

Motion Type:	Rotary
Usage:	Industrial
Output:	Incremental
Max. Resolution:	
Internal electronics:	192,000 counts/rev
External electronics:	480,000 counts/rev

## Series 825S / 825P Rotary Incremental Encoders



Standard Encoder,  
Above Standard  
Performance.

The Series 825 is a family of industrial-grade optical incremental encoders, available in two different models. They have the same mechanical and electrical features, but differ in performance and price.

The following features are common to both models:

- LED illumination for reliability
- Push-pull phototransistors for signal stability
- Optional zero index
- Combination synchro/face mount, or square-flange mount

- Medium-duty housing, or optional environmentally sealed housing
- Sealed ABEC Class 7 bearings for protection against contaminants
- Precise chrome-on-glass disc

*Two Models available:*

**Model 8125:** Resolution up to 8 times the line count on the disc

**Model 8225:** Dual reading heads for improved accuracy. Resolution up to 80 times the line count on the disc.



# SPECIFICATIONS

		SEE NOTE	MODEL 8125	MODEL 8225
Maximum line count on disc			6,000	
Max cycles/rev with internal electronics			12,000	48,000
Max counts/rev (after quad edge detection)			48,000	192,000
Max cycles/rev with external electronics		5	N/A	120,000
Max counts/rev with external electronics (after quad edge detection)		5	N/A	480,000
Instrument error, ± arcsec		1,2	45	20
Quadrature error, ± electrical degrees		1,3	30	24
Interpolation error, ± quanta		1,4	0.15	0.10
FREQUENCY RESPONSE	1x square waves		100	
	2x square waves		150	
	5x square waves		N/A	300
	8x square waves		N/A	500
	Up to 20x square waves	5	N/A	1000
Maximum weight, oz (g)			20 (565)	
Starting torque, in-oz (N-m) [at 20°C]			2.0 (14.0 x 10 <sup>-3</sup> )	
Running torque, in-oz (N-m) [at 20°C]			1.0 (7.0 x 10 <sup>-3</sup> )	
Moment of inertia, in-oz-s <sup>2</sup> (g-cm <sup>2</sup> )			9.0 x 10 <sup>-4</sup> (63.2)	
Maximum acceleration, rad/s <sup>2</sup>			2 x 10 <sup>6</sup>	
Operating temperature range, °F (°C)			32 to 158 (0 to 70)	
Storage temperature range, °F (°C)			0 to 160 (-18 to 71)	
Humidity, % RH non-condensing			98	
Shock			50 g, 11 ms	
Vibration			15 g, 0-2000 Hz	

NOTES:

- Total Optical Encoder Error* is the algebraic sum of *Instrument Error + Quadrature Error + Interpolation Error*. Typically, these error sources sum to a value less than the theoretical maximum. Error is guaranteed at 20°C and is defined at the signal transitions. It does not include quantization error, which is ±1/2 quantum. ("Quantum" is the final resolution of the encoder, after user's 1x, 2x or 4X quadrature decode.)
- Instrument Error* is the sum of disc pattern errors, disc eccentricity, bearing runout and other mechanical imperfections within the encoder. This error tends to vary slowly around a revolution.
- Quadrature Error* is the combined effect of phasing and duty cycle tolerances and other variables in the basic analog signals. This error applies to data taken at all four transitions within a cycle; if data are extracted from 1X square waves on a 1X basis (i.e., at only one transition per cycle), this error can be ignored.  

$$\text{Error in arcseconds} = (3600) \times (\text{error in electrical degrees}) / (\text{disc line count})$$
- Interpolation Error* is present only when the resolution has been electronically increased to more than four data points per optical cycle. It is the sum of all the tolerances in the electronic interpolation circuitry.  

$$\text{Error in arcseconds} = (1296000) \times (\text{error in quanta}) / (\text{counts/rev})$$
- With external Model HR2A High Resolution Electronics. Frequency response is as stated for output signals, or 50 kHz at the disc, whichever is limiting.

**As part of our continuing improvement program, these specifications are subject to change without notice.**

## EXTENDED RESOLUTION

The series 825 offers resolution up to 192,000 counts/rev (6.75 arcsec/count) after 4x quadrature edge detection. If finer resolution is required (up to 480,000 counts/rev, or 2.7 arcsec/count), the HR2A external electronics package provides a wide range of options that ensures compatibility with virtually all commercially available counter circuits, dedicated encoder interface cards and programmable logic controllers:

- Any number of quadrature square waves from 1 to 20 times the line count on the disc
- Fixed-duration pulses at 1, 2 or 4 times any integer from 1 to 20
- A choice of CW/CCW or PULSE/DIRECTION output pulse format
- A zero-index (reference) signal in either gated 1/2 cycle, gated 1/4 cycle, or fixed duration pulse format
- EIA/RS-422 or open collector line drivers
- On-board low-dropout voltage regulator

Refer to the HR2A data sheet for full details.

