# Q5X Laser Measurement Sensor with Background Suppression

## Quick Start Guide

Laser sensor with dual outputs and IO-Link

This guide is designed to help you set up and install the Q5X Laser Measurement Sensor with Background Suppression. For complete information on programming, performance, troubleshooting, dimensions, and accessories, please refer to the Instruction Manual at www.bannerengineering.com. Search for p/n 208794 to view the Instruction Manual. Use of this document assumes familiarity with pertinent industry standards and practices.

**WARNING:**

- **Do not use this device for personnel protection**
- Using this device for personnel protection could result in serious injury or death.
- This device does not include the self-checking redundant circuitry necessary to allow its use in personnel safety applications. A device failure or malfunction can cause either an energized (on) or de-energized (off) output condition.

## Features

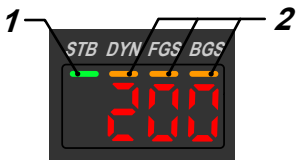

1. Two output indicators (amber)
2. Display
3. Buttons

### Display and Indicators

The display is a 4-digit, 7-segment LED. Run mode is the primary view displayed.

For 2-pt, BGS, FGS, and DYN TEACH modes, the display shows the current distance to the target in centimeters. For Dual TEACH mode, the display shows the percentage matched to the taught reference surface. A display value of 999P indicates the sensor has not been taught.

*Figure 1. Display in Run Mode*




1. Stability Indicator (STB—Green)
2. Active TEACH Indicators
   - DYN—Dynamic (Amber)
   - FGS—Foreground Suppression (Amber)
   - BGS—Background Suppression (Amber)

**Output Indicator**

- On—Output is on
- Off—Output is off

**Stability Indicator (STB)**

- On—Stable signal within the specified sensing range
- Flashing—Marginal signal, the target is outside the limits of the specified sensing range, or a multiple peak condition exists
- Off—No target detected within the specified sensing range

**Active TEACH Indicators (DYN, FGS, and BGS)**

- DYN, FGS, and BGS all off—Two-point TEACH mode selected (default)
- DYN on—Dynamic TEACH mode selected
- FGS on—Foreground suppression TEACH mode selected
- BGS on—Background suppression TEACH mode selected
- DYN, FGS, and BGS all on—Dual TEACH mode selected

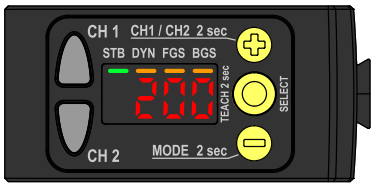
### Buttons

Use the sensor buttons **(SELECT)(TEACH)**, **(+)(CH1/CH2)**, and **(-)(MODE)** to program the sensor.


Original Document
208795 Rev. D

16 December 2020

208795




**(SELECT)(TEACH)**

- Press to select menu items in Setup mode
- Press and hold for longer than 2 seconds to start the currently selected TEACH mode (the default is two-point TEACH)

**(-)(MODE)**

- Press to navigate the sensor menu in Setup mode
- Press to change setting values; press and hold to decrease numeric values
- Press and hold for longer than 2 seconds to enter Setup mode

**(+)(CH1/CH2)**

- Press to navigate the sensor menu in Setup mode
- Press to change setting values; press and hold to increase numeric values
- Press and hold for longer than 2 seconds to switch between Channel 1 and Channel 2

**Note:** When navigating the menu, the menu items loop.

## Class 2 Laser Description and Safety Information

**CAUTION:**

- **Return defective units to the manufacturer.**
- Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.
- Do not attempt to disassemble this sensor for repair. A defective unit must be returned to the manufacturer.

**CAUTION:**

- **Never stare directly into the sensor lens.**
- Laser light can damage your eyes.
- Avoid placing any mirror-like object in the beam. Never use a mirror as a retroreflective target.

**For Safe Laser Use - Class 2 Lasers**

- Do not stare at the laser.
- Do not point the laser at a person's eye.
- Mount open laser beam paths either above or below eye level, where practical.
- Terminate the beam emitted by the laser product at the end of its useful path.

Class 2 lasers are lasers that emit visible radiation in the wavelength range from 400 nm to 700 nm, where eye protection is normally afforded by aversion responses, including the blink reflex. This reaction may be expected to provide adequate protection under reasonably foreseeable conditions of operation, including the use of optical instruments for intrabeam viewing.

Low-power lasers are, by definition, incapable of causing eye injury within the duration of a blink (aversion response) of 0.25 seconds. They also must emit only visible wavelengths (400 to 700 nm). Therefore, an ocular hazard may exist only if individuals overcome their natural aversion to bright light and stare directly into the laser beam.

**Class 2 Red Lasers with maximum range of 2000 mm: Reference IEC 60825-1:2007**

*Figure 2. FDA (CDRH) warning label (Class 2)*


**Output:** < 1.0 mW

**Laser wavelength:** 640 to 670 nm

**Pulse Duration:** 20 µs to 2 ms

**Class 2 Red Lasers with maximum range > 2000 mm: Reference IEC 60825-1:2014**

*Figure 3. FDA (CDRH) warning label (Class 2)*


**Output:** < 1.0 mW

**Laser wavelength:** 640 to 670 nm

**Pulse Duration for <5 m Models:** 20 µs to 2 ms

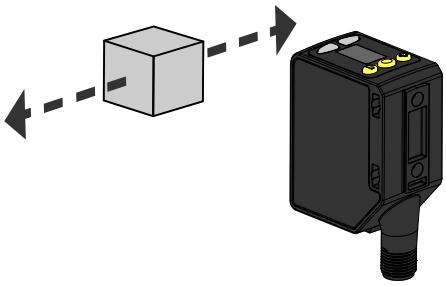
**Pulse Duration for ≥ 5 m Models:** 3 µs

# Installation

## Sensor Orientation for the Triangulation Models (Maximum Range < 5000 mm)

Optimize detection reliability and minimum object separation performance with correct sensor-to-target orientation. To ensure reliable detection, orient the sensor as shown in relation to the target to be detected.

*Figure 4. Optimal Orientation of Target to Sensor*



See the following figures for examples of correct and incorrect sensor-to-target orientation as certain placements may pose problems for sensing some targets. The Q5X can be used in the less preferred orientation and at steep angles of incidence and still provide reliable detection performance due to its high excess gain. For the minimum object separation distance required for each case, refer to Performance Curves on p. 12.

