WORLD-BEAM QS18U Ultrasonic Sensors

Miniature Ultrasonic Sensors with TEACH-Mode Programming

Features
• Fast, easy-to-use TEACH-Mode programming; no potentiometer adjustments
• Ultra-compact housing
• One discrete output: NPN or PNP, depending on model
• Two bi-colored status LEDs
• Rugged encapsulated version for harsh environments
• Choose 2 meter or 9 meter unterminated cable, 4-pin Euro-style or 4-pin Pico-style QD connectors (either integral or with 150 mm pigtail)
• Wide operating range of -20° to +60° C (-13° to +140° F)
• Temperature compensation
• Configurable for normally open or normally closed operation
• Fast response time (15 milliseconds)

Models

Models	Sensing Range	TEACH Option	Cable*	Supply Voltage	Output
QS18UNA	50 mm to 500 mm (2 in to 20 in)	Integral push button or remote TEACH (IP67, NEMA 6P)	4-wire, 2 m (6.5 ft) cable with shield	12-30V dc	NPN
QS18UPA					PNP
QS18UNAE		Remote TEACH (epoxy-encapsulated, IP68, NEMA 6P)			NPN
QS18UPAE					PNP

Overview

1	Green: Power Indicator
2	Yellow: Light Sensed Indicator
3	Cutoff Point Adjustment Screw
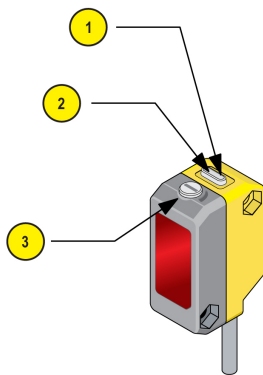
Figure 1. Sensor features
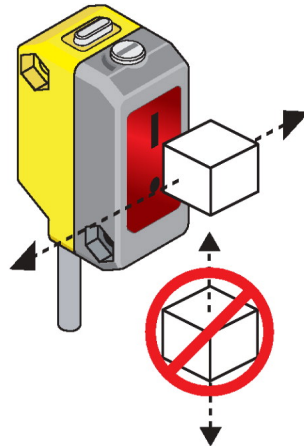
Sensor Installation

Figure 2. Required Orientation of Object to Sensor

Principles of Operation

Ultrasonic sensors emit one or multiple pulses of ultrasonic energy, which travel through the air at the speed of sound. A portion of this energy reflects off the target and travels back to the sensor. The sensor measures the total time required for the energy to reach the target and return to the sensor. The distance to the object is then calculated using the following formula:

$$D = \frac{ct}{2}$$

D = distance from the sensor to the target
c = speed of sound in air
t = transit time for the ultrasonic pulse

To improve accuracy, an ultrasonic sensor may average the results of several pulses before outputting a new value.

Temperature Effects

The speed of sound is dependent upon the composition, pressure and temperature of the gas in which it is traveling. For most ultrasonic applications, the composition and pressure of the gas are relatively fixed, while the temperature may fluctuate.

In air, the speed of sound varies with temperature according to the following approximation:

In metric units: $C_{m/s} = 20 \sqrt{273 + T_C}$ In English units: $C_{ft/s} = 49 \sqrt{460 + T_F}$

$C_{m/s}$ = speed of sound in meters per second $C_{ft/s}$ = speed of sound in feet per second

T_C = temperature in °C T_F = temperature in °F

Temperature Compensation

Changes in air temperature affect the speed of sound, which in turn affects the distance reading measured by the sensor. An increase in air temperature shifts both sensing window limits closer to the sensor. Conversely, a decrease in air temperature shifts both limits farther away from the sensor. This shift is approximately 3.5% of the limit distance for a 20° C change in temperature.

The QS18U series ultrasonic sensors are temperature compensated This reduces the error due to temperature by about 90%. The sensor will maintain its window limits to within 1.8% over the -20° to +60° C (−4° to +140° F) range.

> **NOTE:**
> - Exposure to direct sunlight can affect the sensor's ability to accurately compensate for changes in temperature.
> - If the sensor is measuring across a temperature gradient, the compensation will be less effective.
> - The temperature warmup drift upon power-up is less than 7% of the sensing distance. After 5 minutes, the apparent switchpoint will be within 0.6% of the actual position. After 25 minutes, the sensing position will be stable.

