



**OPTICAL ENCODERS**

- Eliminates Rotary Mechanical Contacts
- Accurate Resolution up to 128 Positions
- Logic Compatible
- Selects Menu or Display Items
- Includes Data Input Switch
- Up to 10 Million Trouble-Free Cycles

**MECHANICAL ENCODERS**

- Standard BCD and Multiple Code Outputs
- As Small as 1/2" Diameter
- Economical Means to Provide Code Output

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Optical and Mechanical Encoders

## QUADRATURE

All Grayhill encoders use quadrature output code, which is the same as a 2-bit, repeating gray code. Quadrature is the most popular and cost effective output format because only two detectors are required. However, quadrature can only be used in applications where incremental data is required. Absolute positioning is not possible because the code repeats every four positions. In other words, changes in the encoder in magnitude and direction can be determined, but the actual position of the encoder cannot. In most applications this is not a problem.

In a quadrature rotary optical encoder two detectors are used to provide outputs, "A" and "B". The code rotor either blocks the infrared light or allows it to pass to the detectors. As the shaft turns the rotor, the outputs change state to indicate position. The resulting output is two square waves which are 90° out of phase.

## OPEN COLLECTOR OUTPUT

The open collector output is typical of the Series 61B, 61C and 62, and is the simplest form of output available. The first step in interfacing with open collector outputs is to provide an external pull-up resistor from each output to the power source. These pull-up resistors provide the output with the high-state voltage when the phototransistor is "off".

In a phototransistor, base current is supplied when light strikes the detector, which effectively grounds the output. Typically, the detector is operated in saturation. This means sufficient light is provided to completely sink, or ground, all the current provided by the pull up resistor plus that of the interfacing electronics. In the logic high state, the light is sufficiently blocked by the rotor and the detector functions like an open circuit. The pull up resistor then provides sourcing current to the interfacing electronics. This "on" or "off" digital arrangement allows the open collector to interface with popular integrated circuit technologies such as TTL, TTL LS, CMOS, and HCMOS.

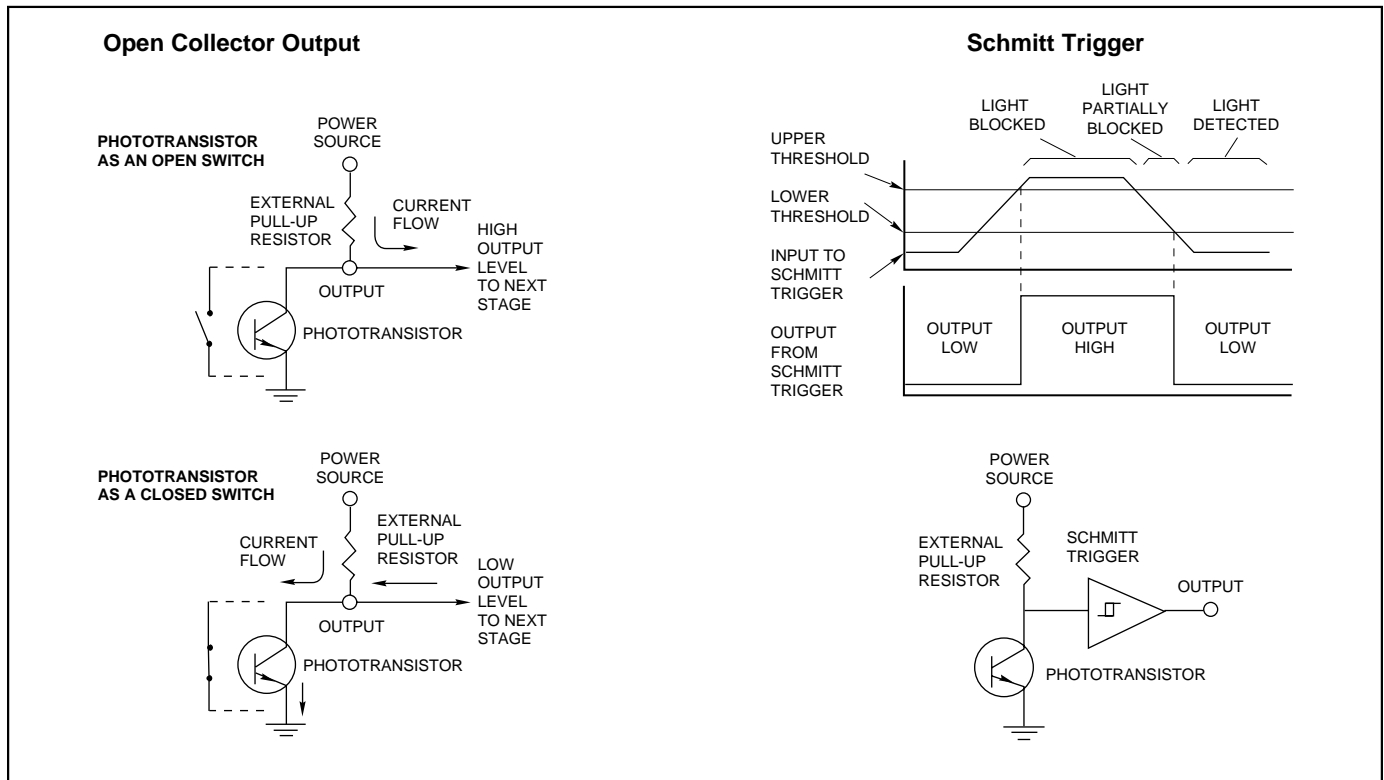
## SCHMITT TRIGGERS

To provide signal enhancement it is recommended that a Schmitt Trigger be connected to each output. This device is already included in the Series 61K and 61R encoder. The Schmitt Trigger "cleans up" the output into a pure digital signal. It does this by removing the small linear region between the "on" and "off" states of the detector. During this transition the light is only partially blocked and the output is somewhere between what the interfacing circuit might consider to be "on" or "off". In other words, the output is not completely digital. The Schmitt Trigger contains a very important feature which makes it attractive for this application. The

device has a higher threshold, or trigger level, when it is in the "on" state than it does in the "off" state. This hysteresis filters any electrical noise, which can cause the output to change state rapidly during the transition. And since the output from the Schmitt Trigger is a pure digital signal and is isolated from the phototransistor, the signal is basically immune to loading problems that can effect encoders without the Schmitt Trigger. Schmitt Triggers are available in most popular IC technologies.

## SHAFT AND PANEL SEAL

A shaft and panel seal are available to provide water-tight mounting for the Series 61B, 61D, 61K, 61R and 62 encoders. Sealing is accomplished by an o-ring shaft seal and a panel seal washer. The panel seal washer in the 61B and 61D encoders does not affect the overall dimensions of the switches. In the 61K and 61R encoders, the .045" thick washer is placed over the threads and sits flat on the base of the bushing. The 61KS and 61RS are also epoxy-sealed on the bottom of the switch to provide a completely sealed switch.



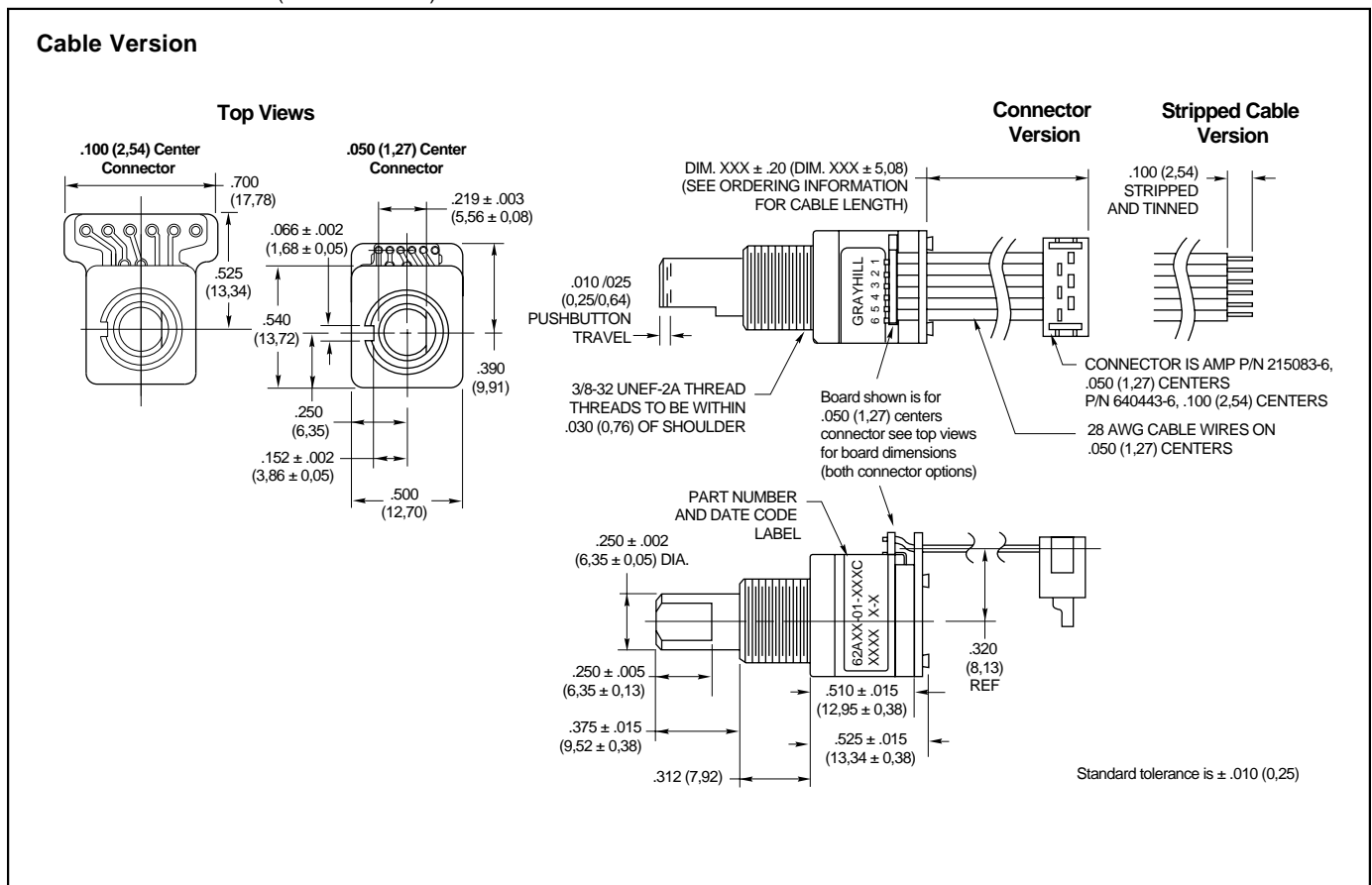
## SERIES 62A 1/2" Package

### FEATURES

- Low Cost
- Long Life
- Economical Size
- Optically Coupled for More than a Million Cycles
- With or Without Integral Pushbutton
- Compatible with CMOS, TTL and HCMOS Logic
- Available in 16, 20, 24 and 32 Detent Positions (Non-detent Also Available)
- Choices of Cable Length and Terminations
- Used to Set Radio Frequency, Drill Depth, RPM, Menu Selection, Parameter Selection for Patient Monitoring Devices, etc.

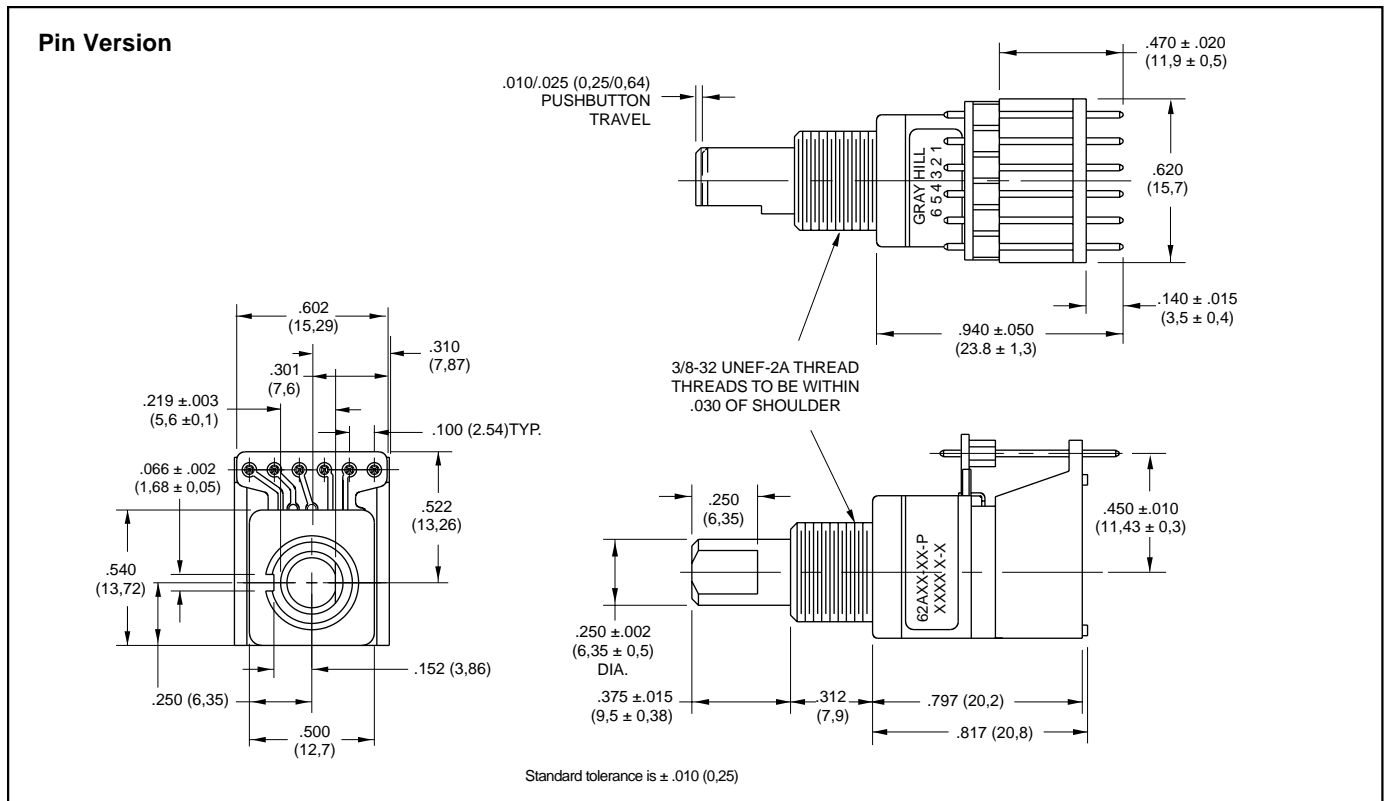


### DIMENSIONS In inches (and millimeters)

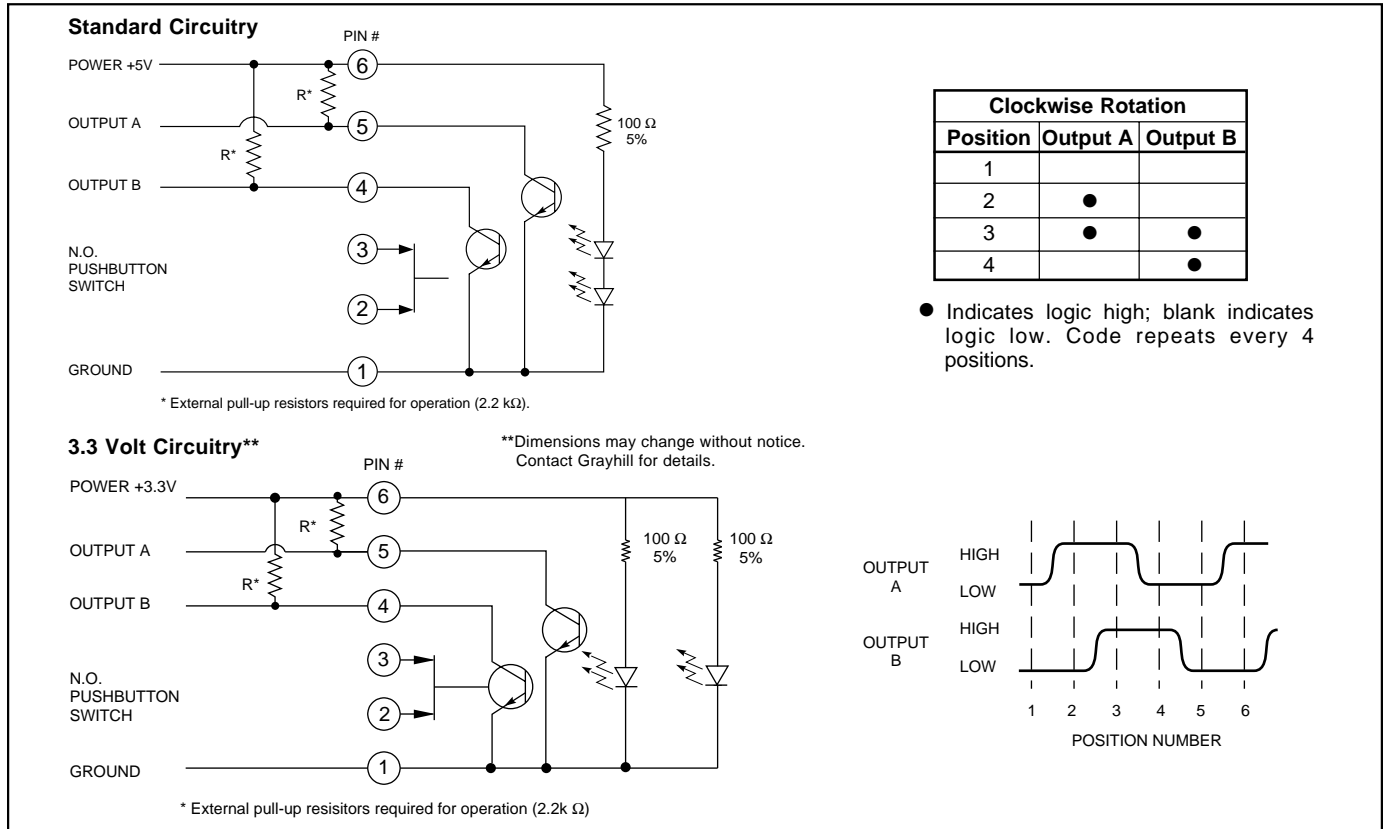




## DIMENSIONS In inches (and millimeters)



## CIRCUITRY, TRUTH TABLE, AND WAVEFORM STANDARD: Quadrature 2-Bit Code



**SPECIFICATIONS**

**Pushbutton Switch Ratings**

**Rating:** 5 Vdc and 3.3 Vdc, 10 mA, resistive  
**Contact Resistance:** less than 10 ohms (TTL or CMOS compatible).  
**Voltage Breakdown:** 250 Vac between mutually insulated parts.  
**Contact Bounce:** less than 4 mS at make and less than 10 mS at break  
**Actuation Life:** 3,000,000 operations  
**Actuation Force:** 1000 ± 300 grams

**Logic Rise and Fall Times:** less than 30 mS  
**Operating Torque:** 2.0 ±1.4 in-oz initially; less than 1.5 in-oz. for non-detent  
**Rotational Life:** 1,000,000 cycles of operation (1 cycle = 360° rotation and return)  
**Shaft Push Out Force:** 45 lbs minimum  
**Mounting Torque:** 15 in-lbs maximum  
**Operating Speed:** 100 RPM maximum  
**Axial Shaft Play:** .010 maximum

**Materials and Finishes**

**Bushing:** Zinc casting  
**Shaft:** Zinc or aluminum  
**Shaft Retaining Ring:** Stainless steel  
**Detent Spring:** Stainless steel  
**Printed Circuit Boards:** NEMA grade FR-4  
**Terminals:** Brass, tin-plated  
**Mounting Hardware:** One brass, nickel-plated nut and lockwasher supplied with each switch. Nut is 0.094 inches thick by 0.562 inches across flats  
**Rotor:** Thermoplastic  
**Code Housing:** Thermoplastic  
**Pushbutton Dome:** Stainless steel  
**Pushbutton Housing:** Thermoplastic  
**Pushbutton Contact:** Brass, nickel-plated  
**Dome Retaining Disk:** Thermoplastic  
**Strain Relief:** Stainless steel  
**Cable:** 28 AWG, stranded/top coated wire, PVC coated on .050 centers (cable version only)

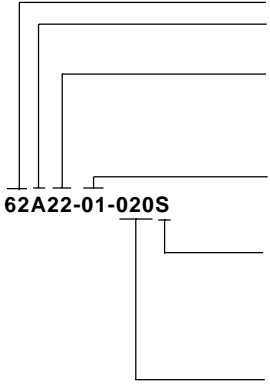
**Encoder Ratings**

**Coding:** 2-bit quadrature coded output  
**Operating Voltage:** 5.0 ±.250 Vdc  
 3.3 ±.125 Vdc  
**Supply Current:** 30 mA maximum at 5.0 Vdc  
 50 mA maximum at 3.3 Vdc  
**Logic High:** 3.8V minimum (5.0 Vdc)  
 2.3V minimum (3.3 Vdc)  
**Logic Low:** 0.8V maximum (5.0 Vdc)  
 0.8V maximum (3.3 Vdc)

**Environmental Ratings**

**Operating Temperature Range:** -40°C to 85°C  
**Storage Temperature Range:** -55°C to 100°C  
**Relative Humidity:** 90–95% at 40°C for 96 hours  
**Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204  
**Mechanical Shock:** Test 1: Tested at 100g for 6 mS, half sine, 12.3 ft/s Test 2: 100g for 6mS, sawtooth, 9.7 ft/s

**ORDERING INFORMATION**



**Series**  
**Style:** A = standard, V = standard w/3.3V input

**Angle of Throw:** (*detent*) 11 = 11.25° or 32 pos.  
 15 = 15° or 24 positions  
 18 = 18° or 20 positions  
 22 = 22.5° or 16 positions  
 (*non-detent*) 01 = 11.25° or 32 pos.  
 05 = 15° or 24 pos.  
 08 = 18° or 20 pos.  
 02 = 22.5° or 16 pos.

