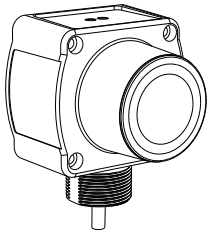
U-GAGE® QT50UDB Series Sensors with Dual-Discrete Outputs

Datasheet



- Fast, easy-to-use TEACH-Mode programming; no potentiometer adjustments
- Selectable dual NPN or PNP outputs via DIP switch
- Access to bank of 8 DIP switches through sealed cover for superior user functionality
- Rugged encapsulated design for harsh environments
- Unique housing design allows for multiple mounting configurations
- Choose models with integral unterminated 2 m (6.5 ft) or 9 m (30 ft) cable, or with Mini-style or M12/Euro-style quick-disconnect connection
- Wide operating range of –20 °C to +70 °C (–4 °F to +158 °F)
- Temperature compensation

WARNING: Not To Be Used for Personnel Protection

Never use this device as a sensing device for personnel protection. Doing so could lead to serious injury or death. This device does not include the self-checking redundant circuitry necessary to allow its use in personnel safety applications. A sensor failure or malfunction can cause either an energized or de-energized sensor output condition.

Models [1]	Sensing Range	Cable	Supply Voltage	Output
QT50UDB	200 mm to 8 m (8 in to 26 ft)	5-wire, 2 m (6.5 ft) cable	10 to 30 V dc	Dual NPN or PNP selectable
QT50UDBQ6		5-pin Euro-style QD		
QT50UDBQ		5-pin Mini-style QD		

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 = 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: $C_{m/s} = 20\sqrt{273 + T_C}$

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

T_C = temperature in °C

In English units: $C_{ft/s} = 49\sqrt{460 + T_F}$

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

T_F = temperature in °F

In metric units: $C_{m/s} = 20\sqrt{273 + T_C}$

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

T_C = temperature in °C

In English units: $C_{ft/s} = 49\sqrt{460 + T_F}$

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

T_F = temperature in °F

The speed of sound changes roughly 1% per 6° C (10° F). QT50U series ultrasonic sensors have temperature compensation available, via the 8-pin DIP switch. Temperature compensation will reduce the error due to temperature by about 90%.

[1] To order the 9 m cable models, add the suffix **w/30** to the model number of a cabled sensor (for example, **QT50UDB w/30**). A model with a QD connector requires a mating cable. Information about analog-output models is available on Banner Engineering website *http://www.bannerengineering.com*.

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ПРОМЭЛЕКТРОНИКА/ sales@prom-elec.com

Note: If the sensor is measuring across a temperature gradient, the compensation will be less effective.

Configuration

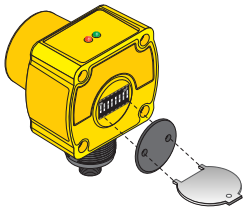


Figure 1. Removing the Access Cover

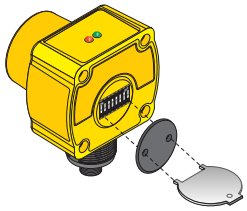


Figure 2. DIP Switch Location

The QT50U features an 8-pin DIP switch bank for user setup. The DIP switches are located behind the access cover on the back of the sensor as shown. A spanner tool is included with each sensor for removing the cover.

Switch	Function	Settings	
1	PNP or NPN Select	ON = Both outputs set for PNP OFF* = Both outputs set for NPN	
2	Window/Fill Level	ON = High/Low (fill level control) OFF* = ON/OFF (window)	
3	Output Operation	**Window selected on Switch 2:** ON* = Normally open OFF = Normally closed **Fill Level selected on Switch 2:** ON = Pump-in OFF = Pump-out	
4	Teach/Disable Control	ON* = Configured for remote teach OFF = Configured for transmit disable	
5 and 6	**Response (100 ms/cycle)** 1 cycle 4 cycles* 8 cycles 16 cycles	**Switch 5** OFF ON* OFF ON	**Switch 6** OFF OFF* ON ON
7	Temperature Compensation	ON* = Enabled OFF = Disabled	
8	Factory Calibration	ON = For factory calibration only; switch should be set to OFF for use OFF* = DIP-switch settings in control	

* Factory default settings

DIP Switch Selectable Functions

CAUTION:

- **Electrostatic Discharge (ESD) Sensitive Device**
- ESD can damage the device. Damage from inappropriate handling is not covered by warranty.
- To avoid damage to the sensor, observe proper ESD precautions (grounding) while adjusting the DIP switches.