*Figure 5. Orientation by a wall*

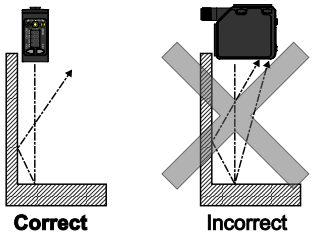



*Figure 6. Orientation for a moving object*

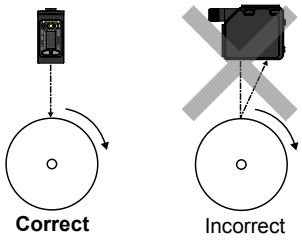



*Figure 7. Orientation for a height difference*

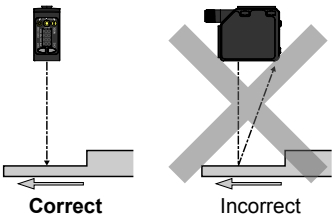



*Figure 8. Orientation for a color or luster difference*

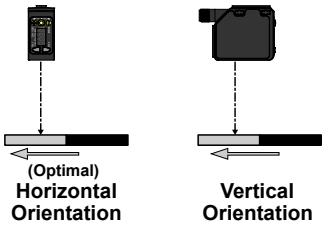
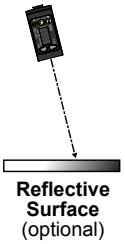



*Figure 9. Orientation for highly reflective target*[1]




[1] *Applying tilt to sensor may improve performance on reflective targets. The direction and magnitude of the tilt depends on the application, but a 15° tilt is often sufficient.*

## Mount the Device

1. If a bracket is needed, mount the device onto the bracket.
2. Mount the device (or the device and the bracket) to the machine or equipment at the desired location. Do not tighten the mounting screws at this time.
3. Check the device alignment.
4. Tighten the mounting screws to secure the device (or the device and the bracket) in the aligned position.

## Wiring Diagram

*Figure 10. Channel 2 as PNP Discrete or PFM Output*

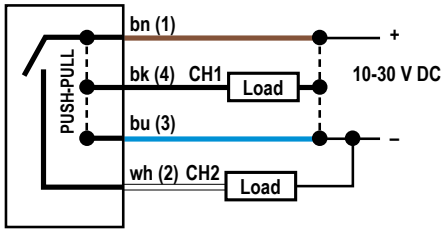
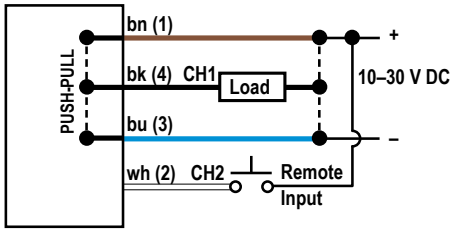
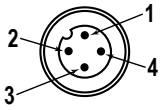



*Figure 11. Channel 2 as Remote Input*



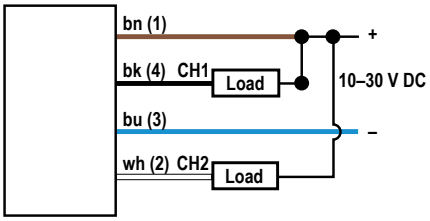




**Note:** Open lead wires must be connected to a terminal block.

**Note:** The Channel 2 wire function and polarity is user-selectable. The default for the wire is PNP output. Refer to the Instruction Manual (p/n 208794) for details regarding use as a remote input or pulse frequency modulation (PFM) output.

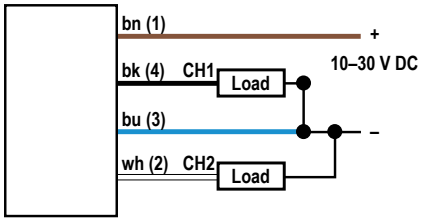
### NPN Discrete Outputs

*Figure 12. Channel 1 = NPN Output, Channel 2 = NPN Output*



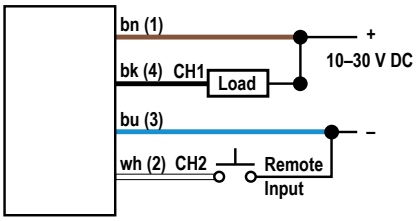

### PNP Discrete Outputs

*Figure 13. Channel 1 = PNP Output, Channel 2 = PNP Output*



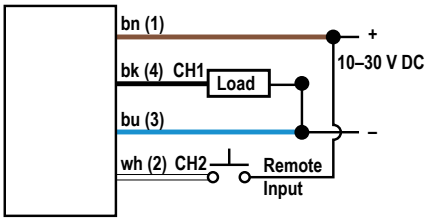

### NPN Output and Remote Input

*Figure 14. Channel 1 = NPN Output, Channel 2 = NPN Remote Input*




### PNP Output and Remote Input

*Figure 15. Channel 1 = PNP Output, Channel 2 = PNP Remote Input*



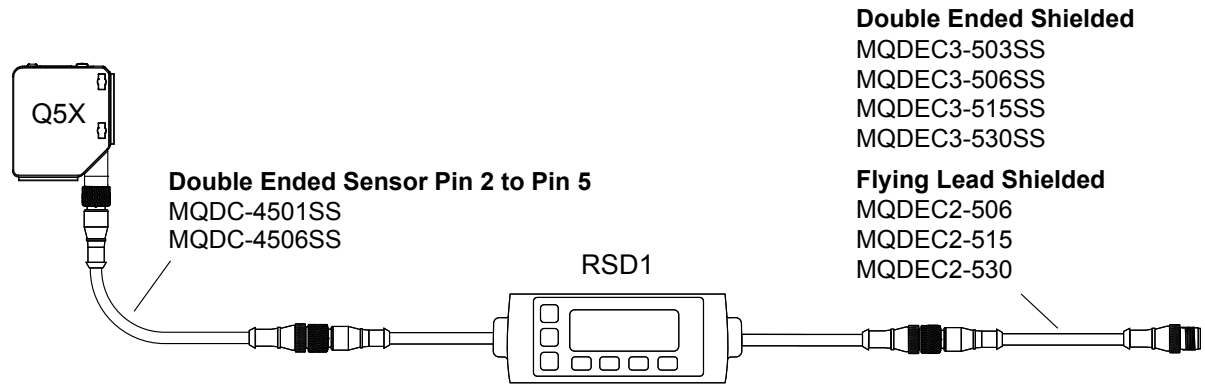

## Cleaning and Maintenance

Handle the sensor with care during installation and operation. Sensor windows soiled by fingerprints, dust, water, oil, etc. may create stray light that may degrade the peak performance of the sensor. Blow the window clear using filtered, compressed air, then clean as necessary using only water and a lint-free cloth.