Sensor Programming

Figure 3. Sensor Features
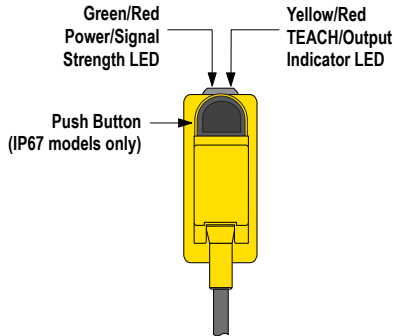
Two TEACH methods may be used to program the sensor:
- Teach individual minimum and maximum limits, or
- Use Auto-Window feature to center a sensing window around the taught position

The sensor may be programmed either via its push button, or via a remote switch. Remote programming also may be used to disable the push button, preventing unauthorized personnel from adjusting the programming settings. To access this feature, connect the white wire of the sensor to 0V dc, with a remote programming switch between the sensor and the voltage.

Programming is accomplished by following the sequence of input pulses (see programming procedures starting on page 4). The duration of each pulse (corresponding to a push button "click"), and the period between multiple pulses, are defined as "**T**":

0.04 seconds < T < 0.8 seconds
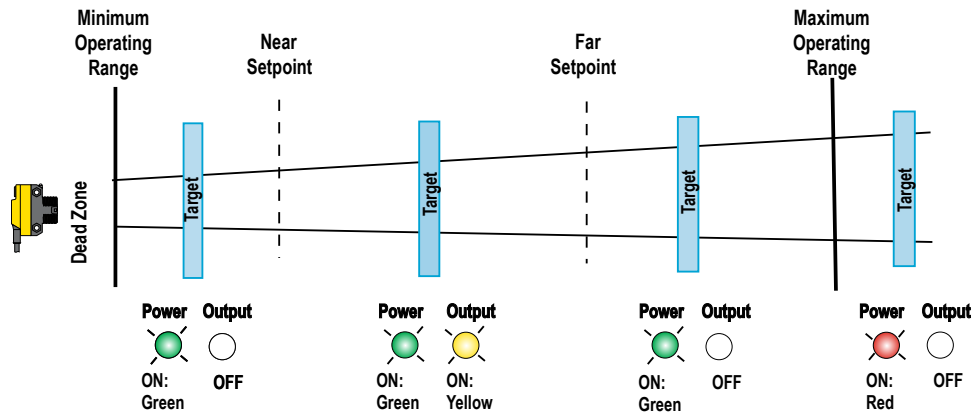
Figure 4. TEACH Interface

Status Indicators

Power ON/OFF LED	Indicates		Output/Teach LED	Indicates
OFF	Power is OFF		OFF	Target is outside window limits (normally open operation).
ON Red	Target is weak or outside sensing range.		Yellow	Target is within window limits (normally open operaton).

Power ON/OFF LED	Indicates		Output/Teach LED	Indicates
ON Green	Sensor is operating normally, good target.		ON Red (solid)	In Teach Mode, waiting for first limit.
			ON Red (flashing)	In Teach Mode, waiting for second limit.

Teaching Minimum and Maximum Limits

General Notes on Programming

- The sensor will return to RUN mode if the first TEACH condition is not registered within 120 seconds.
- After the first limit is taught, the sensor will remain in PROGRAM mode until the TEACH sequence is finished.
- To exit PROGRAM mode without saving any changes, press and hold the programming push button > 2 seconds (before teaching the second limit). The sensor will revert to the last saved limits.
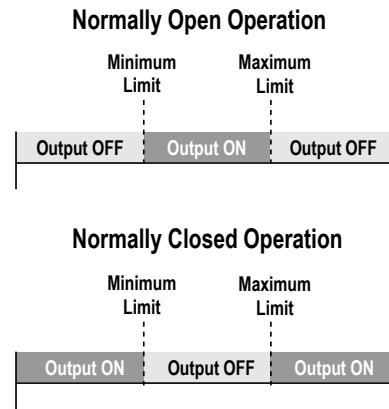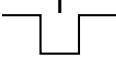
Normally Open Operation