Switch 1: Output Mode Select

ON = Both outputs set to PNP (current sourcing)
OFF = Both outputs set to NPN (current sinking)

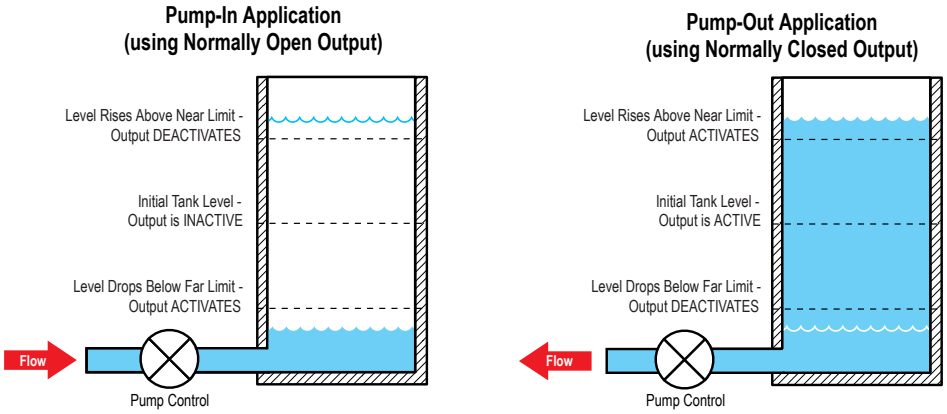
This switch configures the sensor internally to use either the PNP or NPN output configuration.

Switch 2: High/Low Level Control

ON = High/Low (fill level control)
OFF = ON/OFF (window)

This switch determines whether the sensor is in fill level control mode or normal ON/OFF mode. The fill level control is shown. When switch 2 is ON, the switch 3 setting will determine whether the sensor is set up for pump-in or pump-out operation.

In ON/OFF mode, the sensor is either ON or OFF when the target is within the window limits and opposite when outside of the window limit.



The **HIGH/LOW** mode (switch #2 ON) provides the switching logic required for fill-level, web tensioning control, and similar applications. In the HIGH/LOW mode, the output energizes when the target reaches the first sensing window limit, and stays energized until the target moves to the second limit. The output then de-energizes at the second limit and does not re-energize until the target moves, again, to the first limit.

Switch 3: ON/OFF Mode

ON = normally open (output is energized when the target is within window)
OFF = normally closed (output is energized when the target is outside window)

Switch 4: Teach/Transmit Enable Control

ON = Gray (or yellow) wire configured for remote teach
OFF = Gray (or yellow) wire configured for transmit disable. **High (5 to 30 V dc or open):** Transmit Enabled (Power LED solid Green) or **Low (0 to 2 V dc):** Transmit Disabled (Power LED flashes at 2 Hz).

When switch 4 is ON, the gray or yellow wire is used to teach the sensor's window limits. When switch 4 is OFF, the gray or yellow wire is used to enable and disable the sensor's transmit burst. This function may be used when multiple sensors are operating in close proximity and may be vulnerable to cross-talk interference. A PLC can be used to enable the sensors one at a time to avoid cross-talk.

When disabled, the sensor outputs will react as if no target is being sensed.

Switches 5-6: Response Speed Adjustment

The speed of the output response is set using DIP-switch positions 5 and 6. There are four values for response speed, which relate to the number of sensing cycles over which the output value is averaged.

