SA6A: Ultrasonic Analog Distance Detection Sensors

Key features of the SA6A include:

- Noise protection is available in two modes of operation
- Fuzzy logic eliminates the adverse effects of temperature uctuation and air turbulence
- Hold mode is ideal for sensing liquid levels without the chatter often caused by surface ripples
- Three sensing ranges optimize resolution:
  Short range: 1.97" to 11.81" (± 0.04")
  Medium range:3.94" to 39.37" (± 0.08")
  Long range:7.87" to 78.74" (± 0.19")
- Shape, size, color, and material do not impair high-precision measurement
- Select analog output (4 to 20mA) for continuous values; use digital output (on/off); or use both
- An eight-dot LED meter provides a dynamic display of detected positions

General Specifications		
	Power Voltage	12 to 24V DC (ripple 10% maximum)
	Current Draw	100mA (maximum)
	Dielectric Strength	Between live and dead parts: 1000V, 50/60Hz, 1 minute
	Insulation Resistance	Between live and dead parts: 100MΩ (minimum) with 500V DC megger
	Operating Temperature	−10 to +60C (performance will be adversely affected if the sensor becomes coated with ice)
	Storage Temperature	−30C to +70C
	Operating Humidity	35 to 70% RH (avoid condensation)
	Vibration Resistance	Damage limits: 10 to 55Hz, amplitude 1.5mm p-p, 2 hours in each of 3 axes (when de-energized)
	Shock Resistance	Damage limits: 500m/sec^2 (approximately 50G) 3 shocks in each of 3 axes
	Noise Resistance	Power line: 500V; Pulse width: 1μsec, 50/60Hz (using a noise simulator)
	Material	Housing: diecast zinc; Coverplate: polyarylate
	Degree of Protection	IP65 — IEC Pub 529: Sensors rated IP65 are dust-tight, water-resistant, and perform best when not subjected to heavy particle or water blasts
	Cable	Cable type: 6-core cabtyre cable 0.2mm^2, 6'–6-3/4" (2m) long
	Weight	Short and medium range: 260g; Long range: 270g
	Dimensions	Short and medium range: 1.96"H x 0.82"W x 3.19"D (50mm H x 21mm W x 81mm D) Long range: 3.19"H x 1.14"W x 3.33"D (50mm H x 29mm W x 84.5mm D)

Part Numbers: Short Sensing Range

Part Number	Output	Sensing Range (A Mode)	Sensing Range (B Mode)	Linearity/Resolution
SA6A-L1K4S SA6A-L1L4S	NPN PNP	3.94" to 11.81" ± 0.4" (100mm to 300mm ± 10mm)	1.97" to 11.81" ± 0.4" (50mm to 300mm ± 10mm)	± 0.04" (1mm)

Part Numbers: Medium Sensing Range

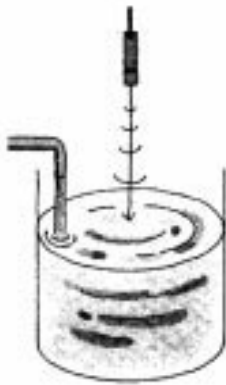| Part Number	Output	Sensing Range (A Mode)	Sensing Range (B Mode)	Linearity/Resolution
SA6A-LK4S SA6A-LL4S	NPN PNP	7.87" to 39.37" ± 0.8" (200mm to 1m ± 20mm)	3.94" to 39.37" ± 0.8" (100mm to 1m ± 20mm)	± 0.08" (2mm)

Part Numbers: Long Sensing Range

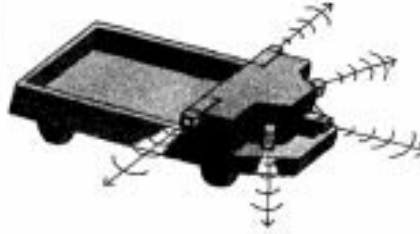| Part Number	Output	Sensing Range (A Mode)	Sensing Range (B Mode)	Linearity/Resolution
SA6A-L2K4S SA6A-L2L4S	NPN PNP	15.75" to 78.74" ± 1.6" (400mm to 2m ± 40mm)	7.87″ to 78.74″ ± 1.6" (200mm to 2m ± 40mm)	± 0.19" (5mm)

