Gurley Model V860H
Virtual Absolute® Encoder

Motion Type:

Rotary

Usage Grade:

Metrology/Industrial

Output:

Absolute

Max Resolution*:

2^{20} (1,048,576) steps/rev

Natural Binary Absolute Output

The **V860H** is a high-performance optical encoder that utilizes unique *Virtual Absolute* technology to combine the opto-mechanical simplicity and ruggedness of an incremental encoder with the system reliability and interfacing ease of an absolute encoder.

This encoder has been designed for quasi-military applications such as radar pedestals and tracking mounts.

* Custom resolutions available up to 24 bits. Please contact factory for more information

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ISO
9001
Certified

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*Resolution	2^{20} (1,048,576) words/rev
** Installed Accuracy	±1.5 arcs, including quantization & coupling errors
Initialization angle	0.308°
Output code	Parallel natural binary
Output device	TTL-compatible tri-state buffer registers
Max. data update rate	1 MHz
Parity	Odd
Shaft direction for increasing count	Clockwise, looking at bellows end
Input power	+12Vdc ±0.5V @375 mA max
Illumination source	LEDs, screened and derated for 100,000-hr life
Max. operating speed	120°/s
Operating temperature, °F (°C)	-40 to +185 (-40 to +85)
Storage temperature, °F (°C)	-58 to 212 (-50 to + 100)
Humidty	98% rh, non-condensing
Weight, encoder + coupling lb (kg)	12 lb (5.5)
** Starting torque, in-oz (N-m)	16 (0.11)
** Running torque, in-oz (N-m)	12 (0.08)
Moment of inertia, in-oz-s^2 (g-cm)	0.27 (19 x 10^3)
Sealing	IP64

* Custom resolutions available up to 24 bits. Please contact factory for more information.

** At 20°C

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

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A Gurley *Virtual Absolute (VA)* encoder employs an optical encoding technique which is still relatively new to the motion control industry. Like an incremental encoder, the *VA* optical disc uses only incremental and index code tracks. The incremental track is structured and read by quadrature sensors in the usual way. However, neither the encoder nor the host system accumulate incremental counts as the read station traverses. Instead, the four quadrature states per optical cycle are decoded to control the spatial timing of indexing operations, whereby the absolute position information is obtained. The index track is coded differently from a conventional incremental encoder. On the index track, an opaque or transparent region exactly one optical cycle wide aligns correspondingly with every opaque/transparent line pair in the adjacent incremental track. Around the full circumference of the disc, any given index mark is equally likely to be clear or opaque. The bit sequence into which the index marks will be translated by the detector dedicated to this track is *pseudorandom*. Absolute position is encoded serially in this one track rather than in parallel over many tracks. This simplifies optomechanical alignment compared with traditional absolute encoders.

A 14-bit *VA* employs a sequence of 16384 indices. These are decoded for cycle position, to which 6 bits of interpolated *position within the cycle* are appended. Every possible grouping of 14 consecutive indices in the sequence is unique due to the non-repeating design of the code. Every optical cycle of the incremental timing track is thus tagged by a unique 14-bit code whose first bit is immediately adjacent to the cycle, and whose remaining 13 bits trail behind. This arrangement is sometimes called a *chain code*. Because the coding sequence is such that each 14-bit code tag shares 13 bits with its neighboring tags to the left and right, in overlapping fashion, one might conclude that the code progression is monostrophic (like Gray code) with only one bit differing between consecutive tags. Not so. While adjacent tags share all but one bit, the positions of all the shared bits within the tags are shifted. Tags which truly differ by only one bit are located in seemingly random sections of the scale. Improperly decoded tags would therefore result in gross position errors. Partly for this reason, a sophisticated sequence verification capability is an integral part of GPI's proprietary *Virtual Absolute* tag decoder design.

On power-up, absolute position is unknown. An initialization procedure is executed to obtain a complete tag for decoding. (There are ways to build a pseudorandom encoder so that absolute information is available on power-up without initializing, but these techniques require far more complex sensing hardware; they often impose slower operation as well. And none of them offers the sophisticated built-in testing of GPI's *Virtual Absolute* technology.) Because the index track is viewed by a single sensor the read station must be *bumped* in either direction, or *wiggled* in both, to cover a minimum net angle. In this case, a net motion infinitesimally less than 14 optical cycles guarantees 14 major cycle boundaries of the incremental timing track will be crossed. This corresponds to 0.308 maximum initialization traverse from any starting position of the disc. Discs with higher line counts require shorter initialization traverses, but are correspondingly more difficult to install and align. Cycle boundary phasing with respect to the index marks is such that indices are sampled only at their centers, i.e., spatially timed. For this reason, the incremental track is sometimes called the *timing* track. This arrangement has two important benefits:

● As with conventional incremental encoders, the readout accuracy (linearity) of the *VA* encoder depends only on the regularity of its incremental track lines. These are easy to create on the disc with precision, and easy for the quadrature detectors to read accurately through slit gratings that average out microscopic optical printing imperfections and moderate amounts of contamination. This also results in healthier signal amplitudes. Conventional absolute encoders have difficulty employing a similar optical averaging technique to improve readout accuracy and signal-to-noise ratio.

