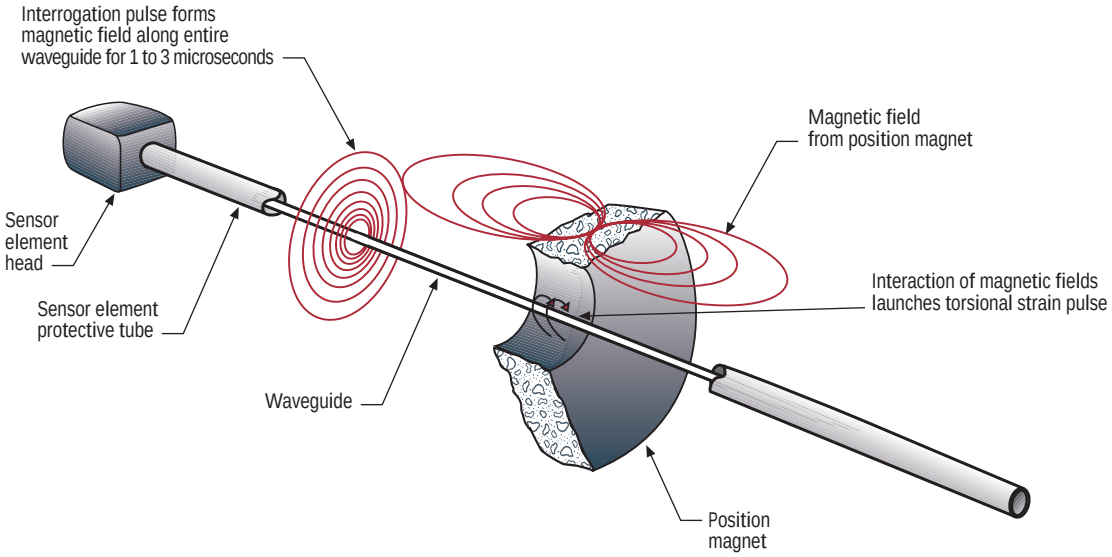
GLOSSARY

Below are terms which are used throughout the Temposonics documentation.

MAGNETOSTRICTION

In a Temposonics position sensor, a pulse is induced in a specially-designed magnetostrictive waveguide by the momentary interaction of two magnetic fields. One field comes from a movable magnet which passes along the outside of the sensor tube, the other field comes from a current pulse or interrogation pulse launched along the waveguide. The interaction between the two magnetic fields produces a strain pulse, which travels at sonic speed along the waveguide until the pulse is detected at the head of the sensor. The position of the magnet is determined with high precision by measuring the elapsed time between the launching of the electronic interrogation pulse and the arrival of the strain pulse. As a result, accurate non-contact position sensing is achieved with absolutely no wear to the sensing components.



CIRCULATIONS (commonly referred to as *recirculations*)

This refers to the number of times that the sensor element is interrogated to produce a position reading. By increasing the circulation/interrogation count and averaging the readings, the effective resolution of the position measurement is increased.

Circulation Count = 1 ÷ (G x F x R)

where:
G = Gradient (range: 8.6-9.5 µs/inch, or 0.34-0.37 µs/mm
F = Crystal frequency of the counter (standard: 27-28 MHz)
R = Resolution (in inches or millimeters)

When using L Series sensors with PWM output, the "**duty cycle**" of the pulse duration is proportional to the circulation count (1 to 15). Temposonics III sensors do not require multiple circulations. Temposonics III resolution is available up to 2 microns with a single circulation/interrogation.

CRYSTAL FREQUENCY

The resolution of the clock which measures the time interval between the interrogation pulse and the return signal.

ENCLOSURE RATINGS

An enclosure is a surrounding case constructed to provide some degree of protection to the enclosed equipment against various environmental conditions. An enclosure rating specifies the types of protection an enclosure can provide.

