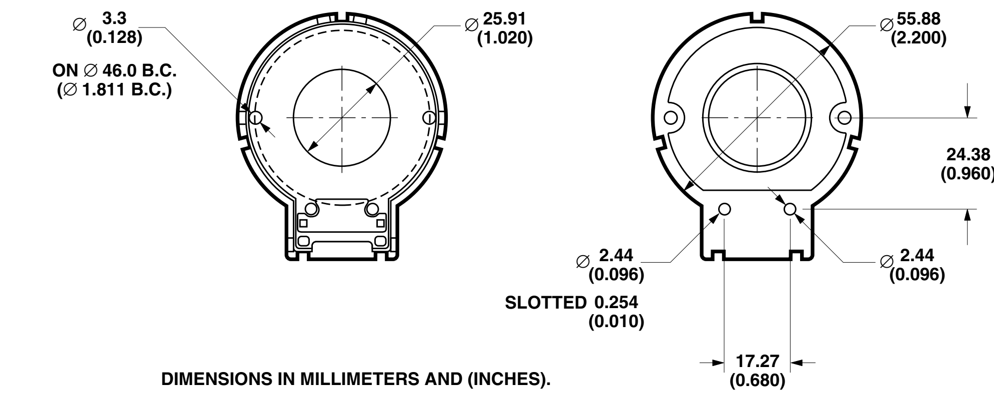
Note: Avago Technologies encoders are not recommended for use in safety critical applications. Eg. ABS braking systems, power steering, life support systems and critical care medical equipment. Please contact sales representative if more clarification is needed.



Assembled Unit

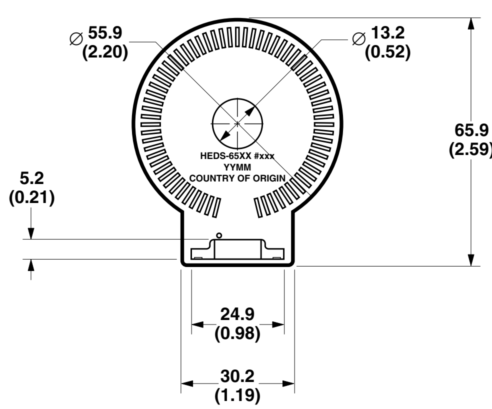


Base Plate



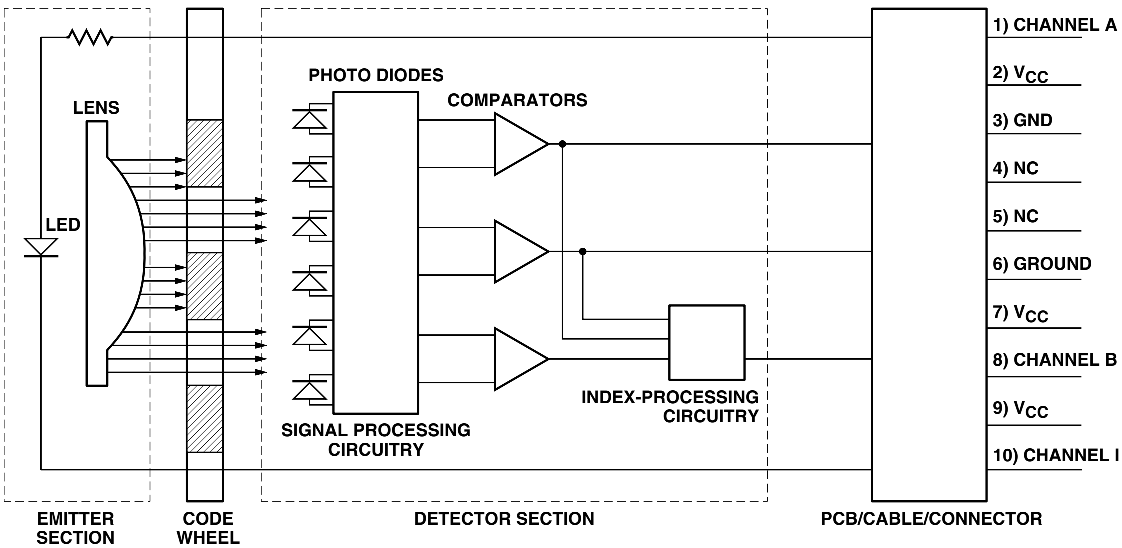
DIMENSIONS IN MILLIMETERS AND (INCHES).

Top Cover (Housing)

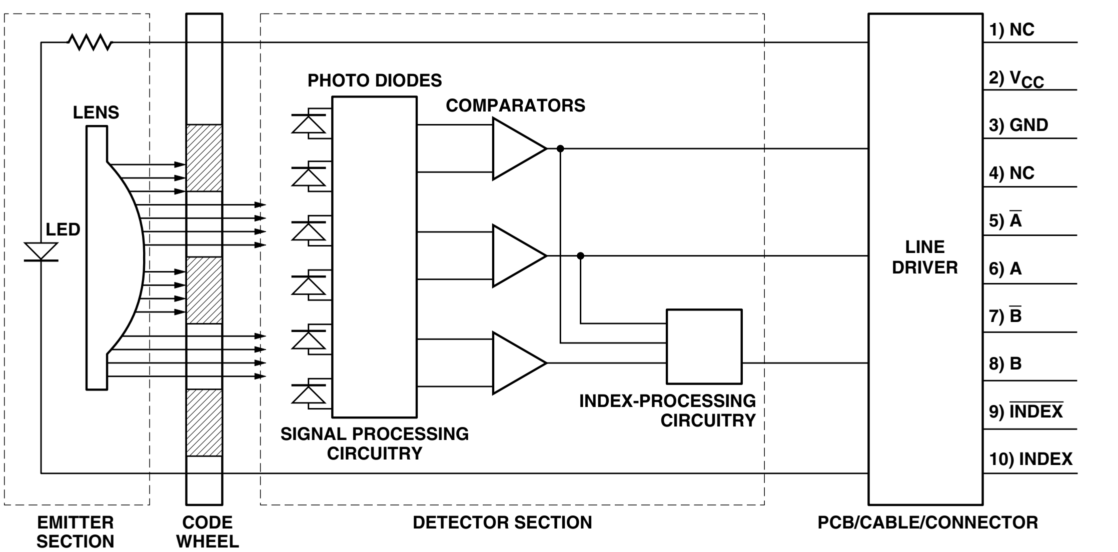


DIMENSIONS IN MILLIMETERS AND (INCHES).

