Gurley Model VB
Interpolating Decoder

For Use With:

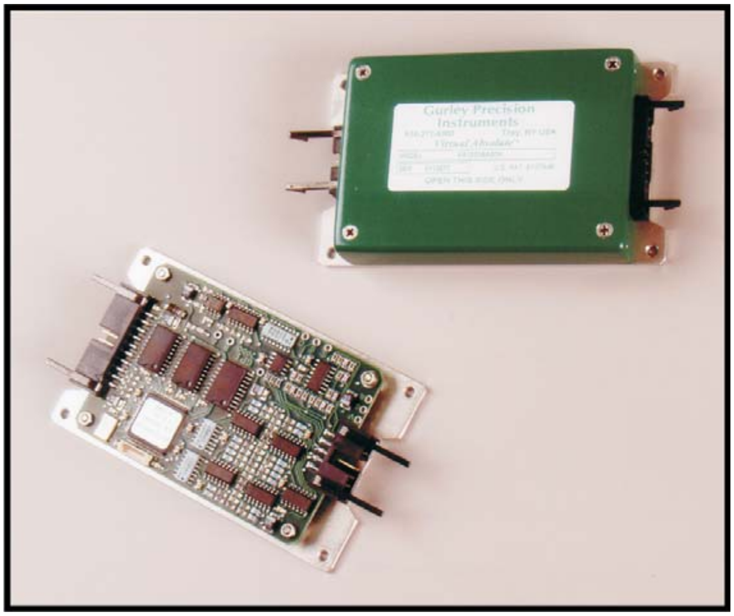
VL18, Vx20, Vx35H

Output:

Multiplexed
Natural Binary

Max Resolution:

20 bits (1,048,576)
Virtual Absolute



Small Package - Big Performance

The credit-card-size **Model VB** interpolating decoder is used with selected housed encoders to form an absolute rotary or linear system with resolution up to 20 bits. Maximum resolution depends on which encoder is used with the **VB**.
GPI's *Virtual Absolute*® technology is a unique encoding method that combines the opto-mechanical simplicity of an incremental encoder with the system reliability and interfacing ease of an absolute encoder. Please refer to the specific encoder data sheet for full details on the encoder.

The disc or scale in a *Virtual Absolute* (*VA*) encoder is similar to an incremental disc or scale in that both contain a cyclic track and an index track. In an incremental encoder, the index occurs at one place in the full travel, but in a *VA* encoder, the index track is a continuous serial code (similar in appearance to a bar code). You don't know position immediately upon power-up, as you do in a conventional absolute, but after a very short travel*, in either direction and starting from anywhere*, you know exactly where you are. In a rotary *VA*, this *initialization* angle is typically about one degree, depending on the encoder's line count; in a linear *VA* encoder, less than 1 mm of motion is needed. From then on, the encoder is truly absolute. (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.)

The **Model VB** provides patented high-speed circuitry to decode the special serial index track and interpolation to increase the final resolution up to 20 bits total. In addition to the natural binary position output, a *Status* bit tells you when the encoder is initialized. This bit is at a logic high whenever the supply voltage has been interrupted, when the initializing motion is not yet complete, or when some other effect such as electrical noise, damage, or fouling of the disc interferes with the proper code sequence from the index track. When these self-tests are all satisfied and the encoder is initialized, the Status bit is low, indicating the position data output is valid.

ISO
9001
Certified

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ingenuity@work®

Input	Differential buffered sinusoids
Use with encoder model	VL18 linear; Vx20, Vx35 rotary
Max code length on disc or scale	15 bits (32,768 cycles). See encoder data sheet.
Interpolated resolution	5 bits (32 steps per optical cycle)
Max final resolution	20 bits (1,048,576 steps)
Absolute output	Natural binary byte-wide multiplexed
Max input frequency	200 kHz disc/scale data rate
Max update rate (see note 1)	At least 1 MHz, user dependent. See timing diagram.
Auxiliary output (see note 2)	Quadrature square waves plus index at disc/scale resolution
Max input cable length (see note 3)	50 ft (15 m)
Operating temperature range Standard (commercial) Optional (automotive)	 0°C to 70°C -40°C to +85°C
Weight, oz (g) PKG = 0 (board only) PKG = 1 (board + mounting plate) PKG = 2 (fully enclosed	 0.9 (26) 2.1 (60) 3.1 (88)

Notes:

1. At maximum speed, the **Encoder + VB** system may have an LSB rate up to 6.4 MHz. Due to dynamic effects, the lowest 2 or 3 bits may not be accurate. However, accuracy returns as the encoder slows down again, and no "counts" are lost because a ***Virtual Absolute*** encoder is *not* an incremental encoder. See the **Model VB Interpolating Decoder User's Manual** for a more thorough explanation of *effective resolution* versus speed - Gurley's "automatic transmission" for high resolution encoders.