The IEC (International Electrotechnical Commission) issues ingress protection (IP) standards that enclosures are measured against. Temposonics sensors have the following enclosure rating:

IP67: Enclosure totally protected against dust and the effects of temporary immersion in water between 15 cm and 1 m.

To better understand IP standards, see the table below. The first number in the classification indicates the degree of protection against solid objects, the second number in the classification indicates the degree of protection against liquids.

	SOLIDS		***LIQUIDS***
IP	**Specification**	**IP**	**Specification**
0	No protection	0	No Protection
1	Protected against solid objects up to 50 mm	1	Protected against vertically falling drops of water
2	Protected against solid objects up to 12 mm	2	Protected against direct sprays of water up to 15° from vertical
3	Protected against solid objects over 2.5 mm	3	Protected against sprays to 60° from vertical
4	Protected against solid objects over 1 mm	4	Protected against water sprayed from all directions (limited ingress permitted)
5	Protected against dust (limited ingress, no harmful deposit)	5	Protected against low pressure jets of water from all directions (limited ingress permitted)
6	Totally protected against dust	6	Protected against strong jets of water
		7	Protected against temporary immersion between 15 cm and 1 m

GRADIENT (also known as *Scale Factor*)

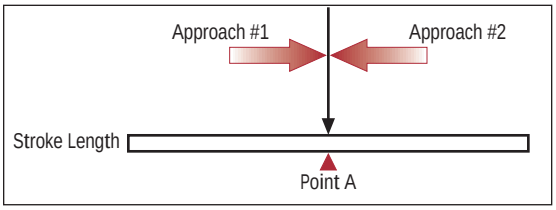
The rate that a pulse signal propagates through the magnetostrictive waveguide (gradient ≈ 9 µs/inch or 0.35 µs/mm); the gradient will vary slightly from sensor to sensor. Gradient values for sensors with digital pulse outputs are indicated on the label attached to each sensor.

Note:
Gradient values are not typically published on analog, or Temposonics II sensors because all timing measurements are internal to the sensor.

The propagation rate, or "gradient", published on the sensor labels is an average for that sensor.

HYSTERESIS

The difference in indicated position for the same point along a stroke length when reached from ***opposing directions***.



Note:
The hysteresis specification for Temposonics position sensors is minimal and can, in most applications, be ignored.

INTERNAL INTERROGATION FREQUENCY

The frequency with which the sensor element is interrogated. Interrogation frequency is a function of the sensor's stroke length; it reflects the time required to receive the return signal. The return signal/pulse propagates through the waveguide medium at sonic speed.

NON-LINEARITY

The degree that the indicated position of the magnet at points along the stroke length of the sensor varies from the *actual* physical position. In magnetostrictive sensors, this variability is caused by minute differences in the propagation rate of the return signals through the waveguide medium. Non-linearity is expressed in absolute error or as a percentage of the active stroke length.

OUTPUTS

1.) True analog output: The Temposonics L Series product line provides a true analog output (voltage or current). The analog output is not digitally derived, and resolution is determined by the customer interface. The analog output signal is proportional to the magnet position along the active stroke length of the sensor.

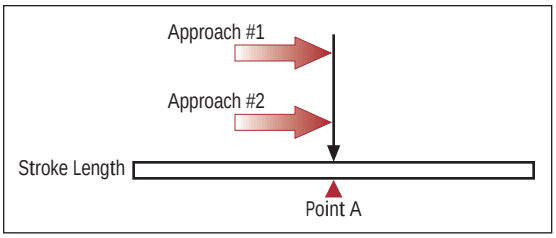
2.) Digitally-derived analog output: The Temposonics III product line offers a digitally-derived analog output. A digital position count is converted to an analog signal (voltage or current) via a digital/analog converter.

3.) Digital pulse output: The Temposonics L Series product line provides a digital pulse output in either start/stop or PWM (pulse-width modulated) format. Both formats require an external counter to measure the time interval between the launching of an interrogation pulse and the receipt of a return signal. The time intervals produced are converted to position counts by the controller.