**Pushbutton Option:** 01 = w/o pushbutton, 02 = with pushbutton

**Termination:** S = stripped cable; .050" centers  
 SH = stripped cable; .100" centers  
 C = connector; .050" centers  
 CH = connector; .100" centers  
 P = pin w/.100" centers

**Cable Length:** 020 = 2.0 inches minimum to 250 = 25.0 inches maximum.  
 Provided in increments of 1/2 inch. Example 035 = 3.5", 060 = 6.0".  
*\*Eliminate cable length if ordering pins. (Ex: 62A22-02-P)*

Custom materials, styles, colors, and markings are available. Control knobs available, see page E-39.

**Available from your local Grayhill Distributor.** For prices and discounts, contact a local Sales Office, an authorized local Distributor, or Grayhill.

Optical and Mechanical Encoders

## SERIES 62C Concentric Shaft

### FEATURES

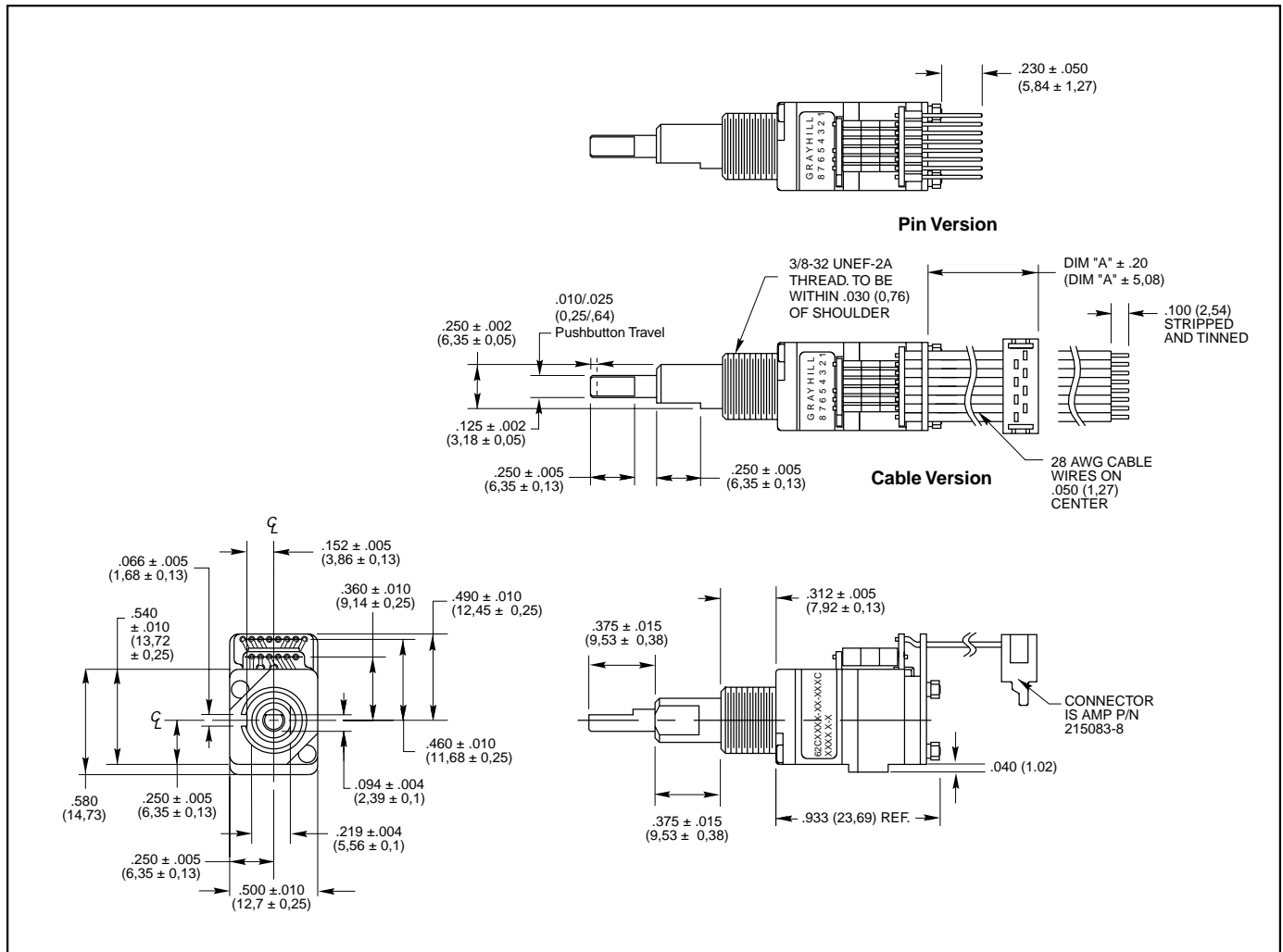
- Economical Size
- Combined Functionality
- Optically Coupled for More than a Million Cycles of Operations
- With or Without Integral Pushbutton
- Compatible with CMOS, TTL, and HCMOS Logic
- Available with 16, 24, and 32 Detent Positions for Each Code Section
- Choices of Cable Length and Terminations
- Available in 3.3 Volt Input (Contact Grayhill for details)



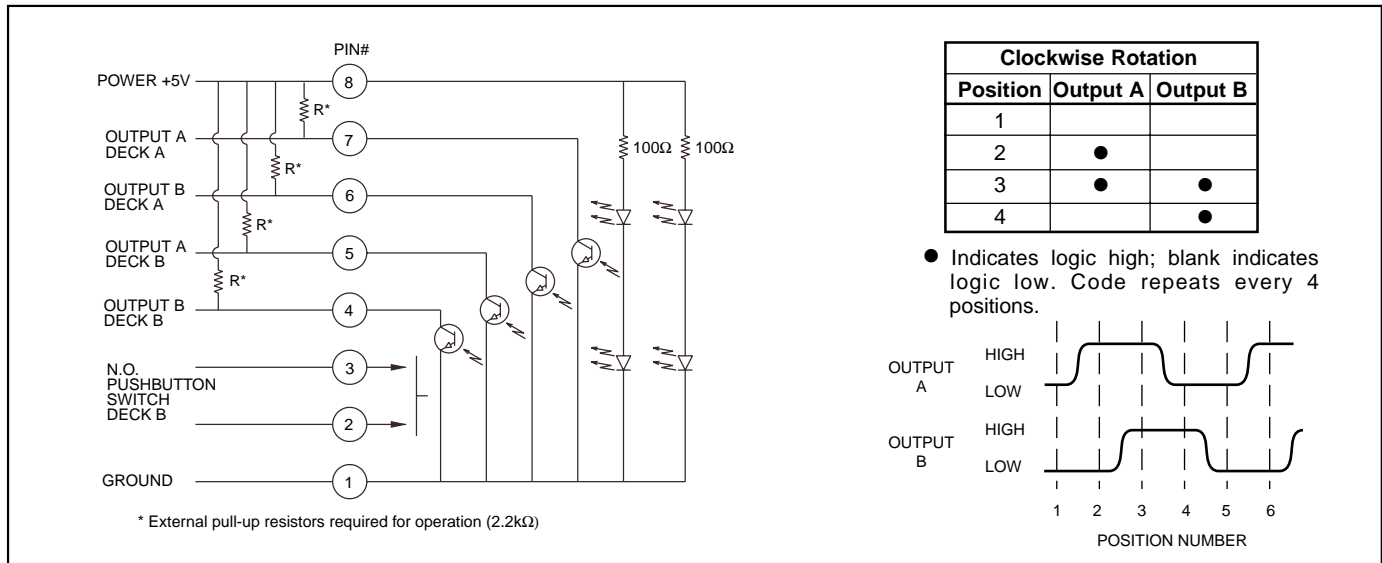
### APPLICATIONS

- Used to Set Radio Frequency, Drill Depth, RPM, Menu Selection, Parameter Selection for Patient Monitoring Devices, etc.

### DIMENSIONS In inches (and millimeters)



**CIRCUITRY, TRUTH TABLE AND WAVEFORM: Standard Quadrature 2-Bit Code**



**SPECIFICATIONS**

**Pushbutton Switch Ratings**

- Rating:** 5 Vdc, 10 mA, resistive
- Contact Resistance:** less than 10 ohms (TTL or CMOS compatible)
- Voltage Breakdown:** 250 Vac between mutually insulated parts
- Contact Bounce:** less than 4 mS at make, less than 10 mS at break
- Actuation Life:** 3,000,000 operations
- Actuation Force:** 1000 ± 300 grams

**Encoder Ratings**

- Coding:** 2-bit quadrature coded output
- Operating Voltage:** 5 ± .25 Vdc
- Supply Current:** 50 mA maximum at 5 Vdc
- Logic High:** 3.8V minimum
- Logic Low:** 0.8V maximum
- Logic Rise and Fall Times:** less than 30 mS
- Operating Torque:** 2.0 in-oz ± 1.4 in-oz initially

- Rotational Life:** more than 1,000,000 cycles of operation (1 cycle = 360° rotation and return)
- Shaft Push Out Force:** 45 lbs minimum
- Mounting Torque:** 15 in-lbs maximum
- Operating Speed:** 100 RPM maximum
- Axial Shaft Play:** .010 maximum for each shaft

**Environmental Ratings**

- Operating Temperature Range:** -40°C to 85°C
- Storage Temperature Range:** -55°C to 100°C
- Relative Humidity:** 90–95% at 40°C for 96 hours
- Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204
- Shock Resistance:** Test 1: Tested at 100g for 6 mS, half sine, 12.3 ft/s Test 2: 100g for 6 mS, sawtooth, 9.7 ft/s

**Materials and Finishes**

- Bushing:** Zinc casting
- Shaft:** Aluminum
- Shaft Retaining Ring:** Stainless steel
- Detent Spring:** Stainless steel
- Printed Circuit Board:** NEMA grade FR-4
- Terminals:** Brass, tin-plated
- Mounting Hardware:** One brass, nickel-plated nut and lockwasher supplied with each switch. (Nut is 0.094 inches thick by 0.562 inches across flats)
- Rotor:** Thermoplastic
- Code Housing:** Reinforced thermoplastic
- Pushbutton Dome:** Stainless steel
- Pushbutton Housing:** Thermoplastic
- Pushbutton Contact:** Brass, nickel-plated
- Dome Retaining Disk:** Thermoplastic
- Strain Relief:** Stainless steel
- Cable:** 28 AWG, stranded/top coated wire, halogen-free insulation on .050 centers (cable version only)
- Header Pins:** Phosphor bronze, tin-plated
- Insulator:** Glass-filled polyester
- Spacer:** Thermoplastic

**ORDERING INFORMATION**

**62C2211-02-020C**

- Series**
- Style:** C = Concentric
- Angle of Throw (Deck A):** 11 = 11.25° or 32 positions, 15 = 15° or 24 positions, 22 = 22.5° or 16 positions
- Angle of Throw (Deck B):** 11 = 11.25° or 32 positions, 15 = 15° or 24 positions, 18 = 18° or 20 positions, 22 = 22.5° or 16 positions
- Termination:** S = stripped cable, C = connector, P = pins
- Cable Length\*:** 020 = 2.0 inches minimum to 250 = 25.0 inches maximum. Provided in increments of 1/2 inch. Example: 035 = 3.5", 060 = 6"
- \*Eliminate cable length if ordering pins.** (Ex: 62C2211-02-P)
- Pushbutton Option:** 01 = w/o pushbutton, 02 = with pushbutton

Custom custom shaft, pushbutton actuation force and termination options are available. Control knobs available, see page E-39.

**Available from your local Grayhill Distributor.** For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

Optical and Mechanical Encoders



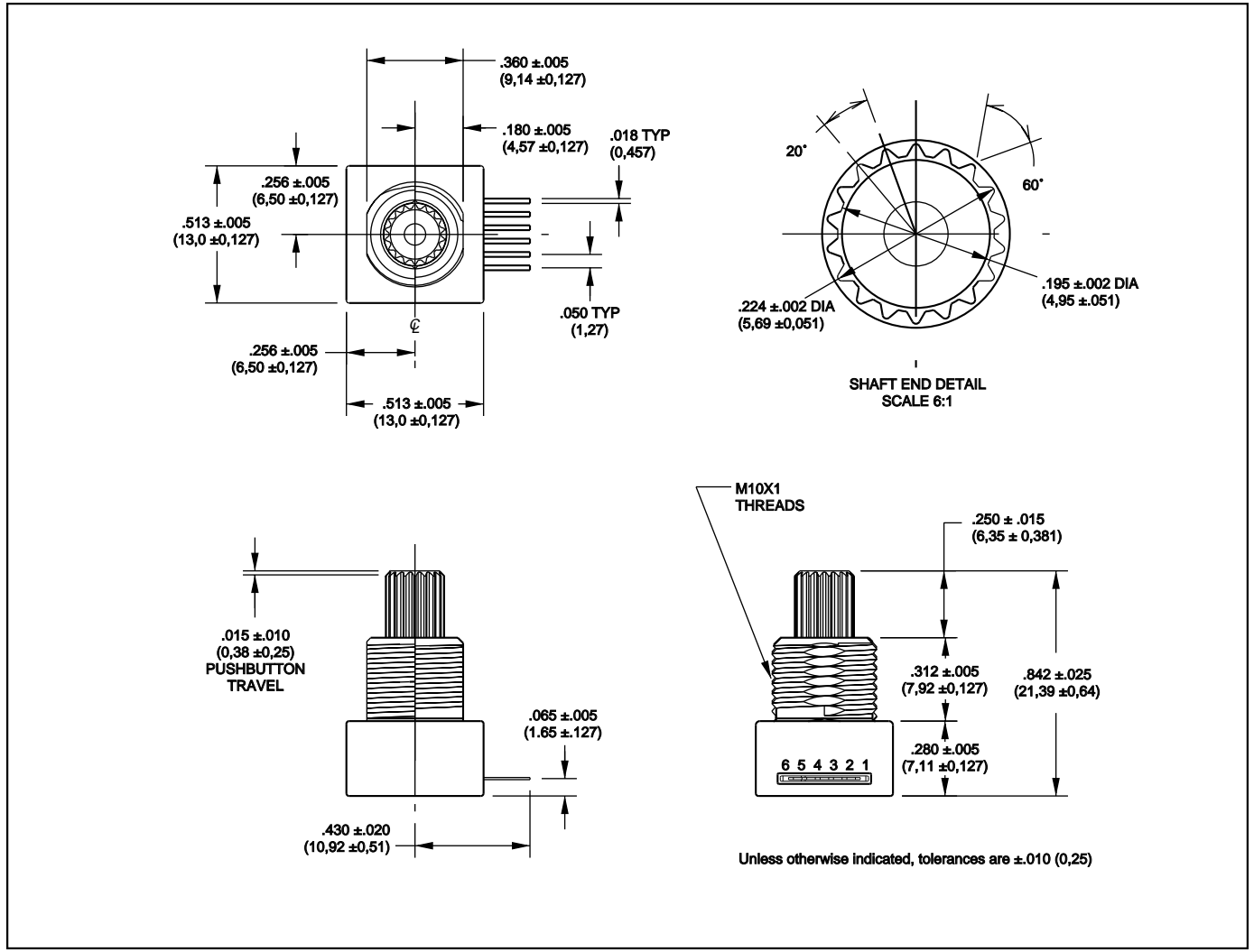
**SERIES 62L**  
Low Cost, 1/2" Package

**FEATURES**

- Low Cost
- Economical Size
- Half Million Cycles
- Optically Coupled
- Optional Integral Pushbutton
- Compatible with CMOS, TTL and HCMOS Logic
- Available in 16 or 24 Detent Positions

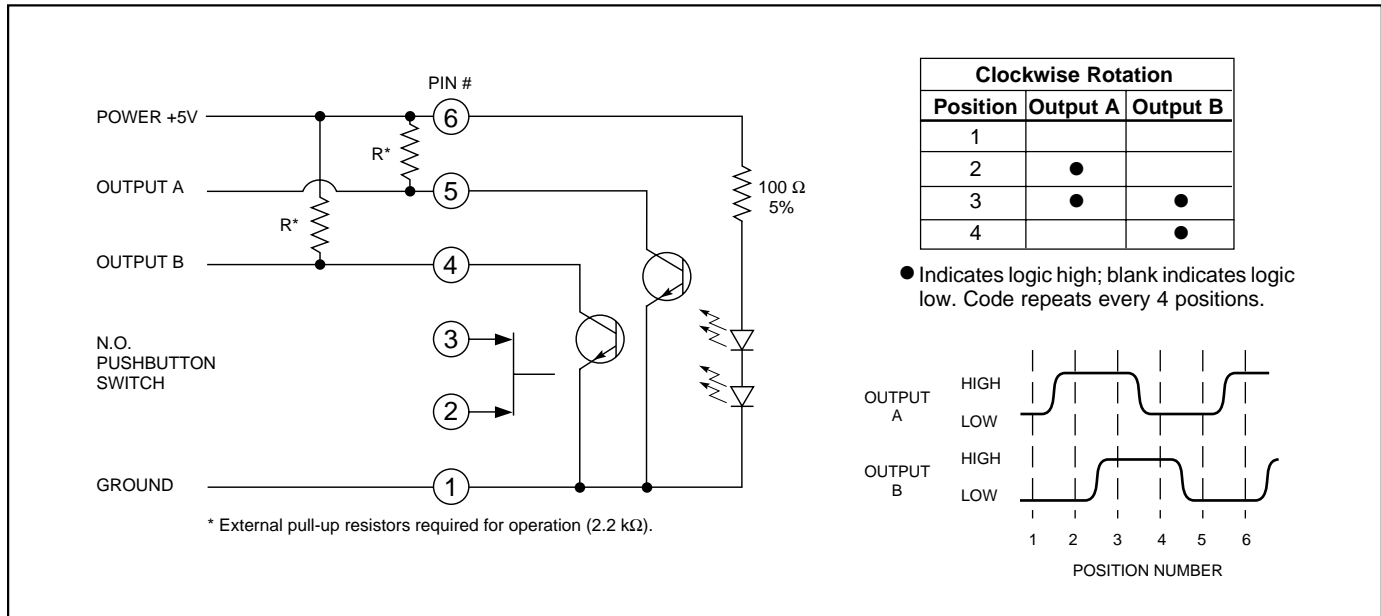


**DIMENSIONS** In inches (and millimeters)



Optical and Mechanical Encoders

**CIRCUITRY, TRUTH TABLE AND WAVEFORM: Standard Quadrature 2-Bit Code**



**SPECIFICATIONS**

**Pushbutton Switch Ratings**

**Rating:** 5.0 Vdc at 10mA resistive  
**Contact Resistance:** less than 10 ohms  
**Voltage Breakdown:** 250 Vac  
**Contact Bounce:** less than 4mS at make  
 less than 10 mS at break  
**Actuation Life:** 1,000,000 operations  
**Actuation Force:** 500 ±150 grams

**Encoder Ratings**

**Coding:** 2-bit quadrature-coded output  
**Operating Voltage:** 5.0 ±.25 Vdc  
**Supply Current:** 30 mA maximum at 5.0 Vdc  
**Logic High:** 3.8V minimum  
**Logic Low:** 0.8V maximum  
**Logic Rise and Fall:** less than 30 mS

**Mechanical Ratings**

**Operating Torque:** 0.9 in-oz ± 0.4 in-oz  
**Rotational Life:** more than 500,000 cycles  
 (1 cycle = 360° rotation and return)  
**Shaft Push Out Force:** 20 lbs minimum  
**Mounting Torque:** 9 in-lbs maximum  
**Operating Speed:** 100 RPM maximum  
**Axial Shaft Play:** .010 maximum for each shaft

**Environmental Ratings**

**Operating Temperature Range:** -40°C to 85°C  
**Storage Temperature Range:** -55°C to 100°C  
**Relative Humidity:** 90-95% at 40°C for 96 hours  
**Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204  
**Shock Resistance:** Test 1: Tested at 100g for 6 mS, half sine, 12.3 ft/s Test 2: 100g for 6mS, sawtooth, 9.7 ft/s

**Materials and Finishes**

**Shaft:** Reinforced thermoplastic  
**Detent Spring:** Beryllium copper  
**Printed Circuit Boards:** Thermoplastic, beryllium copper  
**Terminals:** Gold-plated  
**Rotor:** Reinforced thermoplastic  
**Mounting Hardware:** One plastic mounting nut supplied with each encoder  
**Housing:** Reinforced thermoplastic  
**Pushbutton Dome:** Stainless steel  
**Pushbutton Contact:** Beryllium copper, gold-plated  
**Cable:** 28 AWG in nomex insulation, .050 centers (cable version only)  
**Aperture:** Polystyrene  
**PC Mount Bracket:** Stainless steel

**ORDERING INFORMATION**

**Series**  
**Style:** L = Low Cost Standard  
**Angle of Throw:** 15 = 15° or 24 positions  
 22 = 22.25° or 16 positions  
**Pushbutton Option:** 01 = Without pushbutton, 02 = With pushbutton

**62L22-01-060S-V**

**PC Mount Bracket:** Leave blank if bracket is not required (V = vertical or H = horizontal)  
**Termination:** S = stripped cable, .050" center; C = connector, .050" center, P = pin, .050" center (Example for pin: 62L22-01-P)  
**Cable Length:** Available in 2, 6, or 12 inches (Example for 6-inch length: 62L22-01-060S)  
 \*For custom lengths contact Grayhill. \*Eliminate cable length if ordering pins. (Ex: 62L2201-S)

Custom bushing and shaft options are available. Control knobs available also. See Page E-39.

