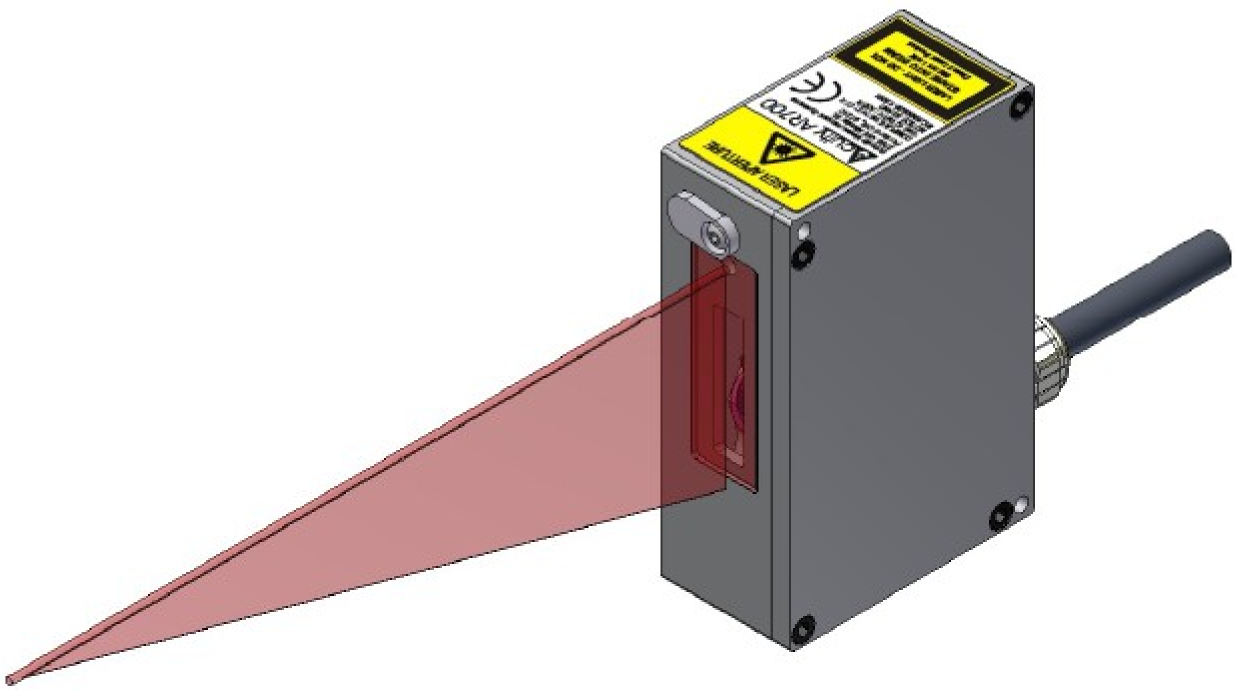
AccuRange AR700™ Laser Distance Gauge

User's Manual



Rev. 1.4
For use with AR700™ Rev. 0.10
December 12, 2008

Acuity
A product line of Schmitt Industries, Inc.
2765 NW Nicolai St.
Portland, OR 97210
www.acuitylaser.com

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2. Ship the product to Schmitt Industries, postage prepaid, together with your bill of sale or other proof of purchase. your name, address, description of the problem(s). Print the RMA number you have obtained on the outside of the package.

This device has been tested for electromagnetic emissions and immunity and has been found to be in compliance with the following directives for class A equipment:

EN 61000-6-2:2001
EN 61326:1997 (Amended by A1:1998 and A2:2001 and A3:2003)

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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User's Manual for the
AR700™ Series Laser Distance Gauge
Rev. 1.4
For use with AR700 Rev. 0.10

Table of Contents

1. Introduction

This section is a guide to getting started with the AR700 and this manual. The AR700 has a number of configurable parameters, but many applications can use the sensor in its default configuration.