Minimum Limit — Maximum Limit

Output OFF | Output ON | Output OFF

Normally Closed Operation

Minimum Limit — Maximum Limit

Output ON | Output OFF | Output ON

Figure 5. Teaching independent minimum and maximum limits

	Procedure		Result
	Push Button 0.04 seconds ≤ "Click" ≤ 0.8 seconds	**Remote Line** 0.04 sec < T < 0.8 sec	
Programming Mode	• Press and hold push button	• No action required; sensor is ready for 1st limit teach	**Output LED:** ON Red **Power LED:** ON Green (good signal) or ON Red (no signal)
Teach First Limit	• Position the target for the first limit	• Position the target for the first limit	**Power LED:** Must be ON Green
	• "Click" the push button	• Single-pulse the remote line T	**Teach Accepted** **Output LED:** Flashing Red **Teach Unacceptable** **Output LED:** ON Red
Teach Second Limit	• Position the target for the second limit	• Position the target for the second limit	**Power LED:** Must be ON Green
	• "Click" the push button	• Single-pulse the remote line T	**Teach Accepted** **Output LED:** Yellow or OFF **Teach Unacceptable** **Output LED:** Flashing Red

Teaching Limits Using the Auto-Window Feature

Normally Open Operation

Taught Position

Position - 10 mm →		← Position + 10 mm
Output OFF	Output ON	Output OFF

Normally Closed Operation

Taught Position

Position - 10 mm →		← Position + 10 mm
Output ON	Output OFF	Output ON

Figure 6. Using the Auto-Window feature for programming each output
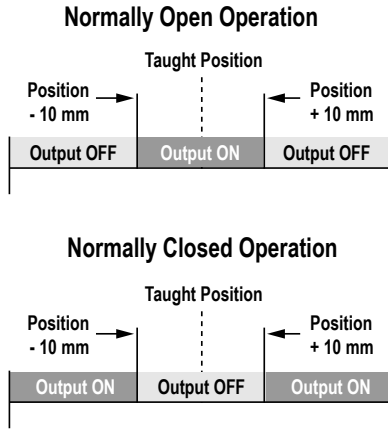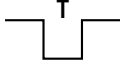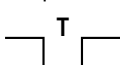
Teaching the same limit twice automatically centers a 20 mm window on the taught position.

General Notes on Programming

- The sensor will return to RUN mode if the first TEACH condition is not registered within 120 seconds.
- After the first limit is taught, the sensor will remain in PROGRAM mode until the TEACH sequence is finished.
- To exit PROGRAM mode without saving any changes, press and hold the programming push button > 2 seconds (before teaching the second limit). The sensor will revert to the last saved program.

|	Procedure		Result
	Push Button 0.04 seconds ≤ "Click" ≤ 0.8 seconds	**Remote Line** 0.04 sec < T < 0.8 sec	
Program-ming Mode	• Press and hold push button	• No action required; sensor is ready for 1st limit teach	**Output LED:** ON Red **Power LED:** ON Green (good signal) or ON Red (no signal)
Teach First Limit	• Position the target for the first limit	• Position the target for the center of the window	**Power LED:** Must be ON Green
	• "Click" the push button	• Single-pulse the remote line	**Teach Accepted** **Output LED:** Flashing Red **Teach Unacceptable** **Output LED:** ON Red
Re-Teach Limit	• Without moving the target, "click" the push button again	• Without moving the target, single-pulse the remote line again	**Teach Accepted** **Output LED:** Yellow or OFF **Teach Unacceptable** **Output LED:** Flashing Red
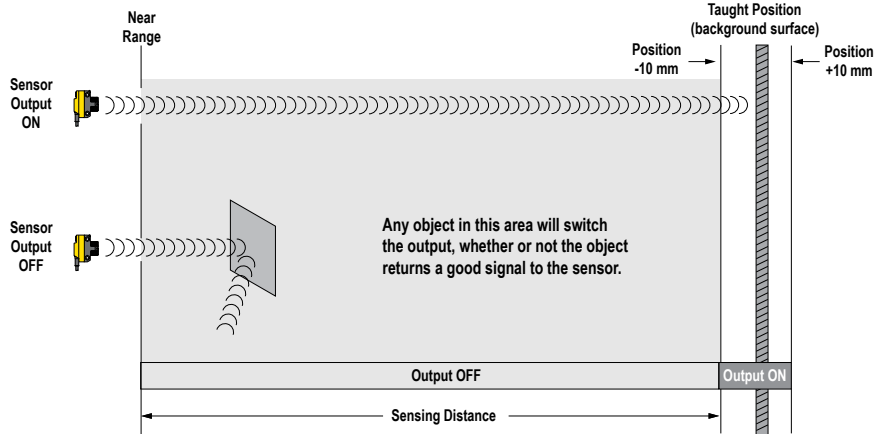
Figure 7. An application for the Auto-Window feature (retroflective mode)