**Available from your local Grayhill Distributor.** For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

Optical and Mechanical Encoders

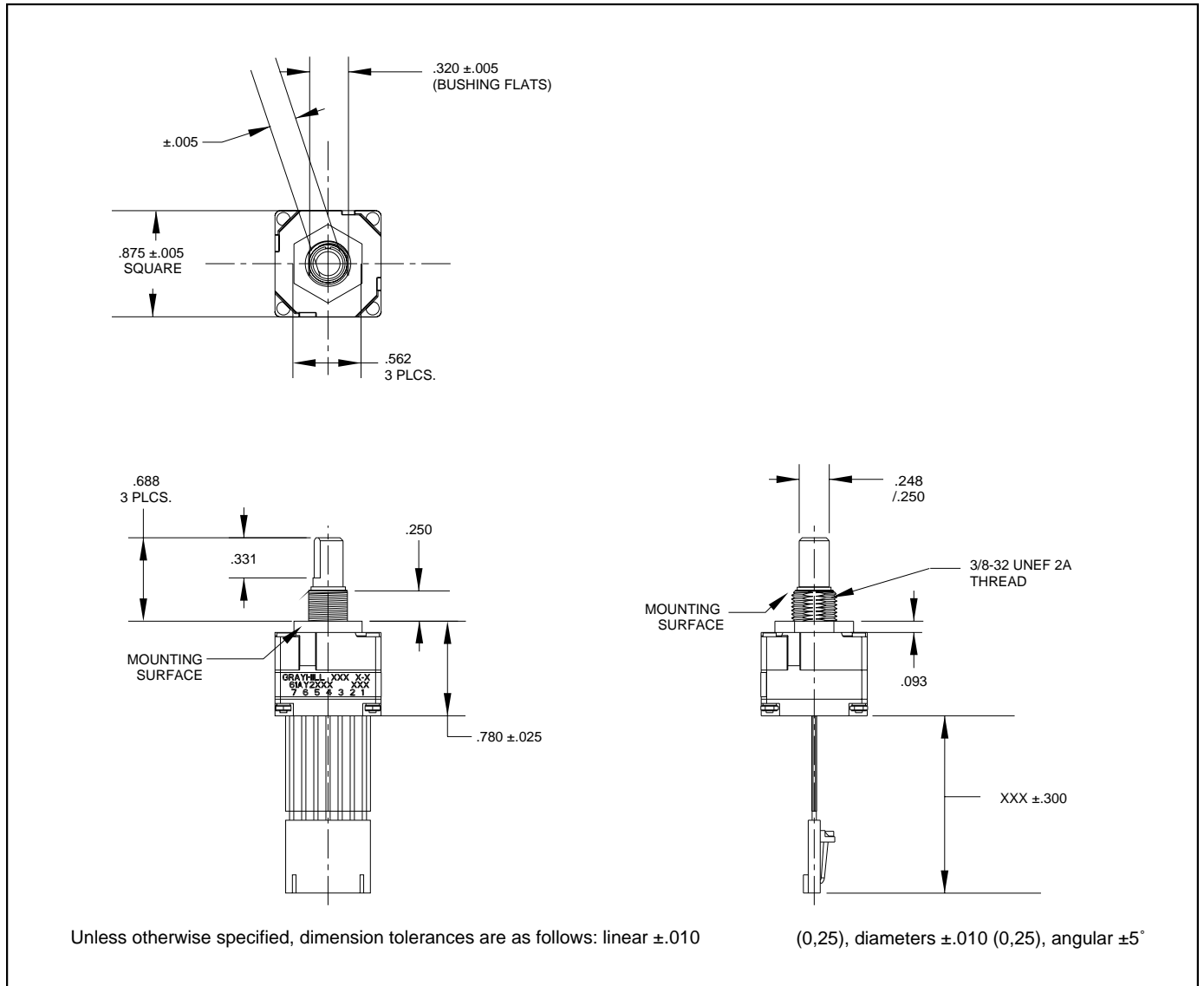
**SERIES 61A**  
Custom, Absolute

**FEATURES**

- Absolute Position Sensing
- 3, 4, or 5-Bit Custom Output Coding
- 8 to 32 Positions
- Continuous Rotation and Fixed Stops Available
- Angles of Throw to 45° (Design Specifications Will Dictate the Angle of Throw)



**DIMENSIONS** In inches (and millimeters)



Optical and Mechanical Encoders

**SPECIFICATIONS**

**Ratings**

**Operating Voltage:** 5 ±.25V DC  
**Supply Current:** 85 mA maximum at 5V DC  
**Life:** 1 million cycles of operation; 1 cycle is rotation through all positions and a full return  
**Rotational Torque:** 1.5 in-oz (Initial)  
**Output High:** 3.8V minimum for CMOS & HCMOS; 2.7V minimum for TTL  
**Output Low:** 0.8V maximum  
**Shaft Push Out Force:** 25 lbs.  
**Mounting Torque:** 10 in-lb maximum  
**Load Current:** 5 mA maximum per channel  
**Logic Rise and Fall Times:** 30 mSec typical

**Environmental**

**Operating Temperature Range:** -40°C to +85°C  
**Storage Temperature Range:** -55°C to +100°C  
**Vibration:** MIL-STD 202, method 204, condition B  
**Mechanical Shock:** 100 g's, 6 ms, half Sine 12.3 ft/s and 100 g's, 6 ms, sawtooth, 9.7 ft/s  
**Humidity:** 90-95% Relative humidity at 40°C for 96 hrs.

**Materials and Finishes**

**Detent Housing/Bushing:** Nylon 6/10  
**Shaft:** Glass-filled nylon  
**Detent Balls:** Steel, nickel-plated  
**Code Housings:** Nylon 6/10  
**Backplate:** Nylon 6/10  
**Aperture:** Chemically etched stainless steel with black oxide finish  
**Rotor:** Electroformed nickel and chemically etched stainless steel with black nickel finish  
**Detent Springs:** Tinned music wire  
**PC Boards:** NEMA grade FR-4  
**Through Bolts:** Stainless steel, unplated  
**Through Bolt Nuts:** Stainless steel  
**Switch Assembly Cover:** Thermosetting plastic  
**Mounting Hardware:** One brass, cadmium-plated nut and lockwasher supplied with each switch. Nut is 0.094 inches thick by 0.562 inches across flats.

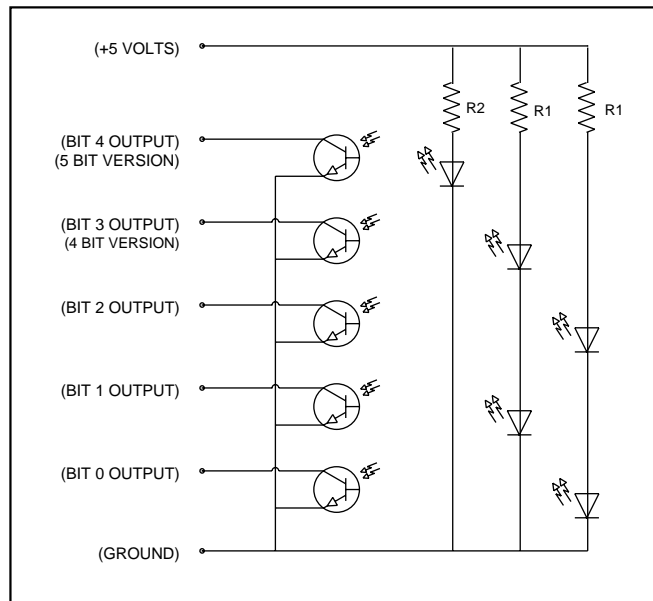
**ACCESSORIES**

See page E-23. For control knobs see page E-39.

**ORDERING INFORMATION**

Options include stainless steel detent housing for higher rotational torque applications. Metal shaft and bushing available. Custom shaft and bushing configurations available. Contact Grayhill for information on angles of throw and stop strength.

**CIRCUITRY**



**TRUTH TABLE**

32 BIT					
	BIT4	BIT3	BIT2	BIT1	BIT0
1					
2	X				
3	X	X			
4	X	X	X		
5	X	X	X	X	
6	X	X	X	X	X
7		X			
8		X	X		
9		X	X	X	
10		X	X	X	X
11			X		
12			X	X	
13			X	X	X
14				X	
15				X	X
16					X
17	X				X
18	X	X			X
19	X	X	X		X
20	X	X		X	
21	X	X		X	X
22	X			X	X
23	X		X	X	X
24	X		X		
25	X		X		X
26	X		X	X	
27	X			X	
28		X			X
29		X		X	X
30		X	X		X
31		X		X	
32			X		X

Optical and Mechanical Encoders

## SERIES 61B

### 16, 24 or 32 Position

### with or without Pushbutton

#### FEATURES

- Positions Screen Cursor
- More Friendly than Keyboards
- Permits Visual Concentration
- Economic Touchscreen Alternative
- Pushbutton for Entry Function
- Detent for Tactile Feedback and Minimal Backlash
- Optical Coupling for Long Life
- Rugged Construction



#### APPLICATIONS

##### Display Input

The Series 61 rotary encoder switch can move cursor or icon on a display. Use the rotary and pushbutton switch to simply select a menu item and enter it, or write more elaborate display software. Use the Series 61 to input limit settings for a monitored function. Change an item on a checklist to a new value while viewing the remainder of the list.

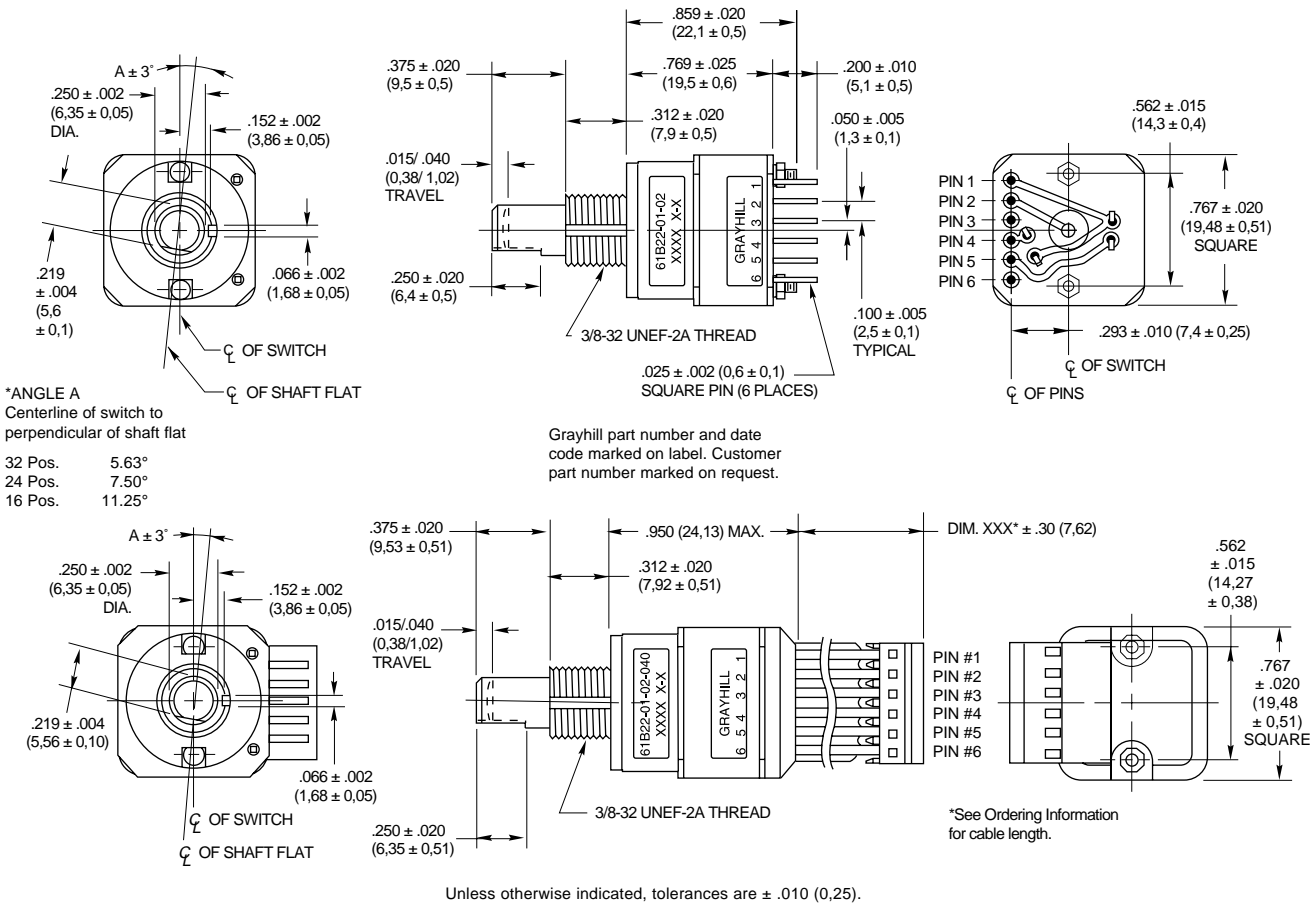
##### Incremental Input

Use the Series 61 with an interface chip to provide step by step input for setting radio frequency, drill depth, RPM, etc. These changes are usually a few steps, and you need not turn the switch several revolutions for the desired value. Some examples are as follows:

- Robot Position
- Volume Setting
- Radio Tuning
- Limit Setting
- Motor Control

#### DIMENSIONS In inches (and millimeters)

Diagram illustrates a 16-position switch with integral pushbutton switch.





**SPECIFICATIONS**

**Pushbutton Switch Ratings**

**Rating:** 5 Vdc, 10 mA, Resistive  
**Contact Resistance:** less than 10 (TTL or CMOS Compatible)  
**Voltage Breakdown:** 250 Vac between mutually insulated parts.  
**Contact Bounce:** Less than 4 milliseconds at make and less than 10 milliseconds at break  
**Actuation Life:** 3,000,000 operations  
**Actuation Force:** Maximum actuation force of 450 grams and a minimum actuation force of 300 grams.

**Encoder Ratings**

**Coding:** 2-bit quadrature coded output  
**Operating Voltage:** 5 ±.25 Vdc  
**Supply Current:** 30 mA maximum at 5 Vdc  
**Logic High:** 3.8V minimum  
**Logic Low:** 0.8V maximum  
**Logic Rise and Fall Times:** Rise Time less than 30 mS at 16.6 RPM. Fall Time less than 30 mS at 16.6 RPM.

**Operating Torque:** 1.5 in-oz ± 50%  
**Rotational Life:** more than 1,000,000 cycles of operation (1 cycle = 360° rotation and return)  
**Shaft Push Out Force:** 50 lbs minimum  
**Mounting Torque:** 20 in-lbs maximum

**Environmental Ratings**

**Operating Temperature Range:** -40°C to 85°C  
**Storage Temperature Range:** -55°C to 100°C  
**Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204  
**Shock Resistance:** Test 1: 100g for 6 mS half sine wave with velocity change of 12.3 ft/s. Test 2: 100g for 6 mS, sawtooth wave with velocity change of 9.7 ft/s.  
**Relative Humidity:** 90–95% at 40°C for 96 hours

**Materials and Finishes**

**Detent Cover:** Thermosetting plastic  
**Bushing:** Zinc casting, cadmium-plated per QQP-416, Class 2, Type II  
**Shaft:** Reinforced thermoplastic *Note: Earlier versions may have electropolished stainless steel shafts (still available in customs only).*  
**Detent Balls:** Passivated, stainless steel  
**Detent Spring:** Tinned music wire  
**Printed Circuit Boards:** NEMA Grade FR-4  
**Board Terminals:** Copper alloy, CDA No. 725  
**Through Bolts:** Stainless steel, unplated  
**Through Bolt Nuts:** Stainless steel  
**Switch Assembly Cover and Code Rotor:** PBT polyester thermoplastic  
**Mounting Hardware:** One brass, cadmium-plated nut and lockwasher supplied with each switch. Nut is 0.094" thick by 0.562" across flats.  
**Aperture:** Brass, black oxide finish  
**Strain Relief:** PBT polyester thermoplastic (cable version only)  
**Cable:** 26 AWG, stranded/tinned wire, PVC coated on .100 (2,54) centers (cable version only)

**CIRCUITRY, TRUTH TABLE, AND WAVEFORM: Standard Quadrature 2-Bit Code**

Clockwise Rotation		
Position	Output A	Output B
1		
2	●	
3	●	●
4		●

● Indicates logic high; blank indicates logic low. Code repeats every 4 positions.

POSITION NUMBER

\*EXTERNAL PULL UP RESISTORS REQUIRED FOR OPERATION. 8.2 kΩ IS SUGGESTED FOR TTL; 3.3 kΩ IS SUGGESTED FOR CMOS

**ORDERING INFORMATION**

**Series**  
**Style:** B = Standard, unsealed  
**Angle of Throw:** 11 = 11.25° or 32 Positions  
 15 = 15° or 24 Positions  
 22 = 22.25° or 16 Positions  
**Coding:** 01 = Quadrature  
**Pushbutton Option:** 01 = Without pushbutton, 02 = With pushbutton

**Termination:** Blank (no dash or numbers) = pins as described in drawing  
 Cable Termination 020 = 2.0 inches minimum to 250 = 25 inches maximum. Provided in increments of 1/2 inch. Example 035 = 3.5", 060 = 6 inches. Cable is terminated with standard Amp Connector 640442-6. Use any 6 position, .100 center header to mate with the cable assembly. Contact Grayhill

**61B11-01-02-020**

Custom shaft and bushing lengths, shaft/panel seal, and additional supply voltages are available through Grayhill only. Control knobs available, see page E-39.

Available from your local Grayhill Distributor. For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

**ACCESSORIES**

See page E-23.

Optical and Mechanical Encoders

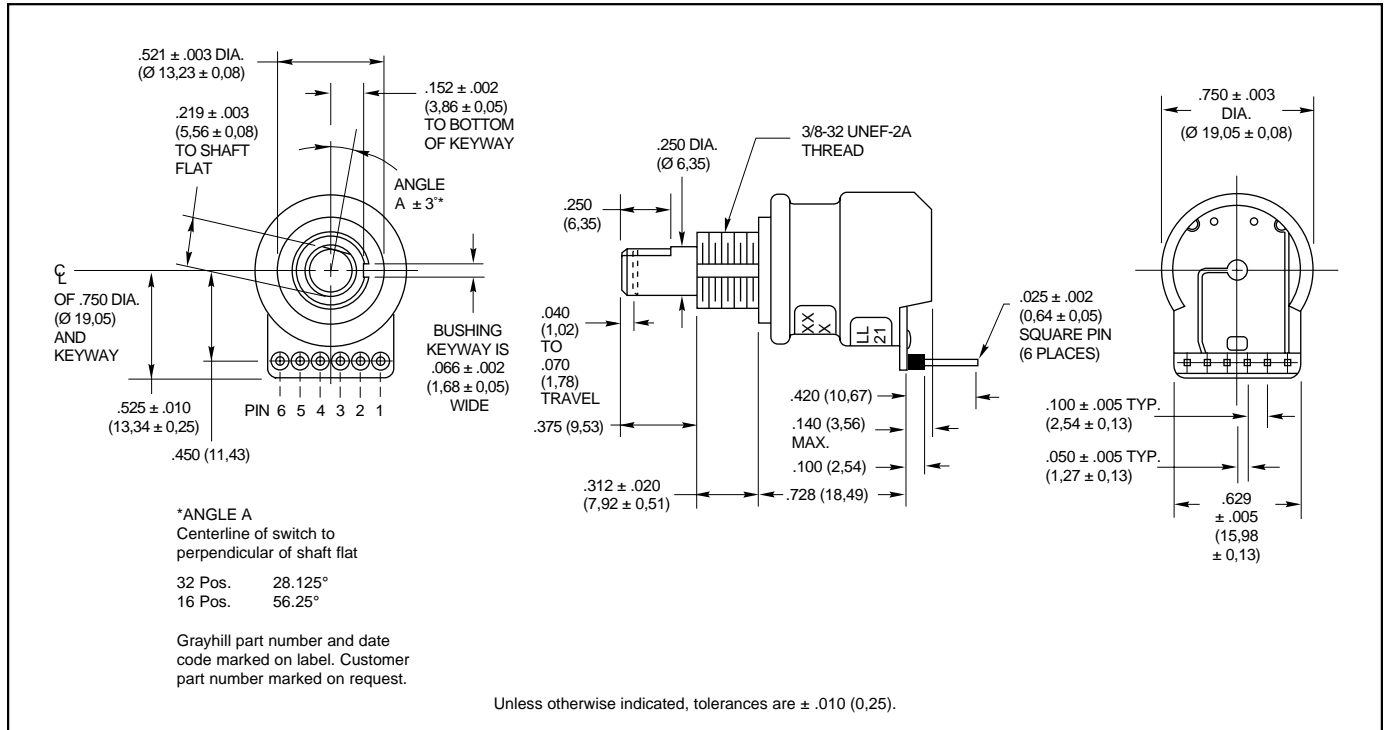
## SERIES 61C 16 or 32 Position with Pushbutton

### FEATURES

- Competitively Priced to Similar Electromechanical Switches
- Optically Coupled For More Than A Million Trouble-Free Rotations
- Has Data Entry Pushbutton Switch Activated By Switch Shaft
- Compatible With CMOS, TTL and HCMOS Logic
- Operationally Used to Move Display Icon and Input Data
- Used to Set Radio Frequency, Drill Depth, RPM, etc.

