

# GURLEY MODEL A25S ABSOLUTE ENCODER

MOTION TYPE:

ROTARY

USAGE GRADE:

INDUSTRIAL

OUTPUT:

ABSOLUTE

MAX RESOLUTION:

$2^{17}$  (131,072 WORDS)



## COMPACT, FAST & ACCURATE

Gurley Precision Instruments' Model A25S absolute optical encoder is unique with its advanced design featuring new encoder technology. The following features make it far more capable than competitive products:

- Faster and more accurate than either a resolver-based system, or any competitive optical encoder.
- Up to 17-bit resolution, the highest available in an encoder designed and priced for industrial applications.
- A rugged, compact transducer (2.5" dia x 1.25" long) makes the encoder easier to design into tight spaces.
- Fully accurate data at 600 rpm permits use at higher shaft speeds.
- Very high data update rate (1 MHz parallel, 100 kHz serial) allows the encoder to be used whenever "real time" data is needed, such as velocity feedback applications or wide-bandwidth positioning servos.
- Unique circuitry eliminates hysteresis deadband, so there's no error due to bi-directional operation.
- Natural binary bus-compatible output permits straightforward hardware and software interfacing.
- Optional interface card simplifies communication between the encoder and a computer.

ISO  
9001  
CERTIFIED

Gurley Precision Instruments  
514 Fulton Street  
Troy, NY 12180 U.S.A.  
(800) 759-1844, (518) 272-6300, fax (518) 274-0336,  
Online at [www.gurley.com](http://www.gurley.com), e-mail: [info@gurley.com](mailto:info@gurley.com)



# SPECIFICATIONS

## MECHANICAL

Maximum weights	
Steel transducer, 48" cable*	19 oz (540 g)
Aluminum Transducer, 48" cable**	13 oz (370 g)
External electronics	5 oz (140 g)
Jacketed cable	0.118 oz/in (132 g/m)
Moment of inertia	$9.0 \times 10^{-4}$ in-oz-s <sup>2</sup> (63.2 g-cm <sup>2</sup> )
Starting torque	2.0 in-oz ( $14.0 \times 10^{-3}$ N-m)
Running torque	1.0 in-oz ( $7.0 \times 10^{-3}$ N-m)
Max. recommended shaft load	
Axial	13 lb (58 N)
Radial	10 lb (45 N)
Bearings	Sealed ABEC 7
Code disc	chrome on glass
Max. operating speed	600 rpm
Max. slew speed	10,000 rpm
* TEMP = A or T	
** TEMP = C	

## ENVIRONMENTAL

Operating temperature	
Commercial	32°F to +158°F (0°C to +70°C)
Automotive	-40°F to +185°F (-40°C to +85°C)
Storage temperature	-40°F to +194°F (-40°C to +90°C)
Humidity	98% rh, non-condensing
Altitude	0-50,000 ft, (0 - 15.24 km)
Shock	50 g, 11ms
Vibration	15 g, 0-2000 Hz
Transducer	IP40
Electronics	IP60

## ELECTRICAL

Input power	+5 Vdc $\pm 0.25$ Vdc, 300 mA max (excluding output buffer requirements)
Illumination	Light-emitting diodes, screened and rated for 100,00-hr life
Max resolution	2 <sup>17</sup> (131,072) unique words per shaft revolution (other resolutions available; see Ordering Info.)
Accuracy	Each data transition is within $\pm 15$ arcsec of its true position, regardless of resolution. The error distribution is such that each output code state is always present and in the correct order.
Output code	Natural binary (consult factory for other codes)
Output format	Parallel or serial
Direction of increasing count	User selectable (factory default = cw)
Parity	User selectable (factory default = odd)
Parallel Output	TTL-compatible tri-state buffered registers. Byte-wide or word-wide (user selectable) format.
Input device	Schmitt trigger input for interrogate pulse. TTL compatible output enable line(s).
Max data update rate	1 MHz
Serial output	Synchronous output with EIA/RS-422 differential line drivers. MSB first; parity last
Input device	EIA/RS-422 differential line receivers for interrogate pulse and clock input.
Max data update rate	100 kHz@3.6 Mbaud

NOTE: These specifications are applicable under all variations of recommended supply voltage, speed, temperature and direction of travel. Improved performance is available under special conditions; please consult factory.