Pinout A

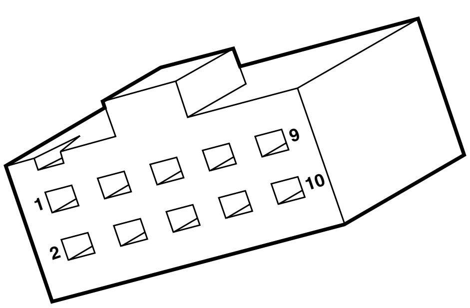


Pinout B



There are two different connector pin-out configurations used with the HEDS-65xx / HEDL-65xx series of encoders. The table below relates the part to its connector pin-out.

Connector Pin-out



Pinout A

HEDS-65xx CONNECTOR PIN OUT	
1	Channel A
2	V_{CC}
3	GND
4	NC
5	NC
6	GND
7	V_{CC}
8	Channel B
9	V_{CC}
10	Channel I

Pinout B

HEDL-65xx CONNECTOR PIN OUT	
1	NC
2	V_{CC}
3	GND
4	NC
5	$\overline{A}$
6	A
7	$\overline{B}$
8	B
9	I (INDEX)
10	$\overline{\text{I (INDEX)}}$

Theory of Operation

The HEDS-65xx / HEDL-65xx translate the rotary motion of a shaft into either a two or three channel digital output.

The HEDS-65xx uses one of the standard HEDS-9000 or HEDS-9040 modules for encoding purposes. The HEDL-654x uses the standard HEDL-9040 for encoding purposes.

As seen in the block diagram, these modules contain a single Light Emitting Diode (LED) as their light source (emitter). The light is collimated into a single parallel beam by means of a plastic lens located directly over the LED. Opposite the emitter is the integrated detector circuit (detector). This circuit consists of multiple sets of photodetectors and the signal processing circuitry necessary to produce the digital waveforms.

The codewheel rotates between the emitter and detector, causing the light beam to be interrupted by a 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 into the signal processing circuitry resulting in A, $\overline{A}$, B, and $\overline{B}$ (I and $\overline{I}$ also in the three channel encoders). 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).

In the HEDS-6540 / HEDL-6540 the output of the comparator for the index pulse is combined with that of the outputs of channel A and channel B to produce the final index pulse. The index pulse is generated once every rotation of the codewheel and is a one state width (nominally 90 electrical degrees), true high index pulse. It is coincident with the low states on channels A and B.

Definitions

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

One Cycle (C): 360 electrical degrees (e), 1 bar and window pair.

One Shaft Rotation: 360 mechanical degrees, N cycles.

Position Error (ΔΘ): The normalized angular difference between the actual shaft position and the position indicated by the encoder cycle count.

Cycle Error (ΔC): An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

Pulse Width (P): The number of electrical degrees that an output is high during one 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.

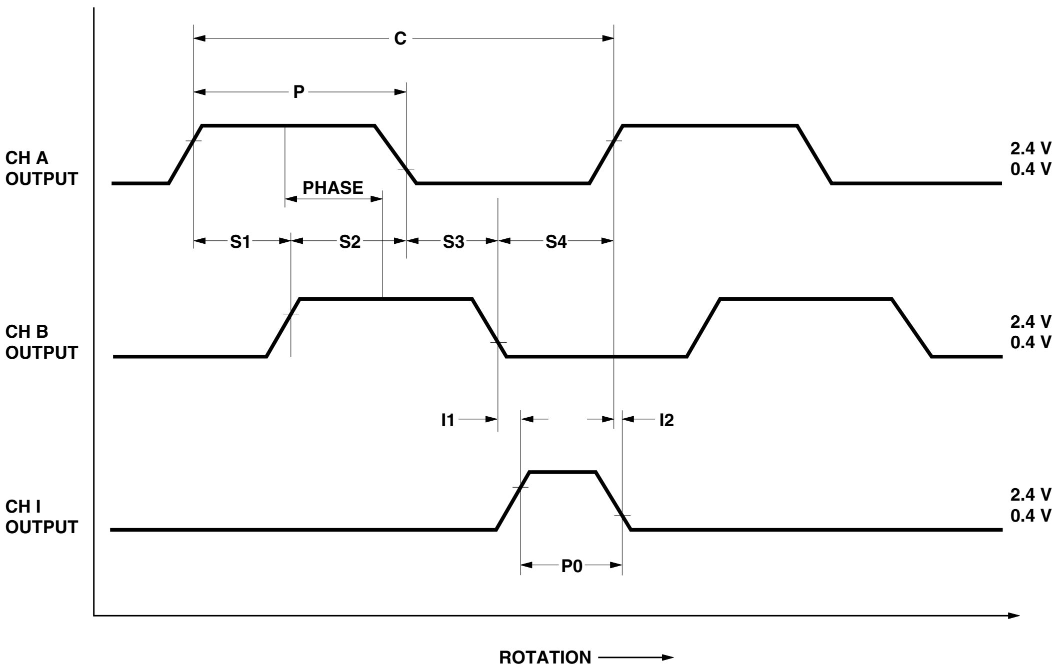
Phase (Φ): the number of electrical degrees between the center of high state on channel A and the center of the high state on channel B. This value is nominally 90 e for quadrature output.