2. This output is not for determining position and is not guaranteed to change synchronously with the absolute output. It is provided to simplify closing the velocity loop as required by some servo systems. Quarter-cycle gated index is active only after encoder initialization.

3. Recommended maximum includes +5V power and assumes proper grounding, shielding, and cable routing. Longer runs are possible, depending on the EMI environment. Encoder-to-decoder cable runs over 99 inches require signal extension cables, ordered separately.

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

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Input Power +5VDC ±0.25VDC @ 300 mA max to power both the **Model VA** and the **9710**.

Output The customer interface is a 20-pin IDC with 3 bytes multiplexed onto 8 data lines:

PIN	NAME	TYPE	DESCRIPTION	PIN	NAME	TYPE	DESCRIPTION
01	Status	Output	0 = Data output valid, 1 = Data not valid	11	D5	Output	Data bit
02	Cos	Output	Quadrature square wave at the frequency of disc/scale	12	D4	Output	Data bit
03	Sin	Output	Quadrature square wave at the frequency of disc/scale	13	D3	Output	Data bit
04	Index	Output	Quarter cycle gated, active only after initialization	14	D2	Output	Data bit
05	Clear	Input	0 = Clear error flags without resetting decoder	15	D1	Output	Data bit
06	Hold	Input	1 = Freeze 24 bit buffer, 0 = Follow data	16	D0	Output	Data bit, LSB
07	A1	Input	MSB, byte select address	17	Reset	Input	0 = Reset decoder by external control
08	A0	Input	LSB, byte select address	18	VCC	Power	Single +5VDC supply
09	D7	Output	Data bit, MSB	19	Ground	Power	Supply return
10	D6	Output	Data bit	20	Case	Power	Cable shield braid & electronics pkg housing

The 20-bit absolute position data is provided in three bytes. Each byte has its own address, which is determined by the states of address lines A1 and A0. The Status bit and three Error Flags are also included as part of the complete 24-bit word.

ADDRESS		DATA		
A1	A0	BYTE	BIT	FUNCTION
1	1	Hi	D7	Status bit: 0 = data valid, 1 = data not valid
			D6	B19, MSB of 20 bit absolute position output word *
			D5	B18
			D4	B17
			D3	B16
			D2	B15
			D1	B14
			D0	B13
1	0	Mid	D7	B12
			D6	B11
			D5	B10
			D4	B09
			D3	B08
			D2	B07
			D1	B06
			D0	B05
0	1	Lo	D7	B04
			D6	B03
			D5	B02
			D4	B01
			D3	B00, LSB of 20 bit absolute position output word
			D2	Flag: 1 = disallowed quadrature state transition detected
			D1	Flag: 1 = analog signal fault detected by watchdog
			D0	Flag: 1 = bit sequence error, synchronization lost
0	0	Hi-Z	D7-D0	All data lines are Tri-stated

* When resolution is less than 20 bits, MSB is always on Hi D6. Any unused Lo D3, D4, D5…etc., are set to zero (logic low). Flag bits stay on D0 - D2 of the Lo byte.

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Gurley *Virtual Absolute* (*VA*) encoders employ an optical encoding technique which is still relatively new to the motion control industry. Like an incremental encoder, the *VA* disc (or scale, in a linear encoder) uses only incremental and index code tracks. The incremental track is structured and read by quadrature sensors in the usual way, but neither the encoder nor the host system accumulates incremental counts as the disc turns. Instead, the quadrature signals control the spatial timing for sampling the index track, where the absolute position code is stored. The index track is coded differently from a conventional incremental encoder. On the index track, an opaque or transparent region exactly one full optical cycle wide aligns correspondingly with every opaque/transparent line pair in the adjacent incremental track. The sequence of digital ones and zeros, into which the index marks will be translated by the detector dedicated to this track, is non-repeating around the disc. The absolute position data is encoded serially in this one track, rather than in parallel over many tracks, as is the case for a conventional absolute. This eases opto-mechanical alignment requirements, reduces cost, and improves intrinsic reliability.