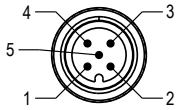
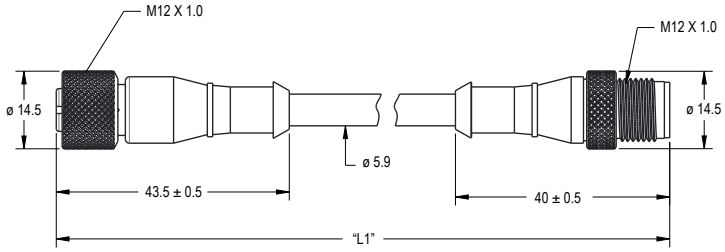
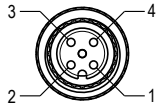
## Connecting to RSD1

The following diagram depicts the connection of the Q5X to the optional RSD1 accessory.

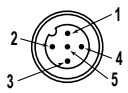
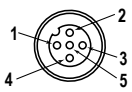
*Figure 16. Q5X to RSD1*

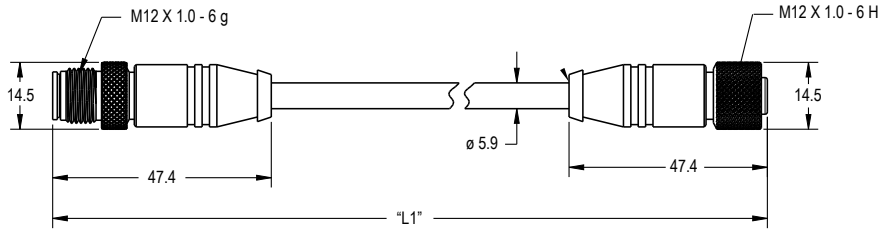


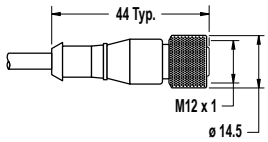
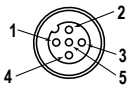
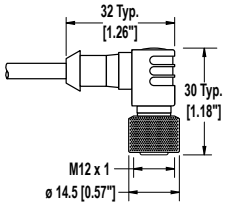

Use these cordsets to connect the RSD1 to the Q5X sensor.

| 4-Pin Female and 5-Pin Male Threaded M12/Euro-Style Cordset—Double Ended | | | |
|---|---|---|---|
| **Model** | **Length "L1"** | **Style** | **Pinout** |
| MQDC-4501SS | 0.30 m (0.98 ft) | Female Straight/ Male Straight | Male<br>  <br>1 = Brown<br>2 = Not Used<br>3 = Blue<br>4 = Black<br>5 = White |
| MQDC-4506SS | 1.83 m (6.00 ft) | | |
|  | | | Female<br>  <br>1 = Brown<br>2 = White<br>3 = Blue<br>4 = Black |

Use these cordsets to connect the RSD1 to any PLC or IO block.

| 5-Pin Male Threaded and 5-Pin Female Quick Disconnect M12/Euro-Style Cordset with Shield—Double Ended | | | | |
|---|---|---|---|---|
| **Model** | **Length "L1"** | **Style** | **Pinout (Male)** | **Pinout (Female)** |
| MQDEC3-503SS | 0.91 m (2.99 ft) | Female Straight/Male Straight |  |  |
| MQDEC3-506SS | 1.83 m (6 ft) | | | |
| MQDEC3-515SS | 4.58 m (15 ft) | | | |
| MQDEC3-530SS | 9.2 m (30.2 ft) | | | |

| 5-Pin Male Threaded and 5-Pin Female Quick Disconnect M12/Euro-Style Cordset with Shield—Double Ended | | | | |
|---|---|---|---|---|
| **Model** | **Length "L1"** | **Style** | **Pinout (Male)** | **Pinout (Female)** |
| | |  | 1 = Brown<br>2 = White<br>3 = Blue | 4 = Black<br>5 = Gray |

| 5-Pin Threaded M12/Euro-Style Cordsets with Shield—Single Ended | | | | |
|---|---|---|---|---|
| **Model** | **Length** | **Style** | **Dimensions** | **Pinout (Female)** |
| **MQDEC2-506** | 2 m (6.56 ft) | Straight |  |  <br>1 = Brown<br>2 = White<br>3 = Blue<br>4 = Black<br>5 = Gray |
| **MQDEC2-515** | 5 m (16.4 ft) | | | |
| **MQDEC2-530** | 9 m (29.5 ft) | | | |
| **MQDEC2-550** | 15 m (49.2 ft) | | | |
| **MQDEC2-506RA** | 2 m (6.56 ft) | Right-Angle |  | |
| **MQDEC2-515RA** | 5 m (16.4 ft) | | | |
| **MQDEC2-530RA** | 9 m (29.5 ft) | | | |
| **MQDEC2-550RA** | 15 m (49.2 ft) | | | |

## Button Map from RSD1 to Sensor

Refer to this table for the RSD1 button association with your sensor.

| Device | Up Button | Down Button | Enter Button | Escape Button |
|---|---|---|---|---|
| **RSD1** |  |  |  |  |
| **Q4X** and **Q5X** |  |  |  | N/A |

# Sensor Programming

Program the sensor using the buttons on the sensor or the remote input (limited programming options).

In addition to programming the sensor, use the remote input to disable the buttons for security, preventing unauthorized or accidental programming changes. See the Instruction Manual, p/n 208794 for more information.