## SERIES 825P

The series 825P is identical to the Series 825S, except that it incorporates a precision-hobbed pinion as an integral part of the encoder shaft; this improves accuracy by eliminating eccentricity and other errors that result from attaching a separate pinion. The pinion shaft is made from hardened 416 stainless steel to minimize wear. The pinion mates with a 10-tooth-per-inch rack, and traverses exactly one inch per revolution. An optional flex-mount bracket keeps the pinion spring-loaded into the rack to virtually eliminate backlash.

The salient benefits of a rack-and-pinion system include good tolerance to misalignments, virtually unlimited measuring length, high resolution, long life and relative insensitivity to contamination. Please refer to the Rack-and-Pinion data sheet for system specifications.

## ELECTRICAL CONNECTIONS

Wire Colors (Connector Code P)	Pin # MS3102E-18-1P (Connector Code M or A)	Buffered Sine Wave Output (Output Code B)	Square Wave Output (Output Code C, F, L, T)		Pulse Output (Output Code P)
			Connector Code M or P	Connector Code A	
Yellow	A	Sin	A	A	CW
Brown	B		$\bar{A}$	B	$\bar{CW}$
Green	C	Cos	B	IND	CCW
Orange	D		$\bar{B}$	+V	$\bar{CCW}$
Blue	E	Index	IND		IND
White	F		$\bar{IND}$	Common	$\bar{IND}$
	G			Case	
Gray	H	Case	Case	$\bar{A}$	Case
Red	I	+V	+V	$\bar{B}$	+V
Black	J	Common	Common	$\bar{IND}$	Common

Pin # DA-15P (Connector Code Q)	Pin # DE-9P (Connector Code S)	Buffered Sine Wave Output (Output Code B)	Square Wave Output (Output Code C, F, L, T)	Pulse Output (Output Code P)
1	6		$\bar{IND}$	$\bar{IND}$
2	2		IND	IND
4	7	+V	$\bar{B}$	CW
5	3	Index	B	$\bar{CW}$
7	8		A	CCW
8	4	Case	A	CCW
9	1	Sin	Case	Case
10	5		+V	+V
11		Cos		
13	9		Common	Common
14			Shield	Shield
15		Common		

**NOTES:**

1. Channel B (Cos) leads Channel A (Sin) for CW shaft rotation, viewed from shaft end
2.  $\bar{A}$ ,  $\bar{B}$ , and  $\bar{IND}$  are provided with line driver outputs only (Output Code L).
3. Connector code S is not available with buffered sinusoid output
4. Shield is not connected at the encoder.

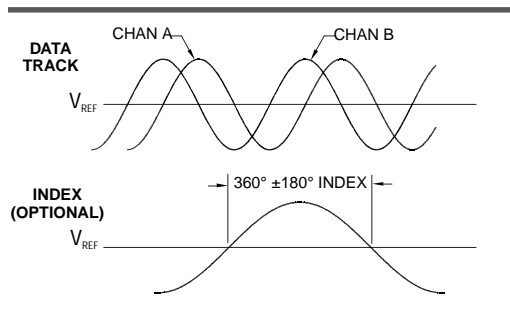
## BEARING LIFE RATINGS/HOURS

Speed (rpm)	Radial Load at End of Shaft, Pounds			
	5	15	30	50
100	1,730,000	726,000	164,000	36,000
200	865,000	363,000	82,000	18,000
500	346,000	145,000	33,000	7,100
1,000	173,000	72,600	16,400	3,600
2,000	86,500	36,300	8,200	1,800
5,000	34,600	14,500	3,300	710
10,000	17,300	7,300	1,640	360

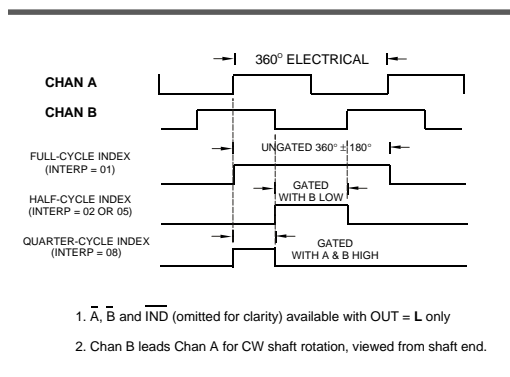
The table gives bearing life as a function of speed and radial load at the end of the shaft, based on fatigue failure criteria. In many long-duration applications, lubrication retention becomes the determining factor.