The encoder disc can contain any number of indices around a full revolution. For illustrative purposes, assume there are 4096 (2^{12}) such marks. These are decoded for cycle position, to which 8 bits of interpolated "position within the cycle" are appended in the **Model VB** electronics. Every possible grouping of 12 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 12-bit code whose first bit is immediately adjacent to the cycle, and whose remaining 11 bits trail behind. This arrangement is sometimes called a *chain code*. Because the coding sequence is such that each 12-bit code tag shares 11 bits with its neighboring tags to the left and right, in overlapping fashion, one might conclude 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, as often as not, located in apparently random sections of the disc. Improperly decoded tags would therefore result in gross position errors. Partly for this reason, a sophisticated self-testing capability is an integral part of Gurley's patented *VA* tag decoder design.

When the encoder is first powered up, absolute position is unknown. An initialization procedure must be executed to obtain a complete tag for decoding. Because the index track is viewed by a single sensor, the shaft must be "bumped". The bump can be in either direction, or can be a "wiggle" in both, so long as a minimum net distance is covered. In this example, the initialization distance is (12)(360/4096) = 1.05°. (In a 9710 linear *VA* encoder with ¼-µm resolution, the initialization distance is 0.768 mm.) Cycle boundary phasing with respect to the index marks is such that the indices are sampled only at their centers. For this reason, the incremental track is sometimes called the *timing* track. There are two very important benefits in this arrangement:

- As with conventional incremental encoders, the readout accuracy 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 position where a transition from light to dark (or vice versa) occurs has no effect on decoding reliability or accuracy.

Once the first tag has been obtained, bit-wise, during the initialization traverse, ensuing motions modify the tag based on direction of motion. As new tags become available, they are decoded to produce monotonic natural-binary absolute position words. During the tag decoding process, each new detected bit obtained from the index track is compared against the bit the tag decoder *predicts* for that direction of motion. In effect, the decoder "knows" the entire chain code, and reports any disagreement between *expected* and *detected* tag bits as a fault condition. In this way, the encoder's design embodies a sophisticated and automatic error detection technique that is constantly on guard against malfunction.

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

- *Wait mode:* Aware of an interruption of power or some other interference to normal operation which it interpreted as an invalid tag, it waits until a (re)initialization traverse has been executed to refresh the code tag in the decoder. The **Model VB** 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 that tag in the overall code sequence. How long this *tag search* will take depends on design characteristics of the decoder including its clock speed, how far away the read station happens to be from the starting point of the search, and whether the decoder is "chasing" the shaft motion from behind as it moves during the search. Typical tag search times are sub-millisecond and are not challenged by velocity.

- *Track mode:* It may be decoding all new indexing code tags obtained from the read station in satisfactory fashion, 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 electrical noise or disc contamination should invalidate the two quadrature signals, the index signal, or even the proper operation of the decoder itself, this will result in a reported fault. The decoder is capable of quickly detecting error in several ways:

- Proper quadrature sequence is verified at all times. Since this can 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 +4.70 VDC, *measured locally*.

If the tag decoder detects a fault condition and is waiting for an initial tag sweep or is still engaged in a tag search, the fault bit will be set, signifying the current output value is invalid and position is unknown. Any fault condition may be cleared by re-initializing. 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 behavior of the Status bit reporting the validity of the absolute position output. The standard design configuration for a *Virtual Absolute* decoder locates the Status bit at the MSB position to offer a simple mechanism for a microprocessor-based host system to quickly assess data validity. Most processors contain instructions in their instruction sets designed to test the most significant bit of a data word, and branch program execution based on the result. Other mask, shift, rotate, and arithmetic operations may then be used to reformat data to BCD, add a position offset adjusting the "zero" position of the axis to a more convenient location, or complement the binary data word to reverse the perceived direction of ascending count.