Phase Error (ΔΦ): The deviation of the phase from its ideal value of 90 e.

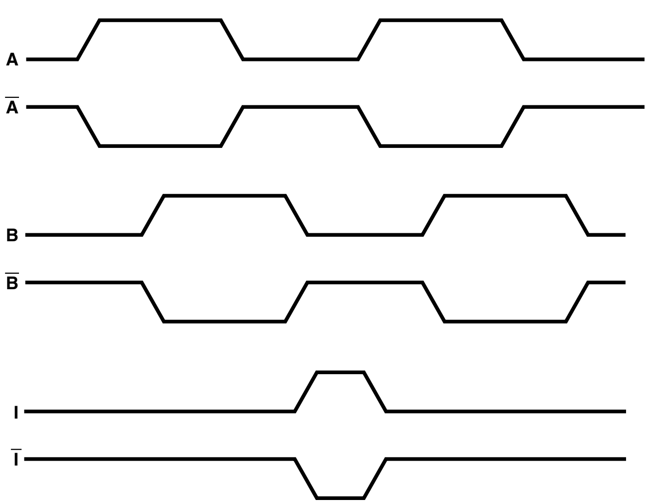
Direction of Rotation: When the codewheel rotates in a counterclockwise direction (when viewed from the encoder end of the motor) channel A will lead channel B. If the codewheel rotates in the clockwise direction channel B will lead channel A.

Index Pulse Width (P0): The number of electrical degrees that an index output is high during one full shaft rotation. This value is nominally 90 e or 1/4 cycle.

Output Waveforms



Waveforms for Encoders without Line Drivers.



Waveforms for Encoders with Line Drivers.

Absolute Maximum Ratings

Parameter	HEDS-6500	HEDS-6540	HEDL-6540	HEDL-6545	
Storage Temperature	-40 to +100	-40 to +100	-40 to +100	-40 to +100	Celsius
Operating Temperature	-40 to +100	-40 to +100	-40 to +100	-40 to +100	Celsius
Supply Voltage	-.5 to +7	-.5 to +7	-.5 to +7	-.5 to +7	Volts
Output Voltage	-.6 to Vcc	-.6 to Vcc	-.6 to Vcc	-.6 to Vcc	Volts
Output Current Per Channel	-1 to 5	-1 to 5			mA
Velocity	30,000	30,000	30,000	30,000	RPM
Vibration	20	20	20	20	Gs
Shaft Axial Play	5	5	5	5	Inch/1000
Radial Play & Eccentricity	2	2	2	2	Inch/1000

Recommended Operating Conditions

Parameter	HEDS-6500	HEDS-6540	HEDL-6540	HEDL-6545	
Temperature	-40 to +100	-40 to +100	-40 to +100	-40 to +100	Celsius
Supply Voltage	4.5 to 5.5	4.5 to 5.5	4.5 to 5.5	4.5 to 5.5	Volts
Load Capacitance	100	100	100	100	pF
Count Frequency	100	100	100	100	kHz
Shaft Eccentricity Plus Radial Play	±.05 (±.002)	±.05 (±.002)	±.05 (±.002)	±.05 (±.002)	mm (Inch/1000)

Note: The HEDS-65XX performance is guaranteed to 100 kHz but can operate at higher frequencies. For frequencies above 100 kHz it is recommended that the load capacitance not exceed 25 pF and pull up resistors of 3.3 kΩ between the output channels and Vcc are included.

Encoding Characteristics

Encoding Characteristics over Recommended Operating Range and Recommended Mounting Tolerances unless otherwise specified. Values are for the worst error in the full rotation.

Part Number	Description	Symbol	Min.	Typ.*	Max.	Units
HEDS-6500***	Pulse Width Error	ΔP		5	35	°e
	Logic State Width Error	ΔS		5	35	°e
	Phase Error	ΔΦ		2	15	°e
	Position Error	ΔΘ		7	20	min. of arc
	Cycle Error	ΔC		5	5.5	°e
HEDS-6540**	Pulse Width Error	ΔP		5	35	°e
	Logic State Width Error	ΔS		5	35	°e
	Phase Error	ΔΦ		2	15	°e
	Position Error	ΔΘ		7	20	min. of arc
	Cycle Error	ΔC		5	5.5	°e
	Index Pulse Width	ΔP0	55	90	125	°e
	CH I fall after CH B or CH A fall					
	-25°C to +100°C	t1	10	100	250	ns
	-40°C to +100°C	t1	-300	100	250	ns
	CH I rise after CH B or CH A rise					
	-25°C to +100°C	t2	70	150	300	ns
	-40°C to +100°C	t2	70	150	1000	ns
HEDL-654x	Pulse Width Error	ΔP		5	35	°e
	Logic State Width Error	ΔS		5	35	°e
	Phase Error	ΔΦ		2	15	°e
	Position Error	ΔΘ		7	20	min. of arc
	Cycle Error	ΔC		5	5.5	°e
	Index Pulse Width	ΔP0		90		°e

*Typical values specified at Vcc = 5.0 V and 25°C.
**HEDS-6540 – Active high Index part. Pull-up of 2.7 kΩ used on all outputs of modules that do not have a line driver.
***HEDS-6500 – 3.3 kΩ pull-up resistors used on all encoder module outputs.