Normally Open / Normally Closed Operation Select

The sensor can be configured for either normally open or normally closed operation via the remote teach wire (white). A series of three pulses on the line will toggle between normally open and normally closed operation. Normally open is defined as the output energizing when the target is present. Normally closed is defined as the output energizing when the target is absent. See Figures 5 and 6.

	Procedure		Result
	Push Button 0.04 seconds ≤ "Click" ≤ 0.8 seconds	**Remote Line** 0.04 sec < T < 0.8 sec	
Toggle be-tween N.O. / N.C. Operation	• Not available via push button	• Triple-pulse the remote line 	Either Normally Open or Nor-mally Closed operation is selec-ted, depending on previous condition.

Push Button Lockout

Enables or disables the push button to prevent unauthorized personnel from adjusting the program settings.

	Procedure		Result
	Push Button 0.04 seconds ≤ "Click" ≤ 0.8 seconds	**Remote Line** 0.04 sec < T < 0.8 sec	
Push But-ton Lock-out	• Not available via push button	• Four-pulse the remote line 	Push buttons are either ena-bled or disabled, depending on condi-tion.

Specifications

Supply Voltage

12 - 30V dc (10% maximum ripple); 25 mA max (exclusive of load)

Supply Protection Circuitry

Protected against reverse polarity and transient voltages

Output Configuration

SPST solid-state switch conducts when target is sensed within sensing window; one NPN (current sinking) or one PNP (current sourcing), depending on model.

Rating: 100 mA maximum load; see Application Note 1

Off-state leakage current: less than 10 μA (sourcing); less than 200 μA (sinking); see Application Note 2

ON-state saturation voltage: NPN: less than 1.6V @ 100 mA; **PNP**: less than 3.0V @ 100 mA

Output Response

NOTE: 300 ms delay on power-up; output does not conduct during this time

15 milliseconds

Repeatability

0.7 mm

Indicators

Range Indicator (Red/Green) and Teach/Output Indicator (Yellow/Red)

Range Indicator: Green - Target is within sensing range; Red - Target is outside sensing range; OFF - Sensing Power is OFF

Teach/Output Indicator: Yellow - Target is within taught limits; OFF - Target is outside taught window limits; Red - Sensor is in TEACH mode

Adjustments

Sensing Window Limits: TEACH-mode programming of near and far window limits may be set using the push button or remotely via TEACH input

Construction

ABS housing, TPE Push Button, ABS Push Button housing, Polycarbonate lightpipes, leakproof design

Connections

2 m (6.5 ft) or 9 m (30 ft) 4-conductor PVC jacketed attached cable, or 4-pin Euro-style integral QD (Q8), or 4-pin Pico-style integral QD (Q7), or 4-pin Euro-style 150 mm (6 in) pigtail QD (Q5), or 4-pin Pico-style 150 mm (6 in) pigtail QD (Q)

Operating Conditions

Relative Humidity: 100% @ 55° C (non-condensing)

Temperature: − 20° to + 60° C (− 4° to + 140° F)

Application Notes

If supply voltage is > 24V dc, derate maximum output current 5 mA/°C above 50°C.

NPN off-state leakage current is < 200 μA for load resistances > 3 kΩ or optically isolated loads. For load current of 100 mA, leakage is < 1% of load current.
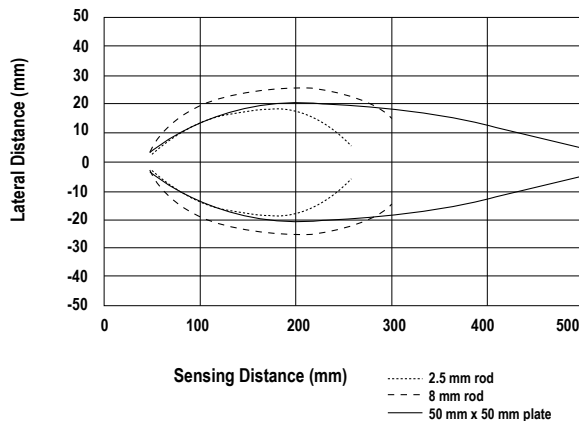
Objects passing inside the specified near limit may produce a false response.