Switch 7: Temperature Compensation

ON = Temperature compensation is enabled
OFF = Temperature compensation is disabled

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. With temperature compensation enabled (Switch 7 ON), the sensor will maintain the window limits to within 1.8% over the –20 °C to +70 °C (–4 °F to +158 °F) range.

Note:

- If temperature compensation is enabled, exposure to direct sunlight can affect the sensor's ability to accurately compensate for changes in temperature.
- With temperature compensation enabled, the temperature warmup drift upon power-up is less than 0.8% of the sensing distance. After 15 minutes, the apparent switchpoint will be within 0.5% of the actual position. After 30 minutes, the apparent switchpoint will be within 0.3% of the actual position.

Switch 8: Factory Calibration

ON = Factory calibration only

OFF = Normal operation

Status Indicators

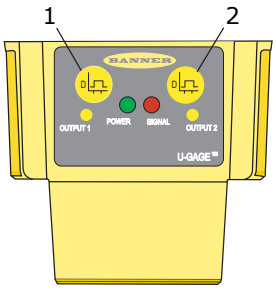


Figure 3. Sensor Features

1 - Output 1 button
2 - Output 2 button
OUTPUT 1 - Output 1 Indicator
POWER - Sensor power indicator
SIGNAL - Target signal strength indicator
OUTPUT 2 - Output 2 indicator

Signal LED (Red) – Indicates the strength and condition of the sensor's incoming signal	
Signal LED Status	**Indicates**
ON Bright	Good signal
ON Dim	Marginal signal strength
OFF	No signal is received [2] or the target is beyond the sensor's range limitations

Output LEDs (Amber or Red) – Indicate the position of the target, relative to the window limits	
Output/Teach LED	**Indicates**
ON Red (Solid)	In Teach mode; waiting for first limit to be taught
ON Red (Flashing)	In Teach mode; waiting for second limit to be taught
ON Amber	Target is within window limits (normally open mode)
OFF	Target is outside window limits (normally open mode)

Power ON/OFF LED (Green) – Indicates the operating status of the sensor	
Power ON/OFF LED	**Indicates**
OFF	Power is OFF
ON Solid	Sensor is operating normally
Flashing at 4 Hz	Output is overloaded (RUN mode)
Flashing at 2 Hz	Transmit disabled

Sensor Programming

Three TEACH methods may be used to program the sensor:

- Teach individual minimum and maximum limits,
- Use the Auto-Window feature to center a sensing window around the taught position, or
- Simultaneously use Auto-Window and position a threshold for background suppression at the taught position.

The sensor may be programmed either via its two push buttons, or via a remote switch. Remote programming also may be used to disable the push buttons, preventing unauthorized personnel from adjusting the programming settings. To access this feature, connect the gray wire of the sensor to 0–2 V dc, with a remote programming switch between the sensor and the voltage.

Note: The impedance of the Remote Teach input is 12 kΩ.

Programming is accomplished by following the sequence of input pulses. The duration of each pulse (corresponding to a push button "click"), and the period between multiple pulses, are defined as **0.04 seconds < T < 0.8 seconds**

[2] If no signal is received, the output will react as if the target is beyond the far limit. In normally open mode, the outputs will be OFF. In normally closed mode, the outputs will be ON.

Teaching Minimum and Maximum Limits

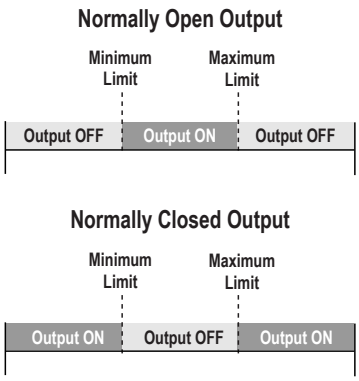


Figure 4. Teaching independent minimum and maximum limits

The outputs are independent. To readjust minimum or maximum limits for either output, follow the teach procedure for that output only.

Repeat the teach procedure for the other output, if used.

Push Button Method

1. Enter Programming Mode

Action	Result
Push and hold the Output 1 button for output 1 or the Output 2 button for output 2	The corresponding output LED turns solid Red and the sensor waits for first limit.