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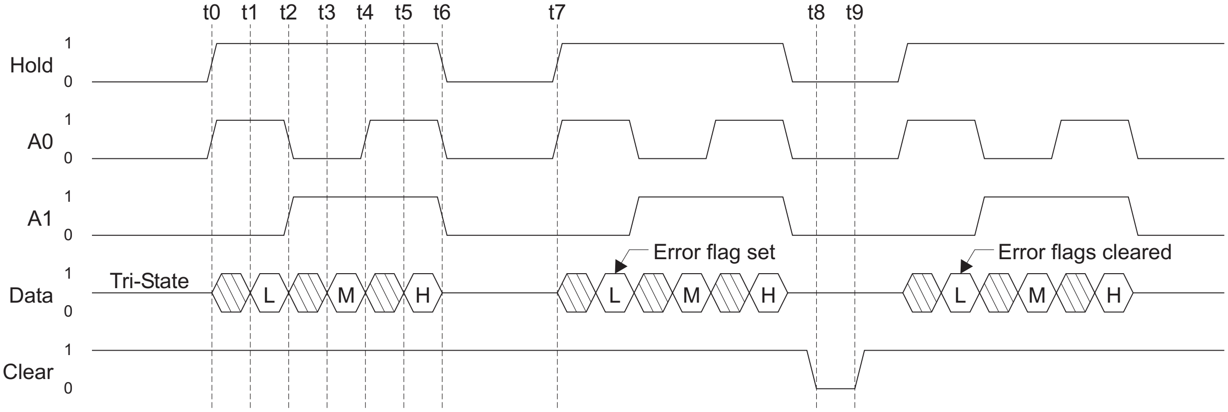
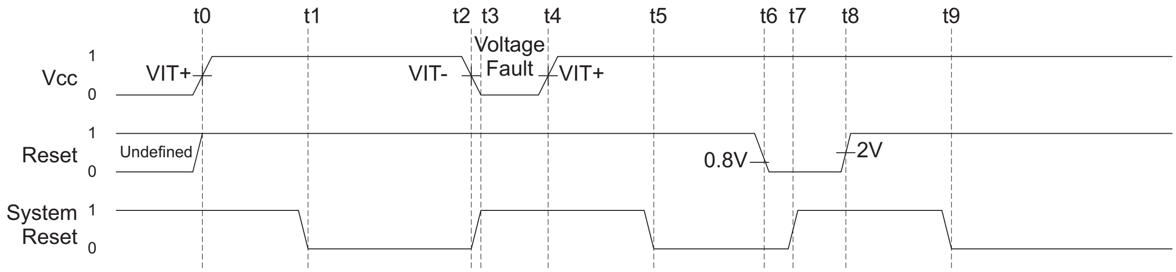
READ TIMING REQUIREMENTS



Time	Min	Max
t1 - t0	63nS	∞
t3 - t2	63nS	∞
t5 - t4	63nS	∞
t7 - t6	375nS	∞
t9 - t8	63nS	∞

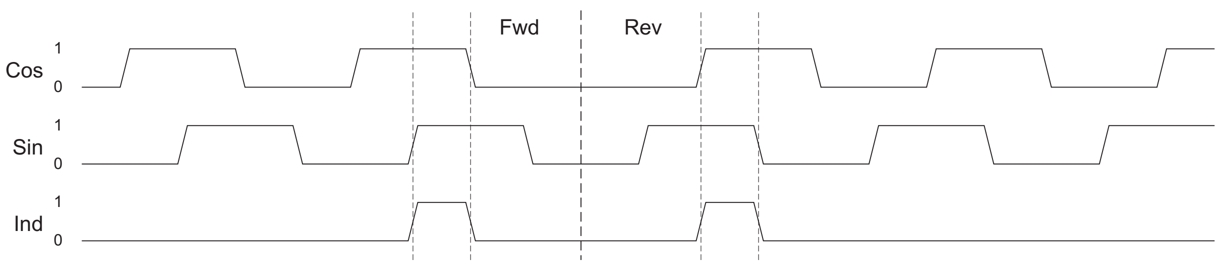
RESET TIMING REQUIREMENTS



Time	Min	Typ	Max
t0 - t1		89mS	100mS
t2 - t3		75nS	150nS
t4 - t5		89mS	100mS
t6 - t7		270nS	500nS
t6 - t8	150nS		∞
t8 - t9		89mS	100mS