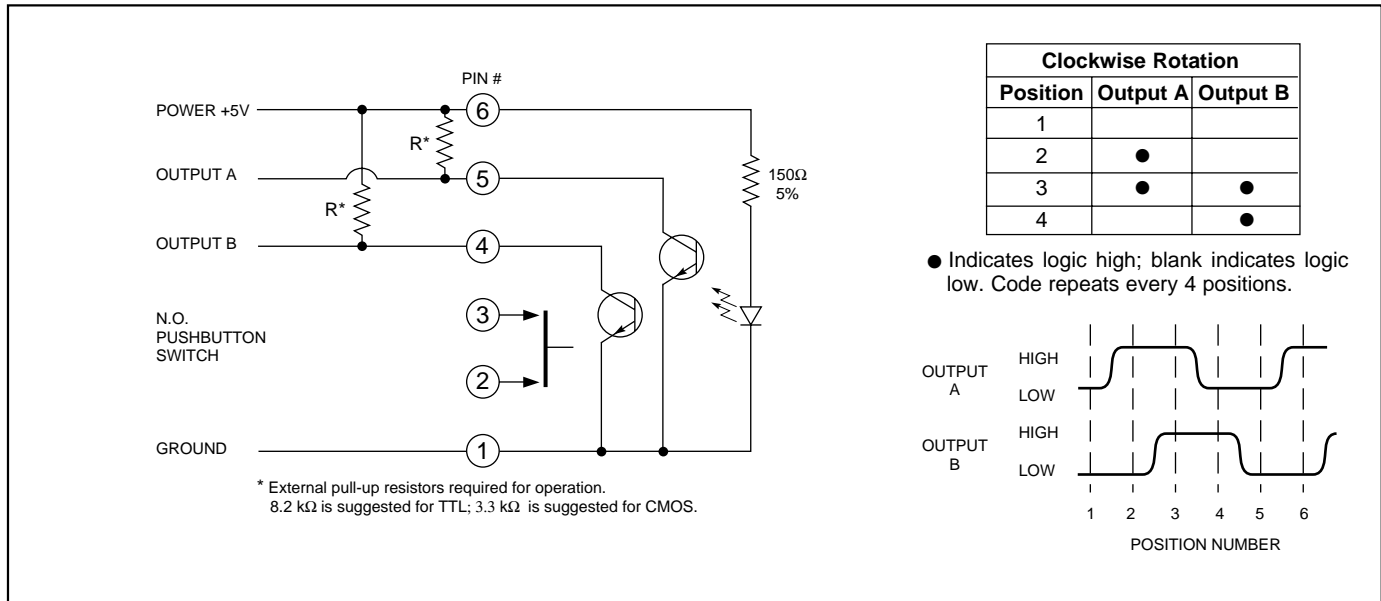


### DIMENSIONS In inches (and millimeters)



Optical and Mechanical Encoders

**CIRCUITRY, TRUTH TABLE, AND WAVEFORM: Standard Quadrature 2-Bit Code**



**SPECIFICATIONS**

**Pushbutton Switch Ratings**

**Rating:** 5 Vdc, 10 mA, resistive  
**Contact Resistance:** less than 10 K ohms (TTL or CMOS Compatible)  
**Voltage Breakdown:** 250 Vac between mutually insulated parts.  
**Contact Bounce:** Less than 4 milliseconds at make and less than 10 milliseconds at break.  
**Actuation Life:** 3,000,000 operations.  
**Actuation Force:** maximum actuation force of 450 grams and a minimum actuation force of 300 grams.

**Encoder Ratings**

**Coding:** 2-bit quadrature coded output.  
**Operating Voltage:** 5.0 ±.25 Vdc  
**Supply Current:** 30 mA maximum at 5 Vdc  
**Logic High:** 3.8V for CMOS and 2.7V for TTL minimum.  
**Logic Low:** 0.8V maximum  
**Logic Rise and Fall Times:** Rise Time less

than 30 mS at 16.6 RPM. Fall Time less than 30 mS at 16.6 RPM.  
**Operating Torque:** 1.5 in-oz ± 50% initial (1.0 in-oz 50% after life for 32 position only)  
**Rotational Life:** more than 1,000,000 cycles of operation (1 cycle = 360° rotation and return)  
**Shaft Push Out Force:** 20 lbs minimum  
**Mounting Torque:** 10 in-lbs maximum

**Environmental Ratings**

**Operating Temperature Range:** -40°C to 85°C  
**Storage Temperature Range:** -55°C to 100°C  
**Relative Humidity:** 90-95% at 40°C for 96 hours.  
**Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204  
**Shock Resistance:** Test 1: Tested at 100g for 6 mS, half sine, 12.3 ft/s Test 2: 100g for 6 mS, sawtooth, 9.7 ft/s

**Materials and Finishes**

**Bushing:** Reinforced thermoplastic  
**Shaft:** Reinforced thermoplastic  
**Detent Balls:** Steel, nickel-plated  
**Detent and Pushbutton Springs:** Tinned music wire  
**Printed Circuit Boards:** NEMA grade FR-4  
**Pushbutton Contact:** Stainless steel, gold-plated  
**Board Terminals:** Phosphor bronze, tin-plated  
**Mounting Hardware:** One brass, cadmium-plated nut and lockwasher supplied with each switch. Nut is 0.094 inches thick by 0.562 inches across flats.  
**Rotor:** Reinforced thermoplastic  
**Aperture:** Brass, black oxide finish

**ORDERING INFORMATION**

**61C22-01-04-02**

**Series**  
**Style:** C = Standard  
**Angle of Throw:** 00 = No detent  
 11 = 11.25° or 32 Positions  
 22 = 22.25° or 16 Positions  
**Coding:** 01 = Quadrature

**Pushbutton Option:** 01 = Without pushbutton, 02 = With pushbutton  
**Number of Changes per Revolution:** 04 for no detent and 22.25° angle of throw  
 08 for no detent and 11.25° angle of throw

Custom knobs available, see page E-39.

Available from your local Grayhill Distributor. For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

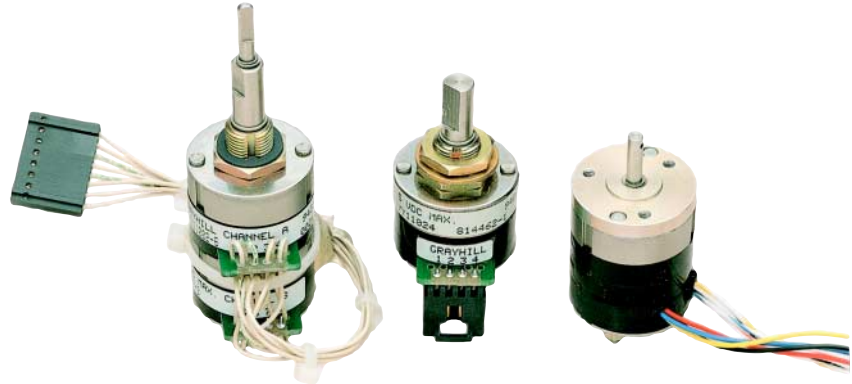
**ACCESSORIES**

See page E-23.

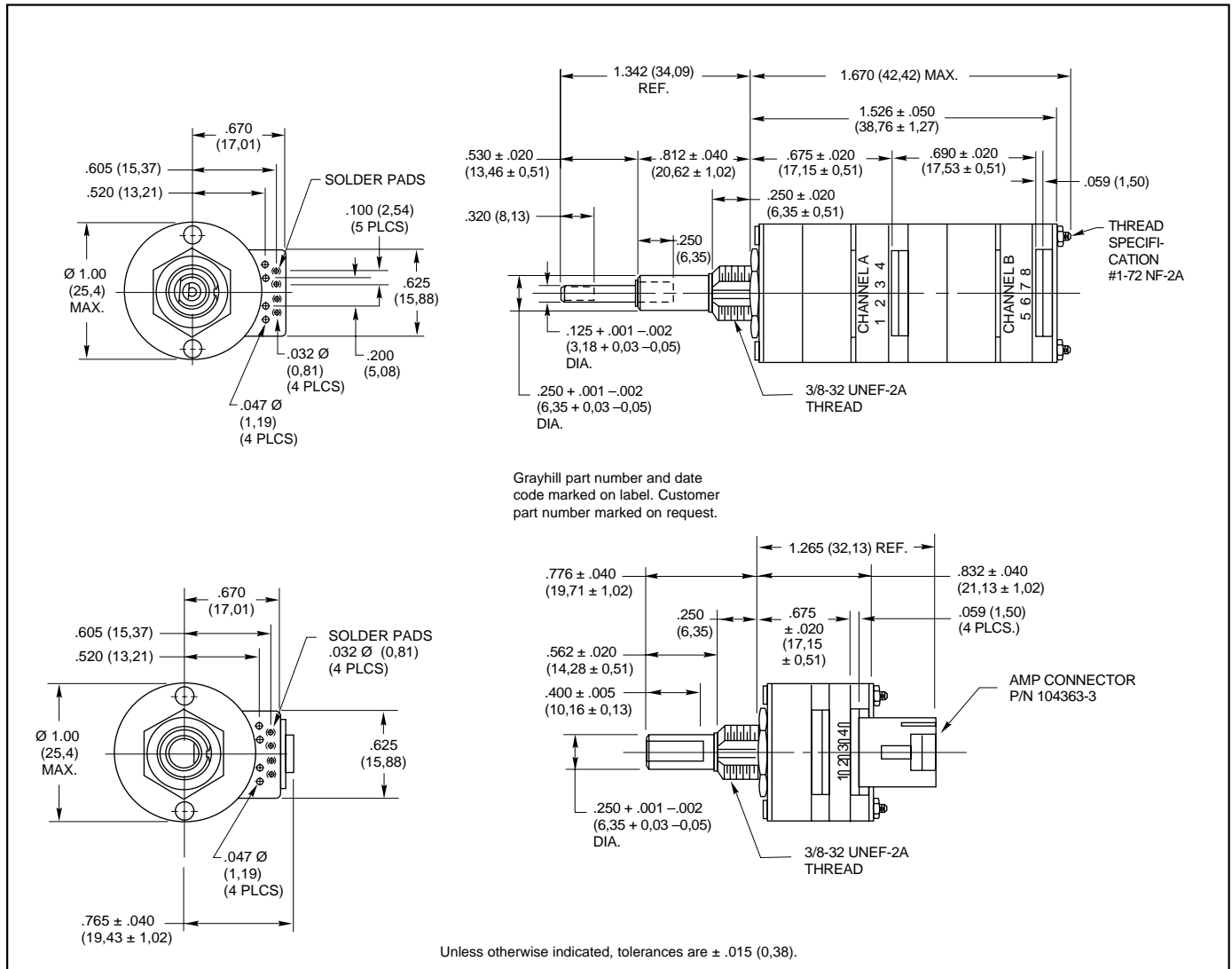
**SERIES 61D**  
Custom, Industrial

**FEATURES**

- Saves Space on Crowded Instrument Panels
- Designed for Operator Input of Distinct Parameters
- One Code Change per Detent Position
- Extended Temperature
- Stainless Steel Shaft and Metal Bushing
- Concentric Shaft Option

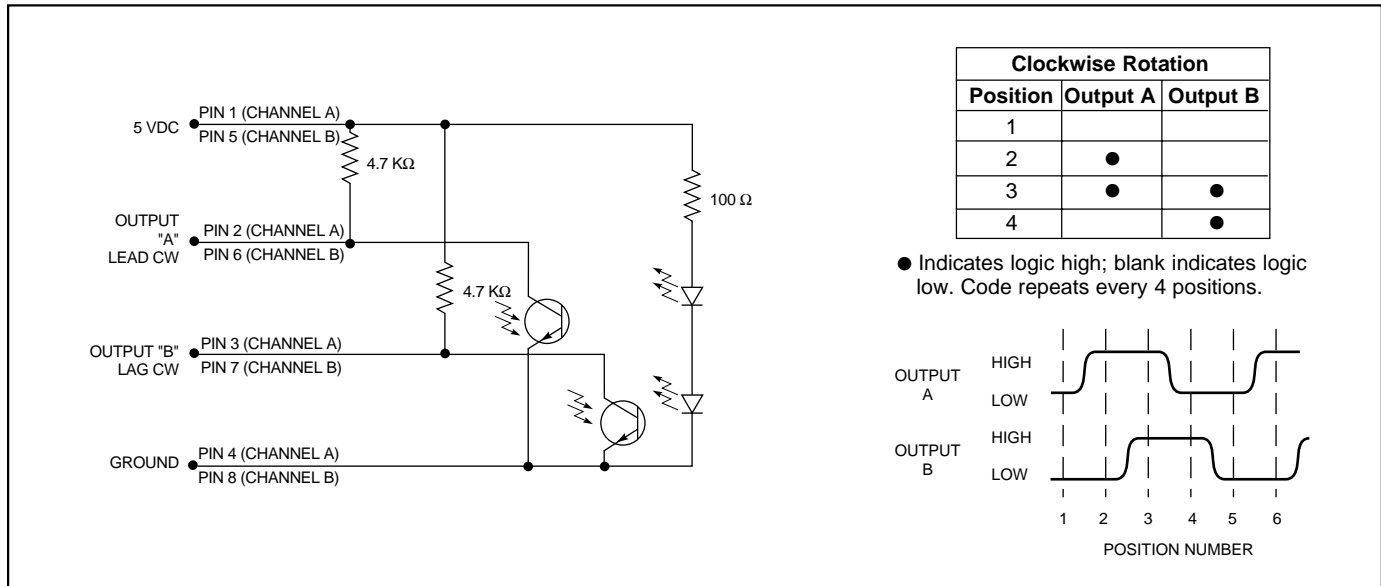


**DIMENSIONS** In inches (and millimeters)



Optical and Mechanical Encoders

**CIRCUITRY, TRUTH TABLE, AND WAVEFORM: Standard Quadrature 2-Bit Code**



**SPECIFICATIONS**

**Electrical Ratings**

- Operating Voltage:** 5.0 ±.25 Vdc
- Supply Current:** 50 mA maximum at 5 Vdc
- Logic High:** 3.8V minimum for CMOS & HCMOS; 2.7V minimum for TTL
- Logic Low:** 0.8V maximum
- Load Current:** 5 mA maximum per channel
- Turn-On Time:** 2.5 µSec
- Turn-Off Time:** 4 µSec
- Coding:** 2-bit quadrature coded output

**Mechanical Ratings**

- Life Expectancy:** 1 million cycles of operation; (1 cycle = 360° rotation and return)
- Rotational Torque:** Various, contact Grayhill
- Shaft Push Out Force:** 100 lbs minimum
- Mounting Torque:** 20 in-lbs maximum

**Environmental Ratings**

- Operating Temperature Range:** -40°C to +85°C
- Storage Temperature Range:** -55°C to +100°C
- Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204
- Shock Resistance:** MIL-STD 202, Method 213, Condition C and I

**Materials and Finishes**

- Bushing:** Zinc casting, cadmium-plated per QQP-416, Class 2, Type II
- Shaft:** Stainless steel
- Detent Balls:** Steel, nickel-plated
- Housing:** Thermosetting plastic
- Printed Circuit Boards:** NEMA grade FR-4
- Board Terminals:** Copper alloy, CDA No. 725, solder coated

- Through Bolts:** Stainless steel, unplated
- Through Bolt Nuts:** Stainless steel
- Switch Assembly Cover:** Thermosetting plastic
- Mounting Hardware:** One brass, cadmium-plated nut and lockwasher supplied with each switch. Nut is 0.094 inches thick by 0.562 inches across flats.

**ACCESSORIES**

See page E-23. For control knobs see page E-39.

**ORDERING INFORMATION**

Available in 16 and 32 position. Other options include various torques, bushing lengths and shaft configurations, pin or cable versions, and a pushbutton option on certain styles. Contact Grayhill for more information.



**SERIES 61K**  
High Resolution, 4-Pin

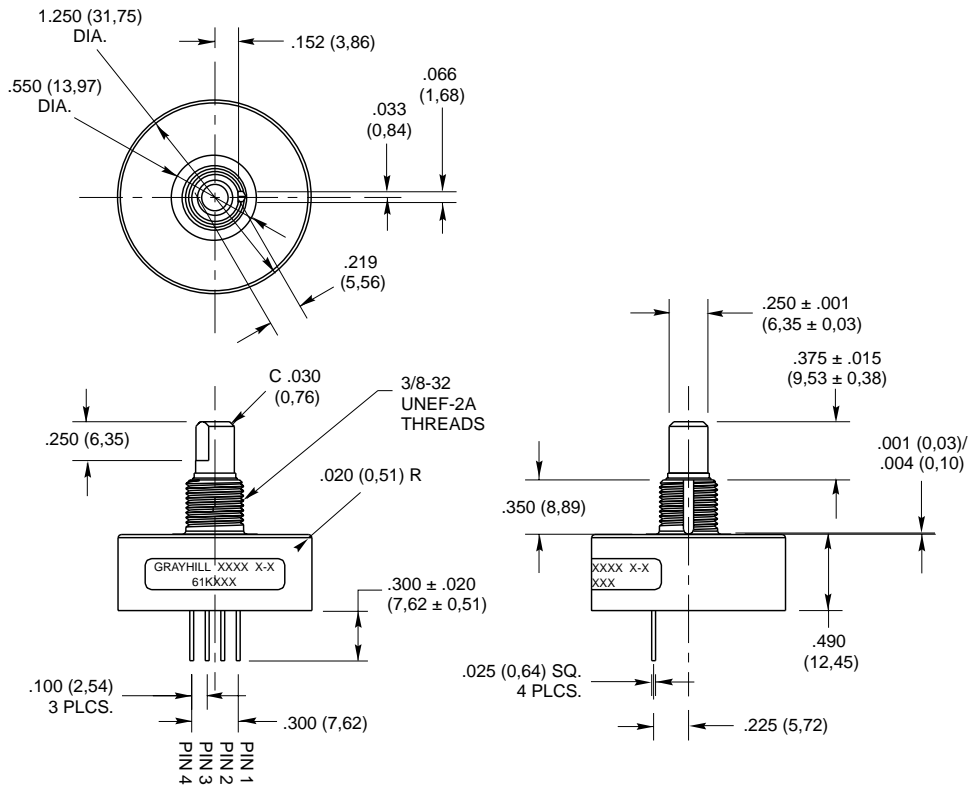
**FEATURES**

- 25, 32, 50, 64, 100, 128 and 256 Cycles per Revolution Available
- Sealed Version Available
- Rugged Construction
- Cable or Pin Versions
- 10 Million Life Cycles
- 300 RPM Shaft Rotation