● The serial indices, which must be viewed through a single mask aperture like a conventional absolute, rather than through a grating, are at their maximal light or dark conditions when sampled. This ensures the greatest electrical noise margin, immunity to contamination, and tolerance of misalignment between disc and read station. Unlike a conventional absolute encoder, the exact angular position of the transition between light and dark has no effect on decoding reliability or accuracy.

Once the first tag has been obtained from the disc, bit-wise, during the initialization traverse, ensuing motions modify the tag based on direction of motion. (Direction sense is always available from the quadrature incremental track waveforms.) As new tags become available, they are decoded into monotonic natural-binary absolute position words. During the tag decoding process, an exor gate compares each new detected bit obtained from the index track against the bit the tag decoder predicts for that direction of motion. In effect, the decoder knows the entire serial code sequence and reports any disagreement between *expected* and *detected* tag bits as a fault condition. In this way, the encoder's design embodies a sophisticated real-time automatic error detection technique that is constantly on guard against malfunction with every motion of the disc. This capability is equivalent to the most fully refined monotonicity test system possible in a conventional absolute encoder, yet imposes no appreciable overhead in hardware because it is a natural byproduct of GPI's patented tag decoding method.

A GPI *Virtual Absolute* encoder system can be in any one of 3 distinct operating modes:

- *Wait mode*: It may be aware of an interruption of power, or some other interference to normal operation which it interpreted as an invalid tag. Until a (re)initialization traverse has been executed to refresh the code tag in the decoder, the *VA* reports a fault condition while it is waiting for a full tag to be acquired.

- *Search mode*: Having acquired a complete new tag from an initialization sweep, it may be busy pinpointing the absolute position of the new tag in the overall code sequence. How long this *tag search* will take depends on specific design characteristics of the decoder, including its 16-MHz clock speed. It also depends on how far away the read station happens to be from the starting point of the search, and whether the decoder is *chasing* the axis position from behind as it also moves during the search. In the worst case scenario, a 14 bit tag search will take about 4 mS.

- *Track mode*: It may be decoding all new indexing code tags obtained from the read station satisfactorily, validating the code bit-wise as it's detected, and providing reliable absolute position information, i.e., tracking the motion input in servo fashion.

If scale contamination or overwhelming electrical noise should invalidate the index signal or even the proper operation of the decoder itself, this will result in a *reported fault*:

- Proper quadrature sequence is verified at all times. Since this could corrupt the tag bit due to improper sample timing, the decoder resets and awaits a fresh tag.

- Successors to a false tag will survive very little following motion of the disc before faulting due to the non-repeating nature of the code sequence.

- A supply voltage supervisor and power-up reset IC is included to reset the decoder if the power supply dips below +4.70VDC *measured locally* inside the encoder.

Most fault conditions may be cleared by re-executing the initialization procedure. In the case of disc damage or fouling, the host system may measure the affected region by approaching it from alternate directions and observing the Status bit reporting the validity of the absolute position output.

The Status bit offers a simple mechanism for a microprocessor-based host system to quickly assess data validity. If the tag decoder detects a fault condition and is waiting for an initial tag sweep or while it is still engaged in a tag search, the Status bit will be set to a logic 1, signifying the current output value is invalid and position is unknown.

For a more thorough discussion, see the **V860H** User's Manual.