When high radial shaft loads are applied to an encoder with a high line count on the disc, the encoder may not meet the stated quadrature tolerance. Please consult the factory if your application requires this combination.

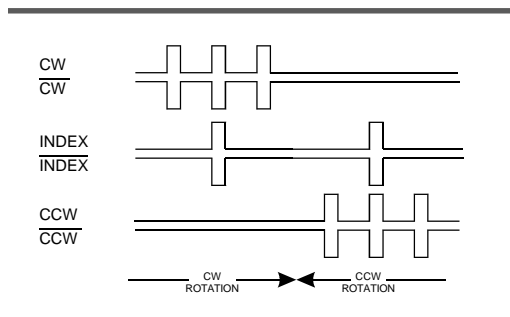
## SINUSOIDAL OUTPUT



## SQUARE WAVE OUTPUT



## PULSE OUTPUT



## POWER SUPPLY OPTIONS

$V_{CC} = +5.0 \text{ VDC} \pm 0.25 \text{ V} @ 225 \text{ mA max}$ ,  
 or  $V_{CC} = 7 \text{ to } 15 \text{ VDC} @ 225 \text{ mA}$  (available  
 with power buffer or line driver options).

## SINUSOIDAL OUTPUT OPTION

This option provides quadrature sinusoids  
 at the same spatial frequency (cycles/rev)  
 as the line count on the disc. At lower  
 line counts, the signals tend to be more  
 trapezoidal than sinusoidal.

## BUFFERED SINUSOIDS

(OUT INTERP = **B01**)

The output device is an op amp  
 referenced to  $(50\% \pm 3\%) \times V_{CC}$ . Typical  
 signal values at 1 kHz with 4.7 k $\Omega$  load to  
 ground (20°C).

- P-P signal amplitude, data channels:  
 $1.0 \pm 0.1 \text{ V}$
- Amplitude ratio, min chan to max chan:  
 $.90 \text{ to } 1.00$
- P-P signal amplitude, index channel:  
 $0.7 \pm 0.3 \text{ V}$

## PULSE OUTPUT OPTIONS

All pulse outputs are direction-sensed  
 (CW pulses and CCW pulses are on  
 different terminals). The output device is  
 an EIA/RS-422 balanced differential line  
 driver protected to survive an extended-  
 duration short circuit across its output.  
 Pulse width is  $0.4 \pm 0.1 \mu\text{s}$ . The index  
 pulse is gated so that it always occurs  
 simultaneously with a specific data pulse.  
 The maximum output pulse rate is 650  
 kHz, based on maintaining adequate  
 separation between pulses; however, the  
 frequency response of the square waves  
 from which the pulses are generated is  
 often the limiting factor in determining  
 maximum encoder speed. Available with  
 either 5 V or 7-15 V encoder power input.

## 1x, 2x, 4x or 8x PULSES

(OUT INTERP = **P01, P02, P04** or **P08**)

Available on both models. Pulses are at  
 1, 2, 4 or 8 times the line count on the  
 disc.

## 5x, 10x, or 20x PULSES

(OUT INTERP = **P05, P10**, or **P20**)

Available on Models 8225 only. Pulses  
 are at 5, 10 or 20 times the line count on  
 the disc

## QUADRATURE SQUARE WAVE OUTPUT OPTIONS

1x or 2x Square Waves  
 Available on both models. Square  
 waves are at the same or twice the  
 spatial frequency (cycles/rev) as the disc  
 line count.

5x or 8x Square Waves  
 Available on Model 8225 only. Square  
 wave spatial frequency is five or eight  
 times the disc line count.

## 1x SQUARE WAVES, TTL COMPATIBLE

(OUT INTERP = **T01**)

Output device is LM339 voltage  
 comparator with internal 2.2k $\Omega$  pull-up  
 resistor.

$$TTL \text{ Fanout} = 5 \quad V_{OH} \geq V_{CC} - 0.25V$$

$$I_{SINK} = -8 \text{ mA} \quad V_{OL} \leq 0.8 \text{ V}$$

## 2x SQUARE WAVES, TTL COMPATIBLE

(OUT INTERP = **T02**)

Output device is high-speed CMOS logic  
 gate. Max rating:

$$I_o = \pm 25 \text{ mA} (V_o = 0 \text{ to } V_{CC})$$

## 1x SQUARE WAVES, OPEN COLLECTOR

(OUT INTERP = **C01**)

Output device is LM 339 voltage  
 comparator with open collector output  
 transistor. Outputs are pulled up to + 5  
 VDC with internal 10 k $\Omega$  resistor.  
 Customer may provide external pull-up  
 as desired, within rating of LM339.

$$V_{COH} \leq + 36 \text{ V} \quad I_{COL} \leq 16 \text{ mA}$$

## 1x, 2x, 5x OR 8x SQUARE WAVES, LINE DRIVER

(OUT INTERP = **L01, L02, L05** or **L08**)

The output device is an EIA/RS-422  
 balanced differential line driver protected  
 to survive an extended-duration short  
 circuit across its output.