**DIMENSIONS** In inches (and millimeters)

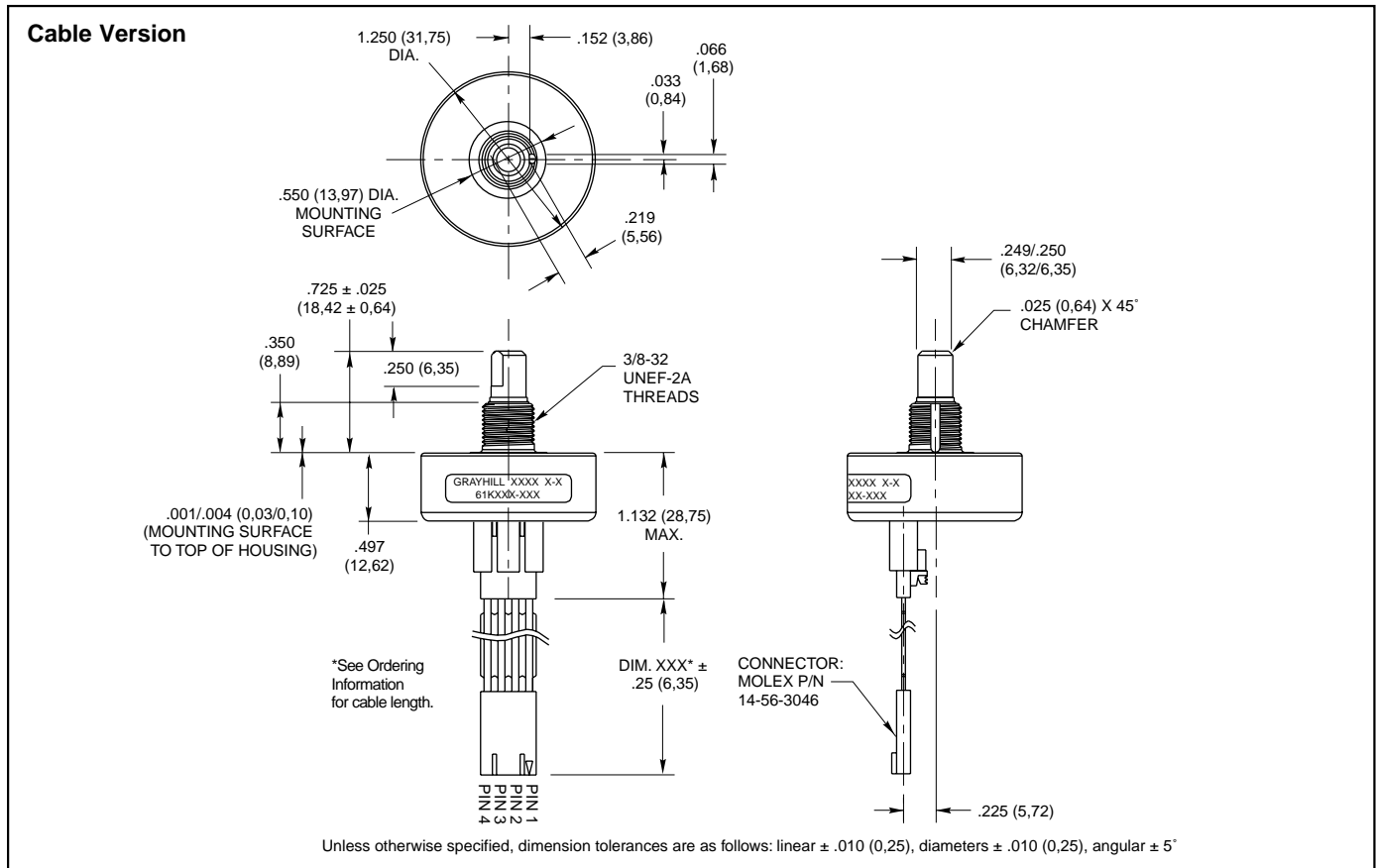
**Pin Version**



Unless otherwise specified, dimension tolerances are as follows: linear  $\pm .010$  (0,25), diameters  $\pm .010$  (0,25), angular  $\pm .005$  (0,13)

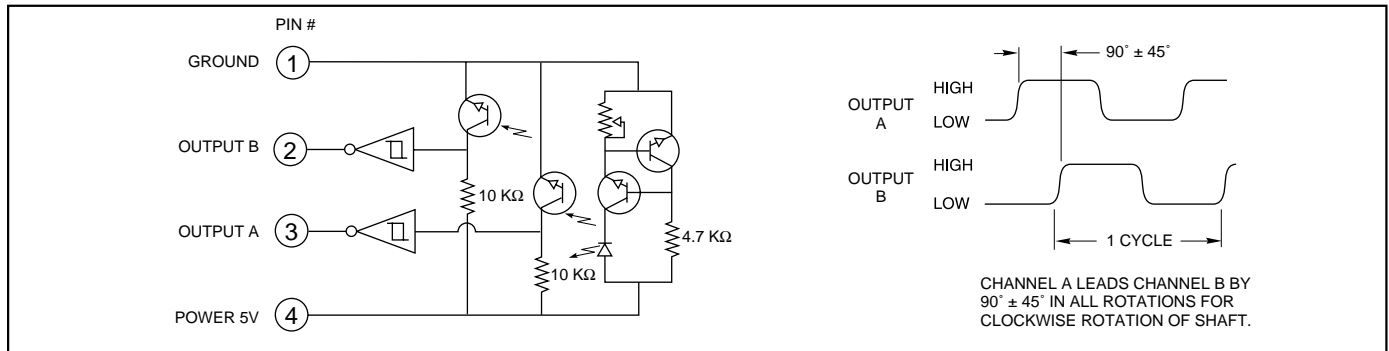
Optical and Mechanical Encoders

**DIMENSIONS** In inches (and millimeters)



Optical and Mechanical Encoders

**CIRCUITRY, TRUTH TABLE, AND WAVEFORM: Standard Quadrature 2-Bit Code**



**SPECIFICATIONS**

**Electrical Ratings**

**Operating Voltage:** 5.0  $\pm$  .25 Vdc  
**Supply Current:** 30 mA maximum at 5 Vdc  
**Logic Output Characteristics:**  
 Output Type: Open collector with integrated Schmitt Trigger and 10K ohms pull-up resistor  
 Maximum Sink Current: 16 mA at .40 volts  
**Power Consumption:** 150 mW maximum  
**Optical Rise Time:** 500 nS typical  
**Optical Fall Time:** 16 nS typical

**Mechanical Ratings**

**Mechanical Life:** 10 million revolutions  
**Time Life:** Guaranteed for 10 years of continuous operation (calculated from emitter degradation data)

**Mounting Torque:** 20 in-lbs maximum  
**Shaft Push Out Force:** 100 lbs  
**Terminal Strength:** 5 lbs terminal pull-out force minimum  
**Solderability:** 95% free of pin holes and voids  
**Operating Torque:** 1.5 in-oz maximum (no detents) for unsealed versions

**Environmental Ratings**

**Operating Temperature Range:** -40°C to 85°C  
**Storage Temperature Range:** -55°C to 100°C  
**Relative Humidity:** 90-95% at 40°C for 96 hours  
**Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204

**Mechanical Shock:** Test 1: 100g for 6 mS, half-sine wave with velocity change of 12.3 ft/s. Test 2: 100g for 6 mS, sawtooth wave with velocity change of 9.7 ft/s.

**Materials and Finishes**

See page E-23.

**ACCESSORIES**

See page E-23. For control knobs see page E-39.

**ORDERING INFORMATION**

See page E-23.

**SERIES 61R**  
**High Resolution, 5-Pin**  
**(Polarized Connection)**

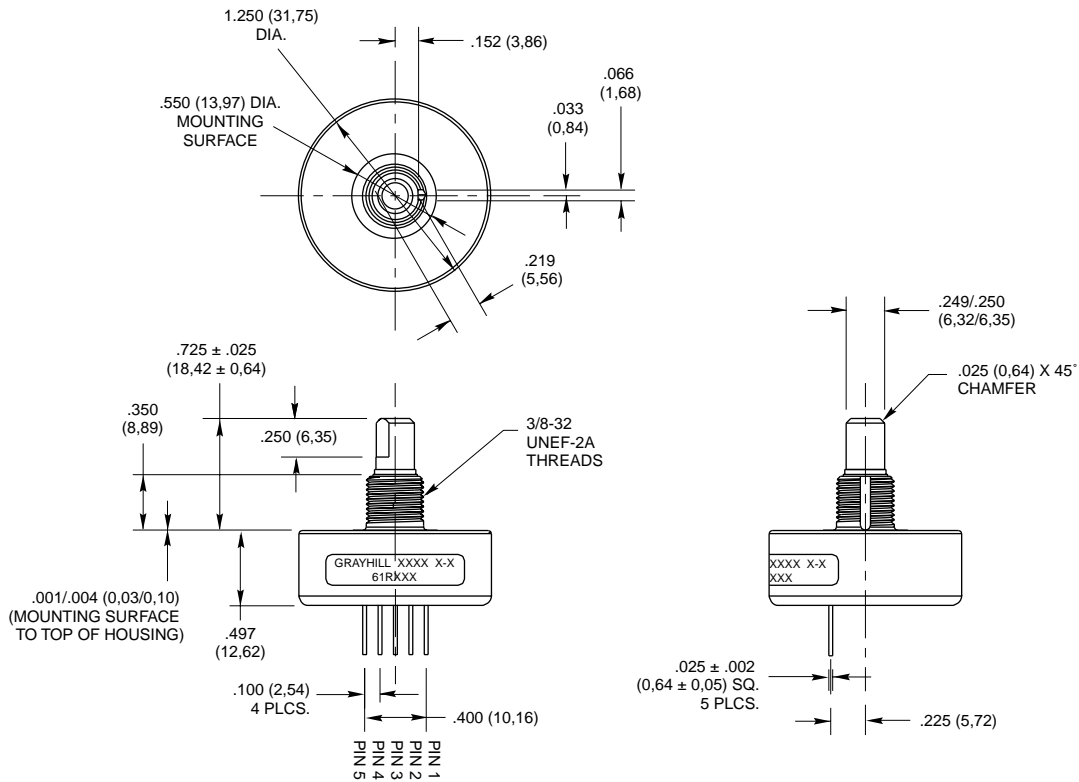
**FEATURES**

- 25, 32, 50, 64, 100, 128 and 256 Cycles per Revolution Available
- Sealed Version Available
- Rugged Construction
- Cable or Pin Version
- 10 Million Life Cycles
- 300 RPM Shaft Rotation
- Index Pulse Available



**DIMENSIONS** In inches (and millimeters)

**Pin Version**



Unless otherwise specified, dimension tolerances are as follows: linear ± .010 (0,25), diameters ± .010 (0,25), angular ± 5°

Optical and Mechanical Encoders



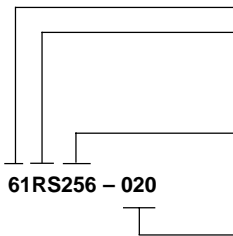
2: 100g for 6 mS, sawtooth wave with velocity change of 9.7 ft/s.

### Materials and Finishes

- Bushing:** Cast zinc, nickel-plated
- Code Housing:** Hiloy 610B
- Shaft:** Stainless steel
- Rotor:** Nylon
- Retaining Ring:** Stainless steel
- Code Rotor and Aperture:** Chemically etched stainless steel/electroformed nickel
- Printed Circuit Board:** NEMA Grade FR-4. Five microinches minimum gold over 100

- microinches minimum nickel over copper
- Optical Barrier:** Polyphenylene sulfide, 94 V-0
- Backplate:** Polyester
- Header:** Phosphor bronze, 200 microinches tin over 50 microinches nickel (pin version only)
- Infrared Emitter:** Gallium aluminum arsenide
- Photo IC:** Planar silicon
- Cable:** 26 AWG, stranded/tinned wire, PVC coated on .100 (2,54) centers (cable version only)

## ORDERING INFORMATION



### Series

- Style:** K = Standard, 4-pin, high resolution  
KS = Sealed, 4-pin, high resolution  
R = Standard, 5-pin, high resolution  
RS = Sealed, 5-pin, high resolution
- Cycles:** per channel per revolution = 25, 32, 50, 64, 100, 128, 256

### Termination:

Blank (no dash or numbers): pins as described in drawing.  
Cable Termination: 020 = 2.0 inches minimum to 250 = 25 inches maximum  
Provided in increments of 1/2 inch. Example 035 = 3.5", 060 = 6". Cable is terminated with standard Molex part no. 14-56-3046 for 61K, 14-56-3056 for 61R. Use any standard .100 center 4-pin header for 61K, 5-pin header for 61R to interface with cable. Recommended to be mounted with Molex header part no. 70543-0003 or 70553-0003 for 61K, 70543-0004 or 70553-0004 for 61R.

Control knobs available, see page E-39.

**Available from your local Grayhill Distributor.** For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

## ACCESSORIES

### Non-Turn Washer

The Series 61 bushing is 3/8 inches in diameter and has a non-turn keyway to prevent rotation of the switch body when the panel is cut to fit. Another way to keep the switch from turning is to use a non-turn washer. The washer is cadmium-plated brass.

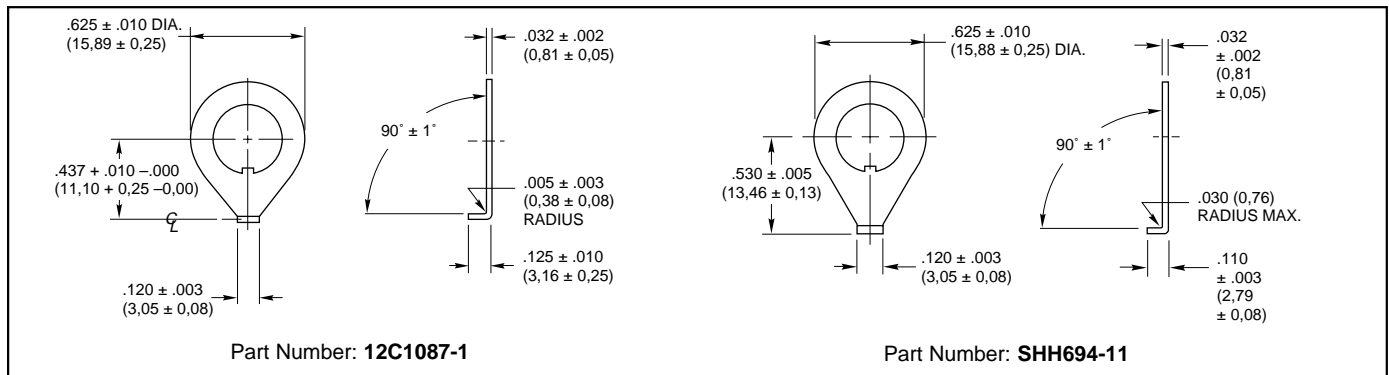
Part number: **12C1087-1**

Part number: **SHH694-11**, 302-2B stainless steel, no plating

### Shaft and Panel Seal

For shaft and panel seal version, the shaft is sealed by an o-ring inside the bushing. The panel is sealed by a flat gasket .045" thick at the base of the bushing. The panel seals will increase the behind panel dimension by .020" to .040", when the switch is mounted. The panel seal is silicon rubber. The shaft seal is an o-ring per MIL-P-5516B.

## DIMENSIONS In inches (and millimeters)





## SERIES 61Z

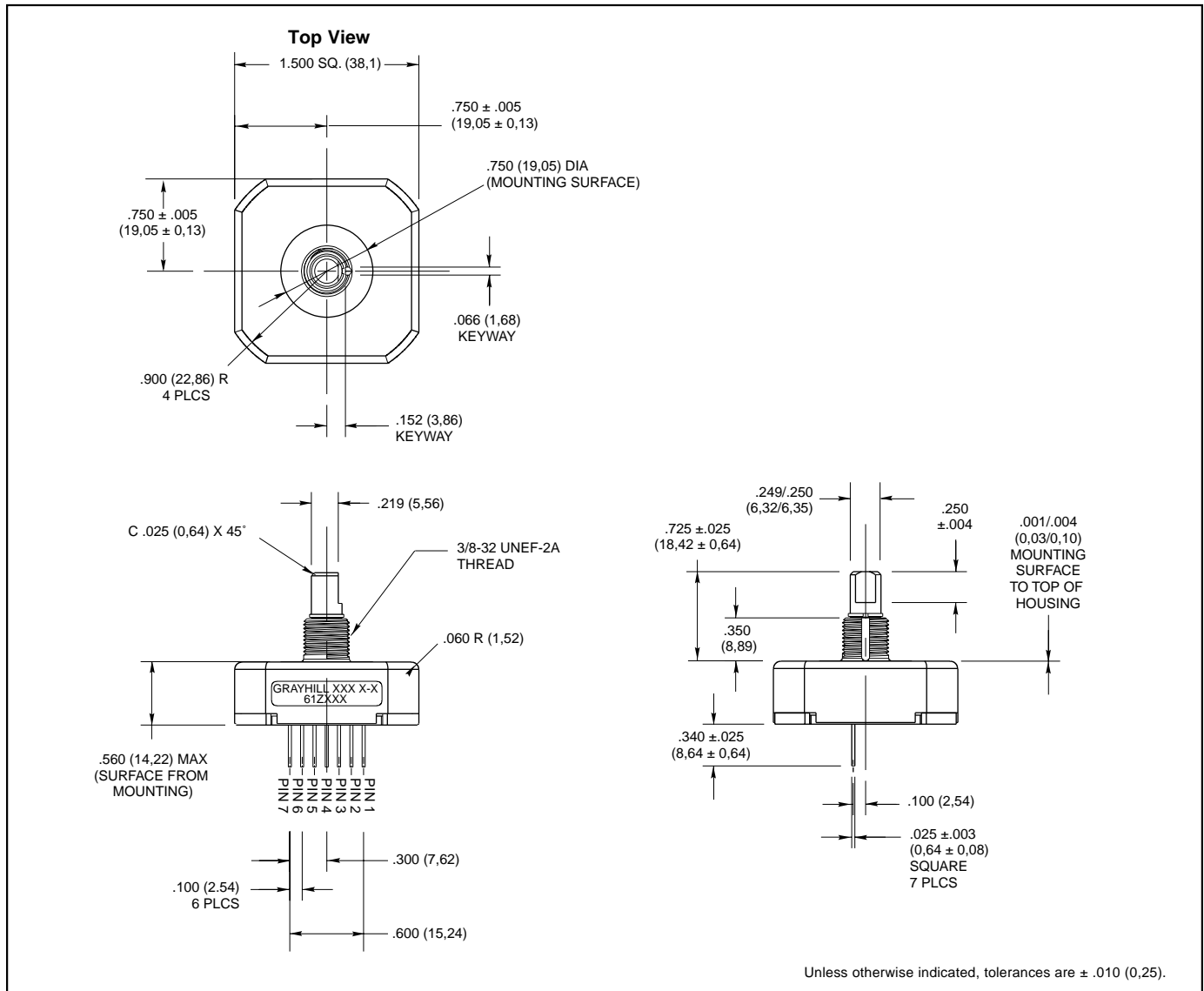
High Resolution, Redundant  
Circuitry, 7-Pin

### FEATURES

- 25, 32, 50, 64, 100, 128 and 256 Cycles per Revolution
- Rugged Construction
- 10 Million Life Cycles
- 300 RPM Shaft Rotation
- Shaft and Panel Seals Available
- Custom Cable Versions

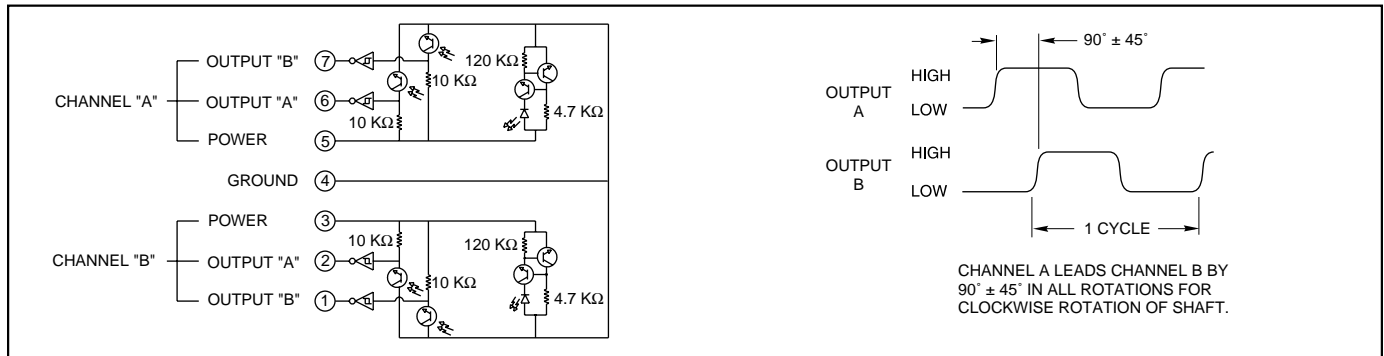


### DIMENSIONS In inches (and millimeters)



Optical and Mechanical Encoders

## CIRCUITRY AND WAVEFORM: Standard Redundant Quadrature 2-Bit Code



## SPECIFICATIONS

### Electrical Ratings

**Operating Voltage:** 5.0 ± .25 Vdc  
**Supply Current:** 50 mA maximum at 5 Vdc  
**Logic Output Characteristics:**  
 Output Type: Open collector and 10 KΩ pull-up resistor with integrated Schmitt Trigger  
 Maximum Sink Current: 16 mA at .40V  
**Power Consumption:** 250 mW maximum at 5 Vdc  
**Optical Rise Time:** 500 nS typical  
**Optical Fall Time:** 16 nS typical

### Mechanical Ratings

**Mechanical Life:** 10 million revolutions  
**Time Life:** Guaranteed for 10 years of continuous operation (calculated from emitter degradation data)  
**Mounting Torque:** 20 in-lbs maximum  
**Shaft Push Out Force:** 100 lbs  
**Terminal Strength:** 5 lbs terminal pull-out force minimum  
**Solderability:** 95% free of pin holes and voids  
**Operating Torque:** 1.5 in-oz maximum (no detents) for unsealed versions

### Environmental Ratings

**Operating Temperature Range:** -40°C to 85°C  
**Storage Temperature Range:** -55°C to 100°C  
**Relative Humidity:** 90-95% at 40°C for 96 hours  
**Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204  
**Shock Resistance:** Test 1: 100g for 6 mS, half-sine wave with velocity change of 12.3 ft/s. Test 2: 100g for 6 mS, sawtooth wave with velocity change of 9.7 ft/s.