Electrical Characteristics

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

Part Number	Symbol*	Min.	Typ.	Max.	Units	Notes
HEDS-6500	Icc		17	40	mA	
	V_{OH}	2.4			V	I_{OH} = -40 µA max
	V_{OL}			0.4	V	I_{OL} = 3.2 mA
	tr		200		ns	C_L = 25 pF, RL = 11 kΩ pull-up.
	tf		50		ns	
HEDS-6540	Icc	30	57	85	mA	
	V_{OH}	2.4			V	I_{OH} = -200 µA max
	V_{OL}			0.4	V	I_{OL} = 3.86 mA
	tr		180		ns	C_L = 25 pF, RL = 3.3 kΩ pull-up.
	tf		40		ns	

*Explanation for symbols.

Icc – Supply current, V_{OH} – High Level Output Voltage, V_{OL} – Low Level Output Voltage, tr – Rise Time, tf – Fall Time.

Electrical Interfaces

To insure reliable encoding performance, the HEDS-6540 three channel encoder requires 2.7 kΩ pull-up resistors to the supply voltage on each of the three output lines Ch. A, Ch. B, and Ch. I located as close as possible to the encoder

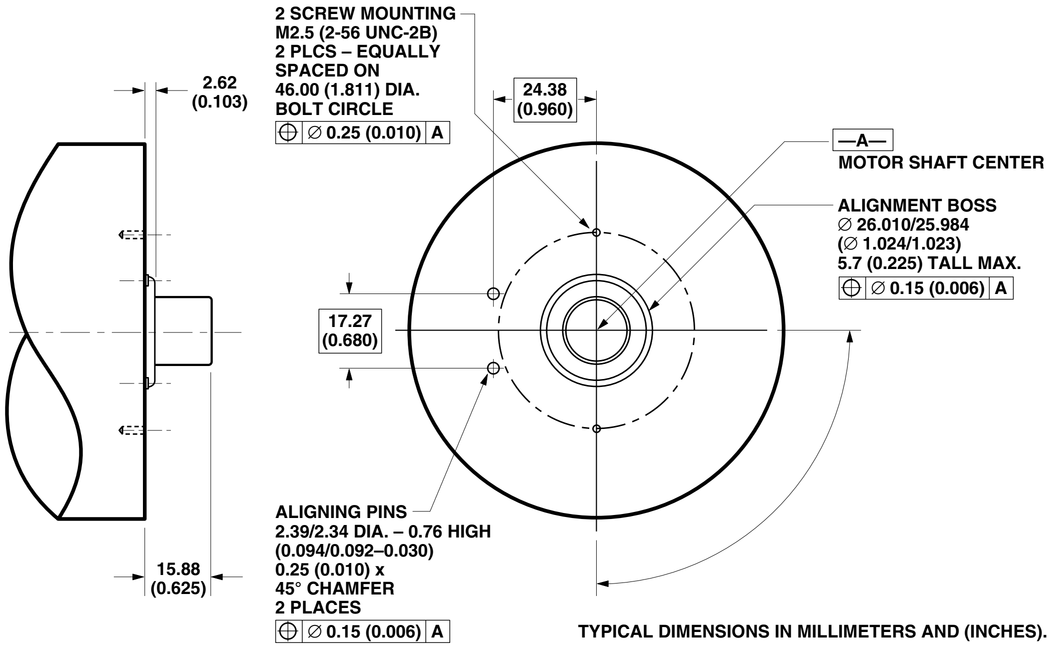
Mechanical Characteristics

Parameter	Symbol	Dimensions	Tolerances [1]	Units
Moment Of Inertia	J	7.7 (110 x 10^{-6})		gcm^2 ($oz\text{-}in\text{-}s^2$)
Required Shaft Length [2]		15.9 (0.625)	±0.6 (.024)	mm (inches)
Bolt Circle [3]		46.0 (1.811)	±0.13 (.005)	mm (inches)
Mounting Screw Size [4] Pan Head Style		2.5 x 0.45 x 5 #2-56 x 3/16		mm Inches
Encoder Base Plate Thickness		3.04 (120)		mm (inches)
Mounting Screw Torque		1.0 (0.88)		Kg (in-lbs)
Hub Set Screw		UNC #2-56		Hex head set screw

Notes:
1. These are tolerances required of the user.
2. Through hole in the encoder housing are also available, for longer shafts.
3. The HEDL-65X0 must be aligned using the aligning pins as specified in the section on "MOUNTING CONSIDERATIONS."
4. The recommended mounting screw torque for 2 screws is 1.0 Kg (0.88 in-lbs).