The recommended order for reading the manual is:

- General Overview – Gives a brief understanding of the sensor operation.
- Operating Guidelines – Provides a few important safety tips.
- Definition of Terms – An aid for proper communication.
- Quick Start Instructions – This should provide the information necessary to connect the sensor and verify its operation, either with a serial terminal program at 9600 baud, or by connecting the current loop or Limit Output interface.
- General Description – Gives important laser, operation, mechanical, and mounting information.
- Installation and Checkout – Tailor the application. Use the other chapters for reference:
  Signal and Power Interface – how to hook everything up
  Serial Interface Operation – modes, formats, bias
  Analog Output Operation – current loop, voltage, scaling
  Limit Output Operation – limit switch settings
  Performance Optimization – Sample Rate, Background Elimination, Exposure control
  AR700 Command Set – explains all commands for customizing the application

1.1. General Overview

The AR700 is a triangulation sensor that measures distance using a laser beam, a camera, and a microprocessor. A variety of models are specified, each to allow a different measurement range. Models vary in range from 0.125 to 50 inches (3.175 to 1270 mm).

The accuracy is generally specified with a linearity of about +/- 0.03% of the range.

A variety of configuration settings can be selected via the serial port or by using the function button and the function display LEDs. The complete list of settings is found in the AR700 Command Set chapter and each setting is discussed in detail in a specific operation chapter.

The Sample Rate can be specified and the sensor has capability above 9400 samples per second. Background Light Elimination, Sample Priority, and Exposure Limit controls enhance the performance. Sampling may be turned on and off. It can even be triggered using an input signal wire or a serial command.

Measurement output can be in the form of serial data (RS232 or RS422), Analog Output (4-20mA current loop or 0-10V voltage), and Limit Outputs (two switches). Serial data, with optional flow control, is available in five formats: Metric, English, Native, and two binary output modes. Offsets, scaling, and a selection of 10 baud rates are provided.

After making changes to the configuration, it may be viewed, saved in non-volatile memory, and restored. At power-on the sensor uses the most recently saved configuration settings.

1.2. Operating Guidelines – Safety issues

Use protective eyewear whenever there is a risk of being exposed to the output beam of a class 3B AR700. Use eyewear specifically designed to block laser light of the wavelength used by the sensor. Use eyewear through which the green "LASER ON" LED is visible.

Do not point the sensor at any person, particularly a person's eyes or face.

Do not attempt to disassemble the sensor. Improper disassembly will destroy the optical alignment of the sensor and necessitate factory repairs.

Do not operate the sensor in areas where the sensor is exposed to direct sunlight for extended periods or where the air temperature is more than 40°C (104°F) or less than 0°C (32°F).

Avoid excessive vibration and shocks. The sensor contains securely mounted but precisely aligned optical components.

Do not scratch the windows on the front face of the sensor. Keep the front windows clean with a damp cotton cloth. The windows are glass with an anti-reflection coating. Avoid the use of cleaning solvents other than alcohol.

Operate only with DC supply voltages between 15 and 24 volts. A 15 volt standard AC to DC power supply is optionally provided with the sensor.

1.3. Definition of Terms

Sensor – The complete AR700 measurement device.

Target – The object of measurement. The relative distance from the sensor to the target is measured by the sensor.

Laser, Laser beam – This bright light is emitted from the sensor, reflected from the target, and collected by the camera lens.

Camera, Detector – An internal imaging device that views the laser spot on the target.

<Range> – The maximum relative distance measurable by the sensor.

Range – 1. <Range>, 2. The region over which the target can be measured. At the near end of the range the sensor measures zero. At the far end of the range the sensor measures its maximum value (its Range value).

Scan – A single exposure of the camera.

Scan Cycle – A complete camera operation, sufficient to produce a result. Two scans with BLE On, one scan with BLE Off.

Sample – A complete sensor measurement with calculated calibrated output. Often it is the average of many scan cycles.