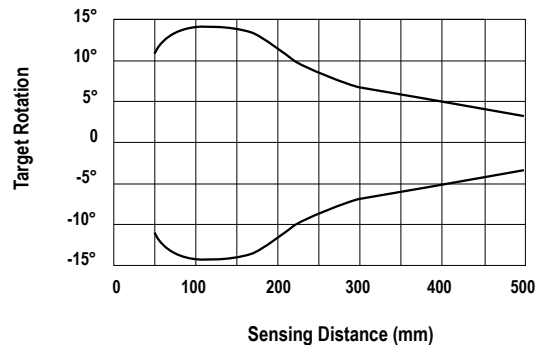**Certifications**

CE c UL US

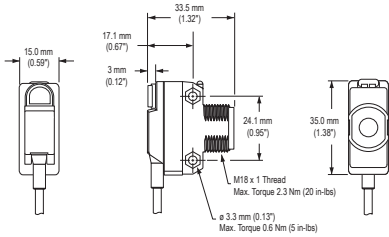# Sensor Response Curves

QS18U Effective Beam Pattern (Typical)
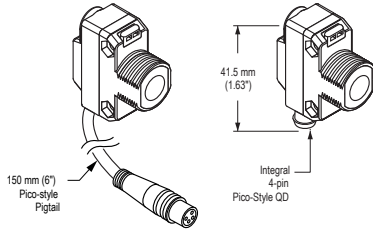

QS18U Maximum Target Rotation Angle

Dimensions

Cabled Models

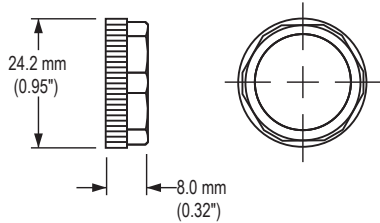

15.0 mm (0.59")

17.1 mm (0.67")

3 mm (0.12")

33.5 mm (1.32")

24.1 mm (0.95")

35.0 mm (1.38")

M18 x 1 Thread
Max. Torque 2.3 Nm (20 in-lbs)

ø 3.3 mm (0.13")
Max. Torque 0.6 Nm (5 in-lbs)

Pico-Style QD Models

41.5 mm (1.63")

150 mm (6")
Pico-style
Pigtail

Integral
4-pin
Pico-Style QD

Euro-Style QD Models

49 mm (1.93")

150 mm (6")
Euro-style
Pigtail

Integral
4-pin
Euro-Style QD
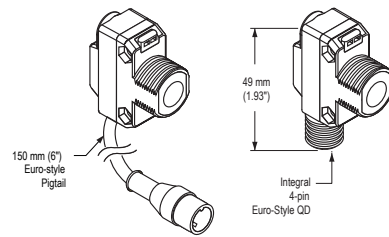
Locknut (included with all models)

24.2 mm (0.95")

8.0 mm (0.32")

Washer (included with all models)

Ø 23.9 mm (0.94")

Ø 17.8 mm (0.70")

1.6 mm (0.06")
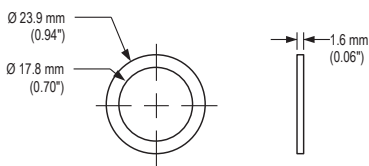
M3 Hardware Packet Contents:
- 2 – M3 x 0.5 x 20 mm SS Screw
- 2 – M3 x 0.5 SS Hex Nut
- 2 – M3 SS Washer

Wiring

NPN (Sinking) Output Models

bn
bu
bk
wh
shield

+
12 - 30V dc
−

Load

Remote programming
switch (normally open)

PNP (Sourcing) Output Models

bn
bu
bk
wh
shield

+
12 - 30V dc
−

Load

Remote programming
switch (normally open)
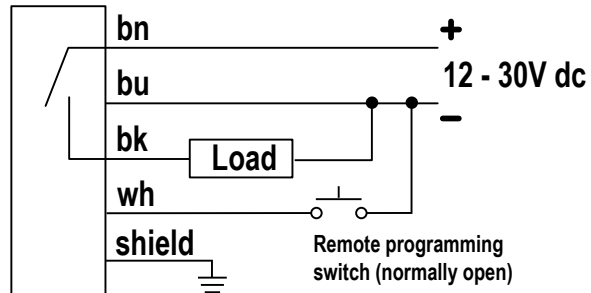
Cable and QD hookups are functionally identical. It is recommended that the shield wire be connected to earth ground. Shielded cordsets are recommended for all QD models.