Mounting Considerations

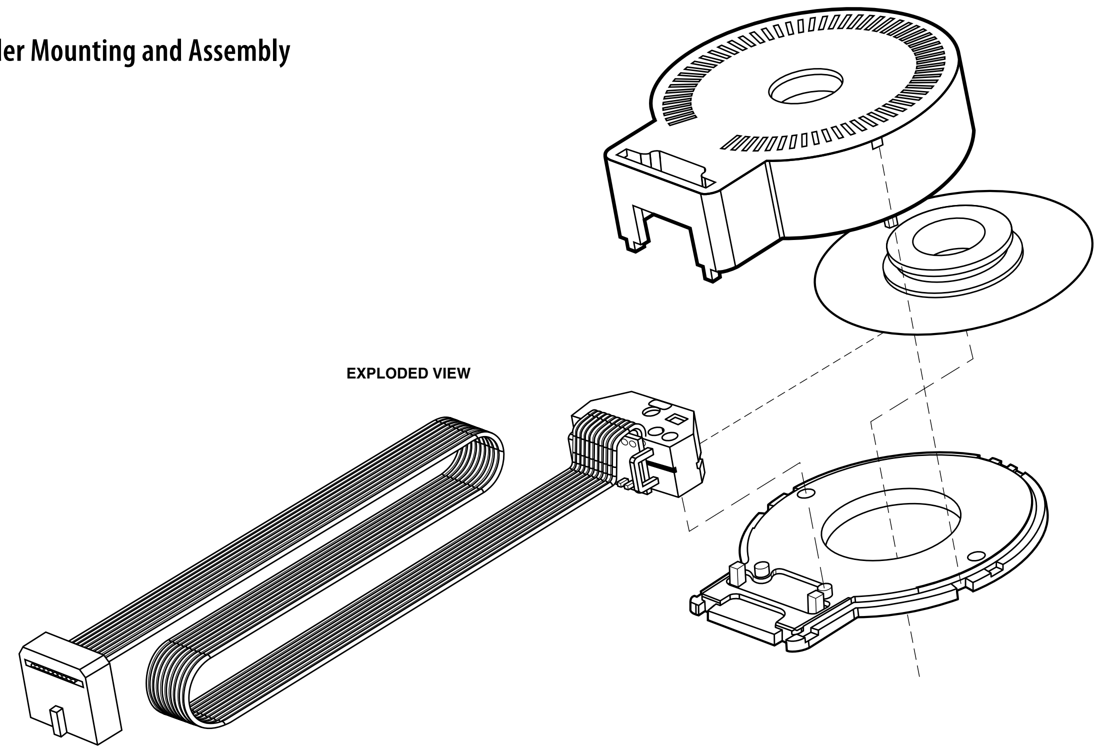
The HEDS-654x/HEDL-654x must be aligned with respect to the optical center (codewheel shaft) as indicated in the following figure.



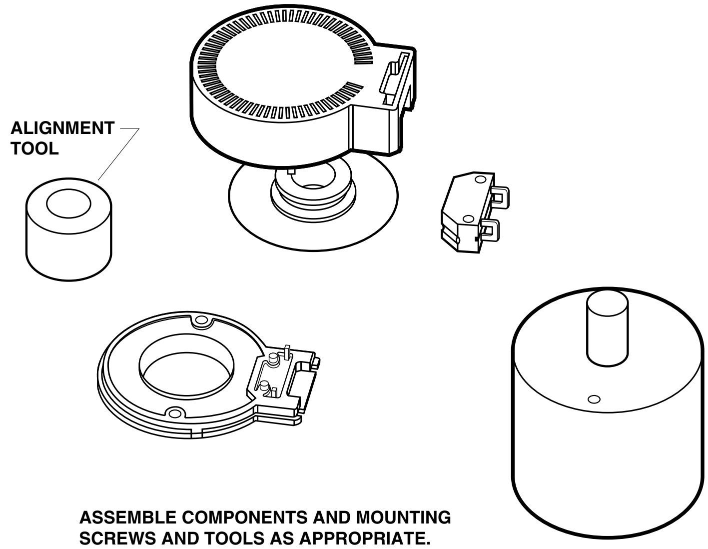
If neither locating pins nor locating boss are available, then a centering tool supplied by Avago can be used (HEDS-6510).

The following figure shows how the main encoder components are organized.

Encoder Mounting and Assembly

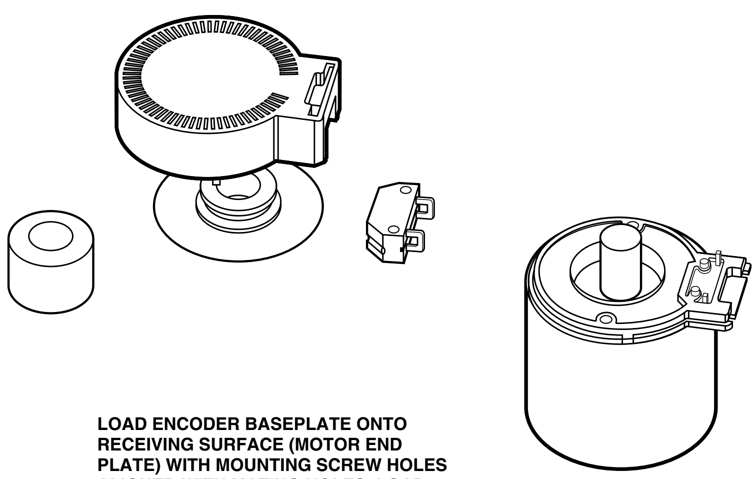


1



ASSEMBLE COMPONENTS AND MOUNTING SCREWS AND TOOLS AS APPROPRIATE.

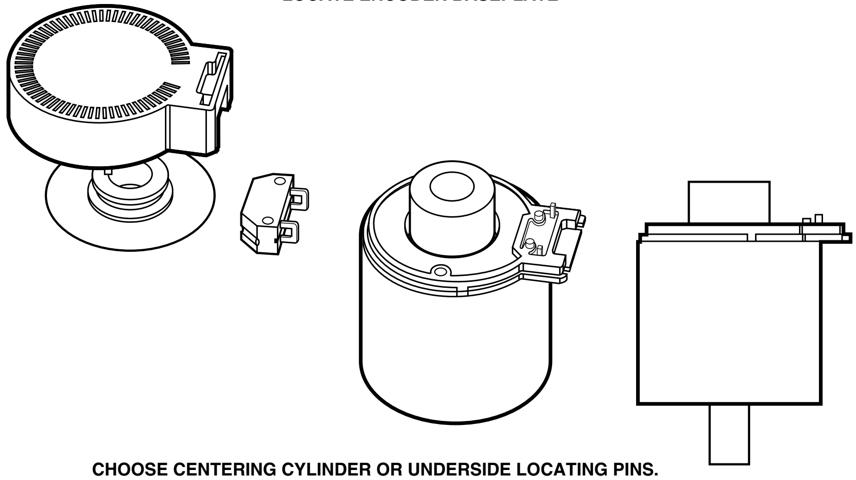
2



LOAD ENCODER BASEPLATE ONTO RECEIVING SURFACE (MOTOR END PLATE) WITH MOUNTING SCREW HOLES ALIGNED WITH MATING HOLES. LOAD MOUNTING SCREWS AND LEAVE SLIGHTLY LOOSE.