Above, Too Far – A target location further from the sensor than the end of the range, but where the laser spot is still visible to the camera. In this condition the sensor can report the subjective location (too far), but not the distance (a number).

Below, Too Close – A target location closer to the sensor than the start of the range, but where the laser spot is still visible to the camera. In this condition the sensor can report the subjective location (too close), but not the distance (a number).

1.4. Quick Start Instructions

This will get the sensor running in its default configuration.

Only one output type (Serial, Analog, or Limit) is needed to indicate sensor operation.

1.4.1. Mounting

Caution for Class 3B sensors: be sure that the laser will not cause an eye hazard. Use eyewear specifically designed to block laser light of the wavelength used by the sensor. Use eyewear through which the green “LASER ON” LED is visible.

Quick suggestion: Lay the sensor on the floor or a table. It may need to be held in place with a clamp or a weight. Orient the laser so that the laser and return paths are not obstructed. Use a piece of paper such as a business card to insert into the beam to use as a measurement target.

Mount the sensor in such a way that the unit is not twisted or warped. Using three hard points along the front and back edges or a slightly compliant mounting system are the best methods. Do not clamp or squeeze the sensor excessively. If the sensor is distorted, its sensitivity and accuracy may be affected.

1.4.2. Power Signals

Connect the red (Supply +) and black (Supply Common) wires of the sensor cable to a 15 to 24 volt DC power supply (or use the power supply if the sensor came with one).

To be sure that the sensor is using default settings, press the function button while turning on the power, then after the function display LEDs start cycling, release the button.

1.4.3. Serial Data Wires

Quick suggestion: Connect the wires to a 9 pin D-SUB male connector that can be plugged into a COM port of a PC (RS232): Black (Ground) to pin 5, Green (Transmit) to pin 2, and Yellow (Receive) to pin 3. (If the sensor has an interface box, its connector is already wired for this.) Start a HyperTerminal program on the PC and set it for that COM port at 9600 baud, 8 bit, 1 start, 1 stop, no flow control.

The sensor will report its present measurements five times per second in inches. If a target surface is placed in the measurement range of the sensor, the screen should display distance information. The distance is measured from the start of the measurement range. If there is no target in the measurement range, the sensor will output an error code and the laser may flash ten times per second.

1.4.4. Analog Output Signals

Quick suggestion: connect a DVM (digital volt meter) to the wires: Brown to Common, Orange to mA input.

The default mode is 4-20mA current loop. The meter should read near 4 mA when a target is placed in the laser beam near the start of the measurement range and 20 mA near the end.

1.4.5. Limit Signals

Quick suggestion: connect a 1K resistor in series with an LED (cathode to the resistor, anode to the Power Supply) to each wire: Pink and Grey.

The default action is: Limit 1 will go active (LED lights) if a target is missing or placed in the laser beam slightly before the start of the measurement range. Limit 2 will go active (LED lights) if a target is missing or placed in the laser beam slightly after the end of the measurement range..

1.4.6. Laser Disable Wire

Quick suggestion: Leave the white wire disconnected to allow the laser to operate.

Connect the white wire to Ground (black wire) to disable the laser (sensor won't operate).

1.4.7. Important Configuration Considerations

There are several configuration settings that significantly affect the sensor's measurement characteristics. Using the configuration commands to customize these settings for each specific application will help optimize the sensors operation. See Performance Optimization (section 8) for more details on these and other settings.

1.4.7.1. Sample Interval (S)

Use the Sample Interval command to set the maximum average rate at which the sensor produces output. The command's parameter has a range of 21 to 999999 in units of 5 µs. The Sample Rate is therefore 200000 divided by the parameter value. The default setting is 40000 which sets the rate at 5 samples per second (200000 / 40000 = 5). Type 'S20000<Enter>' in HyperTerminal to change it to 10 samples per second (200000 / 20000 = 10).