4.) Digital output: The Temposonics III product line provides digital output in either an SSI, CANbus, or DeviceNet® format. An internal counter is used to precisely measure the time interval between the launching of an interrogation pulse and the receipt of a return signal. The time interval, detected in counts, is then outputted as either an SSI binary or Gray code format, as a CANbus protocol, or as DeviceNet® protocol.

REPEATABILITY

The deviation in indicated position when a point along a stroke length is approached repeatedly from the same direction. For an example, see the illustration, next column.



Example:
Note the indicated position as you arrive at point 'A' from a particular direction. If you leave point 'A' and then return to it from the same direction as before, the change in indicated position between the two readings is described by the repeatability specification.

For magnetostrictive sensors, repeatability is usually equal to resolution.

RESOLUTION

The smallest incremental change in position along the stroke length that can be detected and indicated in an output. For digital systems, resolution is a discrete value normally stated in counts. For true analog systems, resolution is limited by customer interface.

TEMPERATURE COEFFICIENT

Temperature Coefficient (TC) is expressed as ppm/°F or ppm/°C (ppm = part per million). TC is the degree to which the indicated position is affected by ambient temperature changes.

Example (Sensor with analog output):
- Output: 0 to 10 Vdc
- Stroke length: 12 inches
- Temperature change (TC): 5°C

Assume TC = 100ppm/°C

(TC x Full Scale Output in Volts) ÷ [10^6 (constant)]
or
(100 ppm/°C x 10 Vdc) ÷ (10^6) = 1 mV/°C or 0.001 V/°C

If the indicated output at 12 inches is 10 Vdc, the potential change in indicated output per degree Celsius temperature change is equal to 0.001 V (1 mV) or ***a total of 5 mV for a 5° rise****.*

UPDATE TIME

The time period required to interrogate the sensor and obtain an output.

WAVEGUIDE

In a magnetostrictive sensor, the waveguide is the sensing element. It is constructed of magnetostrictive material. The waveguide carries the strain pulse generated by the interaction of the magnetic fields interrogation pulse and the position magnet.

RESOLUTION VS. UPDATE TIME RELATIONSHIP

Because there is a propagation delay through the magnetostrictive waveguide, there is a delay between when the interrogation pulse is launched and when the return signal is generated. This delay varies based on the length of the waveguide. For every one inch of waveguide travel there is a propagation delay of approximately 9 microseconds. Hence, the update time for a 10 inch sensor is a minimum of 90 microseconds with one circulation. Other system parameters may increase this time period. If the sensor's interrogation signal is recirculated to provide an average reading and thus improving resolution, the waveguide travel time must be multiplied by the number of recirculations to determine the minimum update time. In the same example, if the 10 inch sensor is circulated 4 times, the minimum update time is 360 microseconds.

The base resolution of a sensor varies by output. Update time (sometimes referred to as lag time) is based on a single circulation (typically, ≤ 1 msec for both Temposonics III sensors and L Series sensors ≤ 100 inches).

For digital pulse systems (L Series sensor with either start/stop or PWM output) resolution is based on the crystal frequency of the counter (customer interface) that measures the time interval between the interrogation pulse and return signal. This counter resides in the controller. With this clock speed and a single interrogation, output resolution of the sensor is 0.004 inches. Update time is approximately the waveguide travel time for 1 circulation and varies based on sensor length. When circulations are increased and the reading is averaged, resolution is improved and update time increased. These parameters are defined by the formula below:

Resolution (in inches) = 1 ÷ (G x F x C)

where:
G = gradient (µsec./in.)
F = crystal frequency (typically 28 MHz)
C = number of circulations

Update time (µsec.) = C x G x stroke length in inches

For digital sensors the resolution is based on the counter resolution internal to the sensor. Temposonics III resolution is available up to 2 microns. This is achieved with 1 circulation (minimum update time).

Pioneers, innovators, leaders in magnetostrictive sensing.

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