### Materials and Finishes

**Bushing:** 6262-T9 aluminum alloy  
**Housing:** Hiloy 610B  
**Shaft:** Stainless steel insert molded into nylon rotor support  
**Code Rotor and Aperture:** Chemically etched stainless steel/electroformed nickel  
**Printed Circuit Board:** NEMA Grade FR-4. Five microinches minimum gold over 100 microinches minimum nickel over copper  
**Optical Barrier:** Polyphthalamide (PPA)  
**Backplate:** Polyester  
**Pin Header:** Phosphor bronze, 200 microinches tin over 50 microinches nickel (pin version only)  
**Infrared Emitter:** Gallium aluminum arsenide  
**Photo IC:** Planar silicon  
**Retaining Ring:** Stainless steel

## ORDERING INFORMATION

**Series**  
**Style:** Z = Standard, high resolution, redundant circuitry, 7-pin  
 ZS = Sealed, high resolution, redundant circuitry, 7-pin  
**Cycles:** per channel per revolution = 25, 32, 50, 64, 100, 128, 256

**61ZS256**

For Accessories see page E-23 for details. Control knobs available, see page E-39.

**Available from your local Grayhill Distributor.** For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

### SERIES 63K

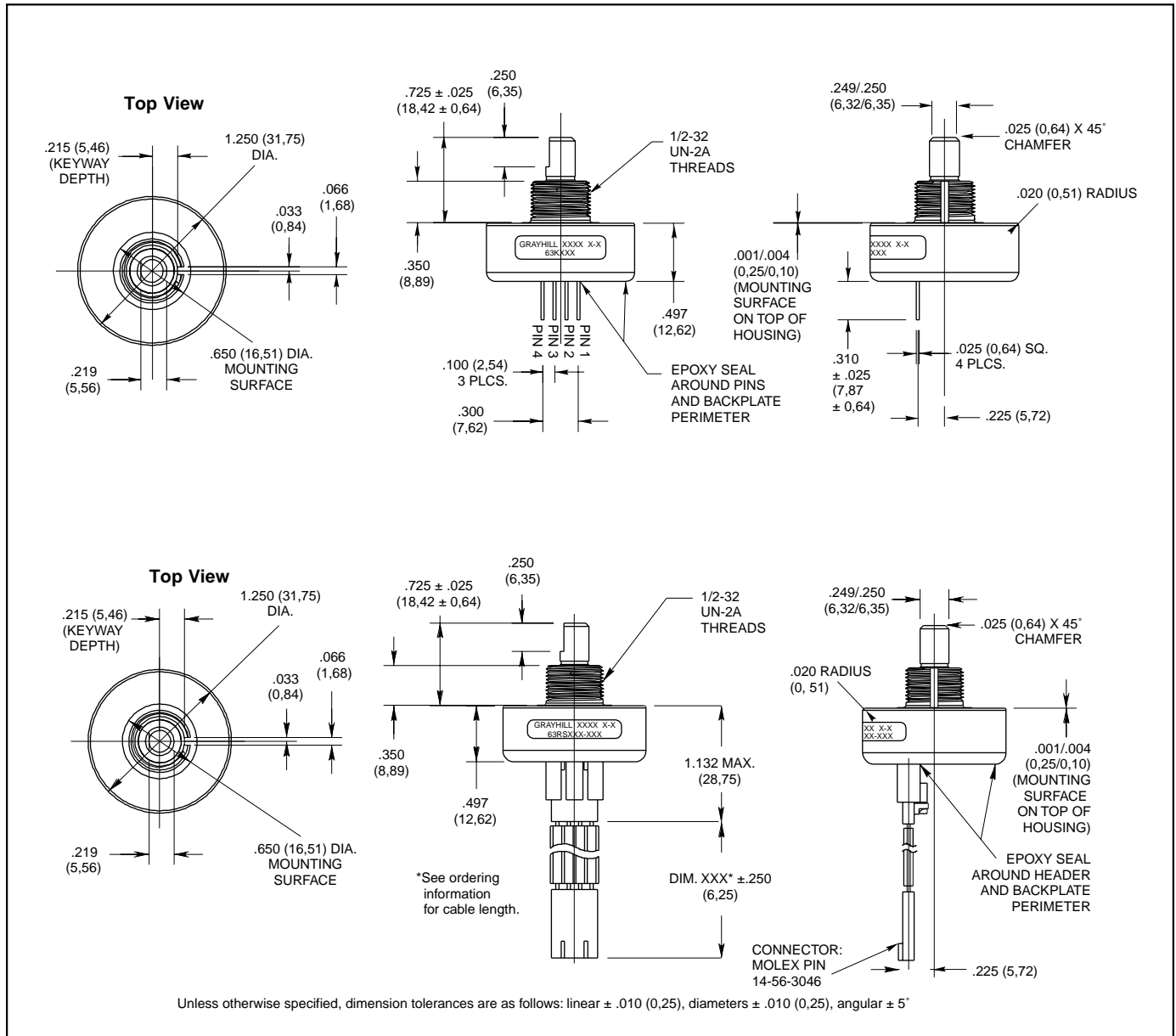
High Resolution, Ball Bearing,  
4-Pin

#### FEATURES

- 25, 32, 50, 64, 100, 128 and 256 Cycles per Revolution Available
- Sealed Version Available
- Rugged Construction
- Cable or Pin Version
- 300 Million Life Cycles
- 5,000 RPM Shaft Rotation

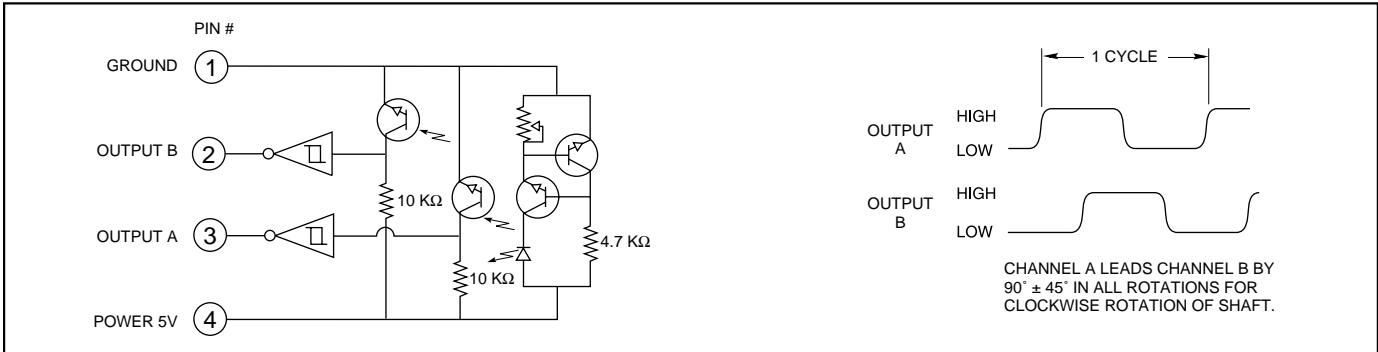


#### DIMENSIONS In inches (and millimeters)



Optical and Mechanical Encoders

## CIRCUITRY AND WAVEFORM: Standard Quadrature 2-Bit Code



### SPECIFICATIONS

#### Electrical Ratings

**Operating Voltage:** 5.0 ±.25 Vdc  
**Supply Current:** 30 mA maximum at 5 Vdc  
**Logic Output Characteristics:**  
 Output Type: Open collector with integrated Schmitt Trigger and 10 KΩ pull-up resistor  
 Maximum Sink Current: 16 mA at .40 volts  
**Power Consumption:** 150 mW maximum  
**Optical Rise Time:** 500 nS typical  
**Optical Fall Time:** 14 nS typical

#### Mechanical Ratings

**Mechanical Life:** 300 million revolutions  
**Time Life:** Guaranteed for 10 years of continuous operation (calculated from emitter degradation data)  
**Mounting Torque:** 20 in-lbs maximum  
**Terminal Strength:** 5 lbs terminal pull-out force minimum  
**Solderability:** 95% free of pin holes and voids  
**Operating Torque:** 0.5 in-oz maximum (no detents) for unsealed versions  
**Externally Applied Shaft Force:** Axial: 15 lbs maximum; Radial: 15 lbs maximum

#### Environmental Ratings

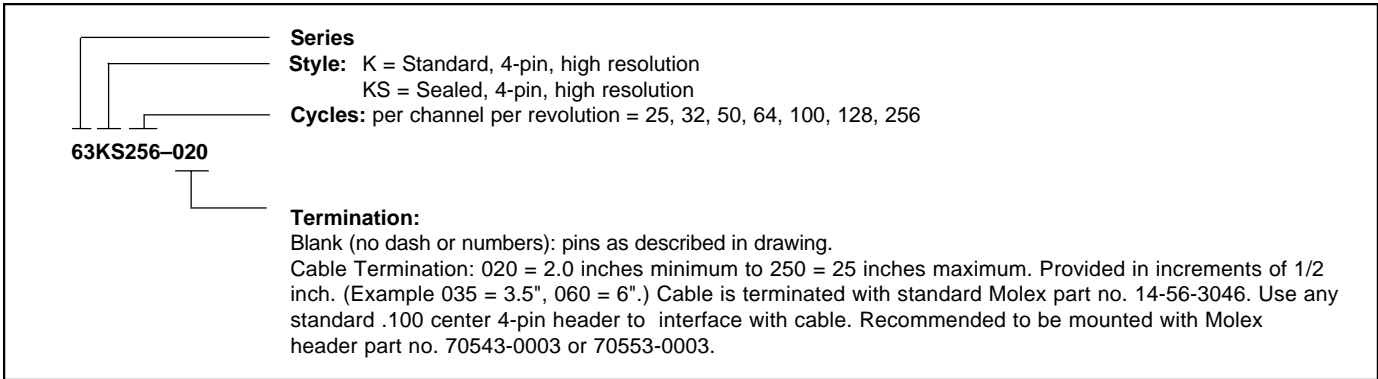
**Operating Temperature Range:** -40°C to 85°C  
**Storage Temperature Range:** -55°C to 100°C  
**Relative Humidity:** 90-95% at 40°C for 96 hours  
**Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204  
**Shock Resistance:** Test 1: 100g for 6 mS, half-sine wave with velocity change of 12.3 ft/s. Test 2: 100g for 6 mS, sawtooth wave with velocity change of 9.7 ft/s.

#### Materials and Finishes

**Bushing:** 6262-T9 aluminum alloy  
**Housing:** Hiloy 610B  
**Code Rotor and Aperture:** Chemically etched stainless steel/electroformed nickel  
**Printed Circuit Board:** NEMA Grade FR-4. Five microinches minimum gold over 100 microinches minimum nickel over copper  
**Optical Barrier:** Polyphenylene sulfide, 94 V-0  
**Backplate:** Polyester  
**Header:** Phosphor bronze, 200 microinches tin over 50 microinches nickel (pin version only)  
**Infrared Emitter:** Gallium aluminum arsenide  
**Photo IC:** Planar silicon  
**Retaining Ring:** Stainless steel  
**Cable:** 26 AWG, stranded/tinned wire, PVC coated on .100 (2,54) centers (cable version only)  
**Connector:** Glass-filled PCT, UL94V-0

**Bearing Subassembly**  
**Bearing:** NSK ABEC 5 (stainless steel)  
**Preload Collar:** 303 (stainless steel)  
**Spacer:** 303 (stainless steel)  
**Bellville Spring:** spring steel (stainless steel)

### ORDERING INFORMATION



Control knobs available, see page E-39.

Available from your local Grayhill Distributor. For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

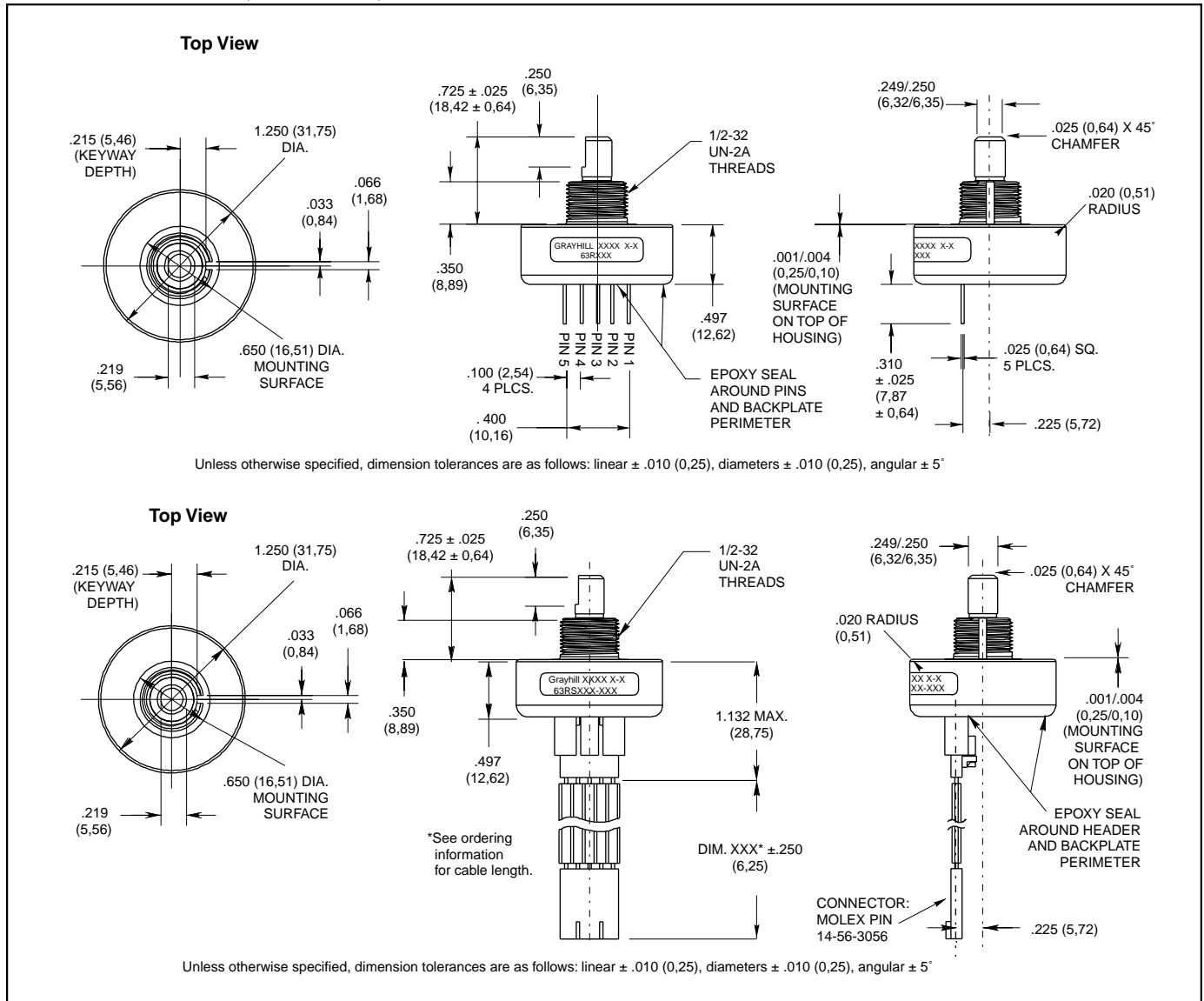
**SERIES 63R**  
**High Resolution, Ball Bearing,**  
**5-pin (Polarized Connection)**

**FEATURES**

- 25, 32, 50, 64, 100, 128 and 256 Cycles per Revolution Available
- Sealed Version Available
- Rugged Construction
- Cable or Pin Versions
- 300 Million Life Cycles
- 5000 RPM Shaft Rotation
- Index Pulse Available



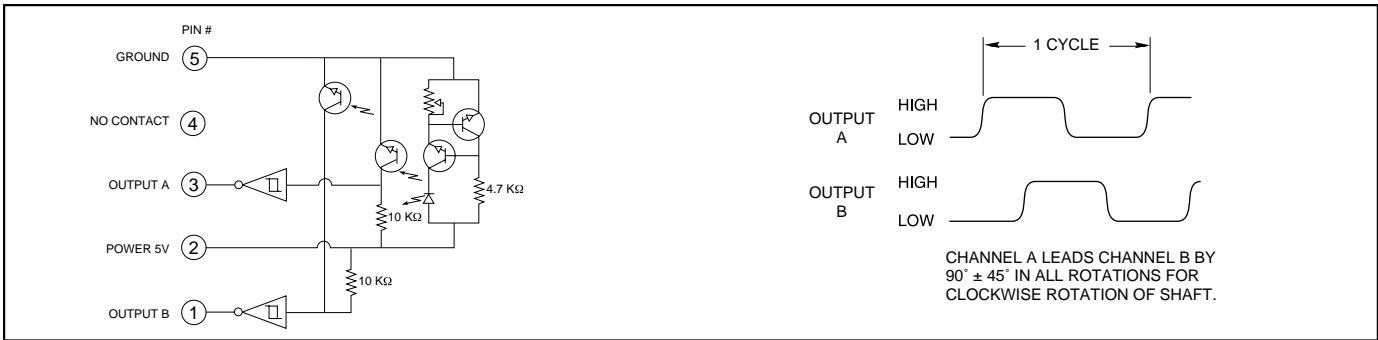
**DIMENSIONS** In Inches (and millimeters)



Optical and Mechanical Encoders



## CIRCUITRY AND WAVEFORM: Standard Quadrature 2-Bit Code



### SPECIFICATIONS

#### Electrical Ratings

**Operating Voltage:** 5 ±.25 Vdc  
**Supply Current:** 30 mA maximum at 5 Vdc  
**Logic Output Characteristics:**  
 Output Type: Open collector with integrated Schmitt Trigger and 10 KW pull-up resistor  
 Maximum Sink Current: 16 mA at .40 volts  
**Power Consumption:** 150 mW maximum  
**Optical Rise Time:** 500 nS typical  
**Optical Fall Time:** 14 nS typical

#### Mechanical Ratings

**Mechanical Life:** 300 million revolutions  
**Time Life:** Guaranteed for 10 years of continuous operation (calculated from emitter degradation data)  
**Mounting Torque:** 20 in-lbs maximum  
**Terminal Strength:** 5 lbs terminal pull-out force minimum  
**Solderability:** 95% free of pin holes and voids  
**Externally Applied Shaft Force:**  
 Axial: 15 lbs maximum; Radial: 15 lbs maximum  
**Operating Torque:** 0.5 in-oz maximum (no detents) for unsealed versions

#### Environmental Ratings

**Operating Temperature Range:** -40°C to 85°C  
**Storage Temperature Range:** -55°C to 100°C  
**Relative Humidity:** 90-95% at 40°C for 96 hours  
**Vibration Resistance:** Harmonic motion with amplitude of 15g, within a varied 10 to 2000 Hz frequency for 12 hours per MIL-STD-202, Method 204  
**Shock Resistance:** Test 1: 100g for 6 mS, half-sine wave with velocity change of 12.3 ft/s. Test 2: 100g for 6 mS, sawtooth wave with velocity change of 9.7 ft/s.

#### Materials and Finishes

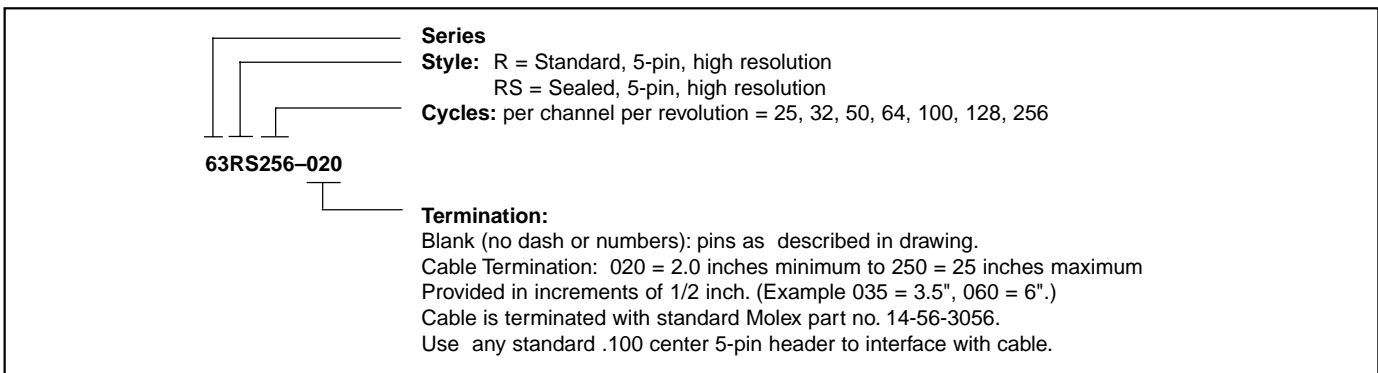
**Bushing:** 6262-T9 aluminum alloy  
**Housing:** Hiloy 610B  
**Shaft:** Stainless steel insert molded into nylon rotor support  
**Code Rotor and Aperture:** Chemically etched stainless steel/electroformed nickel  
**Printed Circuit Board:** NEMA Grade FR-4. Five microinches minimum gold over 100 microinches minimum nickel over copper  
**Optical Barrier:** Polyphenylene sulfide, 94 V-0

**Backplate:** Polyester  
**Header:** Phosphor bronze, 200 microinches tin over 50 microinches nickel (pin version only)  
**Infrared Emitter:** Gallium aluminum arsenide  
**Photo IC:** Planar silicon  
**Retaining Ring:** Stainless steel  
**Cable:** 26 AWG, stranded/tinned wire, PVC coated on .100 (2,54) centers (cable version only)  
**Connector:** Glass-filled PCT, UL94V-0

#### Bearing Subassembly

**Bearing:** NSK ABEC 5 (stainless steel)  
**Preload Collar:** 303 stainless steel  
**Spacer:** 303 stainless steel  
**Bellville Spring:** Spring steel (stainless steel)

### ORDERING INFORMATION



Control knobs available, see page E-39.