## ACHIEVING ACCURACY

These design features assure the high accuracy and long-term stability of the Model A25S:

- Multiple reading heads are used in the transducer to eliminate errors caused by disc eccentricity, pattern irregularities and non-uniform bearing rotation.
- Back-to-back photodiodes "read" the interpolated track in push-pull configuration to eliminate errors caused by LED aging, temperature changes, supply voltage variations and other common-mode effects.
- Interpolation is accomplished with proprietary high-speed phase-angle conversion circuitry, which produces true position data very quickly and very accurately. The circuitry has been designed for reliable and predictable performance over the rated temperature environment.
- Because output data is made available only when the user provides an interrogate pulse, there is no possibility of "chatter" in the vicinity of a data transition, and hence no need for hysteresis in the circuitry. This unique zero-hysteresis feature assures error-free operation in bi-directional applications.

## ABSOLUTE POSITION ENCODING

The Model A25S is a high performance absolute optical encoder designed for resolution in the 2<sup>14</sup>-2<sup>17</sup> range. Its position information is stored in a non-volatile fashion in the multi-track absolute code pattern on the disc. If power is lost and re-applied, absolute position data is immediately available without "homing" the encoder or counting pulses, as is typically required with an incremental device. It is especially well-suited for applications requiring the highest possible data integrity where electrical noise, safety or high performance are important system considerations.

## ROBUST MECHANICAL DESIGN

The A25S consists of a low-profile transducer module and separate electronics package - a configuration that allows it to be used where conventional designs will not fit. The rugged 3/8" dia shaft/bearing assembly assures long life in a variety of industrial applications. A proprietary electronic circuit permits the use of a lower resolution code disc; this minimizes sensitivity to opto-mechanical adjustments and thus maximizes long-term mechanical stability.

## REMOTE ELECTRONICS

The separate electronics is housed in a compact 4.2" x 2.8" x 0.9" enclosure that can be located up to 25 ft from the transducer (standard cable length is 4 ft).

## APPLICATIONS

The encoder is designed so that it may be connected directly to the data bus of a microprocessor or microcomputer. It offers the advantages of high accuracy, simplified hardware and software interfacing, robust opto-mechanical design, wide operating temperature range and very fast response time.

The Model A25S is ideal for any motion control application requiring an absolute encoder with high resolution, accuracy and reliability in a compact configuration. Typical applications include robotics, precision servo controls, radar pedestals and similar AZ-EL mounts, rotary tables and machine tools.

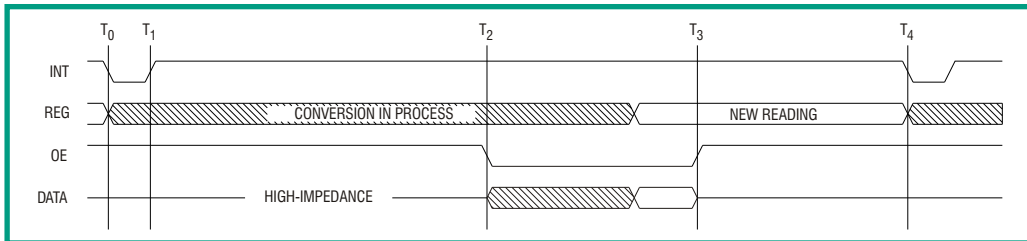
# SPECIFICATIONS

## PARALLEL OUTPUT

Position data is obtained from the encoder by issuing an active low interrogate pulse, which initiates a rotary-to-digital (R/D) conversion. The interrogate pin is a negative-edge-sensitive Schmitt trigger input and may be activated by any digital or analog signal that meets the stated input voltage requirements. R/D conversion proceeds independently of any other signal edge or state, and valid data is available at the output parallel register after 750 ns. Data remains valid until power is removed, or a new interrogate pulse is issued. A valid R/D conversion is not automatically initiated on power-up. Typically, 30-50 ms should be allowed on power-up before interrogation to permit power supplies to settle.