This command sets the maximum average rate. The rate may need to be slowed down if the sensor's camera requires more time to acquire a sufficient image for measurements. Two other commands affect the operation that may cause the samples to be generated at a slower rate.

1.4.7.2. Background Light Elimination (L)

The default setting for Background Light Elimination (BLE) is ON (L1). In this mode the camera makes two measurements, one with the laser on and one with the laser off, and subtracts them to remove the effects of background lighting. When BLE is OFF (L2) the sensor captures a single image and uses it alone to generate the output. Therefore for any given exposure required by the camera, the sample rate with BLE ON is half of the sample rate available with BLE OFF. Type 'L2' in HyperTerminal to turn BLE OFF.

The measurement of brightly illuminated targets with shiny facets may be improved with BLE ON. If the environmental lighting is changing rapidly, the improvement may be reduced. (Note that most non-incandescent lighting is turning on and off 120 times per second.)

1.4.7.3. Sample Priority (P)

The default for the Sample Priority setting is RATE (P1). In this mode the Sample Rate takes priority over sample quality by limiting the camera exposure time. In order to guarantee that samples have sufficient exposure time, change the priority to QUALITY (P2) by typing 'P2' in HyperTerminal. The Sample Rate, if reduced by QUALITY mode, isn't easily determined.

1.4.7.4. Serial Output Rate Considerations

It is common to request a Sample Interval shorter than the time it takes to transmit the serial data. If one sample is being transmitted and another is waiting to be transmitted, then any new sample will replace the waiting sample (the previous waiting sample is 'lost'). For example, it normally takes about 9 milliseconds to send an ASCII sample value at 9600 baud which limits the average serial data rate to about 110 samples per second.

Note that the Analog Output and Limit Outputs are updated for every sample, even for those for which the serial data is 'lost' due to insufficient serial data rates. Serial flow control also doesn't stop the sensor from sampling.

See Serial Data Rate (section 8.5) for more information.

1.5. Road Profile Operation (Road Profiler Models Only)

Road Profile (RP) operation is provided in Road Profiler models, AR700RP. Road Profile operation differs from standard operation in several ways. The RP operating mode is designed to measure the distance to a surface that is moving quickly in a direction perpendicular to the laser beam. Special algorithms are designed to measure as much of the surface as possible during the sample period. This has the effect of averaging over small cracks or pits in the surface being measured.

A few specific differences in the RP operations are noted:

- Road Profile operation can only be selected in RP models. The operator selects the RP operating mode via the BLE command. L3 selects RP mode and is the default BLE mode in the RP model. L1 (BLE ON) and L2 (BLE OFF) commands will select normal AR700 operating modes in the RP models.
- In the RP operating mode the BLE mode is turned OFF. This is because the laser is always turned on allowing the camera to expose as much of the surface as possible.
- In the RP operating mode the Priority is changed to RATE. Attempts to change the priority will be ignored while in the RP mode (L3).
- Generally, a more powerful laser is used for the RP model in order to get a high rate of exposures needed to characterize a surface at highway speeds.
- The V1234 command will report "AR700RP-" instead of "AR700-", allowing the user to verify the Road Profiler firmware installation.
- The Exposure Limit will have no effect for values greater than M52.
- In the RP operating mode the maximum trigger speed is about 3500 Hz with M39 used to help achieve this rate.
- Measurement exposures require a tighter tolerance than standard sensors. Each out-of-tolerance measurement will report an error rather than a computed value.

2. General Description

The AR700 is a laser diode based distance measurement sensor for ranges from 0.125 to 50 inches (3.175 to 1270 mm). The accuracy is generally specified with a linearity of +/- 0.03% of the range. There are many different models as specified in the data sheet. Each model has a different standoff distance, range, and linearity specification. For more detailed specifications see the data sheet. The standoff distance represents the distance from the face of the sensor to the center of the measurement range. The range <Range> is the distance from the start of the measurement range to the end of the range.