GPI
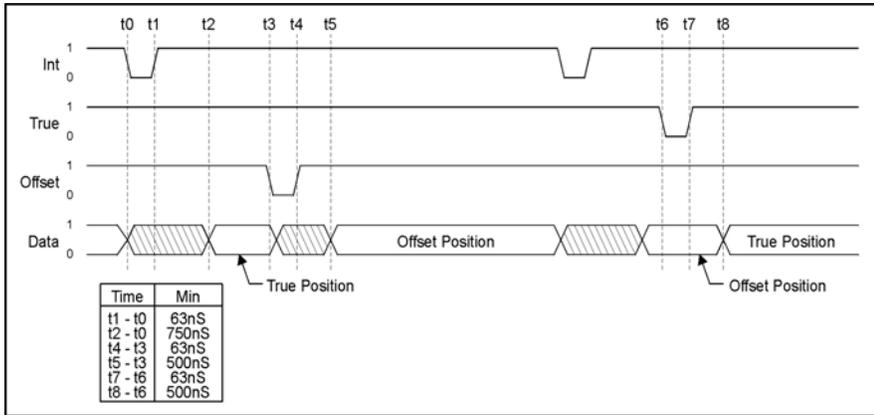
READOUT TIMING REQUIREMENTS

The read cycle is initiated by bringing the Interrogate line low. The data will be valid 750nS after the falling edge of INT. Synchronicity of all data transitions cannot be guaranteed in any device with natural binary output. The output buffer register is provided to avoid reading out a mixture of old and new data bits when sampling the output at the exact moment position data is changing.

SHAFT COUPLING

The optional precision flexible metal bellows assembly P/N DX00432 compensates for small angular misalignment, axial extension or compression, or parallel offset in the installation, without affecting bearing or bellows life. Keeping the misalignments within the following constraints will assure infinite life of the coupling, but will introduce some error. To preserve the encoder's accuracy, misalignments should be kept as small as possible.

$$83.3P + 3E + 0.14A < 1.0$$

P = Parallel offset, inches (max = 0.012")

E = Axial extension or compression, inches (max = 0.336")

A = Angular misalignment, degrees (max = 7)

Parallel offset, P, is equal to the total offset between the centerline of the encoder and the centerline of the user's shaft, plus half the radial runout (TIR/2) of the user's shaft.
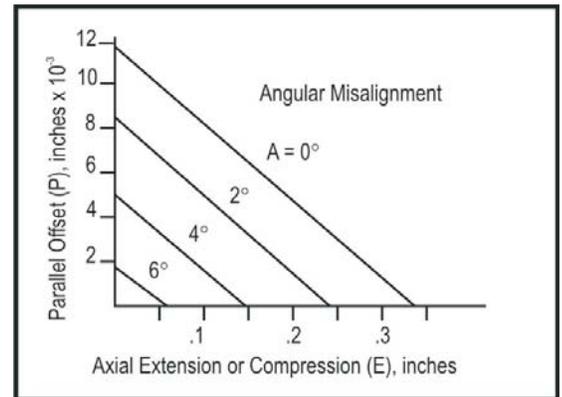

Table 1 - Power Pin Connections, DA-15P

| Pin	Name	Type	Description
1	GND	Power	Ground, power supply common
2	GND	Power	Ground, power supply common
3			
4	GND	Power	Ground, power supply common
5	GND	Power	Ground, power supply common
6	+12	Power	Single +12VDC supply, regulated to +5VDC internally
7			
8			
9	GND	Power	Ground, power supply common
10			
11			
12	GND	Power	Ground, power supply common
13	+12	Power	Single +12VDC supply, regulated to +5VDC internally
14	+12	Power	Single +12VDC supply, regulated to +5VDC internally
15			
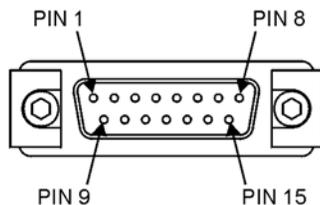
ELECTRICAL CONNECTIONS

If the **V860H** is ordered with connector code P, the three cables are terminated in pigtails; the wire colors are shown on the dimension drawing on page 8. If it is ordered with connector code D, the cables are terminated in two connectors: a DA-15P, which contains all the power leads, and a DC-37P, with all the data. Connector code D interfaces with any cable harness designed for Gurley's discontinued model 60/25H conventional absolute encoder, which had an external electronics package. Since the **V860H** does not have a separate electronics package, the cable and connectors coming from the encoder are wired and polarized to imitate the previous electronic package connectors. Blanks in the pinout tables below signify pins which are not connected to anything inside the encoder. The power interface connector mates with a standard DA-15S D-subminiature connector with spring latches.