## Setup Mode

Access Setup mode and the sensor menu from Run mode by pressing and holding **MODE** for longer than 2 seconds. Use + and − to navigate through the menu. Press **SELECT** to select a menu option and access the submenus. Use + and − to navigate through the submenus. Press **SELECT** to select a submenu option and return to the top menu, or press and hold **SELECT** for longer than 2 seconds to select a submenu option and return immediately to Run mode.

To exit Setup mode and return to Run mode, navigate to End and press **SELECT**.

**Note:** The number that follows a menu option, for example tch1, indicates the channel that is selected. For menu items without a number (excluding submenu items), these menu options are only available from Channel 1 and the settings apply to both channels.

*Figure 17. Sensor Menu Map—Channel 1*

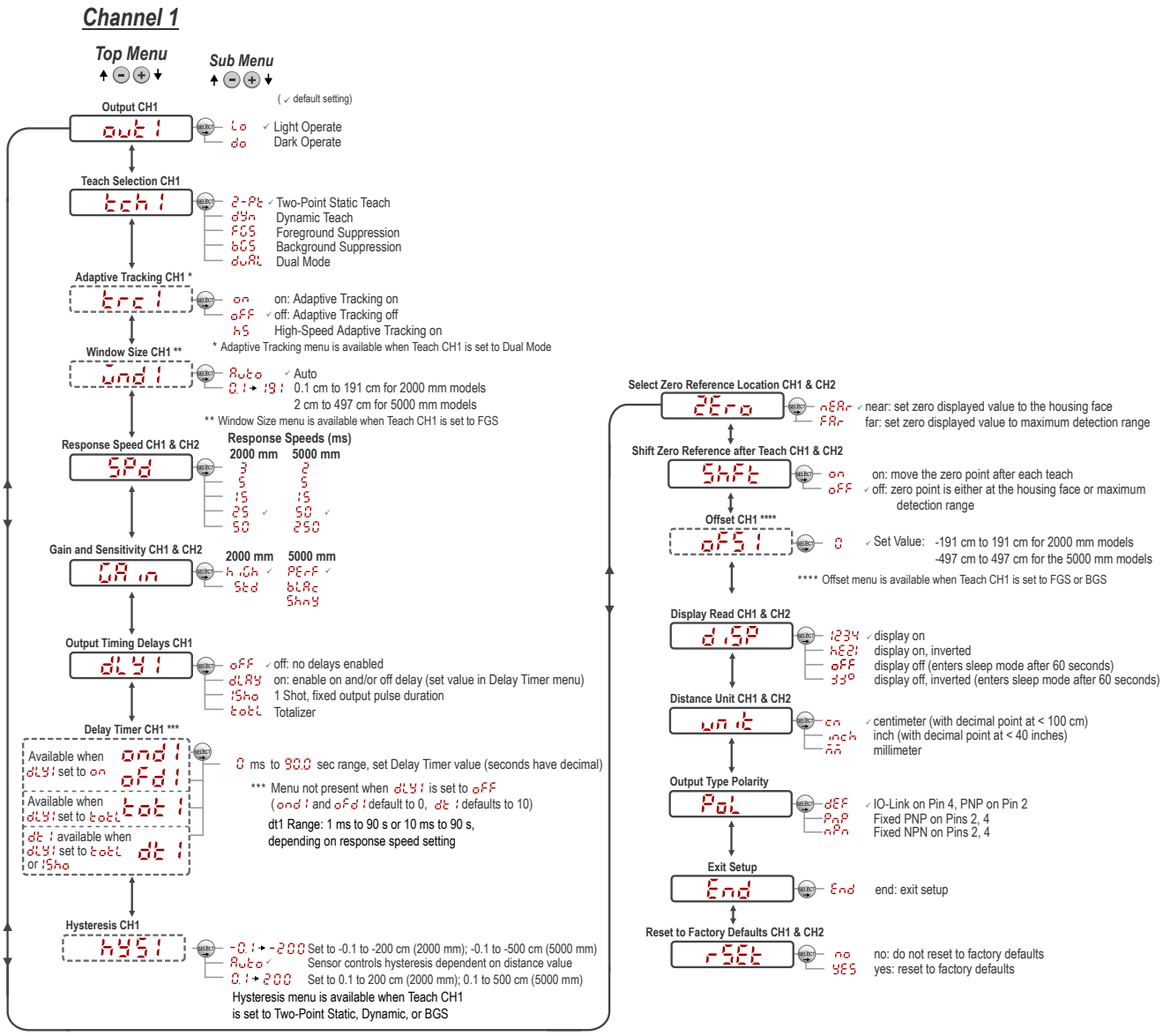
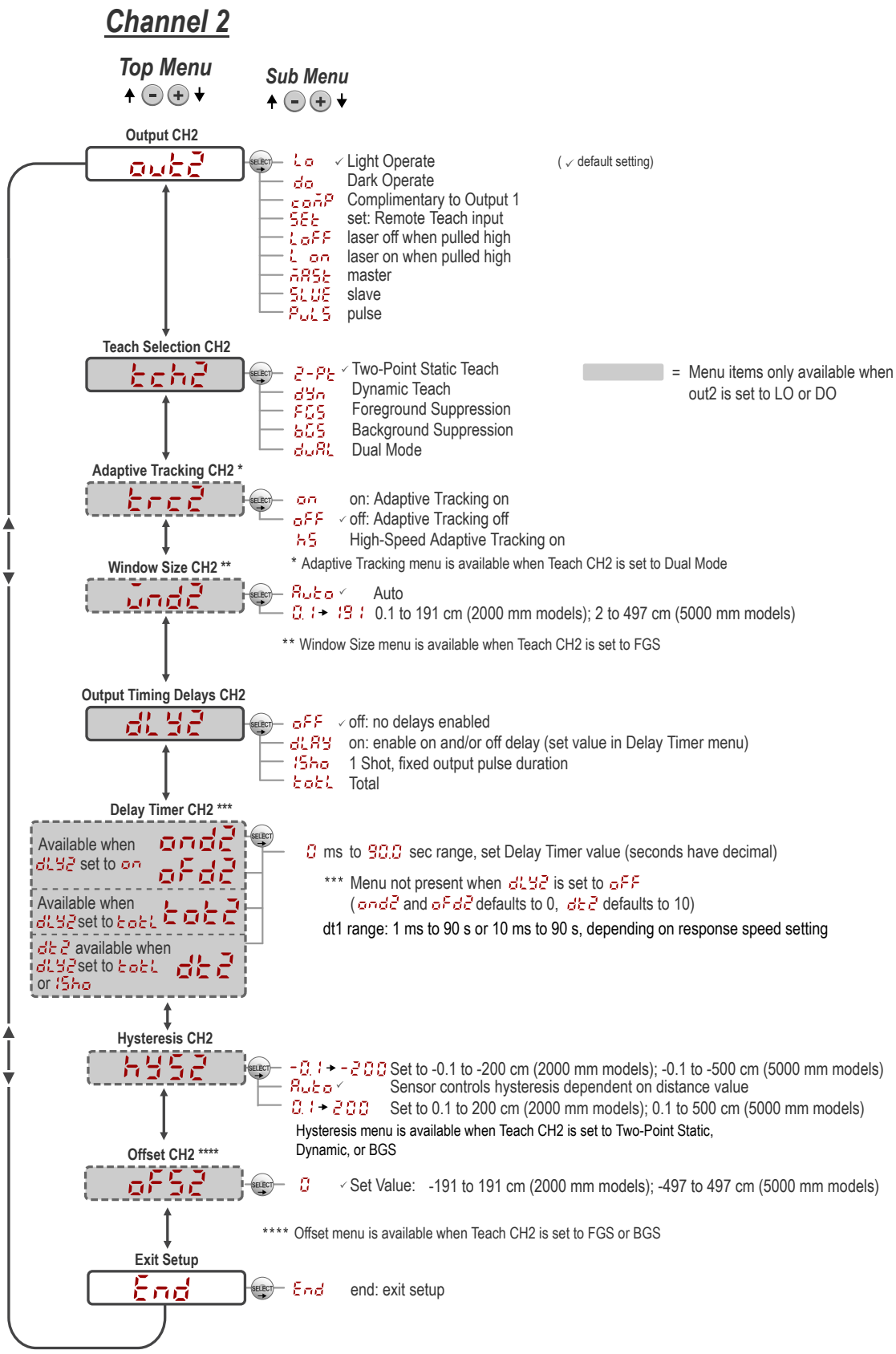