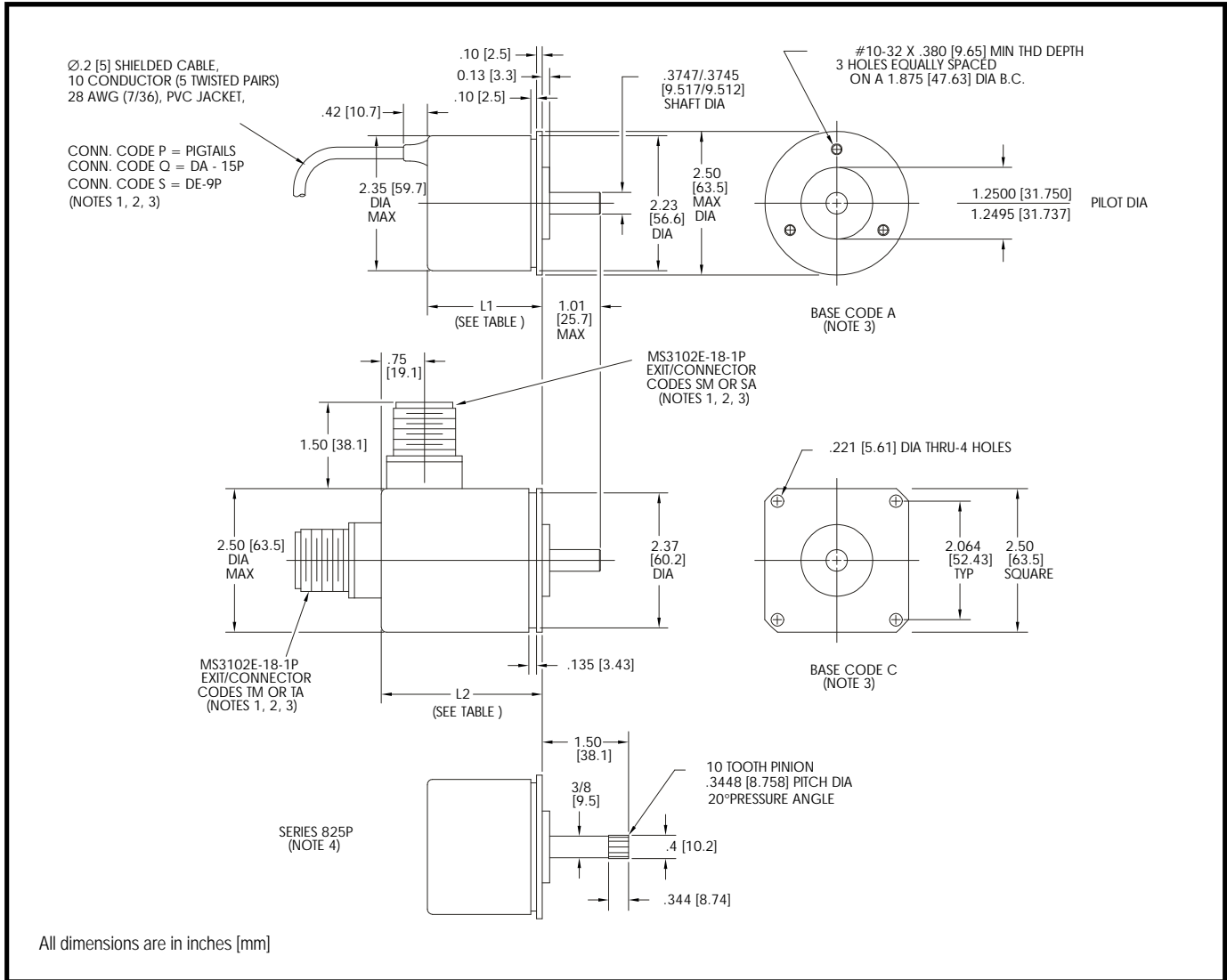
## 1x, 2x SQUARE WAVES, POWER BUFFER

(OUT INTERP = **F01** or **F02**)