Each parallel output line is buffered by a tri-state high speed CMOS bus driver compatible with virtually all TTL and CMOS 5-volt logic inputs. Two active-low output enables (chip selects) may be used to read high and low bytes separately, or they may be tied together for whole-word reads. (With 17-bit resolution, data is available as whole-word only). The parity bit is also tri-state, and is enabled in conjunction with the high byte. The user can select whether parity is odd or even with a jumper in the electronics package. Two or more encoders may share a byte-wide or word-wide output cable, provided conventional tri-state multiplexing restrictions are observed to avoid bus contention.

## TIMING AND SIGNAL CHARACTERISTICS FOR PARALLEL OUTPUT



TIME	MIN	MAX
$T_1 - T_0$	100 ns	
$T_2 - T_0$	500 ns	
$T_3 - T_0$	750 ns	
$T_4 - T_0$	1 µs	
$T_3 - T_2$	100 ns	
$T_4 - T_3$	250 ns	

## DC CHARACTERISTICS

OEL, OEH	MIN	MAX
$V_{IH}$	2.0 V	$V_{CC} + 0.3$ V
$V_{IL}$	-0.3 V	0.8 V
$T_R$		500 ns
$T_F$		500 ns
$C_{IN}$		20 pF

INT	MIN	MAX
$V_{IH}$	3.5 V	$V_{CC} + 0.3$ V
$V_{IL}$	-0.3 V	1 V
$T_R$		
$T_F$		
$C_{IN}$		15 pF

DATA	MIN	MAX
$I_{OUT}$	-25 mA	+25mA
$C_{OUT}$		20pF

## SERIAL OUTPUT

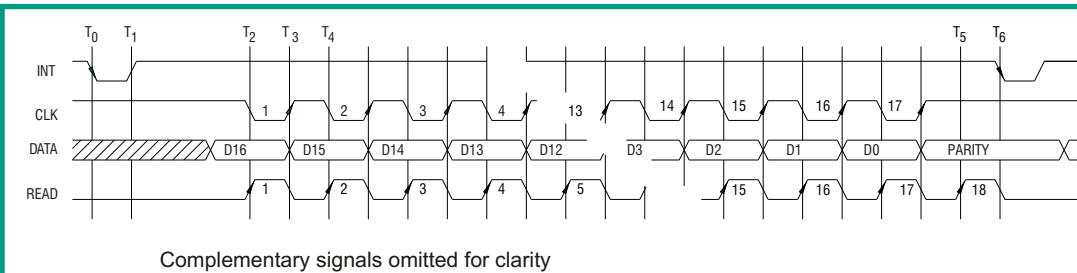
Position data is obtained from the encoder by issuing an active low pulse to the negative-edge-sensitive interrogate input while the clock input is held high; this initiates a rotary-to-digital (R/D) conversion.

R/D conversion proceeds independently of any other signal edge or state, and valid data is available at the output serial register after 900 ns. Data remains valid until power is removed, or a new interrogate pulse is issued. A valid R/D conversion is not automatically initiated on power-up. Typically, 30-50 ms should be allowed on power-up before interrogation to permit power supplies to settle.

Serial output is buffered by RS422 differential line drivers, and is formatted MSB first, LSB last, followed by a parity bit. The user can select whether parity is odd or even by means of a jumper in the electronics package.

Clock line must be held high until  $T_2$ . Interrogation is triggered by falling edge of INT. New data bits become valid about 75 ns after rising clock edge. READ wave form is shown for reference. RS422 receivers and drivers are Fairchild mA9637A and mA9638, respectively. Receivers are terminated by a series RC network (220 Ω and 0.01 mF) spanning the true and complement inputs.