*Figure 18. Sensor Menu Map—Channel 2*



## Basic TEACH Instructions

Use the following instructions to teach the Q5X sensor. The instructions provided on the sensor display vary depending on the type of TEACH mode selected. Two-point TEACH is the default TEACH mode.

1. Press and hold **TEACH** for longer than 2 seconds to start the selected TEACH mode.
2. Present the target.
3. Press **TEACH** to teach the target. The target is taught and the sensor waits for the second target, if required by the selected TEACH mode, or returns to Run mode.
4. Complete these steps only if it is required for the selected TEACH mode.
   a) Present the second target.
   b) Press **TEACH** to teach the target. The target is taught and the sensor returns to Run mode.

See the Instruction Manual for detailed instructions and other available TEACH modes. The TEACH modes include:

- Two-point static background suppression 2-Pt —Two-point TEACH sets a single switch point. The sensor sets the switch point between two taught target distances, relative to the shifted origin location.
- Dynamic background suppression dyn —Dynamic TEACH sets a single switch point during machine run conditions. The sensor takes multiple samples and the switch point is set between the minimum and the maximum sampled distances.
- One-point window (foreground suppression) FGS —One-point window sets a window (two switch points) centered around the taught target distance.
- One-point background suppression bGS —One-point background suppression sets a single switch point in front of the taught target distance. Objects beyond the taught switch point are ignored.
- Dual intensity + distance duAL —Dual mode records the distance and amount of light received from the reference surface. See Dual Mode Reference Surface Considerations on p. 14 for more information about selecting a reference surface. The output switches when an object passing between the sensor and the reference surface changes the perceived distance or amount of returned light.

## Manual Adjustments

Manually adjust the sensor switch point using the (+) and (-) buttons.

1. From Run mode, press either (+) or (-) one time. The selected channel displays briefly, then the current switch point value flashes slowly.
2. Press (+) to move the switch point up or (-) to move the switch point down. After 1 second of inactivity, the new switch point value flashes rapidly, the new setting is accepted, and the sensor returns to Run mode.

**Note:** When FGS mode is selected (FGS indicator is on), manual adjustment moves both sides of the symmetrical threshold window simultaneously, expanding and collapsing the window size. Manual adjustment does not move the center point of the window.

**Note:** When dual mode is selected (DYN, FGS, and BGS indicators are on), after the TEACH process is completed, use the manual adjustment to adjust the sensitivity of the thresholds around the taught reference point. The taught reference point is a combination of the measured distance and returned signal intensity from the reference target. Manual adjustment does not move the taught reference point, but pressing (+) increases the sensitivity, and pressing (-) decreases the sensitivity. When re-positioning the sensor or changing the reference target, re-teach the sensor.

## Locking and Unlocking the Sensor Buttons

Use the lock and unlock feature to prevent unauthorized or accidental programming changes. Three settings are available:

- uLoc —The sensor is unlocked and all settings can be modified (default).
- Loc — The sensor is locked and no changes can be made.
- OLoc —The switch point value can be changed by teaching or manual adjustment, but no sensor settings can be changed through the menu.

**Note:** When the sensor is in either Loc or OLoc mode, the active channel can be changed using **(+)(CH1/CH2)**.

When in Loc mode, Loc displays when the **(SELECT)(TEACH)** button is pressed. The switch point displays when **(+)(CH1/CH2)** or **(-)(MODE)** are pressed, but Loc displays if the buttons are pressed and held.

When in Qloc mode, Loc displays when **(-)(MODE)** is pressed and held. To access the manual adjust options, briefly press and release **(+)(CH1/CH2)** or **(-)(MODE)**. To enter TEACH mode, press the **(SELECT)(TEACH)** button and hold for longer than 2 seconds.

To enter Loc mode, hold (+) and press (-) four times. To enter Qloc mode, hold (+) and press (-) seven times. Holding (+) and pressing (-) four times unlocks the sensor from either lock mode and the sensor displays uLoc.

