U-GAGE™ S18U Series Sensors with Analog Output

Datasheet
18 mm Ultrasonic Sensors with TEACH-mode programming

- Fast, easy-to-use TEACH-Mode programming; no potentiometer adjustments
- Short dead zone
- Scalable output automatically distributes the output signal over the width of the programmed sensing window
- Two bi-colored status LEDs
- Rugged encapsulated design for harsh environments
- Choose 2 meter or 9 meter unterminated cable, or 5-pin Euro-style QD connector
- Wide operating range of −20 °C to +60 °C (−4 °F to +140 °F)
- Choose either straight or right-angle housing
- Temperature compensation
- Selectable response times of 2.5 ms or 30 ms
- Select analog models with either 0 V to 10 V dc or 4 mA to 20 mA output

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

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Sensing Range</th>
<th>Cable</th>
<th>Supply Voltage</th>
<th>Output</th>
<th>Housing Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>S18UUA</td>
<td>30 mm to 300 mm (1.2 in to 11.8 in)</td>
<td>5-wire, 2 m (6.5 ft) cable</td>
<td>10 V dc to 30 V dc</td>
<td>0 V dc to 10 V dc</td>
<td>Straight</td>
</tr>
<tr>
<td>S18UUAQ</td>
<td></td>
<td>5-pin Euro style QD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S18UIA</td>
<td></td>
<td>5-wire, 2 m (6.5 ft) cable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S18UIAQ</td>
<td></td>
<td>5-pin Euro style QD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S18UUAR</td>
<td></td>
<td>5-wire, 2 m (6.5 ft) cable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S18UUARQ</td>
<td></td>
<td>5-pin Euro style QD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S18UIAR</td>
<td></td>
<td>5-wire, 2 m (6.5 ft) cable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S18UIARQ</td>
<td></td>
<td>5-pin Euro style QD</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Information about discrete models is available at [http://www.bannerengineering.com](http://www.bannerengineering.com).

- 9 m cables are available by adding suffix “W/30” to the model number of any cabled sensor (for example, S18UUA W/30).
- A model with a QD connector requires a mating cable.
Configuration Instructions

**Status Indicators**

<table>
<thead>
<tr>
<th>Power On/Off LED State</th>
<th>Indicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>The power is off</td>
</tr>
<tr>
<td>On red</td>
<td>The target is weak or is outside of the sensing range</td>
</tr>
<tr>
<td>On green</td>
<td>The sensor is operating normally, target is good</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output/Teach LED State</th>
<th>Indicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>The target is outside of the window limits</td>
</tr>
<tr>
<td>On yellow</td>
<td>The target is within the window limits</td>
</tr>
<tr>
<td>On red</td>
<td>The sensor is in TEACH mode and is waiting for the first limit</td>
</tr>
<tr>
<td>Flashing red</td>
<td>The sensor is in TEACH mode and is waiting for the second limit</td>
</tr>
</tbody>
</table>

**Sensor Programming**

Use one of two TEACH methods to program the sensor:

- Teach individual minimum and maximum limits
- 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 gray wire of the sensor to 0 V dc to 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 "T": \(0.04 \text{ seconds} < T < 0.8 \text{ seconds}\).

**Analog Output Slope**

The U-GAGE S18U sensor may be programmed for either a positive or a negative output slope, based on which limit is taught first. If the Near limit is taught first, the slope will be positive. If the Far limit is taught first, the slope will be negative. Banner’s scalable output automatically distributes the output signal over the width of the programmed sensing window.

In the event of signal loss, the analog output goes to 3.6 mA or 0 V dc, which may be used to trigger an alarm.
Teach Minimum and Maximum Limits

**NOTE:**
- The sensor returns to Run mode if the first Teach condition is not registered within 120 seconds
- After the first limit is taught, the sensor remains 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 reverts to the last saved limits

1. Enter Programming mode.

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push Button</td>
<td>Press and hold the TEACH button</td>
<td>Output LED: On red Power LED: On green (good signal) or On red (no signal)</td>
</tr>
<tr>
<td>Remote Input</td>
<td>No action required; the sensor is ready for the first limit</td>
<td></td>
</tr>
</tbody>
</table>

2. Present the target for the first limit. The Power LED must be On green.
3. Teach the first limit.

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push Button</td>
<td>Press the TEACH button one time.</td>
<td>Teach Accepted (The sensor learns the 0 V dc or 4 mA limit)</td>
</tr>
<tr>
<td>Remote Input</td>
<td>Single-pulse the remote line.</td>
<td>Teach Not Accepted Output LED: Flashes Red</td>
</tr>
</tbody>
</table>