2. Teaching the First Limit

Action	Result
Position the target for the first limit	
Click the same button (Output 1 button for output 1; Output 2 button for output 2)	Sensor learns the first limit position and the LED for the selected output changes to flashing red

3. Teaching the Second Limit

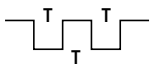
Action	Result
Position the target for the second limit	
Click the same button (Output 1 button for output 1; Output 2 button for output 2)	Sensor stores both limit positions and the LED for the selected output changes to amber

Remote Line Method (0.04 s < T < 0.8 s)

1. Enter Programming Mode

Action	Result
No action required	The corresponding output LED turns solid Red and the sensor waits for first limit.

2. Teaching the First Limit

Action	Result
Position the target for the first limit	
For Output 1: Single-pulse the remote line  For Output 2: Double-pulse the remote line 	Sensor learns the first limit position and the LED for selected output changes to flashing red

3. Teaching the Second Limit

Action	Result
Position the target for the first limit	
Single-pulse the remote line 	Sensor stores both limit positions and the LED for the selected output changes to amber

Teaching Limits Using the Auto-Window Feature

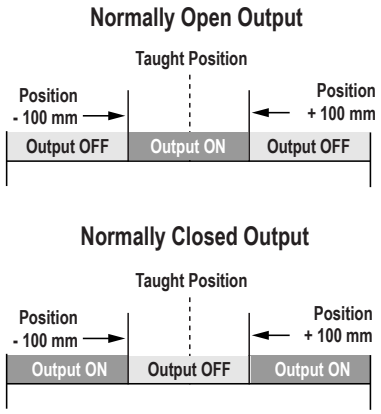


Figure 5. Using the Auto-Window feature for programming each output

Teaching the same limit twice for the same output automatically centers a 200 mm window on the taught position.

The outputs are independent. To readjust a midpoint for either output, follow the teach procedure for that output only. Repeat the teach procedure for the other output, if used.

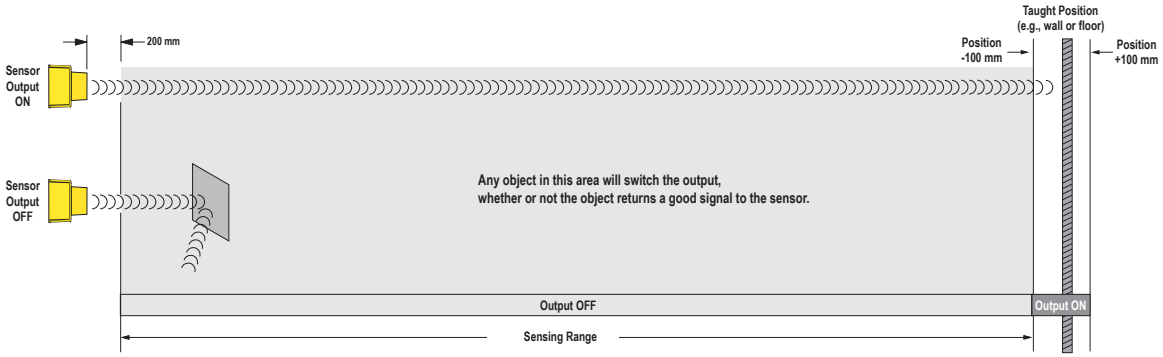


Figure 6. An application for Auto-Window feature (retroreflective mode)

Push Button Method

1. Enter Programming Mode

Action	Result
Push and hold the Output 1 button for output 1 or the Output 2 button for output 2	The corresponding output LED turns ON Red and the sensor waits for first limit.

2. Teaching the Limit

Action	Result
Position the sensor for the midpoint of the sensing window	
Click the same button (Output 1 button for output 1; Output 2 button for output 2)	The LED for the selected output flashes red

3. Re-teaching the Limit

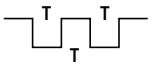
Action	Result
Without moving the target, click the button again (Output 1 button for output 1; Output 2 button for output 2)	LED for the selected output turns solid amber and the sensor stores the sensing window for the selected output. The sensor returns to RUN mode.