## TIMING AND SIGNAL CHARACTERISTICS FOR SERIAL OUTPUT



TIME	MIN	MAX
$T_1 - T_0$	00 ns	
$T_2 - T_0$	900 ns	
$T_4 - T_3$	100 ns	
$T_6 - T_5$	100 ns	

## ELECTRICAL INSTALLATION

We recommend that the +5V supply (300 mA max, excluding atypical data bus termination requirements) for the encoder be provided from a linear regulated power supply located within 20 feet of the installation. Dual supply and return pins are provided to facilitate remote sensing, an option provided on most commercially available linear supplies. A cleanly regulated switch-mode power supply may be adequate in some cases. If the encoder is operated from the same supply as the customer's digital interfacing logic, an LC filter to suppress RFI on the instrument branch of the supply may be desirable. Where possible, terminate the instrument shield (Pin 13 and the D-Sub connector shell) at circuit ground potential as close as possible to the ground terminal of the power supply. The cover is effective primarily against electric field interference. In cases where intense magnetic field disturbances are expected, attention to cable routing and additional magnetic shielding may be wise precautions.

These recommendations should be sufficient to assure reliable operation. However, optical encoder installations are known for their mechanical and electrical variety. Gurley will gladly render applications assistance for difficult installations.

## OUTPUT PINOUTS SHIELDED MALE 25-PIN D SUBMINIATURE CONNECTOR

PIN	14-BIT	15-BIT	16-BIT	17-BIT	SERIAL
1	D5	D6	D7	D8	NC
2	D4	D5	D6	D7	NC
3	D3	D4	D5	D6	NC
4	D2	D3	D4	D5	NC
5	D1	D2	D3	D4	NC
6	D0	D1	D2	D3	NC
7	NC	D0	D1	D2	NC
8	NC	NC	D0	D1	NC
9	OEL	OEL	OEL	D0	INT
10	INT	INT	INT	INT	INT
11	+5V	+5V	+5V	+5V	+5V
12	+5V	+5V	+5V	+5V	+5V
13	CASE	CASE	CASE	CASE	CASE
14	D13	D14	D15	D16	NC
15	D12	D13	D14	D15	NC
16	D11	D12	D13	D14	NC
17	D10	D11	D12	D13	NC
18	D9	D10	D11	D12	NC
19	D8	D9	D10	D11	NC
20	D7	D8	D9	D10	DATA
21	D6	D7	D8	D9	DATA
22	OEH	OEH	OEH	OE	CLK
23	PAR	PAR	PAR	PAR	CLK
24	GND	GND	GND	GND	GND
25	GND	GND	GND	GND	GND

## SETTING THE DIP SWITCHES

Open the electronics assembly by removing the 4 Philips-head screws and lifting off the top cover (the one with the label). The dip switches can be set as follows (this information is also printed on the pc board):

	Position 1	Position 2
ON	Count increases with CCW shaft rotation	Parity is even
OFF	Count increases with cw shaft	Parity is odd

## SETTING THE DIP SWITCHES

It may be desirable to unplug the electronics to snake the cable through a tight spot. First, open the electronics assembly by removing the 4 Philips-head screws and lifting off the top cover (the one with the label). Carefully unplug the ribbon cable and the separate shield connector from the electronics board. When re-mating the transducer to the electronics, make sure that they have the same serial number. A mismatch of these components will result in gross position errors and void the warranty.

## MOUNTING THE ELECTRONICS

The simplest way to mount the electronics is with bracket AX06626 for a single box, or bracket AX06627 to mount a pair of boxes, as in an azimuth/elevation or other two-axis systems. Another choice is to bolt the box directly to a mounting surface: First, open the electronics assembly by removing the 4 Philips-head screws and lifting off the top cover (the one with the label). Unscrew 4 hex stand-offs, and lift out the electronics board and the cable; you don't have to unplug the cable from the pc board. Drill two clearance holes in diagonally opposite corners of the bottom of the lower cover. There's plenty of room under the pc board for screw heads. After the lower cover is bolted in place, carefully reassemble the package by reversing the previous three steps. Or, if your enclosure provides adequate mechanical and EMI protection, you can use the board without the box (order PKG code 0). You can mount the board on stand-offs, but be sure to provide adequate strain relief for the ribbon cable from the transducer.