## Specifications

**Sensing Beam**
Visible red Class 2 laser models, 650 nm

**Supply Voltage (Vcc)**
10 to 30 V DC (Class 2 supply) (10% max ripple within limits)

**Supply Protection Circuitry**
Protected against reverse polarity and transient overvoltages

**Power and Current Consumption, exclusive of load**
2000 mm model: < 1 W
5000 mm model: < 1.4 W

**Sensing Range**
2000 mm model: 95 mm to 2000 mm (3.74 in to 78.74 in)
5000 mm model: 50 mm to 5000 mm (2 in to 16.4 ft)

**Output Configuration**
Channel 1: IO-Link, Push/pull output, configurable PNP or NPN output
Channel 2: Multi-function remote input/output, configurable PNP or NPN, or pulse frequency modulated output

**Output Rating**
Current rating: 50 mA maximum

| Black wire specifications per configuration | | |
|---|---|---|
| IO-Link Push/Pull | Output High: | ≥ Vsupply - 2.5 V |
| | Output Low: | ≤ 2.5 V |
| PNP | Output High: | ≥ Vsupply - 2.5 V |
| | Output Low: | ≤ 1V (loads ≤ 1 MegΩ) |
| NPN | Output High: | ≥ Vsupply - 2.5 V (loads ≤ 50 kΩ) |
| | Output Low: | ≤ 2.5 V |

| White wire specifications per configuration | | |
|---|---|---|
| PNP | Output High: | ≥ Vsupply - 2.5 V |
| | Output Low: | ≤ 2.5 V (loads ≤ 70 kΩ) |
| NPN | Output High: | ≥ Vsupply - 2.5 V (loads ≤ 70 kΩ) |
| | Output Low: | ≤ 2.5 V |

**Boresighting**
2000 mm model: ± 43 mm at 2000 mm
5000 mm model: ± 86 mm at 5000 mm

**Response Speed**
2000 mm model: User selectable 3, 5, 15, 25, or 50 ms
5000 mm model: User selectable 2, 5, 15, 50, or 250 ms

**Delay at Power Up**
< 2.5 s

**Maximum Torque**
Side mounting: 1 N·m (9 in·lbs)

**Ambient Light Immunity**
2000 mm model:
5000 lux at 1 m
2000 lux at 2 m
5000 mm model: 5000 lux

**Connector**
Integral 4-pin M12/Euro-style male quick disconnect

**Construction**
Housing: ABS
Lens cover: PMMA acrylic
Lightpipe and display window: polycarbonate

**Temperature Effect (Typical) for 2000 mm Models**
< 0.5 mm/°C at < 500 mm
< 1.0 mm/°C at < 1000 mm
< 2.0 mm/°C at < 2000 mm

**Temperature Effect (Typical) for 5000 mm Models**
< 0.5mm/°C for up to 3000 mm
< 0.75mm/°C for up to 5000 mm

**Discrete Output Distance Repeatability**

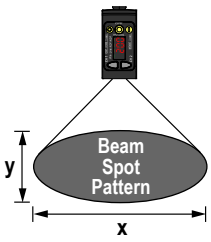
| Distance (mm) | Repeatability (2000 mm Models) |
|---|---|
| 95 to 300 | ± 0.5 mm |
| 300 to 1000 | ± 0.25% |
| 1000 to 2000 | ± 0.5% |

See the charts for the Repeatability of the 5000 mm models.

### Remote Input

Allowable Input Voltage Range: 0 to Vsupply
Active High (internal weak pull-down): High state > (Vsupply – 2.25 V) at 2 mA maximum
Active Low (internal weak pull-up): Low state < 2.25 V at 2 mA maximum

### Beam Spot Size




| 2000 mm Models | | 5000 mm Models | |
|---|---|---|---|
| Distance (mm) | Size (x × y) (mm) | Distance (mm) | Size (x × y) (mm) |
| 100 | 2.6 × 1.5 | 100 | 6 × 4 |
| 1000 | 4.2 × 2.5 | 2500 | 11 ×7 |
| 2000 | 6 × 3.6 | 5000 | 15 × 11 |

Beam spot size is calculated as 1.6 times the D4σ measured value

### Required Overcurrent Protection

**WARNING:** Electrical connections must be made by qualified personnel in accordance with local and national electrical codes and regulations.

Overcurrent protection is required to be provided by end product application per the supplied table.
Overcurrent protection may be provided with external fusing or via Current Limiting, Class 2 Power Supply.
Supply wiring leads < 24 AWG shall not be spliced.
For additional product support, go to www.bannerengineering.com.

| Supply Wiring (AWG) | Required Overcurrent Protection (Amps) |
|---|---|
| 20 | 5.0 |
| 22 | 3.0 |
| 24 | 2.0 |
| 26 | 1.0 |
| 28 | 0.8 |
| 30 | 0.5 |

### IO-Link Interface

Supports Smart Sensor Profile: Yes
Baud Rate: 38400 bps
Process Data Widths: 16 bits
IODD files: Provides all programming options of the display, plus additional functionality.

### Application Note

For optimum performance, allow 10 minutes for the sensor to warm up for the 2000 mm models and 20 minutes for the 5000 mm models.

### Environmental Rating

IEC IP67 per IEC60529

### Vibration

MIL-STD-202G, Method 201A (Vibration: 10 Hz to 55 Hz, 0.06 inch (1.52 mm) double amplitude, 2 hours each along X, Y and Z axes), with device operating

### Shock

MIL-STD-202G, Method 213B, Condition I (100G 6x along X, Y, and Z axes, 18 shocks), with device operating

### Operating Conditions

–10 °C to +50 °C (+14 °F to +122 °F)
35% to 95% relative humidity

### Storage Temperature

–25 °C to +70 °C (–13 °F to +158 °F)

### Certifications

Industrial Control Equipment 3TJJ

Class 2 power
UL Environmental Rating: Type 1

### Excess Gain for the 2000 mm Model

| | High Excess Gain (Standard Excess Gain) Using a 90% White Card [2] | | | |
|---|---|---|---|---|
| Response Speed (ms) | at 100 mm | at 500 mm | at 1000 mm | at 2000 mm |
| 3 | 125 | 50 | 15 | 4 |
| 5 | 125 | 50 | 15 | 4 |
| 15 | 575 (175) | 250 (75) | 70 (25) | 15 (6) |
| 25 | 1000 (650) | 450 (250) | 125 (70) | 30 (15) |
| 50 | 2000 (1000) | 900 (450) | 250 (125) | 60 (30) |

### Excess Gain for the 5000 mm Model [3]

| | Excess Gain Using a 90% White Card | | | |
|---|---|---|---|---|
| Gain Modes | at 50 mm | at 500 mm | at 2000 mm | at 5000 mm |
| Performance | 80 | 600 | 245 | 40 |
| Black | 250 | 1800 | 750 | 135 |
| Shiny | 25 | 200 | 75 | 13 |

[2] Standard excess gain available in 15, 25, and 50 ms response speeds; standard excess gain provides increase noise immunity.
[3] Excess gain is consistent for 15, 50, and 250 ms response speeds. Excess gain is approximately 10% lower in 2 ms and 5 ms response speed modes.