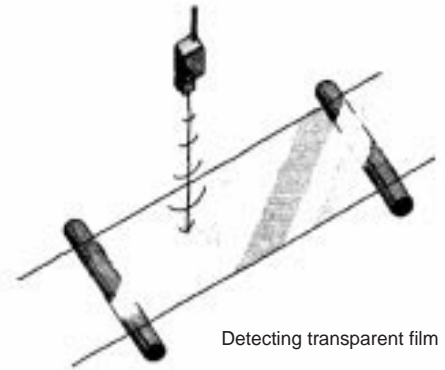|		SA6A-L1K4S, -L1L4S	SA6A-LK4S, -LL4S	SA6A-L2K4S, -L2L4S
Function Specications	**Analog Output**	4 to 20mA (xed range)	4 to 20mA (xed range)	4 to 20mA (xed range)
	Error	± 0.08mA	± 0.04mA	± 0.05mA
		Dened as how accurate the actual analog output is, with respect to distance		
	Resolution	± 0.04" (1mm)	± 0.08" (2mm)	± 0.19" (5mm)
		Dened as the smallest object or the shortest distance that can be detected with reliability		
	Digital Output	NPN or PNP transistor open collector, 100mA, 30V DC (maximum); Residual: 1.5V (NPN), 2.5V (PNP)		
	Alarm Output	NPN or PNP transistor open collector, 100mA, 30V DC (maximum); Residual: 1.5V (NPN), 2.5V (PNP)		
	Level Meter	A or B mode: Represents analog output level on an 8-dot LED display, corresponding to object distance		
	Out LED	On: When digital output is on (red LED)		
	Power LED	On: When power is on (red LED)		
	Alarm LED	On: When environment change occurs (red LED)		
	Stable LED	On: When stable operation is ensured (green LED)		
	Response: Normal Mode	Analog: 12Hz Digital (A mode): 22Hz Digital (B mode): 15Hz	Analog: 8Hz Digital (A mode): 15Hz Digital (B mode): 10Hz	Analog: 5Hz Digital (A mode): 10Hz Digital (B mode): 7Hz
	Response: Fuzzy Mode	Analog/Digital: 4Hz	Analog/Digital: 3Hz	Analog/Digital: 2Hz
	Response: Hold Mode	Analog/Digital: 4Hz	Analog/Digital: 3Hz	Analog/Digital: 2Hz
	Response Time	Analog: 48ms Digital (A mode): 16ms Digital (B mode): 24ms	Analog: 70ms Digital (A mode): 24ms Digital (B mode): 36ms	Analog: 90ms Digital (A mode): 30ms Digital (B mode): 45ms
	Internal Synchronous Mode	Two sensors synchronized, alternate oscillations prevent interference; response time is doubled		
	External Synchronous Mode	Three or more sensors synchronized with timing pulse signal: On/Off (A mode) ≥ 15ms On/Off (B mode) ≥ 20ms	On/Off (A mode) ≥ 20ms On/Off (B mode) ≥ 30ms	On/Off (A mode) ≥ 30ms On/Off (B mode) ≥ 45ms
	Oscillation Frequency	Approximately 290kHz	Approximately 200kHz	Approximately 130kHz
	Directivity	± 10 (half wave: -6 dB)	± 7 (half wave: -6 dB)	± 7 (half wave: -6 dB)
	Temperature Characteristics	± 0.06% per C (± 12 µA per C)		
	Hysteresis	0.24" (6mm)	0.39" (10mm)	0.79" (20mm)
		Dened as the difference between the operating point and the release point		

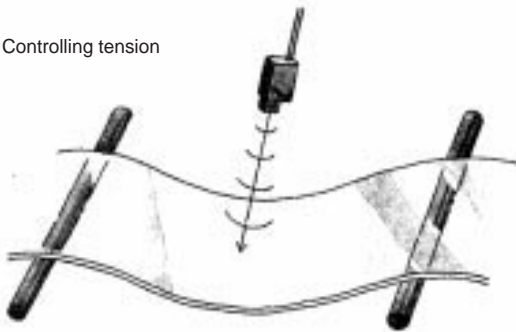## Applications

Controlling liquid level
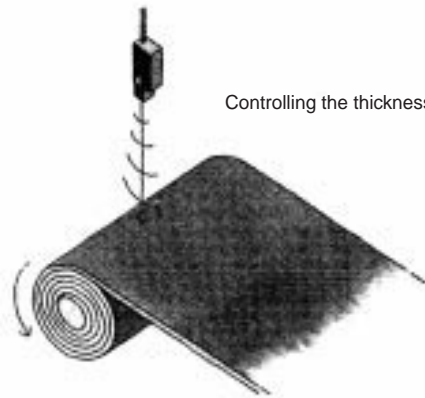
Controlling automatic carriers