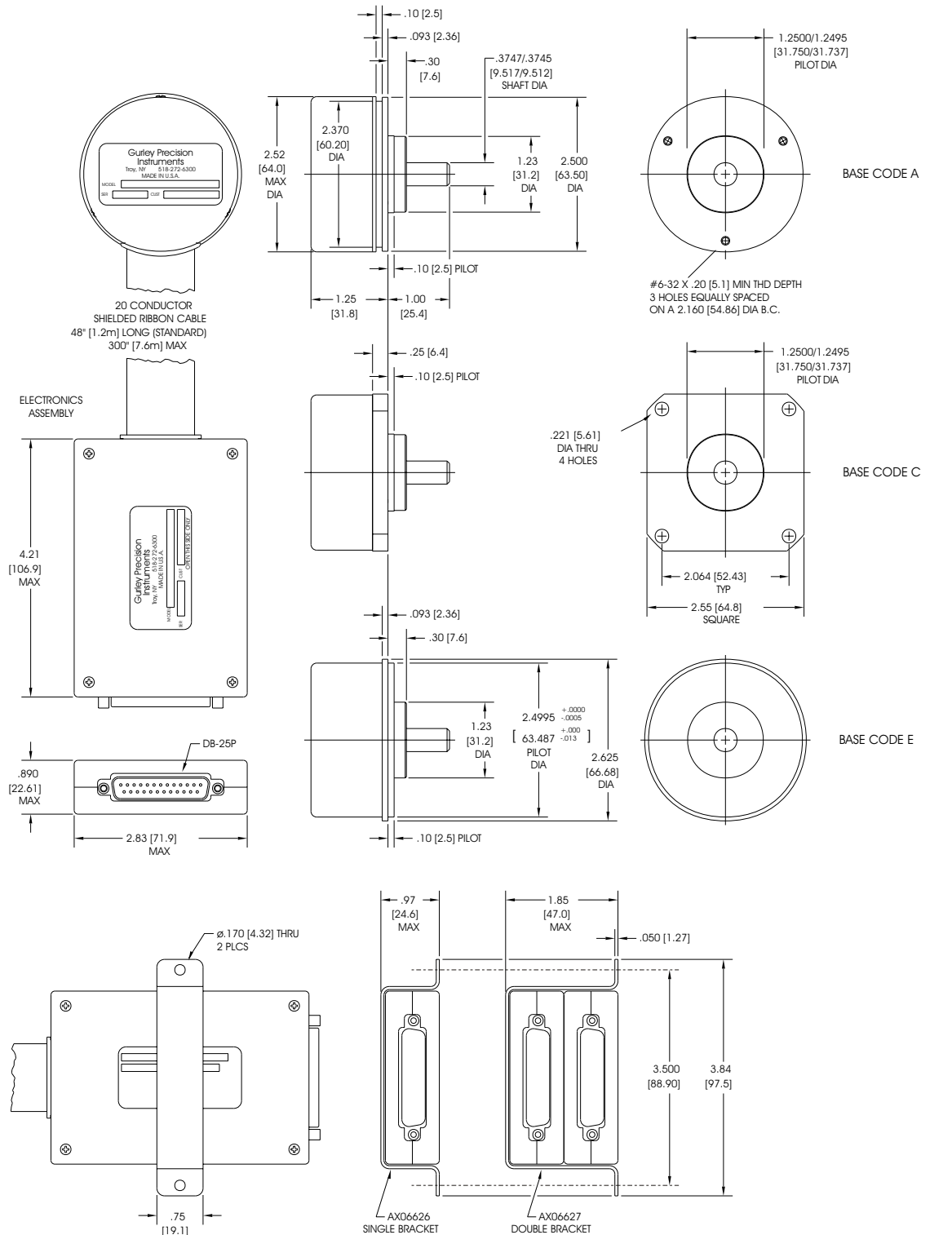
## PERFORMANCE CERTIFICATION

Before shipment, Gurley tests all absolute encoders for monotonicity, which guarantees that all output code states are present and in the correct order, and for accuracy, which verifies that the digital output matches the shaft angle input within the stated tolerance. These tests are performed on our exclusive METRA test system (Master Encoder for Testing Rotary Accuracy), and a printed accuracy plot accompanies each encoder.

The heart of METRA is an exclusive Gurley-designed optical encoder with a resolution of  $2^{21}$  measuring steps/rev, and NIST-traceable absolute accuracy of  $\pm 1/3$  arcsec. (The certified accuracy is limited by available angle standards, not by METRA itself.)