# Performance Curves

## 2000 mm Models

*Figure 19. Minimum Object Separation Distance (90% to 6% reflectance) for the 2000 mm Models*

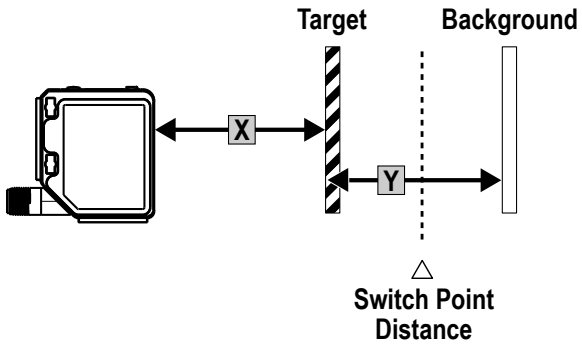
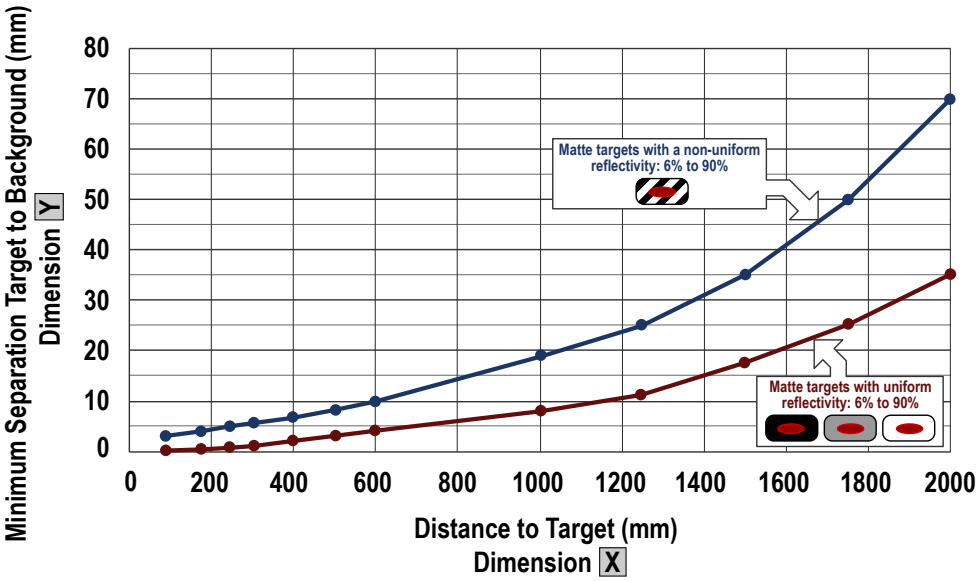