VIT = 4.7V Typ

AUXILIARY COSINE, SINE AND INDEX TIMING



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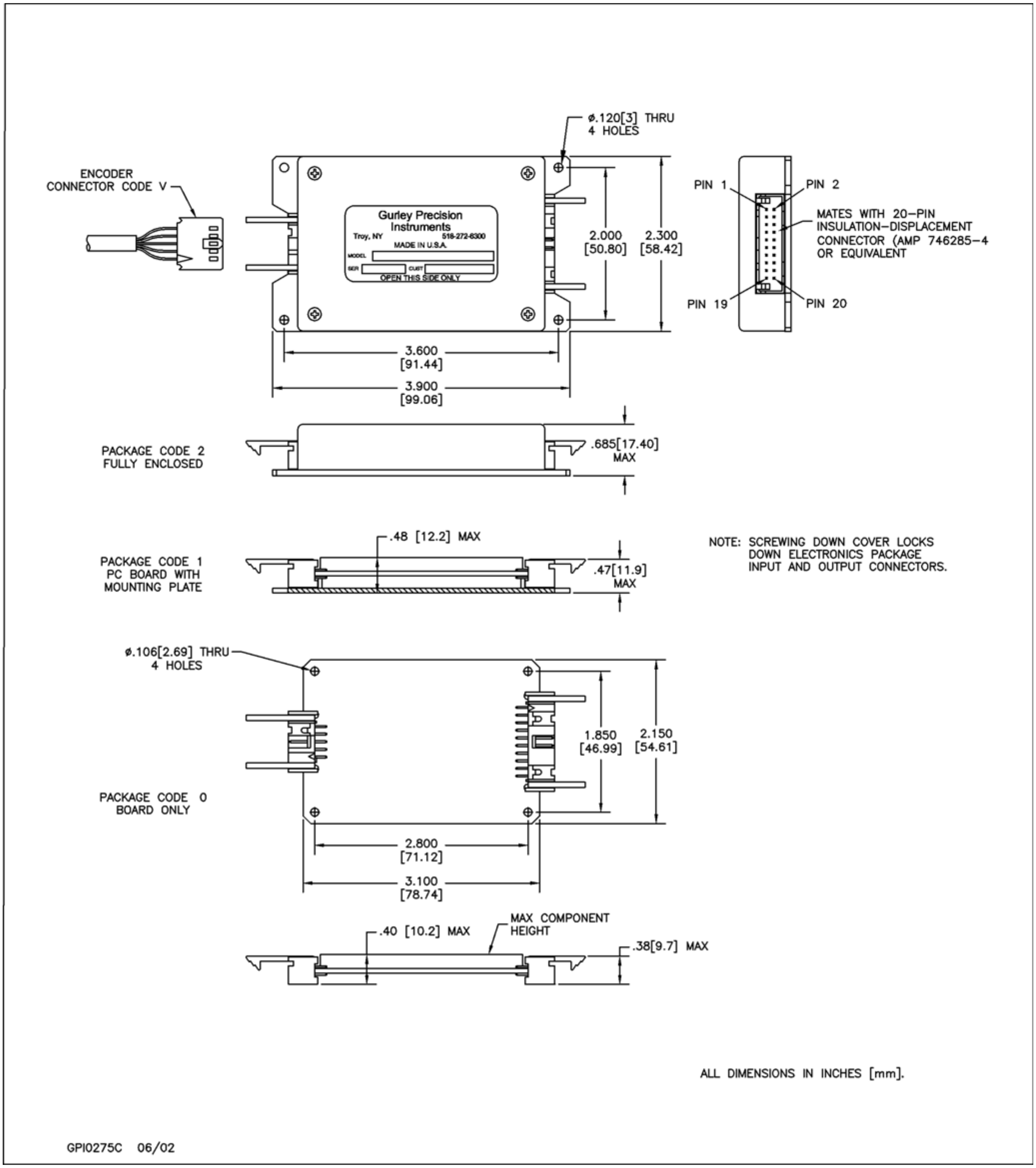

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ORDERING INFORMATION

MODEL	CODE	OUTPUT	INTERP	INPUT	PKG	TEMP	SF
VB		C	05	M			

CODE	**##**	Code length in bits (15 max); see encoder data sheet. See note. (Final system resolution in bits = CODE + INTERP)
OUTPUT	**C**	3-byte-wide multiplexed output
INTERP	**05**	5 bits of interpolation
INPUT	**M**	Differential buffered sinusoids
PKG	**0**	Printed circuit board assembly only
	1	Board assembly with aluminum mounting plate and standoffs
	2	Fully enclosed electronics (case grounded aluminum cover)
TEMP	**C**	0°C to +70°C
	A	-40°C to +85°C
SF	**#**	Issued at time of order to cover special customer requirements
	N	No special features

Note: By using non-binary line counts, the system can provide resolutions such as 1 arcsec or 5 μrad.

SPECIAL CAPABILITIES

For special situations, we can optimize 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 high-performance, high-reliability conditions. We welcome the opportunity to help you with your special 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.

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