Remote Line Method (0.04 s < T < 0.8 s)

1. Enter Programming Mode

Action	Result
No action required	The corresponding output LED turns solid Red and the sensor waits for first limit.

2. Teaching the Limit

Action	Result
Position the target for the midpoint of the sensing window	
For Output 1: single-pulse the remote line  For Output 2: double-pulse the remote line 	The LED for the selected output flashes red

3. Re-teaching the Limit

Action	Result
Without moving the target, single-pulse the remote line again	The LED for the selected output turns solid amber and the sensor stores the sensing window for the selected output. The sensor returns to RUN mode.

Simultaneous Auto-Window/Background Suppression

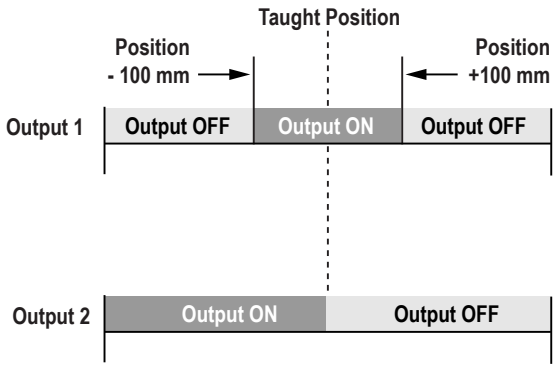


Figure 7. Using simultaneous auto-window/background suppression (normally open illustrated)

Output 1: Auto-Window (automatically centers a 200 mm window on taught position)

Output 2: Background Suppression (sensor ignores objects beyond the taught position)

Taught position is identical for both outputs.

To adjust the Background Suppression limit (different from the limit for Output 1), teach a new limit to Output 2 using the Auto-Window procedure (see *Teaching Limits Using the Auto-Window Feature* on page 6. Output 2 remains in Background Suppression mode until it is taught new min/max limits.

Push Button Method

1. Enter Programming Mode

Action	Result
Push and hold the Output 1 button	Output 1 LED turns solid Red
Click the Output 2 button	Output 2 LED turns solid Red (both Output LEDs should be solid Red)

2. Teaching Limits to Both Outputs Simultaneously

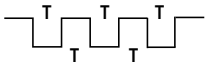
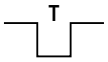
Action	Result
Position the target at the sensing window midpoint/suppression limit	
Click either button	Both output LEDs flash red
Click either button again	Both output LEDs turn solid amber and the sensor stores sensing window on Output 1 and suppression limit on Output 2. The sensor returns to RUN mode.

Remote Line Method (0.04 s < T < 0.8 s)

1. Enter Programming Mode

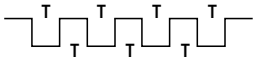
Action	Result
No action required	Both output LEDs turn solid red

2. Teaching Limits to Both Outputs Simultaneously

Action	Result
Position the target at the sensing window midpoint/suppression limit	
Triple-pulse the remote line 	Both output LEDs flash red
Single-pulse the remote line 	Both output LEDs turn solid amber and the sensor stores the sensing window on Output 1 and the suppression limit on Output 2. The sensor returns to RUN mode.

Push Button Lockout

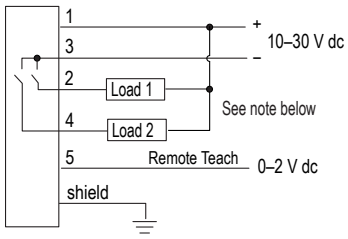
The Push Button Lockout feature enables or disables the keypad to prevent unauthorized personnel from adjusting the programming settings. This feature is not available using the buttons.

Procedure (0.04 s < T < 0.8 s)	Result
Four-pulse the remote line 	Push buttons are either enabled or disabled, depending on previous condition.