3

LOCATE ENCODER BASEPLATE



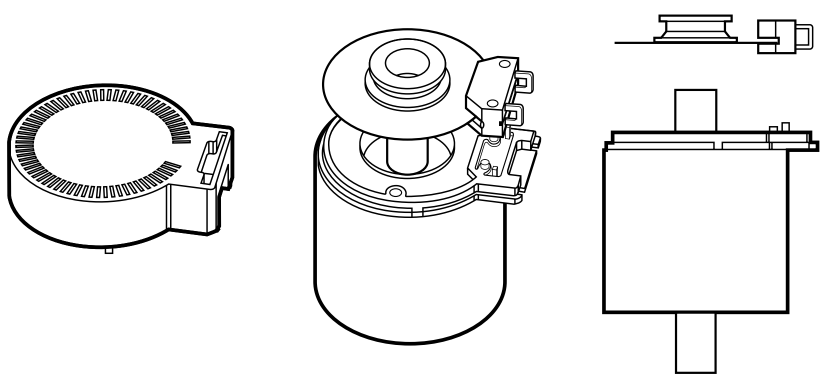
CHOOSE CENTERING CYLINDER OR UNDERSIDE LOCATING PINS.

CENTERING CYLINDER: LOCATE ENCODER BASEPLATE WITH CENTERING CYLINDER. WHEN IN PLACE, TIGHTEN MOUNTING SCREWS.

LOCATING PINS: WITH LOCATING PINS PROPERLY SEATED IN CORRESPONDING RECEIVING HOLES IN ENCODER BASEPLATE, TIGHTEN MOUNTING SCREWS.

4

LOCATE ENCODER MODULE AND CODEWHEEL

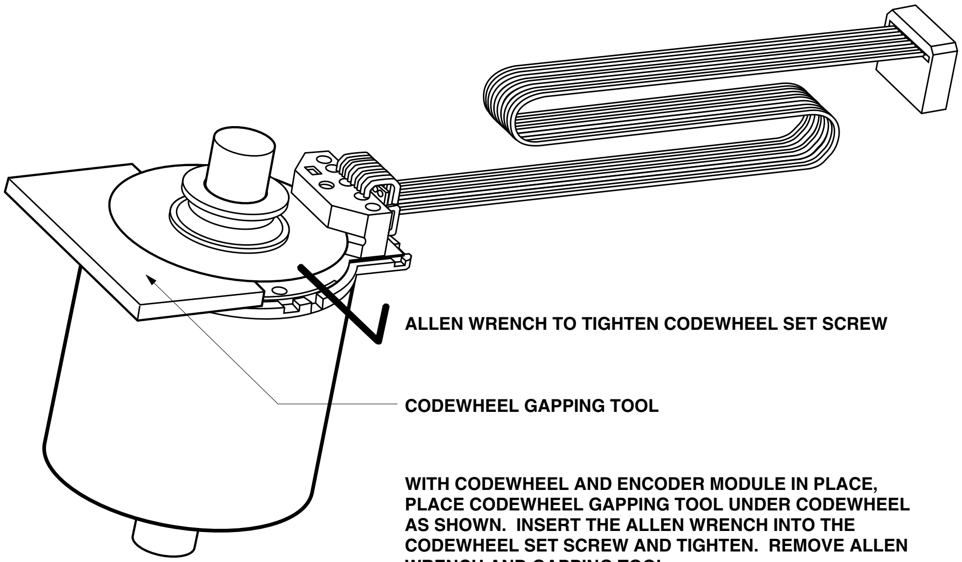


ALIGN ENCODER MODULE AND CODEWHEEL AS SHOWN.
BE CAREFUL NOT TO DAMAGE THE ENCODER INTERNAL COMPONENTS WITH THE CODEWHEEL.

BRING THE ENCODER MODULE AND CODEWHEEL DOWN SUCH THAT THE ENCODER MODULE LOCATING HOLES (ON ITS UNDERSIDE) MATE WITH THE BASEPLATE ROUND PINS. THE BASEPLATE SQUARE PINS SHOULD SEAT INTO THE ENCODER MODULE MOUNTING THRU HOLES.

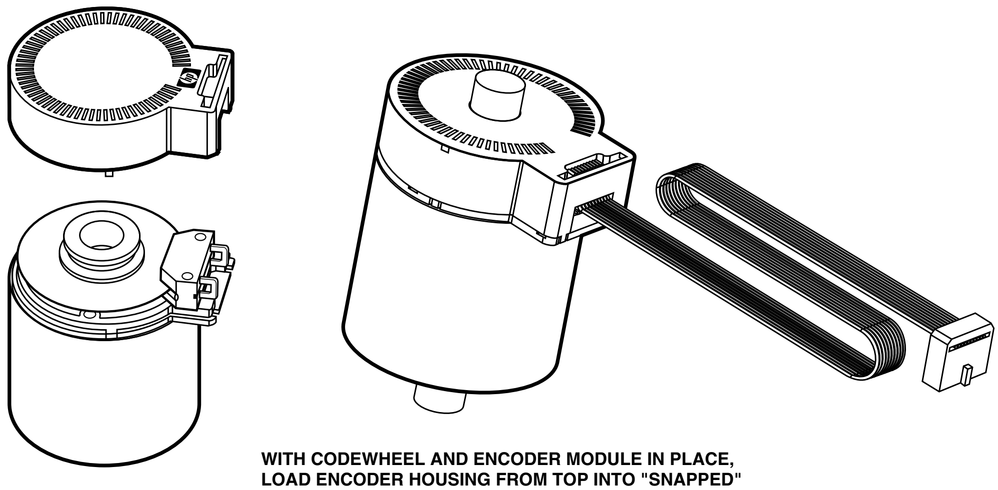
CONCURRENTLY, BRING THE CODEWHEEL DOWN ONTO THE MATING SHAFT.