Quick-Disconnect (QD) Cordsets

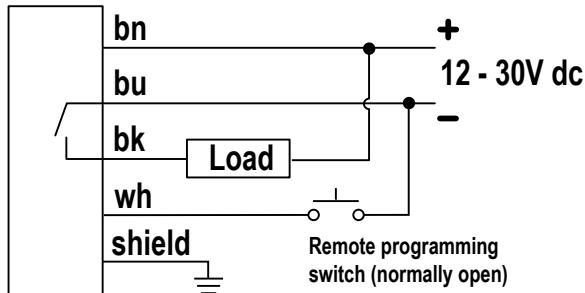| 4-Pin Snap-On M8/Pico-Style Cordsets with Shield				
Model	**Length**	**Style**	**Dimensions**	**Pinout**
PKG4S-2	2.00 m (6.56 ft)	Straight	ø10 mm max. (0.4") 28 mm max. (1.1")	 4 2 3 1 1 = Brown 2 = White 3 = Blue 4 = Black

4-Pin Snap-On M8/Pico-Style Cordsets with Shield

Model	Length	Style	Dimensions	Pinout
PKW4ZS-2	2.00 m (6.56 ft)	Right Angle	25 mm max. (1.0") 20 mm (0.8") ø12 mm max. (0.5")	

4-Pin Threaded M12/Euro-Style Cordsets with Shield

Model	Length	Style	Dimensions	Pinout
MQDEC2-406	1.83 m (6 ft)	Straight	ø 15 mm (0.6") M12 x 1 44 mm max. (1.7")	
MQDEC2-415	4.57 m (15 ft)			
MQDEC2-430	9.14 m (30 ft)			
MQDEC2-406RA	1.83 m (6 ft)	Right-Angle	32 Typ. [1.26"] 30 Typ. [1.18"] M12 x 1 ø 14.5 [0.57"]	1 = Brown 2 = White 3 = Blue 4 = Black
MQDEC2-415RA	4.57 m (15 ft)			
MQDEC2-430RA	9.14 m (30 ft)			

Mounting Brackets

SMB18A	• Right-angle mounting bracket with a curved slot for versatile orientation • 12-ga. stainless steel • 18 mm sensor mounting hole • Clearance for M4 (#8) hardware	

SMBQS18RA	• Right-angle mounting bracket • 14-ga. 304 stainless steel	

SMB18SF	• 18 mm swivel bracket with M18 x 1 internal thread • Black thermoplastic polyester • Stainless steel swivel locking hardware included	

SMB18UR	• 2-piece universal swivel bracket • 300 series stainless steel	

	• Stainless steel swivel locking hardware included • Mounting hole for 18 mm sensor	

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E2EX10D1NN E2E-X14MD1-G E2E-X2D1-G E2EX2ME2N E2E-X3D1-N 10M E2E-X4MD1-G E2FMX1R5D12M E2K-F10MC1 5M
EI1204TBOSL-6 EI5515NPAP BSA-08-25-08 IC08ANC15PO-K IMM2582C 25.161.3253.0 25.332.0653.1 25.352.0653.0 25.352.0753.0
25.523.3253.0 9151710023 922FS1.5C-A4P-Z774 SC606ABV0S30 SM952A126100LE A1220EUA-T F3S-A162-U CL18 QT-08L
34.110.0010.0 TL-C2MF1-M3-E4 IMM32188C IS2 IS31SE5000-UTLS2-TR 34.110.0021.0 34.110.0022.0 CA150-120VACDC
VM18VA3000Q XS508BSCBL2 XS512BLNAM12 XS512BLNBL2 XS512BLPAL5 XS518B1MBU20