Detecting transparent film

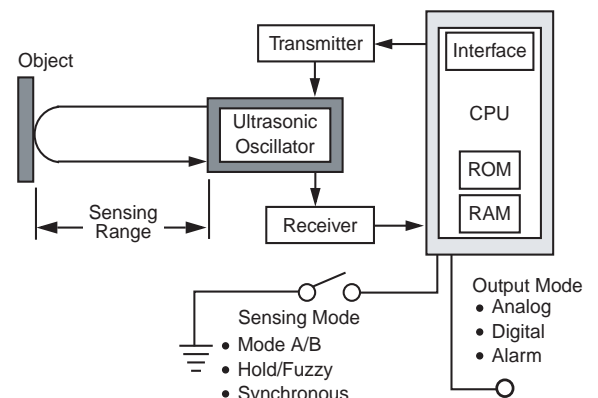Controlling tension

Controlling the thickness of paper rolls

Operation Principle

The ultrasonic distance sensor emits a sonar signal from the ultrasonic oscillator. Reected sound waves are then collected by the receiver , determining the presence of an object for digital output. The characteristics of the returning sonar waves are processed by the CPU, calculating the distance of the object for analog output.

Noise protection is available in two modes of operation. In the A mode, pulse signals are encoded into a pattern recognized by the sensor in the reected wave. Disruption or attenuation of the wave pattern is ignored, providing immunity to inductive noise and ensuring integrity of signals reected from objects at the far end of the sensing range.

In the B mode, the time period of the reected pulse is measured to differentiate between reected sound waves (which occur at regular intervals) and other external noises. Random sound waves are ignored, providing immunity to background noise from machinery and other equipment.

Object

Transmitter

Interface

CPU

ROM

RAM

Ultrasonic Oscillator

Sensing Range

Receiver

Sensing Mode
• Mode A/B
• Hold/Fuzzy
• Synchronous

Output Mode
• Analog
• Digital
• Alarm

Short Range	Medium Range	Long Range
1.97" to 11.81" (50mm to 300mm)	3.94" to 39.37" (100mm to 1m)	7.87" to 78.74" (200mm to 2m)
Linearity/Resolution: ± 0.04" (1mm)	Linearity/Resolution: ± 0.08" (2mm)	Linearity/Resolution: ± 0.19" (5mm)

Operation

Stable LED: Turns on when stable operation is ensured or while far and near limits are being set.

OUT LED: Turns on when digital output is on, when the detected object is within near and far limits.

✋ *1. Output is off for approximately 700ms upon power up, to prevent a transient state. This delay is normal.*

Sensing mode selector: Select hold mode, fuzzy mode, or normal mode, as described below.

Hold mode maintains output for up to 150ms during periods when no reected sound waves are being detected by the sensor . The hold period allows for deected or disrupted pulses, which do not return to the sensor receiver. Every time the sensor detects a pulse, the output is updated to reect new information. Hold mode is used to ignore surface ripples when sensing liquid levels and makes it possible to detect surfaces with moderate peaks and valleys.
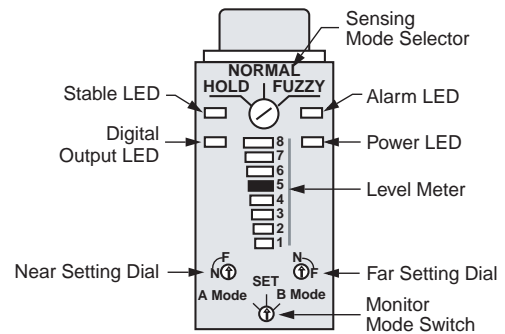
Normal mode incorporates a dual-pulse sonar wave pattern and updates the output only when the next reected pulse matches the preceding one.

Fuzzy mode simulates judgment by mapping the wave characteristics which fall into the "gray" area (reected waves that resemble, but do not match the pulse pattern emitted by the sensor). The sensor compensates for irregular, but pattern-like wave behavior, eliminating inaccuracies and uctuations from high temperature and air motion.
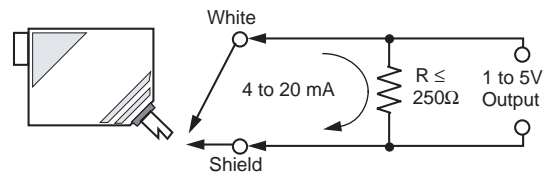
Alarm LED: Turns on when the alarm output is on, indicating that conditions may result in inaccurate sensing. In the Fuzzy mode, an alarm output occurs with excessive temperature uctuations. In the Hold mode, alarm output occurs when three invalid signals are detected within three seconds. When the alarm goes on, the digital output LED and OUT indicator are turned off simultaneously.