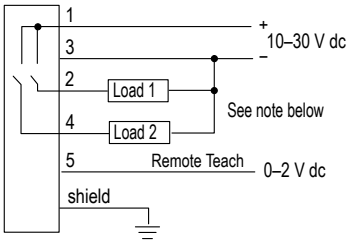
Wiring

Cabled Models

NPN Wiring



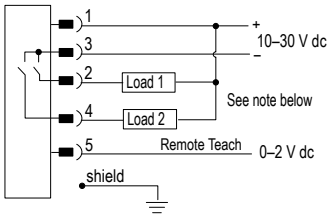
PNP Wiring



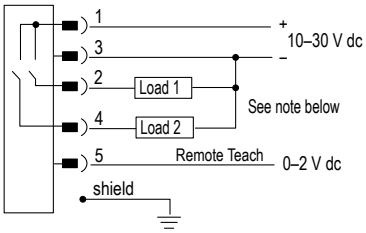
1 = brown
2 = white
3 = blue
4 = black
5 = gray

QD Models

NPN Wiring



PNP Wiring

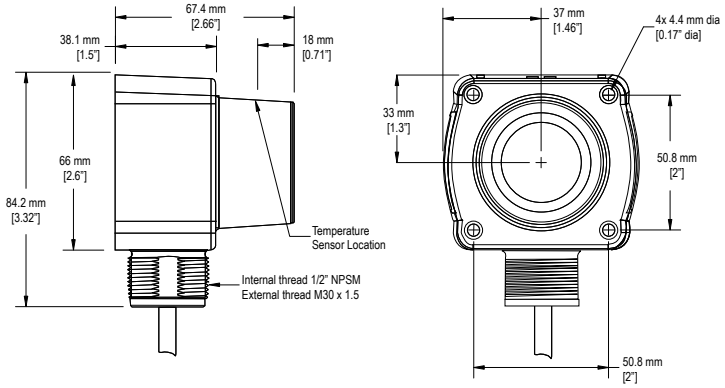


1 = brown
2 = white
3 = blue
4 = black
5 = yellow or gray

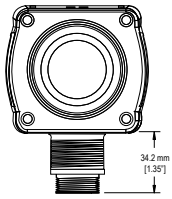
NPN or PNP hookup must agree with DIP-switch settings. Banner Engineering Corp. recommends connecting the shield wire to earth ground or DC common.

Dimensions

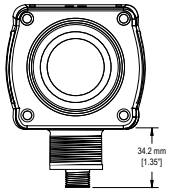
Cabled Models



5-pin Mini-style Models

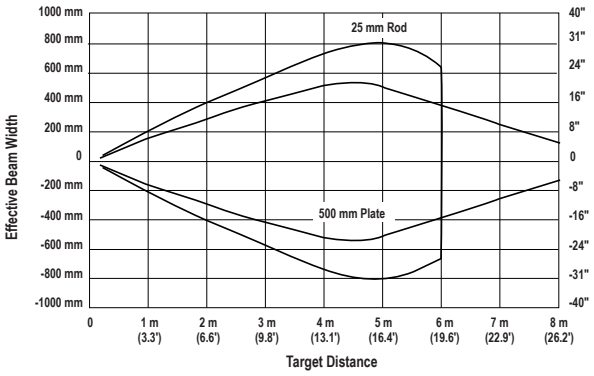


5-pin Euro-style Models

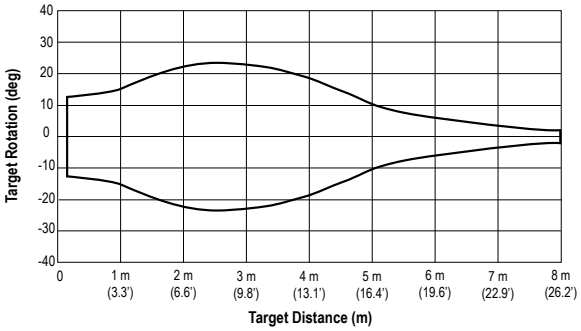


Performance Curves

QT50U Effective Beam Pattern



QT50U (with 500 mm Plate) Maximum Target Rotation Angle



Specifications

Sensing Range
200 mm to 8 m (8 in. to 26 ft)