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, e-mail: info@gurley.com**

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Table 2 - Data Pin Connections, DC-37P

Pin	Name	Type	Description
1	PAR	Output	Parity, odd parity scheme
2	D01	Output	Data bit
3	D03	Output	Data bit
4	D05	Output	Data bit
5	D07	Output	Data bit
6	D09	Output	Data bit
7	D11	Output	Data bit
8	D13	Output	Data bit
9	D15	Output	Data bit
10	D17	Output	Data bit
11	D19	Output	Data bit, LSB weighted 1/1048576 revolution
12	STA	Output	Status, 1 = current data invalid, 0 = current data valid
13			
14			
15	TRU	Input	True, cancel any position offset in effect
16			
17			
18	GND	Power	Ground, power supply common
19			
20	D00	Output	Data bit, MSB weighted 1/2 revolution
21	D02	Output	Data bit
22	D04	Output	Data bit
23	D06	Output	Data bit
24	D08	Output	Data bit
25	D10	Output	Data bit
26	D12	Output	Data bit
27	D14	Output	Data bit
28	D16	Output	Data bit
29	D18	Output	Data bit
30	CLR	Input	Clear, falling edge clears fault flip flop
31	FLT	Output	Fault, 1 = chain code or quadrature error detected & stored
32			
33	OFF	Input	Offset, make current position equal zero
34	INT	Input	Interrogate, copy current position to output buffer register
35			
36			
37	GND	Power	Ground, power supply common

PIN 1   PIN 19

PIN 20   PIN 37
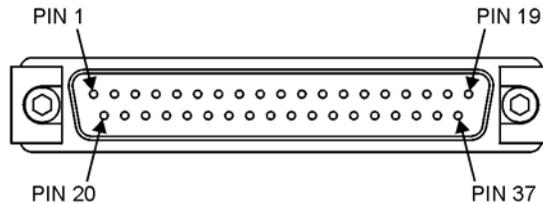
The data I/O interface connector mates with a standard DC-37S D-subminiature connector with spring latches.
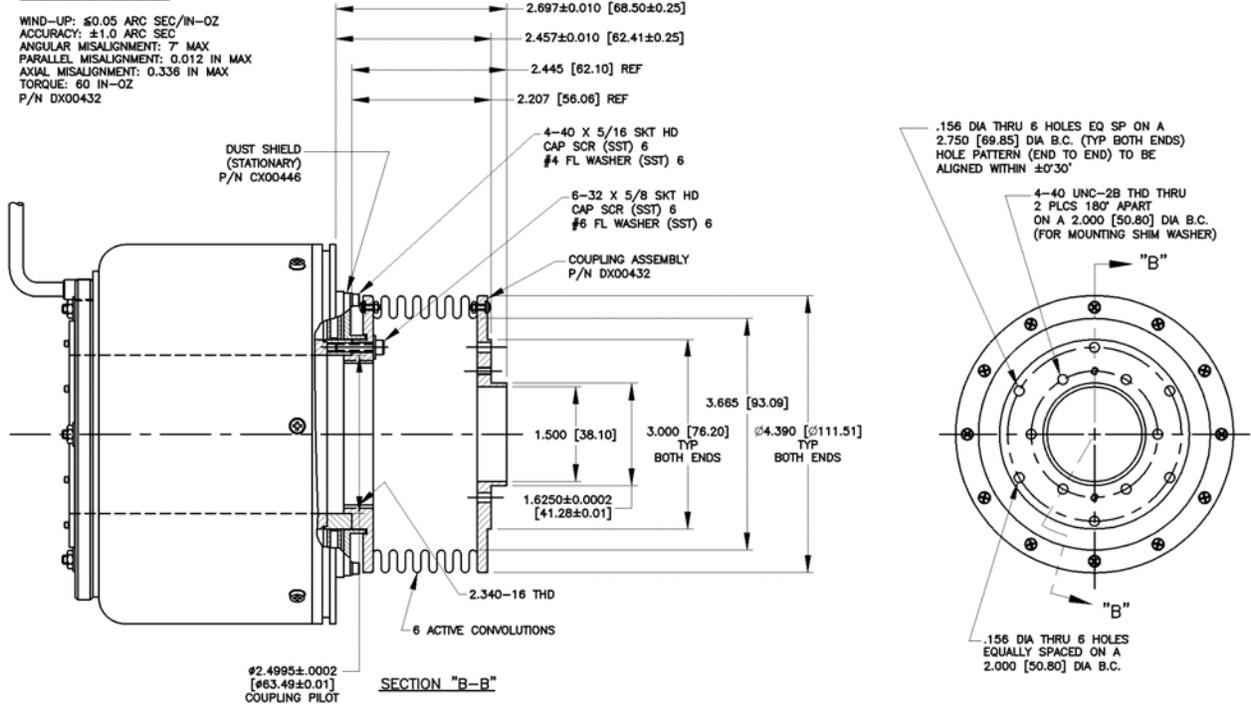
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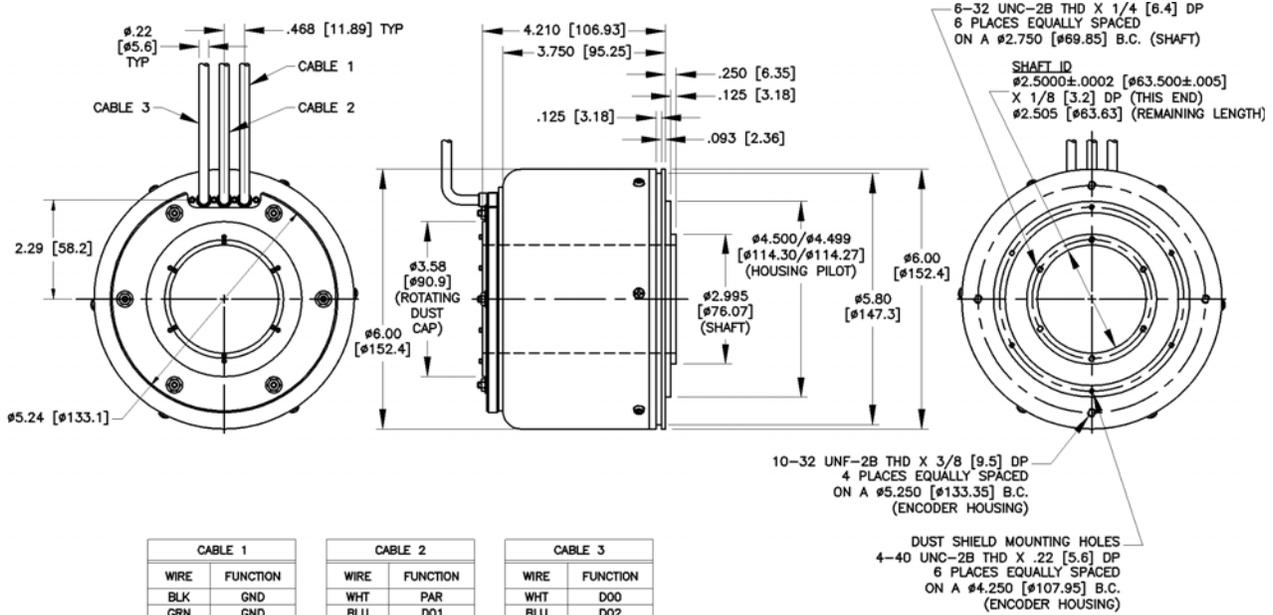
CABLE 1