Available from your local Grayhill Distributor. For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

**SERIES 65**  
Optical Encoder Interface

**FEATURES**

- Interfaces with all Grayhill and Most Standard Quadrature Optical Encoders
- Power Reduction of Up to 75-90% in Optical Encoder Use Through Power Management Feature
- User Selectable Output Modes: Magnitude/Direction, Up/Down, Standard Quadrature
- Simplified Microprocessor Interface Reduces Design Time
- Debounces Encoder Integral Pushbutton Switch
- Ideal for Battery Powered Applications that Include Optical Encoders



**DESCRIPTION**

The GH65C11-X is designed to receive input from standard quadrature optical encoders. The power management feature allows power to the encoder to be applied only during sampling intervals, thus conserving power

(especially advantageous in battery powered systems). Sample rate is a nominal 4K per second allowing high speed quadrature input. The optical encoder interface can operate in 1 of 3 user-selectable output modes. These

modes are: magnitude and direction, up and down count, and standard quadrature. Debouncing of an integral pushbutton switch within the optical encoder can also be accomplished.

Name	Type*	Description
M0, M1	I	Mode selection input pins
V <sub>DD</sub>	P	3-6 Vdc power source
RES	I	Reset pin, normally connected to V <sub>DD</sub>
V <sub>SS</sub>	P	GND, 0v nominal power return
ØAI, ØBI	I	Phase A and B quadrature input pins
SWI	I	Switch input pin
SWO	O	Debounced switch output pin
NC	O	No connect, this pin must be left unconnected
PW	O	Power source for encoder power management
RC	I/O	RC oscillator pin
ØBO/DN/DR	O	Phase B, down, direction, mode conditional output pin
ØAO/UP/MG	O	Phase A, up, magnitude, mode conditional output pin

	SOIC/DIP		SSOP
M0	□ 1	□ 18	□ 20
M1	□ 2	□ 17	□ 19
V <sub>DD</sub>	□ 3	□ 16	□ 18
RES	□ 4	□ 15	□ 17
V <sub>SS</sub>	□ 5	□ 14	□ 16
ØAI	□ 6	□ 13	□ 15
ØBI	□ 7	□ 12	□ 14
SWI	□ 8	□ 11	□ 13
SWO	□ 9	□ 10	□ 12
			□ 11
			□ 10

\* Pin Types: I = Input, O = Output, P = Power.

**ORDERING INFORMATION**

**GH65C11-X-YY**

Temperature: \_\_\_\_\_ Packaging: \_\_\_\_\_  
 C = Commercial (0° C to 70° C) PD = 18 lead 300 mil wide Plastic DIP  
 N = Industrial (-40° C to 85° C) SO = 18 lead 300 mil wide gull wing SOIC  
 SS\* = 20 lead SSOP

\* The SS package style is not available in the -40°C to 85°C temperature range.

Available from your local Grayhill Distributor. For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

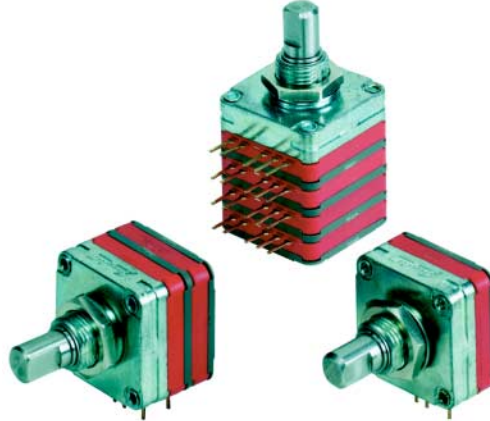
For additional information about the use of the GH65 interface chips with optical encoders request Grayhill Application Note #719.

Optical and Mechanical Encoders

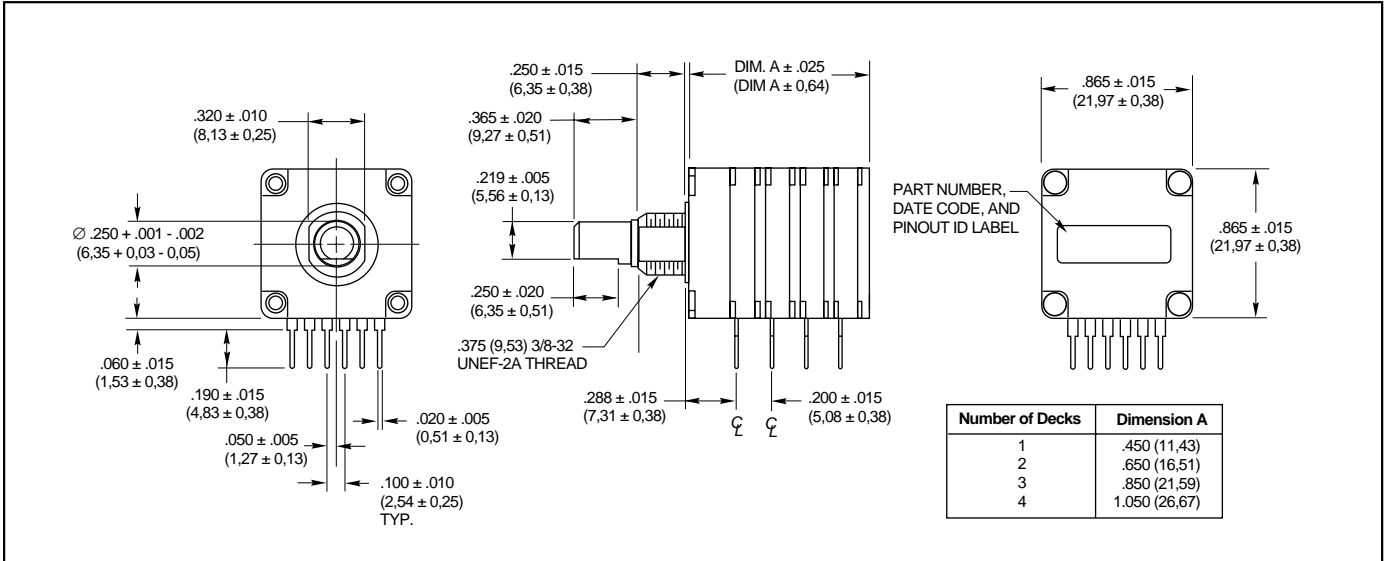
**SERIES 25**  
Multi-Deck

**FEATURES**

- Multiple Code and Indexing Choices
- Reliability Tested to Listed Specifications
- Less than 1.0" Square
- Termination Choices
- Panel and Shaft Seal Option
- Manufactured to ISO 9001 and Military Standards
- Custom Configurations Available



**DIMENSIONS** In inches (and millimeters)



## SPECIFICATIONS

### Electrical Ratings

**Switching Loads:** 150 mA at 120 Vac, resistive; 150 mA at 28 Vdc, resistive

**Current Carrying Capacity:** 250 mA at 28 Vdc, resistive

**Contact Resistance:** 75 mΩ maximum after life

**Insulation Resistance:** 1000 mΩ minimum between terminals and shaft

**Voltage Breakdown:** 1000 Vac minimum between terminals and shaft

**Life Expectancy:** 50,000 cycles at rated loads

**Contacts:** Shorting

### Mechanical Ratings

**Stop Strength:** 10 in-lbs minimum

**Rotational Torque:** 4-20 in-oz, dependent on the number of decks

**Operating Temperature Range:** -65°C to +85°C

**Non-Turn Device:** Flatted mounting bushing, .375" dia. x .320"

**Package Size:** .865" square

**Termination:** PC terminals, .100" on center. Decks are .200" apart.

### Materials and Finishes

**Bushing:** Die cast zinc alloy, plated and chromate-treated

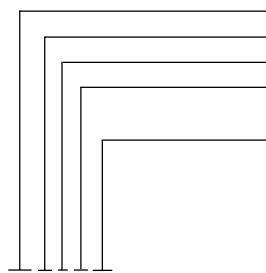
**Shaft, Stop Blades, Detent Balls, Rivets:** Brass, zinc-plated

**Mounting Hardware:** plated brass

**Decks, Deck Separators, End Plate:** Thermoplastic

**Contacts and Terminals:** Gold, silver, nickel-plated beryllium copper

## ORDERING INFORMATION



25BSP10-Q-2-36C

**Series 25:** Multi-deck

**Shaft size:** B = 1/4" diameter shaft

**Sealed or non-sealed:** S = Shaft and panel seal; No letter = no seal

**Terminal structure:** P = PC, perpendicular to shaft; R = PC, rear facing (one deck only); F = PC, front facing (one deck only).

**Angle of throw (determines the maximum number of positions):**

10 = 10°, 36 positions; 11 = 11.25°, 32 positions; 12 = 12°, 30 positions;

15 = 15°, 24 positions; 18 = 18°, 20 positions; 22 = 22.5°, 16 positions;

30 = 30°, 12 positions; 45 = 45°, 8 positions; 60 = 60°, 6 positions;

90 = 90°, 4 positions.

**Stop arrangement:** For switches with maximum positions, add C for continuous rotation; add F for stop between first and last. No notation required for less than maximum positions.

**Number of positions:** Maximum is dependent on the angle of throw. Minimum is two.

**Number of decks:** One through four possible.

**Code output:**

B = Binary available in 22.5°

Q = Quadrature

G = Gray available in 22.5°

Specials include 1/8" diameter shaft, custom angles of throw for binary, binary complement and gray code outputs.

Control knobs available, see page E-39.

**Available from your local Grayhill Distributor.** For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

## SERIES 25L

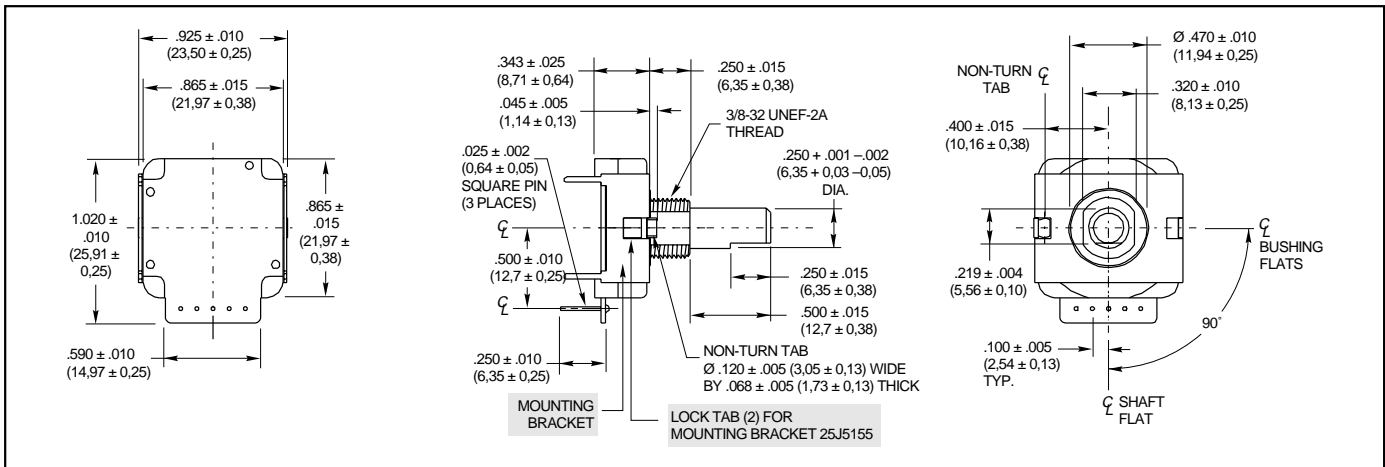
Hex, Gray and Quadrature Code

### FEATURES

- Price Competitive to Similar Designs
- Quality Construction and Contact Materials
- Multiple Code and Indexing Choices
- 100,000 Life Cycles
- Less than 1.0" Square
- Manufactured to ISO 9001 Standards



### DIMENSIONS In inches (and millimeters)



### TRUTH TABLES

Clockwise Rotation					
4-Bit Gray Code-16 Position					
Switch Position	Code Position	1	2	4	8
1	0				
2	1	•			
3	2	•	•		
4	3		•		
5	4		•	•	
6	5	•	•	•	
7	6	•		•	
8	7			•	
9	8			•	•
10	9	•		•	•
11	10	•	•	•	•
12	11		•	•	•
13	12		•		•
14	13	•	•		•
15	14	•			•
16	15				•

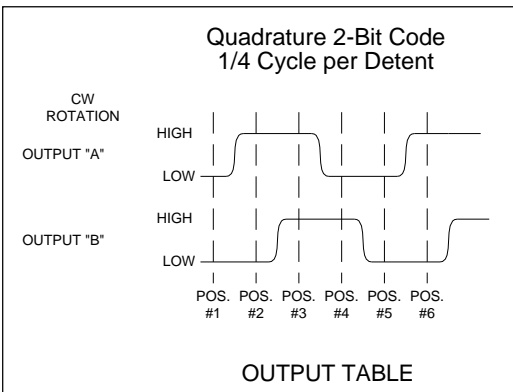
• Indicates closed circuit; blank indicates open circuit.

Clockwise Rotation					
4-Bit Binary Code Hexadecimal-16 Position					
Switch Position	Code Position	1	2	4	8
1	0				
2	1	•			
3	2		•		
4	3	•	•		
5	4			•	
6	5	•		•	
7	6		•	•	
8	7	•	•	•	
9	8				•
10	9	•			•
11	10		•		•
12	11	•	•		•
13	12			•	•
14	13	•		•	•
15	14		•	•	•
16	15	•	•	•	•

• Indicates closed circuit; blank indicates open circuit.

Clockwise Rotation		
Quadrature 2-Bit Code 1/4 Cycle per Detent		
Switch Position	"A" Output	"B" Output
1		
2	•	
3	•	•
4		•
5		
6	•	
7	•	•
8		•
9		
10	•	
11	•	•
12		•
13		
14	•	•
15	•	•
16		•
17		
18	•	
19	•	•
20		•
21		
22	•	
23	•	•
24		•
25		
26	•	
27	•	•
28		•
29		
30	•	
31	•	•
32		•
33		
34	•	•
35	•	•
36		•

• Indicates closed circuit; blank indicates open circuit. Code repeats every 4 positions.



**SPECIFICATIONS**

**Electrical Ratings**

**Switching Loads:** 1.5 mA at 115 Vac, resistive; 150 mA at 14 Vdc, resistive  
**Current Carrying Capacity:** 250 mA maximum at 28 Vdc, resistive load  
**Contact Resistance:** 75 mΩ, typical  
**Insulation Resistance:** 1000 mΩ minimum between terminals  
**Voltage Breakdown:** 1000 Vac minimum between terminals  
**Life Expectancy:** 100,000 cycles of operation at rated loads. One cycle of operation is a rotation through all of the active positions and a return to the starting position.

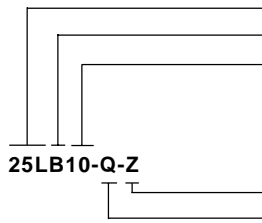
**Mechanical Ratings**

**Rotational Torque:** 2 to 6 in-oz  
**Operating Temperature Range:** -65 C° to +85 C°  
**Storage Temperature Range:** -65 C° to +85 C°  
**Continuous Rotation:** All standard switches are continuous rotation. Desired stop locations supplied upon request.  
**Anti-Rotation Device:** Integral non-turn tab, flatted bushing, .375" diameter, .320 double "D" across flats.  
**Termination:** Standard is PC style, parallel to shaft, facing rear. Options include PC, parallel to shaft, facing front; PC, perpendicular to shaft.  
**Panel Mounting Torque:** 10 in-lbs maximum

**Materials and Finishes**

**Bushing/Housing and Shaft/Rotor:** Reinforced thermoplastic  
**Detent Ball:** Stainless steel, nickel-plated  
**Detent Spring:** Tinned music wire  
**Contacts:** Beryllium copper, gold plate over nickel  
**Terminals:** Copper alloy, CDA #725, solder plate over nickel  
**Output Board:** FR-4, copper/nickel-plated  
**Mounting Hardware:** Brass, cadmium-plated hex nut  
**Mounting Bracket:** Stainless Steel, tin-plated

**ORDERING INFORMATION**



25LB10-Q-Z

\* Cadmium free

**Series:** 25L = Economical, single deck encoder  
**Housing Color:** B = Black housing\*; R = Red housing  
**Angle of Throw:** 10 = 10°, 36 positions; 11 = 11.25°, 32 positions; 15 = 15°, 24 positions; 18 = 18°, 20 positions; 22 = 22.5°, 16 positions; 30 = 30°, 12 positions; 45 = 45°, 8 positions  
**Mounting Bracket:** Z = with bracket, Blank = no bracket  
**Code Output:** H = Hexadecimal available only in 22.5°  
 G = Gray available only in 22.5°  
 Q = Quadrature (2-bit)

Custom materials, styles, color and markings are available. Custom knobs available, see page E-39.

Available from your local Grayhill Distributor. For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.



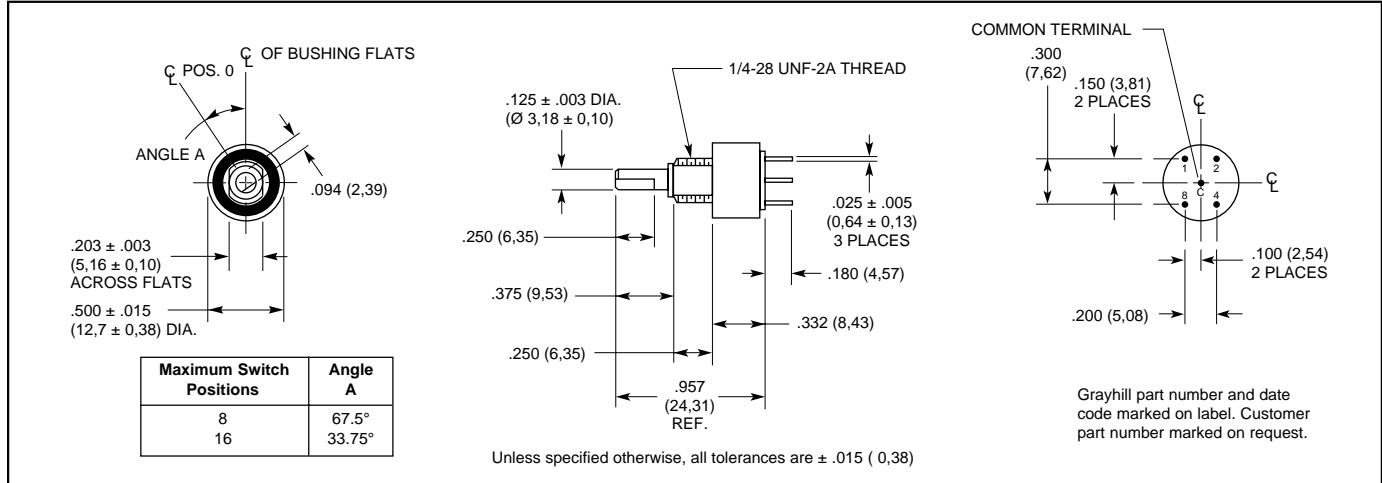
## SERIES 26 Binary and Gray Code

### AVAILABLE CODES

- Hexadecimal
- Octal
- BCD (Adjusted)
- Quadrative
- Custom (4-Bit, 16 position maximum)



### DIMENSIONS In inches (and millimeters)



### SPECIFICATIONS

#### Electrical Ratings

**Rated:** 25,000 cycles with logic compatible loads. Make and break 200 mA.

**Contact Resistance:** 500 milliohms maximum (less than 100 milliohms initially)

**Insulation Resistance:** 1000 megohms minimum (10,000 megohms initially)

**Dielectric Strength:** 250 Vac minimum

#### Materials and Finishes

**Panel Seal:** Silicone Rubber

**Shaft Seal:** Fluorosilicone

**Mounting Nut (mounting hardware—one per switch):** Brass, cadmium-plated

**Internal Tooth Lockwasher (mounting hardware—one per switch):** Steel, cadmium-plated

**Detent Balls:** Carbon steel, nickel-plated

**Detent Spring:** Pretinned music wire

**Detent Rotor:** Thermoplastic

**Shaft, Stop Arm and Stop Pins:** Stainless steel

**Bushing:** Zamak II tin/zinc alloy, zinc-plated

**Switch Base:** Diallyl phthalate

**Printed Circuit Board:** NEMA Grade FR-4.

**Terminals:** Brass, gold-plated over nickel plate

**Contacts:** Copper alloy, gold-plated over nickel plate

#### Additional Characteristics

**Rotational Torque:** 4 to 8 oz-in on a new switch.

**Vibration Resistance:** 10 to 55 Hz at 0.060" double amplitude; no damage and no contact openings per MIL-STD-202, Method 201A

**Shock Resistance:** Passes medium requirement MIL-S-3785 (MIL-STD-202, Method 213)

**Stop Strength:** 5 in-lbs minimum

**Terminals:** All switches are provided with all 5 terminals, regardless of the number of active positions.

**Relative Humidity:** 90-95% at 40°C for 240 hours (MIL-STD-202 Method 103, Test Condition A)

### OPTIONS

#### Adjustable Stop Switches

The switch may have continuous rotation, or be adjusted to limit the rotation. The panel seal ring can be removed to expose the stop pin holes on the front of the switch. Two stop pins and panel seal o-ring are supplied with the switch. One or both may be used to limit the rotation as desired.