4. Present the target for the second limit. The Power LED must be On green.
5. Teach the second limit.

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push Button</td>
<td>Press the TEACH button one time.</td>
<td>Teach Accepted (The sensor learns the 10 V dc or 20 mA limit)</td>
</tr>
<tr>
<td>Remote Input</td>
<td>Single-pulse the remote line.</td>
<td>Teach Not Accepted Output LED: Yellow or OFF</td>
</tr>
</tbody>
</table>

Teaching Limits Using the Auto-Window Feature
Teaching the same limit twice for the same output automatically centers a 10 mm window on the taught position.

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2. $0.04 \, \text{s} < \text{“click”} < 0.8 \, \text{s}$
3. $0.04 \, \text{s} < T < 0.8 \, \text{s}$
NOTE:
- The sensor returns to Run mode if the first Teach condition is not registered within 120 seconds.
- After the first limit is taught, the sensor remains 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 reverts to the last saved limits.
- Using this procedure, the analog output is centered on the taught position at approximately 5 V dc or 12 mA.

1. Enter Programming mode.

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push Button</td>
<td>Press and hold the TEACH button</td>
<td>Output LED: On red Power LED: On red (good signal) or On red (no signal)</td>
</tr>
<tr>
<td>Remote Input</td>
<td>No action required; the sensor is ready for the first limit</td>
<td></td>
</tr>
</tbody>
</table>

2. Position the target for the center of the window. The Power LED must be On green.

3. Teach the limit.

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push Button</td>
<td>Press the TEACH button one time.</td>
<td>Teach Accepted Output LED: Flashing Red</td>
</tr>
<tr>
<td>Remote Input</td>
<td>Single-pulse the remote line.</td>
<td>Teach Not Accepted Output LED: ON Red</td>
</tr>
</tbody>
</table>

4. Teach the limit a second time.

<table>
<thead>
<tr>
<th>Method</th>
<th>Action</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push Button</td>
<td>Without moving the target, press the TEACH button one time.</td>
<td>Teach Accepted Output LED: Yellow or OFF</td>
</tr>
<tr>
<td>Remote Input</td>
<td>Without moving the target, single-pulse the remote line.</td>
<td>Teach Not Accepted Output LED: Flashing Red</td>
</tr>
</tbody>
</table>

**Lock the Buttons**
Enable or disable the buttons to prevent unauthorized adjustment of the program settings.

To lock or unlock the buttons, four-pulse the remote line. The buttons are enabled or disabled, depending on the previous condition.

**Installation**

**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: $D = ct \div 2$

$D =$ 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

$0.04 s \leq \text{“click”} \leq 0.8 s$
$0.04 s < T < 0.8 s$
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 S18U 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°C 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 1.7% of the sensing distance. After 10 minutes, the apparent distance will be within 0.3% of the actual position. After 25 minutes, the sensing position will be stable.

**Wiring Diagrams**

![Cabled Models Diagram](image)

![QD Models Diagram](image)

**NOTE:** It is recommended that the shield wire be connected to earth ground or DC common.

**Specifications**

- **Sensing Range:**
  30 to 300 mm (1.2 in to 11.8 in)

- **Supply Voltage:**
  10 V dc to 30 V dc (10% maximum ripple); 65 mA max. (exclusive of load), 40 mA typical @ 25V input

- **Ultrasonic Frequency:**
  300 kHz, rep. rate 2.5 ms

- **Supply Protection Circuitry:**
  Protected against reverse polarity and transient voltages

- **Output Configuration:**
  Analog Output: 0 to 10V dc or 4 to 20 mA, depending on model
  Output Protection: Protected against short circuit conditions

- **Delay at Power-Up:**
  300 milliseconds

- **Temperature Effect:**
  0.02% of distance/°C

- **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

- **Remote TEACH Input:**
  Impedance: 1.2 kΩ

- **Construction:**
  Threaded Barrel: Thermoplastic polyester
  Push Button: Santoprene
  Push Button Housing: ABS/PC
  Lightpipes: Acrylic

- **Minimum Window Size:**
  5 mm

- **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

- **Indicators:**
  **Range Indicator (Red/Green):**
  - Green—Target is within sensing range
  - Red—Target is outside sensing range
  - OFF—Sensing power is OFF