*Figure 20. Performance for the 2000 mm Models*



## 5000 mm Models

| Minimum Object Separation [4] | Repeatability |
|---|---|

*Figure 21. Minimum Object Separation for 250 ms Response Time*

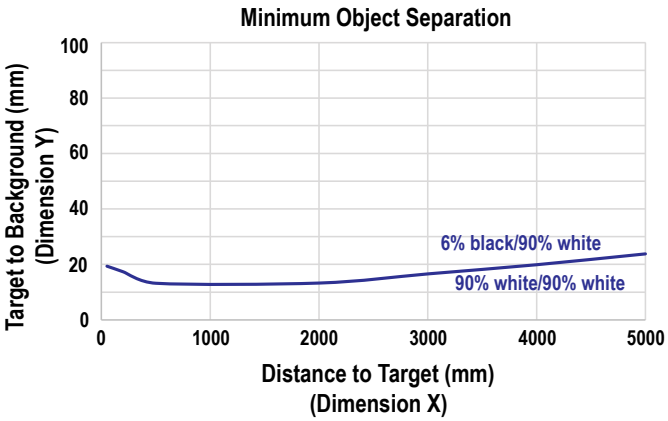



*Figure 22. Repeatability for 250 ms Response Time*

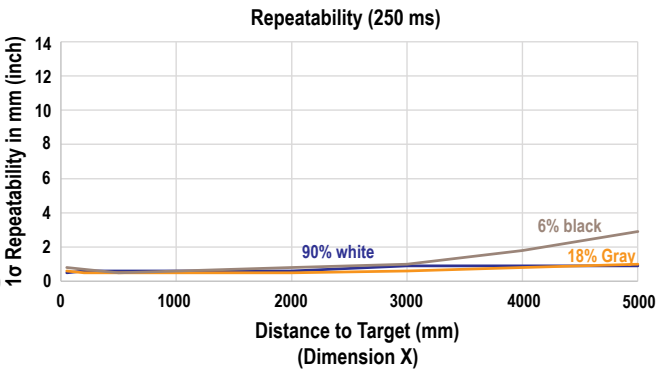



*Figure 23. Minimum Object Separation for 50 ms Response Time*

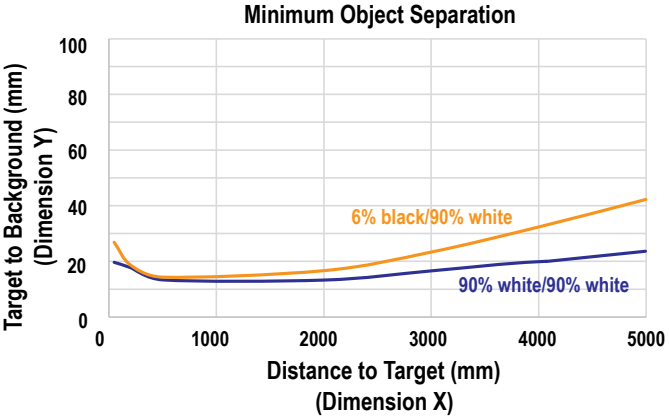



*Figure 24. Repeatability for 50 ms Response Time*

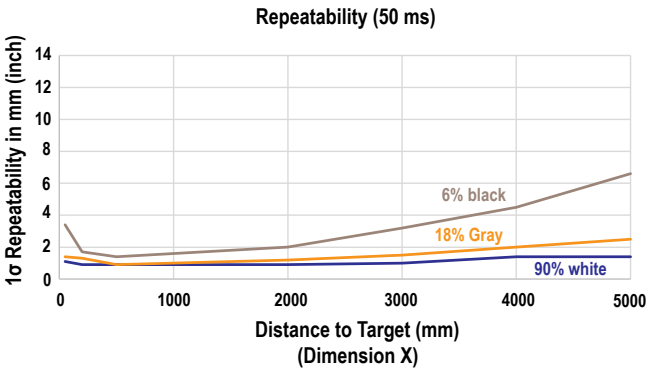



*Figure 25. Minimum Object Separation for 15 ms Response Time*

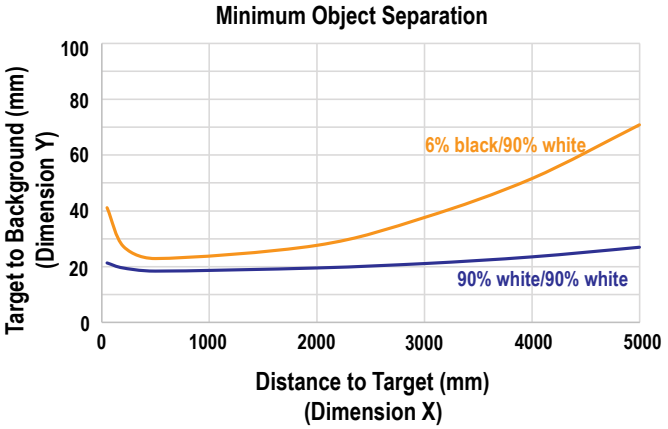
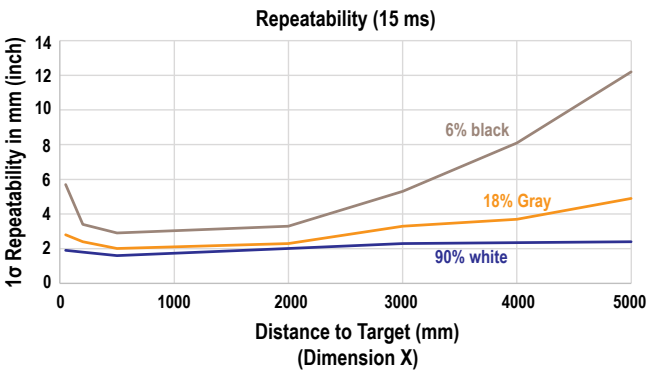



*Figure 26. Repeatability for 15 ms Response Time*




[4] The Repeatability and Minimum Object Separation for 2 ms mode is approximately twice that of 5 ms mode.

| Minimum Object Separation [4] | Repeatability |
|---|---|

*Figure 27. Minimum Object Separation for 5 ms Response Time*

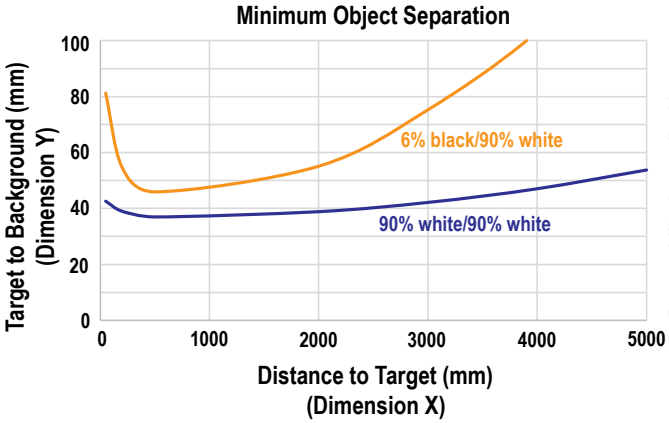
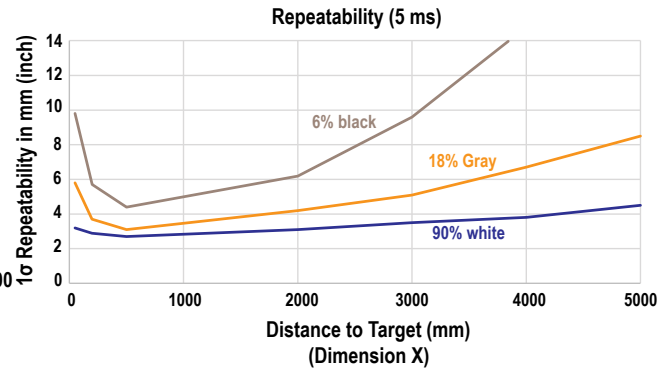



*Figure 28. Repeatability for 5 ms Response Time*




## Dual Mode Reference Surface Considerations

Optimize reliable detection by applying these principals when selecting your reference surface, positioning your sensor relative to the reference surface, and presenting your target. The robust detection capabilities of the Q5X allows successful detection even under non-ideal conditions in many cases. Typical reference surfaces are metal machine frames, conveyor side rails, or mounted plastic targets. Contact Banner Engineering if you require assistance setting up a stable reference surface in your application. For detailed instructions for detecting clear or transparent objects, refer to the Instruction Manual, p/n 208794.

1. Select a reference surface with these characteristics where possible:
   - Matte or diffuse surface finish
   - Fixed surface with no vibration
   - Dry surface with no build-up of oil, water, or dust
2. Position the reference surface between 200 mm (20 cm) and the maximum sensing range.
3. Position the target to be detected as close to the sensor as possible, and as far away from the reference surface as possible.
4. Angle the sensing beam relative to the target and relative to the reference surface 10 degrees or more.

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[4] The Repeatability and Minimum Object Separation for 2 ms mode is approximately twice that of 5 ms mode.