When testing for accuracy, the encoder under test (EUT) is coupled to METRA with precision fixturing. As the two encoders are rotated together, the position information from METRA is used to interrogate the EUT at 2,097,152 positions around a revolution. Thus, this test verifies the location of every single output state of the EUT. This method reveals all encoder errors and does not depend on statistical assumptions based on an incomplete data set.

# DIMENSIONS





## MODEL ASC3N ABSOLUTE SERIAL INTERFACE CARD

The ASC3N greatly simplifies communications between your computer and A25S, so you can use an absolute encoder for a wide variety of motion measurement or control applications. It provides all the necessary signals to interrogate and read in the data from up to 3 encoders simultaneously.

The ASC3N and A25S transmit and receive data serially by RS-422 line drivers and receivers. The A25S requires an active low interrogate pulse to initiate a rotary-to-digital conversion. The ASC3N generates this signal, and sends it on a separate line simultaneously to each of the three encoders. When each encoder has converted rotary position into digital data, the ASC3N starts reading and shifting the serial data into its on-board shift registers. The shift/read clock is generated for all three channels in unison. You can control the data transmission rate to the ASC3N with convenient on-board jumpers. Parameters such as the quality and length of the transmission line and application timing requirements will affect the maximum baud rate allowable. The baud rate can be from 28 kHz to 3.6 MHz, which correspond to maximum data update rates from 1,000 to 100,000 encoder reads per second. You can also configure the data size (from 14 to 17 bits) and parity (even or odd) by jumpers. When you are using more than one encoder, the data size and parity must be the same for all.

The ASC3N checks the parity of the incoming data and reports any errors to the status register, which also has a "busy signal" bit that you can poll. Alternatively, you can assign an IRQ line and ignore the status register, if desired. A simple I/O read from the computer will input the data from the ASC3N to your CPU.

Each ASC3N interface board comes with a comprehensive User's Manual and a 3.5" diskette containing test and utility software and example programs for both DOS and Windows<sup>®</sup>.

### GENERAL

Hardware compatibility	IBM <sup>®</sup> AT-compatible (or higher) computer with an available 16-bit ISA bus expansion card slot.
I/O base address	200-3F0 (hex); occupies 16 contiguous hex addresses (user selectable).
Interrupt request level	IRQ 5, 7, 9, 10, 11, 15, NONE (user selectable).
Data size	14, 15, 16 and 17 bits (user selectable).
Parity	Even or odd (user selectable).
Axes Supported	One, two or three axes.
Connector Interface	3 female, 15-pin, high density D-subminiature connectors (DE-15S).
Serial input from encoder	EIA/RS-422 differential line receivers. Encoder data MSB first, parity last.
Serial output	EIA/RS-422 differential line drivers, interrogate pulse and clock signal.
Maximum data clock rate	3.6 Mhz.
Minimum data clock rate	28 kHz.
Maximum data update rate	100,000 reads per second.
Mating encoder	Model A25S absolute rotary encoder with serial output.

### ELECTRICAL

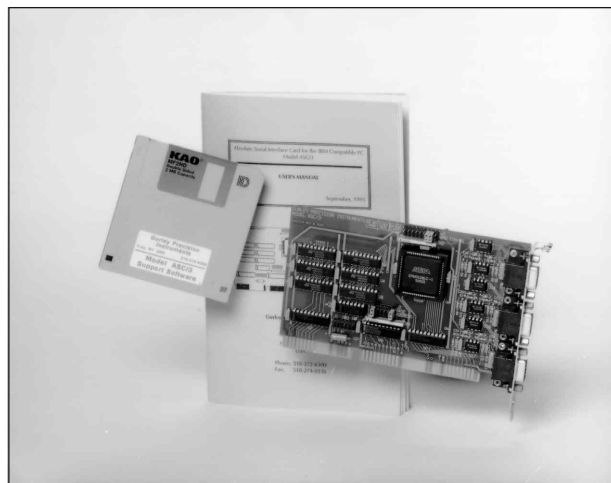
Typ. Power requirements	+5 Vdc, 500 mA max (w/o encoders).
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### ENVIRONMENTAL

Operating temperature	0°C to 70°C (32°F to 158°F).
Operating humidity	0% to 90% (non-condensing).
Storage temperature	-20°C to 70°C (-4°F to 158°F).
Storage humidity	0% to 95% (non-condensing).