WIRE	FUNCTION
BLK	GND
GRN	GND
RED	+12V
WHT	+12V
BLU	+12V

CABLE 2

WIRE	FUNCTION
WHT	PAR
BLU	D01
RED	D03
GRN	D05
ORN	D07
BLU/BLK	D09
WHT/BLK	D11
RED/BLK	D13
GRN/BLK	D15
ORN/BLK	D17
GRN/WHT	D19
BLK/WHT	STA
BLK	GND

CABLE 3

WIRE	FUNCTION
WHT	D00
BLU	D02
RED	D04
GRN	D06
ORN	D08
BLU/BLK	D10
WHT/BLK	D12
RED/BLK	D14
GRN/BLK	D16
ORN/BLK	D18
GRN/WHT	CKR
BLK/WHT	FLT
BLU/WHT	INT

COUPLING SPECIFICATIONS

WIND-UP: ≤0.05 ARC SEC/IN-OZ
ACCURACY: ±1.0 ARC SEC
ANGULAR MISALIGNMENT: 7' MAX
PARALLEL MISALIGNMENT: 0.012 IN MAX
AXIAL MISALIGNMENT: 0.336 IN MAX
TORQUE: 60 IN-OZ
P/N DX00432

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MODEL	RES	FORMAT	INT	BASE	CAB	EXIT	CONN	DIA	TEMP	SPEC
V860H	16384	P	06	A	☐	T	☐	40E	A	☐

RES	**16384**	Disc resolution, lines
FORMAT	**P**	Parallel natural binary output
INT	**06**	6 bits of internal interpolation
BASE	**A**	Standard base & mounting configuration
CAB	**XX**	Cable length, inches
	48	48 inches standard
EXIT	**T**	Top-exit cable
CONN	**P**	Pigtails
	D	DA-15P (power) + DC-37P (data)
DIA	**40E**	2.5-in dia through-hole shaft
TEMP	**A**	-40°C to +85°C operating temperature range
SPEC	**#**	Issued at time of order to cover special customer requirements
	N	No special features

ACCESSORIES (order separately)

DX00432   Bellows-type shaft coupling

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 characteristics. 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.