Supply Voltage
10 to 30 V dc (10% maximum ripple); 100 mA max at 10 V, 40 mA max at 30 V (exclusive of load)

Ultrasonic Frequency
75 kHz burst, rep. rate 96 ms

Supply Protection Circuitry
Protected against reverse polarity and transient overvoltages

Output Protection
Protected against short circuit conditions

Delay at Power-up
1.5 seconds

Output Ratings
150 mA maximum
Off-state leakage current: < 5 µA
Output Saturation NPN: < 200 mV at 10 mA and < 650 mV at 150 mA
Output Saturation PNP: < 1.2 V at 10 mA and < 1.65 V at 150 mA

Output Response Time
100 ms to 1600 ms. See *Configuration* on page 2.

Temperature Effect
Uncompensated: 0.2% of distance/°C
Compensated: 0.02% of distance/°C

Hysteresis
5 mm

Repeatability
1.0 mm

Minimum Window Size
20 mm

Adjustments
Sensing window limits: TEACH-Mode programming of near and far window limits may be set using the push buttons or remotely via TEACH input (see *Teaching Minimum and Maximum Limits* on page 5).

Indicators
Green Power On LED: Indicates power is ON
Red Signal LED: Indicates target is within sensing range, and the condition of the received signal
Teach/Output indicator (bicolor Amber/Red):
Amber – Target is within taught limits
OFF – Target is outside taught window limits
Red – Sensor is in TEACH mode

Remote TEACH
To Teach: Connect gray or yellow wire to 0 to +2 V dc; impedance 12 kΩ

Construction
Transducer: Ceramic/Epoxy composite
Housing: ABS/Polycarbonate
Membrane Switch: Polyester
Lightpipes: Acrylic

Operating Conditions
Temperature: –20 °C to +70 °C (–4 °F to +158 °F)
Humidity: 100% maximum relative humidity

Connections
2 m (6.5 ft) or 9 m (30 ft) shielded 5-conductor (with drain) PVC jacketed attached cable or 5-pin Euro-style quick-disconnect or 5-pin Mini-style quick-disconnect

Environmental Rating
Leakproof design is rated IEC IP67; NEMA 6P

Vibration and Mechanical Shock
All models meet Mil Std. 202F requirements. Method 201A (vibration: 10 to 60 Hz max., double amplitude 0.06 in, maximum acceleration 10G). Also meets IEC 947-5-2 requirements: 30G 11 ms duration, half sine wave

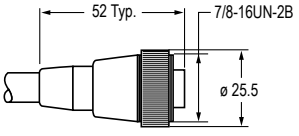
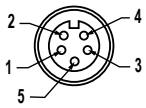
Temperature Warmup Drift
Less than 0.8% of sensing distance upon power-up with Temperature Compensation enabled (see *DIP Switch Selectable Functions* on page 2)

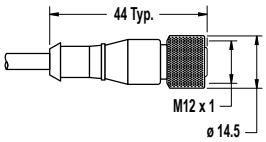
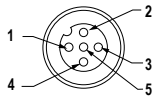
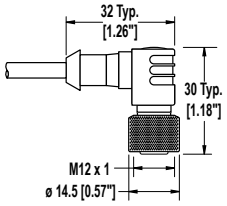
Application Notes
Objects passing inside the specified near limit (200 mm) may produce a false response.