### PHYSICAL

Size	Standard ¾ length IBM <sup>®</sup> PC Card.
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## MODEL SCA SHAFT COUPLING (OPTIONAL)



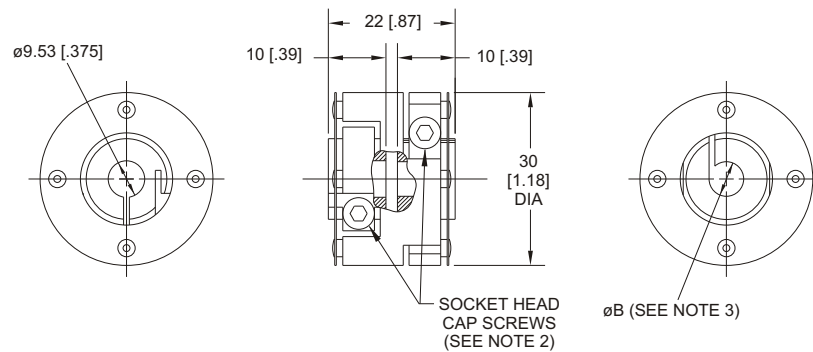
ORDERING INFORMATION  
SCA 063 USER END B

### USER END B

<b>04E</b>	1/4" shaft
<b>05E</b>	5/16" shaft
<b>06E</b>	3/8" shaft
<b>06M</b>	6 mm shaft
<b>08M</b>	8 mm shaft
<b>10M</b>	10 mm shaft

### SPECIFICATIONS

Kinematic accuracy with parallel offset = 0.1 mm [0.004 in] and angular misalignment = 0.09°	±10 arcsec
Torsional rigidity	150 N•m/rad [0.1 in•oz/arcs]
Maximum parallel offset	0.5 mm [0.020 in]
Maximum axial extension or compression	0.5 mm [0.020 in]
Maximum angular misalignment	1°



#### NOTES:

1. DIMENSIONS ARE IN MM [IN].
2. IF øB IS IN INCHES, SCREWS ARE 4-40 X 5/16.  
IF øB IS IN MM, SCREWS ARE M3 X 8.
3. TOLERANCE ON USER'S SHAFT IS ±.012 [±.0005].

# ORDERING INFORMATION

A25S -    -   -  -     
 CODE RES FORMAT CABLE BASE SHAFT PKG TEMP SF

## CODE -

**B** Natural Binary

## RES - Resolution, words/rev

**17**  $2^{17}$  (131,072)

**16**  $2^{16}$  (65,536)

**15**  $2^{15}$  (32,768)

**14**  $2^{14}$  (16,384)

## FORMAT - Data transmission

**S** Serial, RS-422 diff. line driver

**P** Parallel, tri-state TTL

## CABLE - Cable length in inches

**048** Standard

**006** Minimum

**300** Maximum

## BASE -

**A** Combination  
Synchro/face mount  
1.25" pilot dia

**C** Square-flange mount

**E** Synchro mount,  
2.5" pilot dia

## SHAFT

**06E** 3/8" dia.

## PKG - Electronics package

**0** PC board assembly only

**1** With enclosure

## TEMP - Operating temperature range

**C** Commercial (0 to +70°C)

**A** Automotive (-40 to +85°C)

**T** Transducer only (-40 to +85°C)

## SF - Special feature

**#** Issued at time of order to cover  
special customer requirements

**N** No special features

## ACCESSORIES (order separately)

**M04** Mating connector for DB-25P

**ASC3N** IBM PC serial interface card (see page 6)

**CAMxxx** Cable, A25S elect to ASC3N, xxx = length,  
inches (Max. Length = 600)

**SCA06Exxx** Shaft coupling (see page 7)

**AX06399** Synchro cleat kit to mount transducer

**AX06626** Bracket for one electronics box

**AX06627** Bracket for two electronics boxes

## 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.