Power LED: Turns on when the power is on.

Level meter: Indicates near and far limit settings with two continuously blinking red LEDs. Use with digital output, provides a dynamic display of the analog output level on an eight-dot LED display, according to the detected distance.
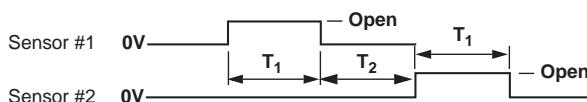
Synchronized Signals

It is not necessary to synchronize the timing of two or more SA6A ultrasonic sensors unless mounted in close proximity (see below). Isolated sensors oscillate continuously. Do not connect unused synchronous lines to other lines.

Minimum Clearance

Short Range
11.81" (300mm)

Medium Range
19.69" (500mm)

Long Range
31.50" (800mm)

Internal synchronization: Use to synchronize timing when only two sensors are mounted in close proximity. With synchronous lines connected, alternate oscillations are used to prevent interference. Response time is doubled for each sensor. The synchronous line is checked upon power-up.

External synchronization: Use to synchronize three or more sensors by connecting a timing pulse to the synchronous line. Specify timing as shown below:

T_1 or T_2	Short Range	Medium Range	Long Range
Mode A	≥ 15ms	≥ 20ms	≥ 30ms
Mode B	≥ 20ms	≥ 30ms	≥ 45ms

✋ *2. During periods when the sensor does not oscillate, previous outputs are maintained (both analog and digital).*
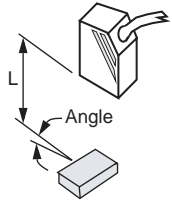
Conversion to voltage output: Current output can be converted to voltage output ranging from 1 to 5V by connecting a resistor which is supplied (or any $R ≤ 250Ω$) as shown below.

White

4 to 20 mA

$R ≤ 250Ω$

1 to 5V Output

Shield

✋ *3. Ultrasonic sensing of non-reective , transparent, liquid, or mirror-like objects is possible. When material absorbs ultrasonic signals, the sensing range may be reduced. Signicant peaks and valle ys in an object's surface may deect all ultr asonic signals away from the sensor undetected.*

Near setting (NS) dial: Move the monitor mode switch to SET. Place the object to be detected at the near limit position, and turn the NS dial until the green stable LED turns on and stays lit. (The LED will not stay on if object is moved.) The near limit is now set, as indicated on the level meter with a continuously blinking red LED.

Far setting (FS) dial: Move the monitor mode switch to SET. Place object to be detected at the far limit position. And, turn the FS dial until the green stable LED turns on and stays lit. (The LED will not stay on if object is moved.) The far limit is now set, as indicated on the level meter with a continuously blinking red LED.

✋ *4. If the FS and NS settings are reversed, then automatic correction results in normal operation.*
5. If the green stable LED does not turn on when the NS or FS dial is turned to any position on the dial setting, then the position of the object may be outside the range for near and far limits.

Range	A Mode		B Mode	
	Near Limit	**Far Limit**	**Near Limit**	**Far Limit**
Short	3.94" (100 mm)	11.81" (300mm)	1.97" (50mm)	11.81" (300mm)
Medium	7.87" (200mm)	39.37" (1m)	3.94" (100mm)	39.37" (1m)
Long	15.75" (400mm)	78.74" (2m)	7.87" (200mm)	78.74" (2m)

Monitor mode switch: Set (SET) the near or far limit to be used with digital output (see below). Or, select one of two different modes of operation, A or B, both with noise protection.
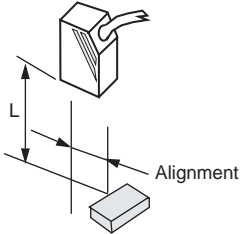
In the A mode, pulse signals are encoded into a pattern the sensor recognizes in the reected wave. Disruption or attenuation of the wave pattern is ignored, providing immunity to inductive noise and ensuring integrity of signals reected from objects at the far end of the sensing range.