5



WITH CODEWHEEL AND ENCODER MODULE IN PLACE, PLACE CODEWHEEL GAPPING TOOL UNDER CODEWHEEL AS SHOWN. INSERT THE ALLEN WRENCH INTO THE CODEWHEEL SET SCREW AND TIGHTEN. REMOVE ALLEN WRENCH AND GAPPING TOOL.

6



WITH CODEWHEEL AND ENCODER MODULE IN PLACE, LOAD ENCODER HOUSING FROM TOP INTO "SNAPPED" POSITION. INSURE THAT ANY CABLES FROM THE ENCODER MODULE ARE FOLDED DOWN SUCH THAT THEY EMERGE FROM THE BOTTOM OF THE HOUSING'S REAR RECTANGULAR PORT.

Ordering Information for 2CH and 3CH Encoder Modules

Encoders Metal Codewheel (up to 100°C)

HEDS - 65 [ ] [ ] OPTION [ ] [ ] [ ]

OUTPUTS
0 – 2 CH
4 – 3 CH

THROUGH HOLE
0 – None
5 – 13.3 mm (0.525 in.)

RESOLUTION (CYCLES/REV)
A = 500
B = 1000
J = 1024

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

		05	06	08	09	10	11	12	13
HEDS-6500#	**A**	*	*	*	*	*	*	*	*
	B	*	*	*	*	*	*	*	*
	J	*	*	*	*	*	*	*	*
HEDS-6505#	**A**								
	B				*	*			
	J				*				
HEDS-6540#	**A**	*	*	*	*	*	*	*	*
	B	*	*	*	*	*	*	*	*
	J	*	*	*	*	*	*	*	*
HEDS-6545#	**A**			*		*			
	B			*					
	J		*		*				

Encoders Film Codewheel (up to 70°C)

HEDM – 65 [ ] [ ] OPTION [ ] [ ] [ ]

OUTPUTS
0 – 2 CH
4 – 3 CH

THROUGH HOLE
0 – None
5 – 13.3 mm (0.525 in)

RESOLUTION (CYCLES/REV)
T – 2000
U – 2048 2 CH only

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

		05	06	08	09	10	11	12	13
HEDM-6500#	**T**		*	*					
	U		*						*
HEDM-6505#	**T**		*	*					
	U								*
HEDM-6540#	**T**						*		*
HEDM-6545#	**T**								

Ordering Information for 2CH and 3CH Encoder Modules with Line Driver

Encoders with Metal Codewheel (up to 100°C)

HEDL - 65 [ ] [ ] OPTION [ ] [ ] [ ]

OUTPUTS	THROUGH HOLE	RESOLUTION (CYCLES/REV)	SHAFT DIAMETER
0 – 2 CH 4 – 3 CH	0 – None 5 – 13.3 mm (0.525 in.)	A = 500 B = 1000 J = 1024	08 – 3/8 in. 09 – 1/2 in. 10 – 5/8 in. 11 – 4 mm 12 – 6 mm 13 – 8 mm

		05	06	08	09	10	11	12	13
HEDL-6540#	**B**						*		*
HEDL-6545#	**B**				*				
	J		*	*	*				

Ordering Information for HEDS=76XX Centering Tools

HEDS-6510 Option 0 [ ] [ ]

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

		05	06	08	09	10	11	12	13
HEDS-6510	0	*	*	*	*	*	*	*	*

Ordering Information for HEDS-65XX Codewheel

Gapping Tool

HEDS-6511

For product information and a complete list of distributors, please go to our website: **www.avagotech.com**

AV02-0991EN January 30, 2008

HEDB-9100 and HEDB-9000

Two Channel Optical Incremental Encoder Modules Bundle With Codewheel

Data Sheet

Description

The HEDB-9100 and HEDB-9000 series are two channel optical incremental encoder modules offered with a codewheel. When used with a codewheel, these low cost modules detect rotary position. Each module consists 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 a unique photodetector array, these modules are extremely tolerant to mounting misalignment.

The HEDB-9100 and 9000 has two channel quadrature outputs.

The HEDB-9100 is designed for use with a HEDS-5120 codewheel which has an optical radius of 11.00 mm (0.433 inch).The HEDB-9000 is designed for use with a HEDS-6100 codewheel which has an optical radius of 23.36 mm (0.920 inch).

The quadrature signals and the single 5V supply input are accessed through five 0.025 inch square pins located on 0.1 inch (pitch) centers.

Features

- High Performance
- Resolution from 96 CPR Up To 1000 CPR (Counts Per Revolution)
- Low Cost
- Easy to Mount
- No Signal Adjustment required
- Small Size
- Operating Temperature: -40ºC to 100ºC
- TTL Compatible
- Two Channel Quadrature Output
- Single 5V Supply

Applications

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

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.

Theory of Operation

The HEDB-9100 and 9000 is emitter/detector modules. Coupled with a codewheel, these modules translate the rotary motion of a shaft into a two-channel digital output.

As seen in Figure 1, the modules contain 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 produce 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 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, Abar, B, Bbar. 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

Note: Refer to Figure 2

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

One Cycle (C): 360 electrical degrees (°e), 1 bar and window pair.

One Shaft Rotation: 360 mechanical degrees, N cycles.

Position Error (ΔΘ): The normalized angular difference between the actual shaft position and the position indicated by the encoder cycle count.

Cycle Error (ΔC): An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/N of a revolution.