Certifications
CE

Accessories

Cordsets

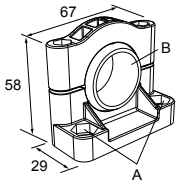
5-Pin Mini-Style Cordsets—with Shield				
Model	**Length**	**Style**	**Dimensions**	**Pinout (Female)**
MBCC2-506	1.83 m (6 ft)	Straight		 1 = Brown 2 = White 3 = Blue 4 = Black 5 = Yellow
MBCC2-512	3.66 m (12 ft)			
MBCC2-530	9.14 m (30 ft)			

5-Pin Threaded M12/Euro-Style Cordsets—with Shield				
Model	**Length**	**Style**	**Dimensions**	**Pinout (Female)**
MQDEC2-506	1.83 m (6 ft)	Straight		 1 = Brown 2 = White 3 = Blue 4 = Black 5 = Gray
MQDEC2-515	4.57 m (15 ft)			
MQDEC2-530	9.14 m (30 ft)			
MQDEC2-550	15.2 m (50 ft)			
MQDEC2-506RA	1.83 m (6 ft)	Right-Angle		
MQDEC2-515RA	4.57 m (15 ft)			
MQDEC2-530RA	9.14 m (30 ft)			
MQDEC2-550RA	15.2 m (50 ft)			

Brackets

SMB30SC

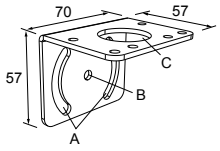
- Swivel bracket with 30 mm mounting hole for sensor
- Black reinforced thermoplastic polyester
- Stainless steel mounting and swivel locking hardware included



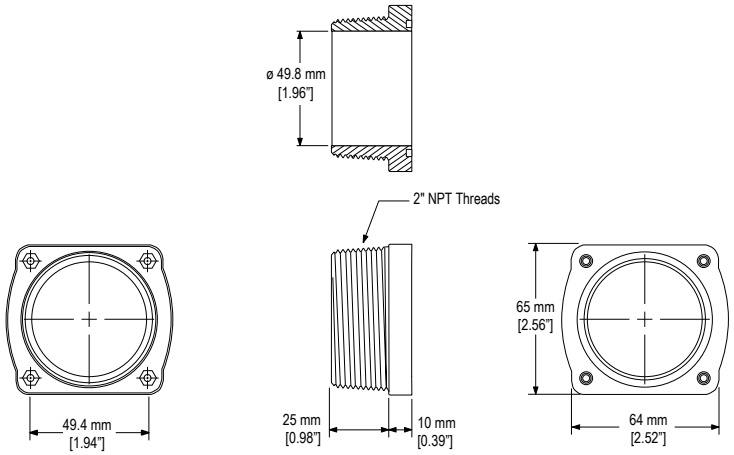
Hole center spacing: A=ø 50.8
Hole size: A=ø 7.0, B=ø 30.0

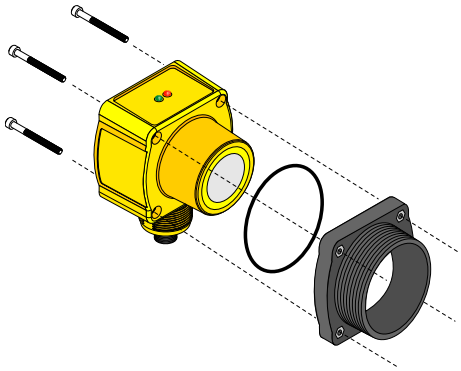
SMB30MM

- 12-ga. stainless steel bracket with curved mounting slots for versatile orientation
- Clearance for M6 (¼ in) hardware
- Mounting hole for 30 mm sensor



Hole center spacing: A = 51, A to B = 25.4
Hole size: A = 42.6 x 7, B = ø 6.4, C = ø 30.1

SAFQT50U	• PVC mounting flange mounts to the front of a QT50U sensor (not for use with chemical-resistant models). • Adapts sensor to thread into standard 50.8 mm (2 in) NPT female threads
	

SAFQT50U	• PVC mounting flange mounts to the front of a QT50U sensor (not for use with chemical-resistant models). • Adapts sensor to thread into standard 50.8 mm (2 in) NPT female threads
	1. Place o-ring in flange groove. 2. Assemble sensor onto threaded flange as shown, using the M4 screws supplied with the QT50U sensor. 3. Using the supplied hex wrench, torque screws to approximately 1.1 kg/m (10 in/lbs). 4. Mount sensor/flange assembly into the 50.8 mm (2 in) NPT fitting.

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