Output device is 2N3725 driver  
 transistor. Outputs are pulled up to  
 supply voltage with an internal 10 k $\Omega$   
 resistor. Customer may provide external  
 pull-up as desired, within the range of the  
 output device.

$$V_{COH} \leq + 40 \text{ V} \quad I_{COL} \leq 200 \text{ mA}$$

# DIMENSIONS



## ENCODER LENGTH

L1	L2	OUTPUT INTERP. CODES
2.30 [58.4]	2.45 [62.2]	<b>B01, C01, F01, F02, L01, L02</b> <b>T01, T02, P01, P02, P04, P08</b>
2.65 [67.3]	2.80 [71.1]	<b>L05, L08</b> <b>P05, P10, P20</b>

## NOTES:

1. Mating connector is optional. Order **M01** to mate with connector code **Q**, **M02** for connector code **A** or **M**, or **M06** for connector code **S**.
2. With connector codes **P**, **Q** and **S**, the cover is drawn aluminum can. With connector code **M** and **A**, the cover is a rugged aluminum extrusion with an O-ring between the cover and the base.
3. Any connector code can be used with any base code.
4. See Rack-and-Pinion data sheet for rack details.

# ORDERING INFORMATION

MODEL	SHAFT -	LINES	IND	-	V	OUT	INTERP -	BASE	CAB	EXIT	CONN	-	06E	SPEC

**MODEL**

- 8125 Standard accuracy
- 8225 High accuracy

**SHAFT** - Shaft type

- S Solid shaft
- P Pinion shaft

**LINES** - Disc line count

00036	00048	00100	00125	00127
00128	00200	00250	00300	00360
00400	00500	00512	00600	00635
00720	00900	01000	01024	01200
01250	01270	01500	01600	01800
02000	02048	02400	02500	02514
02540	02700	03000	03125	03175
03200	03240	03392	03600	04000
04050	04096	04200	04500	05000
05400	06000			

*Consult factory for other line counts*

**IND** - Index format

- F Full cycle ungated (INTERP = 01)
- H Half cycle gated (INTERP = 02, 05)
- Q Quarter cycle gated (INTERP = 08)
- P Pulse index (OUT = P)
- N None

**V** - Input voltage

- 5 5 volts dc
- R 7-15 volts dc (OUT = F, L or P)

**OUT** output format

- B Buffered sinusoids (INTERP = 01)
- C Open collector (single-ended sq. waves) (INTERP = 01)
- F Power Buffer (single-ended sq. waves) (INTERP = 01, 02)
- L RS-422 differential line driver (INTERP = 01, 02, 05, 08)
- T Single-ended TTL (INTERP = 01, 02)
- P Pulses (cw and ccw)  
(INTERP = 01, 02, 04, 05, 08, 10, 20)

**SPECIAL CAPABILITIES**

For special situations, we can optimize catalog encoders to provide higher frequency response, greater accuracy, wider temperature range, reduced torque, non-standard line counts, or other modified parameters. In addition, we regularly design and manufacture custom encoders for user-specific requirements. These range from high-volume, low-cost, limited-performance commercial applications to encoders for military, aerospace and similar high-performance, high-reliability conditions. We would welcome the opportunity to help you with your encoder needs.

**WARRANTY**

Gurley Precision Instruments offers a limited warranty against defects in material and workmanship for a period of one year from the date of shipment.

**INTERP** - Interpolation factor

- 01 With buff. sinusoid output
- 01, 02, 05, 08 With square wave output
- 01, 02, 04, 05, 08, 10, 20 With pulse output

**BASE** - Base type

- A Synchro/face mount
- C Square-flange mount

**CAB** - Cable length, inches (04-99)

- 18 Standard
- 00 With CONN code M, A or T

**EXIT** Cable exit or connector location

- S Side (CONN = M or A)
- T Top (CONN = P, Q, S, M, A or T)

**CONN** - Connector

- P Pigtails (no connector) (EXIT = T)
- Q DA-15P (EXIT = T)
- M MS3102E-18-1P (see wiring table)
- A MS3102E-18-1P (see wiring table)
- S DE-9P (EXIT = T)
- T Screw Terminals (use only with HDT; see separate Data sheet)

**SPEC** - Special code

- X To define non-standard features
- N No special features

**Accessories** (order separately)

- SCA-06E-XXE or M Shaft coupling  
(see separate data sheet)
- AX06399 Synchro cleats (see separate data sheet)
- M01 Mating connector for DA-15P
- M02 Mating connector for MS3102E-18-1P
- M06 Mating connector for DE-9P
- HDT Heavy-duty housing (see separate data sheet)
- ISC3N Interface card for IBM® PC