In the B mode, the time period of the reected pulse is measured to differentiate between reected sound waves (which occur at regular intervals) and the sounds of other external noises. Random sound waves are ignored, providing immunity to background noise from machinery and other equipment.
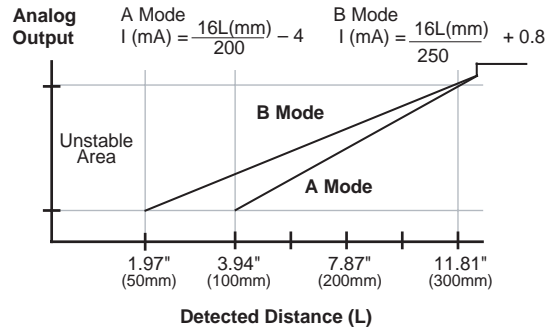
Sensors

Short Sensing Range Style

Standard Sensing object:
1.57" x 1.57" (40 x40mm)
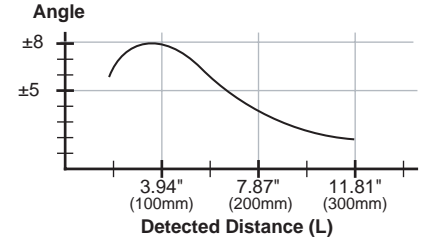
Analog Output Characteristics and Distance

Analog Output

A Mode
$$I\,(mA) = \frac{16L\,(mm)}{200} - 4$$

B Mode
$$I\,(mA) = \frac{16L\,(mm)}{250} + 0.8$$

B Mode

A Mode

Unstable Area

Detected Distance (L): 1.97" (50mm) — 3.94" (100mm) — 7.87" (200mm) — 11.81" (300mm)

Effects of Object Angle on Sensing Range

Angle: ±8, ±5

Detected Distance (L): 3.94" (100mm) — 7.87" (200mm) — 11.81" (300mm)

Effects of Sensing Range on Alignment

Alignment

Detected Distance (L): 3.94" (100mm) — 7.87" (200mm) — 11.81" (300mm)

Analog output provides current output ranging from 4 to 20mA in response to the distance detected. The relationship between analog output and distance is not exactly linear. Test output characteristics for 30 minutes prior to actual application.

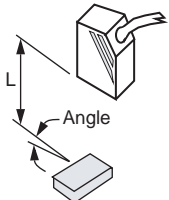*1. Analog output is unstable when the object is nearer than than the minimum detected distance.*
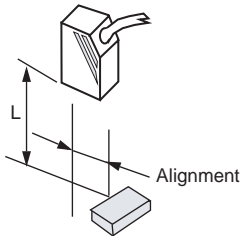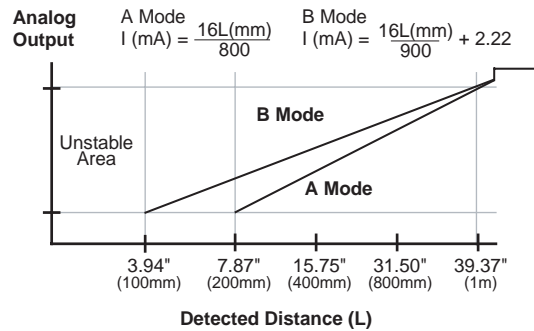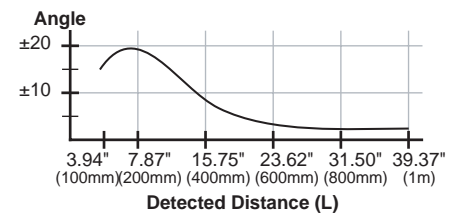
Medium Sensing Range Style

Standard Sensing object:
1.57" x 1.57" (40 x40mm)

Analog Output Characteristics and Distance

Analog Output

A Mode
$$I\,(mA) = \frac{16L\,(mm)}{800}$$

B Mode
$$I\,(mA) = \frac{16L\,(mm)}{900} + 2.22$$

B Mode

A Mode

Unstable Area

Detected Distance (L): 3.94" (100mm) — 7.87" (200mm) — 15.75" (400mm) — 31.50" (800mm) — 39.37" (1m)

Effects of Object Angle on Sensing Range

Angle: ±20, ±10

Detected Distance (L): 3.94" (100mm) — 7.87" (200mm) — 15.75" (400mm) — 23.62" (600mm) — 31.50" (800mm) — 39.37" (1m)