#### Shaft and Panel Seal

All switches are provided with a shaft and panel seal.

### ACCESSORIES

Control knobs available, see page E-39.

### ORDERING INFORMATION

#### BCD Output—Adjustable Stop

Number of Positions	Part Number
8 Positions	26ASD45-01-1-AJS
16 Positions	26ASD22-01-1-AJS

**Available from your local Grayhill Distributor.**

For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

### CODE AND TRUTH TABLE

Switch Position	Code Position	BCD Output*				Gray Output*			
		1	2	4	8	1	2	4	8
1	0								
2	1	●				●			
3	2		●			●	●		
4	3	●	●				●		
5	4			●			●	●	
6	5	●		●		●	●	●	
7	6		●	●		●			●
8	7	●	●	●					●
9	8				●			●	●
10	9	●			●	●		●	●
11	10		●		●	●	●	●	●
12	11	●	●		●		●	●	●
13	12			●	●		●		●
14	13	●		●	●	●	●		●
15	14		●	●	●	●			●
16	15	●	●	●	●				●

\*Dot indicates terminal tied to common.

#### Gray Code Output—Continuous Rotation\*\*

Number of Positions	Part Number
16 Positions	26GS22-01-1-16S-C

All switches have shorting contacts.

\*\* Contact Grayhill for availability of Series 26 Gray Code Output switches with adjustable stops.

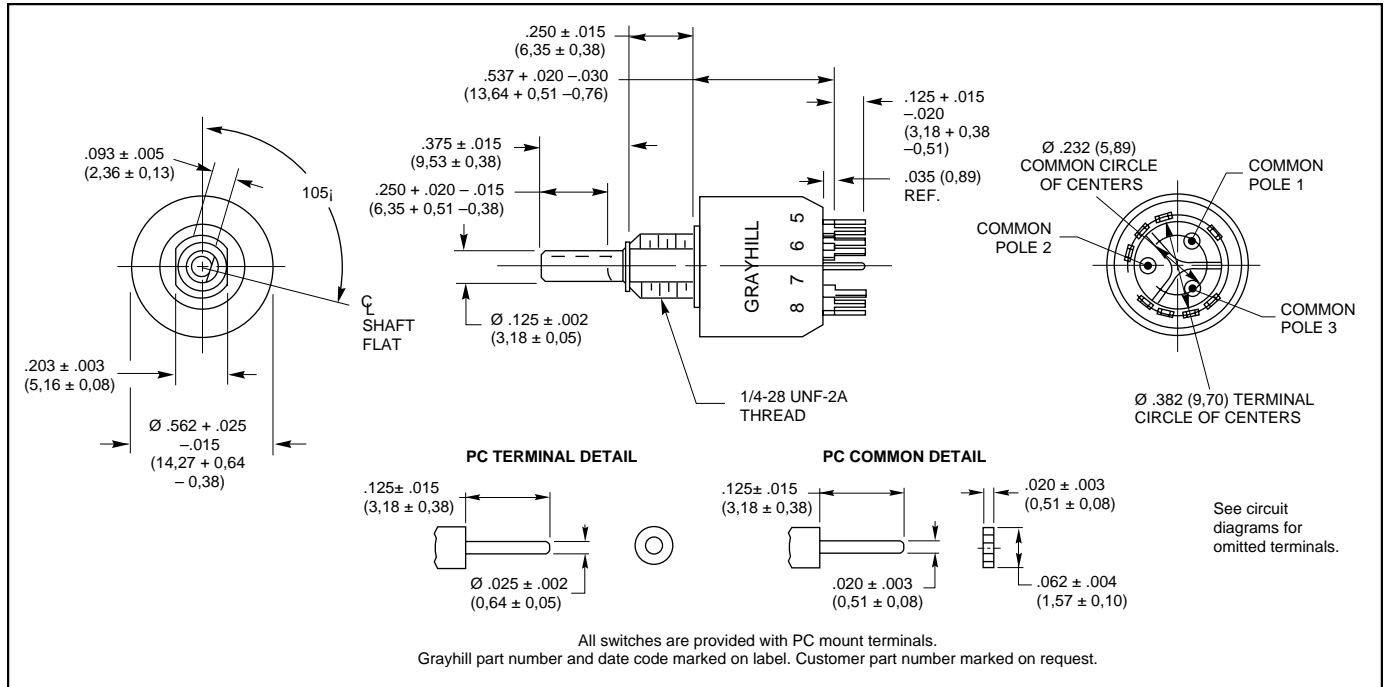
**SERIES 51**  
Binary or Binary  
Complement Code

**FEATURES**

- PC Mount, 30° Angle of Throw
- 2 to 12 Positions
- .562" Diameter, 200 mA
- Shaft and Panel Seal
- Adjustable Stop Versions



**DIMENSIONS** In Inches (and millimeters)



Optical and Mechanical Encoders

**CIRCUIT DIAGRAMS**

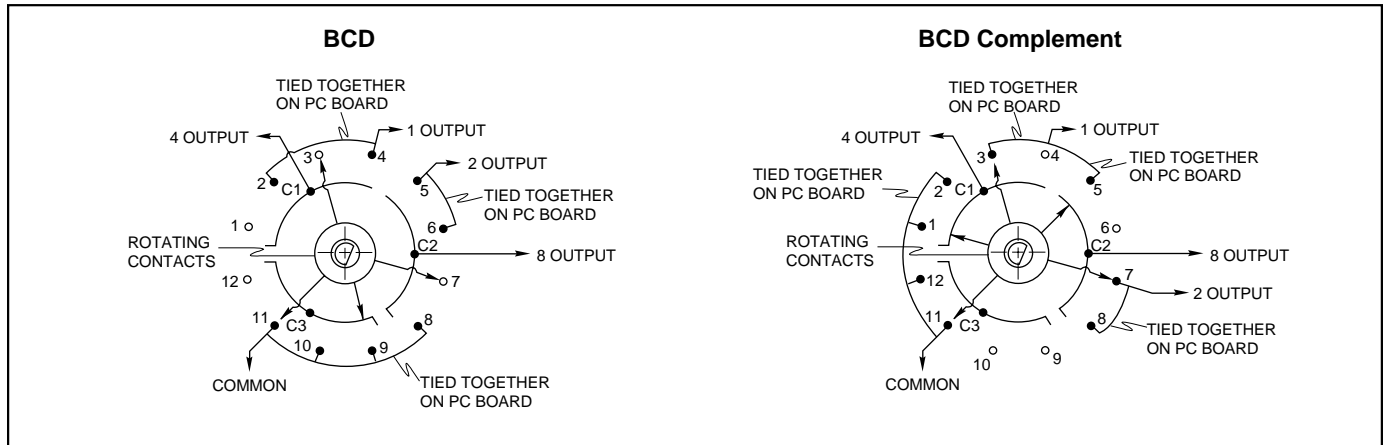
Switch is viewed from the shaft end and shown in switch position number 1, which is decimal number zero and BCD number zero.

- Indicates Terminal is present.
- Indicates Terminal is omitted.

Note: Connections must be made on PC board to

generate code output.

Switch position numbers do not correspond to the decimal input or binary output. See Truth Tables.



## TRUTH TABLES

### Binary Code Decimal

Dec. No.	Switch Pos'n.*	2nd Pin**	Output Terminal			
			1	2	4	8
0	1	4-5				
1	2	5-6	●			
2	3	6-7		●		
3	4	7-8	●	●		
4	5	8-9			●	
5	6	9-10	●		●	
6	7	10-11		●	●	
7	8	11-12	●	●	●	
8	9	12-1				●
9	10	1-2	●			●
10	11	2-3		●		●
11	12	3-4	●	●		●

### Binary Code Decimal Complement

Dec. No.	Switch Pos'n.*	2nd Pin**	Output Terminal			
			1	2	4	8
0	1	12-1	●	●	●	●
1	2	1-2		●	●	●
2	3	2-3	●		●	●
3	4	3-4			●	●
4	5	4-5	●	●		●
5	6	5-6		●		●
6	7	6-7	●			●
7	8	7-8				●
8	9	8-9	●	●	●	
9	10	9-10		●	●	
10	11	10-11	●		●	
11	12	11-12			●	

● Indicates contact made to common

\* The switch position number is the terminal location opposite the shaft flat; it is not the same as the decimal number.

\*\* To limit an adjustable stop switch to the decimal number shown, insert the second pin in the hole lying between the 2 switch positions indicated.

## OPTIONS

### Adjustable Stops

Set and reset stops to limit rotation. All dimensions are the same as for fixed stop switches. Switches are shipped with the stop blades located to limit rotation to 11 switch positions. For continuous rotation, remove both blades. For limited rotation, remove the 2nd (clockwise) blade and move it to the hole located between the positions shown in the Truth Tables. Removal of a plastic washer provides access to the blades and slots. Adjustable stop versions are available in unsealed styles only.

### Shaft and Panel Seal

Switches are available in sealed or unsealed styles. For sealed style, the panel is sealed by an o-ring at the base of the bushing. The shaft is sealed by an o-ring inside of bushing. After the switch is mounted, seals do not alter the dimensions of the unsealed style.

## SPECIFICATIONS

### Electrical Rating

**Rated:** To make and break 125 mA 30 Vdc resistive load for 25,000 cycles of operation.

**Cycle:** (1 cycle = 360° rotation and return) Test conditions are standard atmospheric pressure, 25°C and 68% relative humidity.

**Contact Resistance:** 20 milliohms initially, 300 milliohms maximum after life

**Insulation Resistance:** 50,000 megohms initially, 10,000 megohms after life

**Voltage Breakdown:** 500 Vac between mutually insulated parts

### Materials and Finishes

**Bases:** Thermoset plastic

**Detent Rotor:** Nylon

**Shaft, Stop Blades, Stop Arm, Thrust Washer And Retaining Ring:** Stainless steel

**Detent Balls:** Steel, nickel-plated

**Bushing:** Zinc, cadmium-plated

**Detent Spring:** Stainless steel

**Common Terminals and Rings:** Brass, gold plate .00003" minimum over silver plate .0003" minimum

**Terminals:** Brass with silver contact surface, gold-plated .00003"

**Rotor Contact:** Beryllium copper with silver contact surface

**Shaft And Panel Seal:** Silicone rubber

**Mounting Hardware:** One mounting nut, .089" thick by .375" across flats, and one internal tooth lockwasher are supplied with the switch.

### Additional Characteristics

**Contact Type:** Wiping contacts

**Shaft Flat Orientation:** Switch position is defined as that position that is opposite the shaft flat. The location of the contacts in relation to the shaft flat is shown on the circuit diagram.

**Terminals:** Only the active position terminals, as shown in the circuit diagram are supplied with the switch. All common terminals are supplied.

**Stop Strength:** 7.5 in-lbs minimum

**Rotational Torque:** 8 to 16 in-oz

**Bushing Mounting:** Required for these switches

## ORDERING INFORMATION

Type Of Switch	Maximum No. Of Positions	BCD Output		BCD Complement	
		Unsealed	Sealed	Unsealed	Sealed
Fixed Stop	7	513360-7	513374-7	513361-7	513375-7
	8	513360-8	513374-8	513361-8	513375-8
	9	513360-9	513374-9	513361-9	513375-9
	10	513360-10	513374-10	513361-10	513375-10
	11	513360-11	513374-11	513361-11	513375-11
	12	513360-12-F	513374-12-F	513361-12-F	513375-12-F
Continuous Rotation	12	513360-12-C	513374-12-C	513361-12-C	513375-12-C
Adjustable Stop	12	513385	—	513384	—

The -C suffix indicates continuous rotation. The -F suffix indicates a fixed stop between positions 1 and 12.

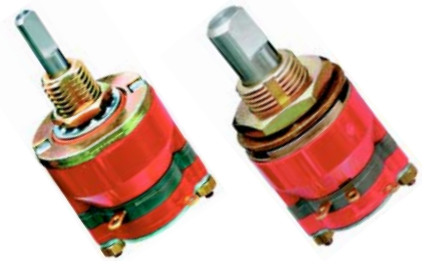
Custom knobs available, see page E-39.

**Available from your local Grayhill Distributor.** For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

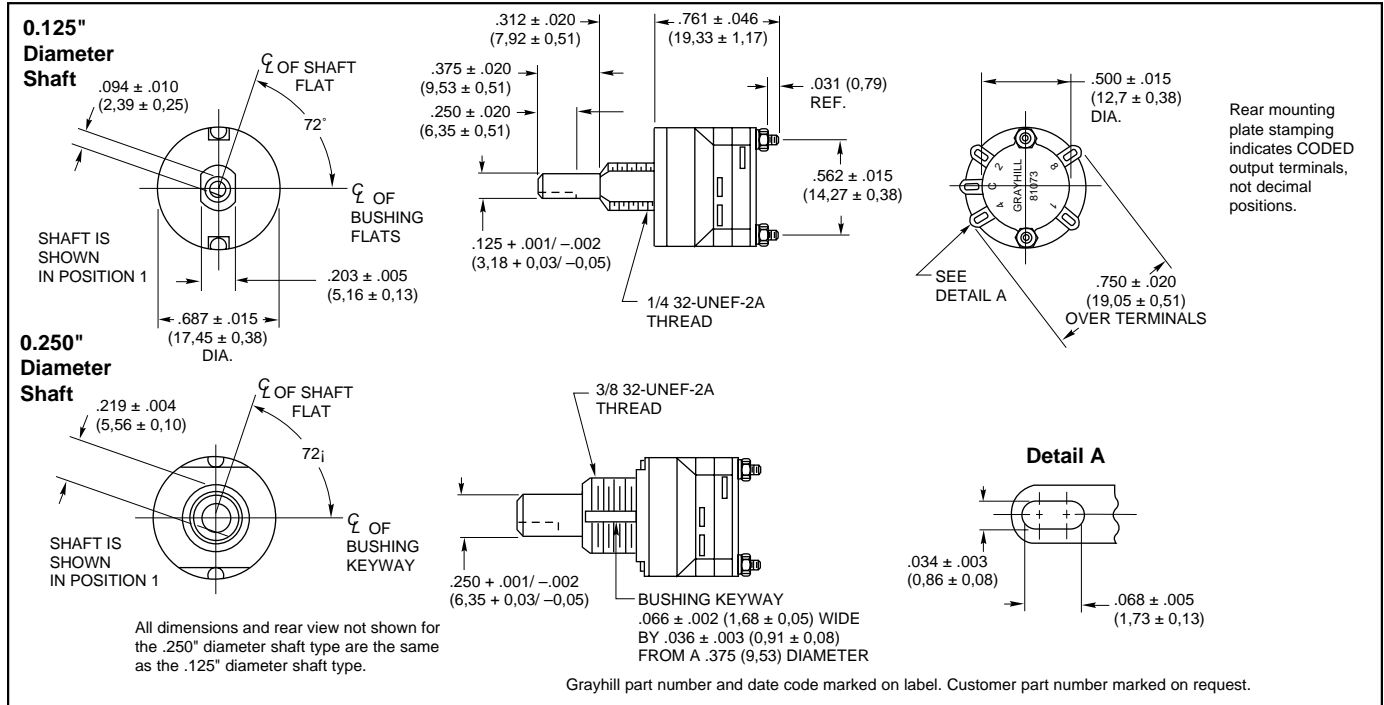
**SERIES 71**  
**Binary Code**

**FEATURES**

- 1/4" or 1/8" Shaft Diameters
- 25,000 Cycles at 125 mA
- Optional Seal Versions
- Adjustable Stop Versions



**DIMENSIONS** In inches (and millimeters)



**CODE AND TRUTH TABLE**

Output Terminal	0	1	2	3	4	5	6	7	8	9
1		●		●		●		●		●
2			●	●			●	●		
4					●	●	●	●		
8									●	●

● Indicates contact is made to the common.

**SPECIFICATIONS**

**Electrical Rating**

**Rated:** To make and break 125 mA at 30 Vdc resistive at standard conditions

**Life Expectancy:** 25,000 cycles at rated load; 50,000 cycles mechanical. For ratings at different loads and conditions, contact Grayhill.

**Contact Resistance:** 100 milliohms maximum (50 milliohms initially)

**Insulation Resistance:** As measured between mutually insulated parts

Initially: 50,000 megohms minimum

After Life: 10,000 megohms minimum

**Voltage Breakdown:** 500 Vac between mutually insulated parts

**Carry Current:** These switches will carry 3 amperes with a maximum contact temperature rise of 20°C.

**OPTIONS**

**Shaft and Panel Seal**

Shaft is sealed by o-ring inside the bushing; panel is sealed by o-ring at the base of the bushing. Seals do not alter dimensions as shown in the drawing when switch is mounted. Panel seal is silicone rubber. Shaft seal is an o-ring per MIL-P-5516B. Shaft and panel seal is not available on adjustable stop switch.

**Additional Characteristics**

**Rotational Torque:** 8 to 16 oz-in.

**Contacts:** Non-shortening wiping contacts

**Shaft Flat Orientation:** As shown in the drawing, switch would provide a decimal 1 output.

**Materials and Finishes**

**Base:** Diallyl per MIL-M-14

**Rotor Mounting Plate:** Thermoplastic.

**Rotor Contact:** Phosphor Bronze, gold-plated 30 microinches minimum

**Terminals:** Brass, gold plate (20 microinches) minimum over silver plate (300 microinches) minimum

**Additional Materials:** Other switch materials and finishes are the same as listed for the standard switch. See Standard Switch.

**Adjustable Stop Switches**

Adjustable stop switch lets you limit the number of positions. Remove and relocate pins in the front plate. A sticker holds the pins in place. With the exception of holes in the front plate, all dimensions, ratings, and characteristics are the same as the other Series 71 coded switches. For diagrams, see Standard Switch.

**ACCESSORIES**

Control knobs available, see page E-39.

**ORDERING INFORMATION**

Shaft Diameter And Description	Part Number
1/8" Continuous Rotation	<b>71AY23401</b>
1/8" Cont. Rot., Sealed	<b>71AY23402</b>
1/4" Continuous Rotation	<b>71BY23403</b>
1/4" Cont. Rot., Sealed	<b>71BY23404</b>
1/8" Adjustable Stops	<b>71AD36-3118</b>
1/4" Adjustable Stops	<b>71BD36-3119</b>

**Available from your local Grayhill Distributor.** For prices and discounts, contact a local Sales Office, an authorized local Distributor or Grayhill.

**STANDARD SWITCH PAGES**

Series 71 Switch begins on page F-31.

Optical and Mechanical Encoders

### CONTROL KNOBS

Ideally Suited for Encoder and Rotary Switches

#### FEATURES

- Standard Fit for Grayhill Encoder and Rotary Switches
- Custom Materials, Styles, Colors and Markings Available
- Standard Black or Gray
- Choice of Spring Clip (Press-On) or Metal Insert with Set Screw Versions

Contact Grayhill for special design considerations



Optical and Mechanical Encoders

#### DIMENSIONS In inches (and millimeters)

<p><b>Style 5013</b></p> <p><b>Top View</b></p> <p>Available in .250 Dia. Shaft only.*</p>	<p><b>Style 5014</b></p> <p><b>Top View</b></p>
<p><b>Style 5015</b></p> <p><b>Top View</b></p>	<p><b>Style 5017</b></p> <p><b>Top View</b></p> <p>Available in .125 and .157 (4mm) dia. shaft in spring clip (press-on) version only.*</p>

\*See Ordering Information.



**DIMENSIONS** In inches (and millimeters)

<p><b>Style 5019</b></p> <p><b>Top View</b></p>	<p><b>Style 5020</b></p> <p><b>Top View</b></p> <p>Available in ABS, .250 dia. shaft in spring clip (press-on). The locking clip is also available, requires a custom shaft.**</p>
<p><b>Style 5028</b></p> <p><b>Top View</b></p> <p>Available in .250 dia. shaft only*</p>	<p><b>Style 5029</b></p> <p><b>Top View</b></p>

\*See Ordering Information.

\*\*Contact Grayhill representative

**ORDERING INFORMATION**

**11K5028-KCNB**

**Series**  
**Style\*:** 5013, 5014, 5015, 5017, 5019, 5020, 5028, 5029  
 (see dimension drawings for style options)

**Shaft Diameter:**  
**J** = .125 dia. shaft  
**E** = .157 (4mm) dia. shaft  
**K** = .250 dia. shaft

**Knob Color:**  
**B** = Black  
**G** = Gray

**Material:**  
**A** = ABS (available on the styles 5017 and 5020 only)  
**N** = Nylon

**Version:**  
**C** = Spring Clip (press-on)  
**L** = Locking Clip (available on the style 5020 only)  
**M** = Metal Insert w/Set Screw(s)

Custom materials, styles and colors are available.  
 For prices and discounts, contact a local sales office or Grayhill.

Optical and Mechanical Encoders