  **Teach/Output Indicator (Amber/Red):**
  - Yellow—Target is within taught limits
  - OFF—Target is outside taught window limits
  - Red—Sensor is in TEACH mode
Linearity
2.5 ms response: ± 1 mm
30 ms response: ± 0.5 mm

Resolution
2.5 ms response: ± 1 mm
30 ms response: ± 0.5 mm

Output Response Time (for a 95% step change)
2.5 milliseconds: Black wire at 5 to 30 V dc
30 milliseconds: Black wire at 0 to 2 V dc (or open)
Contact Banner Engineering for other response speed options

Output Ratings
Analog Voltage Output:
2.5 kΩ minimum load resistance
Minimum supply for a full 10V output is 12V dc (for supply voltages between 10 and 12, V out max is at least V supply -2)

Analog Current Output:
1 kΩ max at 24V input
Max load resistance = (Vcc-4)/0.02 ohms

For current output (4-20 mA) models, ideal results are achieved when the total load resistance R = [(Vin – 3)/0.020] Ω. Example, at Vin = 24 V dc, R = 1 kΩ (1 watt). A worst-case shift of 1% of sensing distance is caused by operating the sensor at Vin = 30 V dc and R = 0 Ω.

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 http://www.bannerengineering.com.

<table>
<thead>
<tr>
<th>Supply Wiring (AWG)</th>
<th>Required Overcurrent Protection (Amps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>5.0</td>
</tr>
<tr>
<td>22</td>
<td>3.0</td>
</tr>
<tr>
<td>24</td>
<td>2.0</td>
</tr>
<tr>
<td>26</td>
<td>1.0</td>
</tr>
<tr>
<td>28</td>
<td>0.8</td>
</tr>
<tr>
<td>30</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Dimensions

Straight Housing

Linearity and resolution are specified using a 50 mm x 50 mm (2” x 2”) aluminum plate at 22°C under fixed sensing conditions.
**Response Curves**

![Response Curves Image](image_url)

*Figure 6. Effective Beam Pattern (Typical)*

*Figure 7. Maximum Target Rotation Angle*

**Accessories**

**Quick-Disconnect Cables**

<table>
<thead>
<tr>
<th>Model</th>
<th>Length</th>
<th>Style</th>
<th>Dimensions</th>
<th>Pinout (Female)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQDEC2-506</td>
<td>1.83 m (6 ft)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MQDEC2-515</td>
<td>4.57 m (15 ft)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MQDEC2-530</td>
<td>9.14 m (30 ft)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MQDEC2-550</td>
<td>15.2 m (50 ft)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P/N 110738 Rev. D

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## 5-Pin Threaded M12/Euro-Style Cordsets—with Shield

<table>
<thead>
<tr>
<th>Model</th>
<th>Length</th>
<th>Style</th>
<th>Dimensions</th>
<th>Pinout (Female)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQDEC2-506RA</td>
<td>1.83 m (6 ft)</td>
<td>Right-Angle</td>
<td>32 Typ. [1.26&quot;]</td>
<td>ø 14.5 [0.57&quot;]</td>
</tr>
<tr>
<td>MQDEC2-515RA</td>
<td>4.57 m (15 ft)</td>
<td>Right-Angle</td>
<td>30 Typ. [1.18&quot;]</td>
<td>ø 14.5 [0.57&quot;]</td>
</tr>
<tr>
<td>MQDEC2-530RA</td>
<td>9.14 m (30 ft)</td>
<td>Right-Angle</td>
<td>30 Typ. [1.18&quot;]</td>
<td>ø 14.5 [0.57&quot;]</td>
</tr>
<tr>
<td>MQDEC2-550RA</td>
<td>15.2 m (50 ft)</td>
<td>Right-Angle</td>
<td>41 Typ. [1.61&quot;]</td>
<td>ø 18.5 [0.73&quot;]</td>
</tr>
</tbody>
</table>

### 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

Hole center spacing: A to B = 24.2
Hole size: A = ø 4.6, B = 17.0 × 4.6, C = ø 18.5

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

Hole center spacing: A = 36.0
Hole size: A = ø 5.3, B = ø 18.0

#### SMB18UR
- 2-piece universal swivel bracket
- 300 series stainless steel
- Stainless steel swivel locking hardware included
- Mounting hole for 18 mm sensor

Hole center spacing: A = 25.4, B = 46.7
Hole size: B = 6.9 × 32.0, C = ø 18.3

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