Effects of Sensing Range on Alignment

Alignment

Detected Distance (L): 3.94" (100mm) — 7.87" (200mm) — 15.75" (400mm) — 23.62" (600mm) — 31.50" (800mm) — 39.37" (1m)

Analog output provides current output ranging from 4 to 20mA in response to the distance detected. The relationship between analog output and distance is not exactly linear. Test output characteristics for 30 minutes prior to actual application.
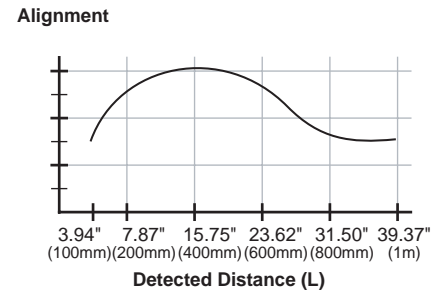
2. Analog output is unstable when the object is nearer than the minimum detected distance.
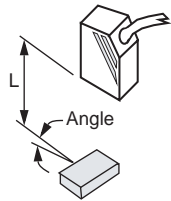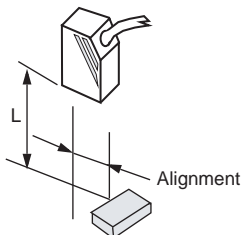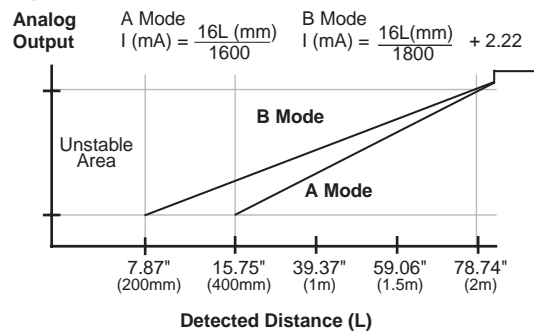
Long Sensing Range Style

Standard Sensing object:
3.94" x 3.94" (100 x 100mm)

Analog Output Characteristics and Distance

Analog Output

A Mode
$$I\,(mA) = \frac{16L\,(mm)}{1600}$$

B Mode
$$I\,(mA) = \frac{16L\,(mm)}{1800} + 2.22$$

B Mode

A Mode

Unstable Area

Detected Distance (L): 7.87" (200mm) — 15.75" (400mm) — 39.37" (1m) — 59.06" (1.5m) — 78.74" (2m)

Effects of Object Angle on Sensing Range

Angle: ±12, ±10, ±2

Detected Distance (L): 39.37" (1m) — 78.74" (2m)

Effects of Sensing Range on Alignment

Alignment
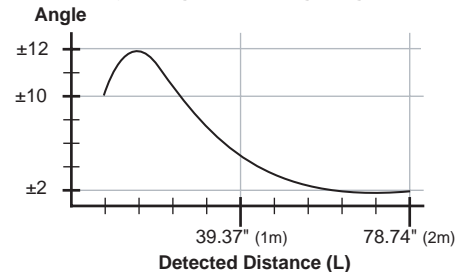
Detected Distance (L): 39.37" (1m) — 78.74" (2m)

Analog output provides current output ranging from 4 to 20mA in response to the distance detected. The relationship between analog output and distance is not exactly linear. Test output characteristics for 30 minutes prior to actual application.
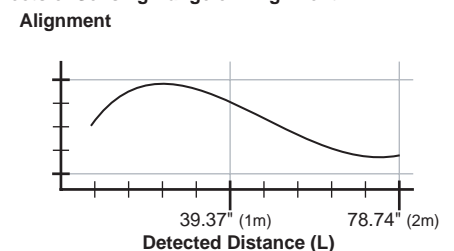
3. Analog output is unstable when the object is nearer than the minimum detected distance.

Installation

Wiring

Wire Color	Name	Function
Brown	+V	12 to 24V DC, 100 mA (maximum)
Blue	GND	Power Ground (0 V)
Black	OUT	Digital Output, 100mA, 30V DC
Orange	ALM	Alarm Output, 100mA, 30V DC
White	ANALOG	Analog Output, 4 to 20mA
Orange/Purple	TIMING	Synchronous Input
Shield	A.GND	Analog Ground

Schematics

Analog output line may be extended up to 33' (10m), as long as the cable used is equal to or superior to the cable provided. Other lines may be extended up to 164' (50m), using #22 AWG (0.3mm^2) wire.

NPN

PNP

Dimensions