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.

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

Direction of Rotation: When the codewheel rotates in the clockwise direction viewing from top of the module (direction from V to G), channel A will lead channel B. If the codewheel rotates in the opposite direction, channel B will lead channel A.

Optical Radius (Rop): The distance from the codewheel's center of rotation to the optical center (O.C) of the encoder module.

Specification

For encoder electrical, mechanical specifications, codewheel technical specifications and additional informations pls refer to :

- HEDS-9000 /9100 Datasheet.
- HEDS/HEDG/HEDM – 51xx /61xx Codewheel Datasheet

Block Diagram

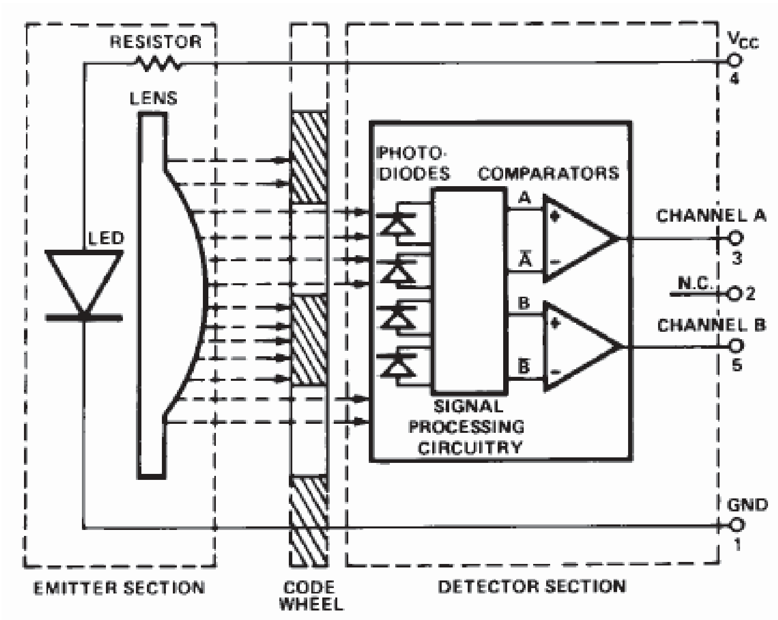


Figure 1. Block Diagram

Output Waveforms

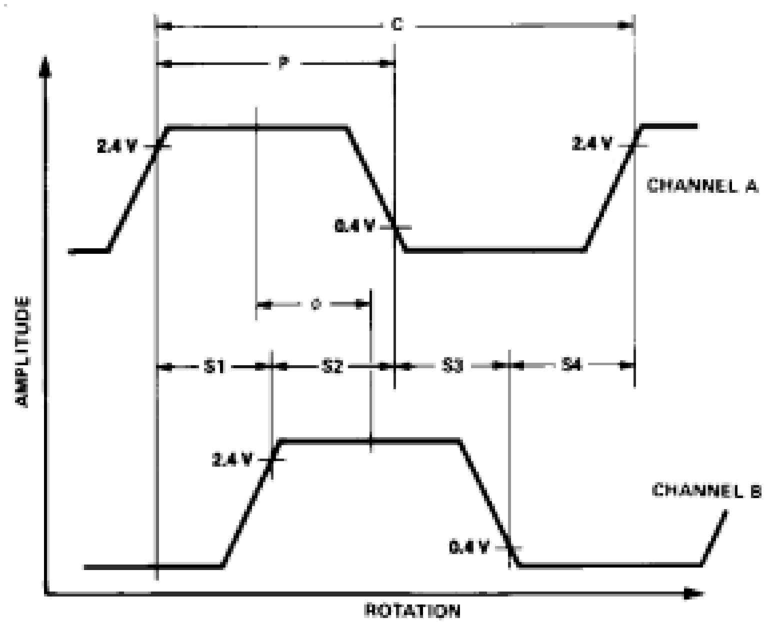


Figure 2. Output waveforms

Ordering Information

Three Channel Encoder Modules with Codewheel, 11 mm and 23.36 Optical Radius

HEDB - 9 [ ] 00 - [ ] [ ][ ]

Codewheel Rop

0 - 23.36 mm
1 - 11.00 mm

Resolutions (Cycle/Rev)

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

Shaft Diameter

01 - 2mm
02 - 3mm
03 - 1/8 in
04 - 5/32 in
05 - 3/16 in
06 - 1/4 in
08 - 3/8 in
09 - 1/2 in
10 - 5/8 in
11 - 4mm
12 - 6mm
13 - 8mm
14 - 5mm

Available Options

Part Number	CPR	Shaft Diameter Options												
		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDB-9100	K		•										•	
	C		•				•				•	•	•	•
	E						•					•		
	G		•	•		•	•				•			•
	H		•			•	•				•	•	•	•
	A	•	•	•	•	•	•				•	•		•
	I		•		•		•				•	•	•	

Part Number	CPR	Shaft Diameter Options												
		01	02	03	04	05	06	08	09	10	11	12	13	14
HEDB-9000	A								•			•	•	
	B						•	•	•	•				

Bundle Part Number Breakdown List

Note :
The bundle part HEDB-9100/9000 consists of HEDS-9100/9000 and HEDS-5120/6100.
The diagram below provides the breakdown list.

HEDB - 9100 - [CPR] [Shaft Diameter]

- Encoder Module : HEDS-9100 - [CPR] 00
- Codewheel : HEDS - 5120 - [CPR] [Shaft Diameter]

HEDB - 9000 - [CPR] [Shaft Diameter]

- Encoder Module : HEDS-9000 - [CPR] 00
- Codewheel : HEDS - 6100 - [CPR] [Shaft Diameter]

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

5989-4045EN - May 29, 2006