2.1. Principles of Operation

The AR700 uses triangulation to measure distance. The laser beam is projected from the housing's aperture and shines on a target surface, where it is focused to a small spot. From there the laser light is scattered in all directions. A collection lens is located in the sensor to the side of the laser aperture. It focuses an image of the spot on a linear array camera, which views the entire measurement range. The position of the laser spot imaged in the camera is then processed to determine the distance to the target. The sensor controls the exposure according to the amount light falling on it, so longer exposure times allow greater sensitivity to targets with weak reflections.

The exposure time and laser power level are controlled to optimize the accuracy of the measurements for the signal strength and environmental light level measured. Internal averaging is performed for all scan cycles that fit in the programmed sample interval. Measurement time and laser power are adjusted for the next scan cycle based on the results from the previous scan cycle, so rapidly changing conditions may result in momentary loss of signal or overexposure. If the sensor cannot acquire a usable scan cycle within the sample interval then an error code (no target) will be generated.

As described in Quick Start (section 1.4), there are several configuration settings that significantly affect the behavior of the sensor. The first of these is **Sample Interval**. Longer sample intervals allow more averaging of the scan cycles and lower noise levels. Shorter sample intervals give the best results when the reflected signal is relatively strong.

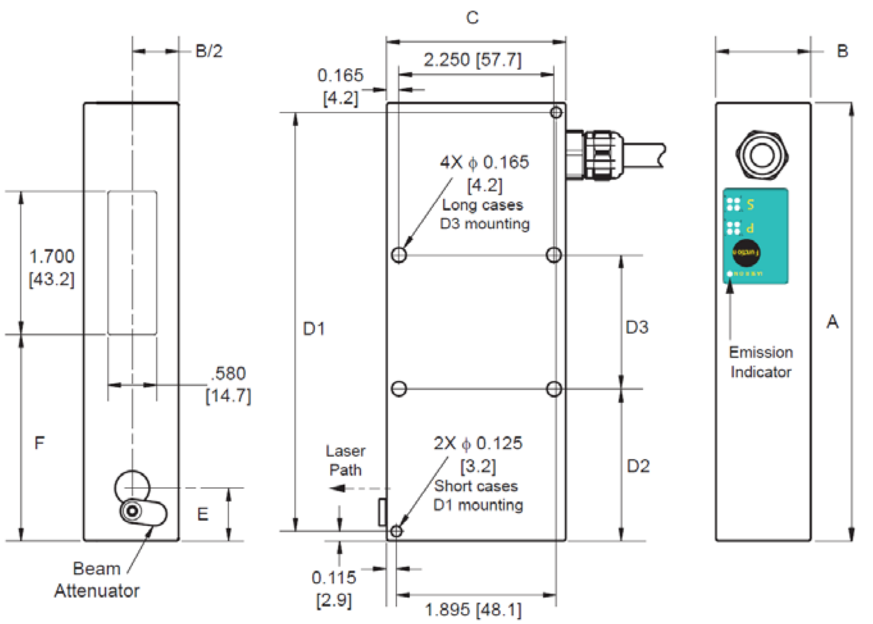
The **Sample Priority** setting is also used to control the exposure. With priority set to QUALITY, the sensor is allowed to use a longer measurement time than would normally fit in the programmed sample interval if it is needed for a good exposure. Under reduced reflection conditions this can causes the samples to be generated at a slower rate than expected. With priority set to RATE, the sensor limits the measurement time so that a sample can always be reported at the expected sample rate, even if the measurement is too short to acquire a good signal, resulting in an error code.

If high levels of ambient light are present, the use of the **Background Light Elimination** mode may improve measurement quality. With this mode ON, a camera exposure is taken with the laser off and subtracted from a subsequent exposure with the laser on. This will eliminate many ambient light effects, unless the ambient light levels in the target area are changing rapidly. In this case the light measured during the laser on exposure may be different from that during the laser off exposure, reducing the benefits of this mode. The total time required for obtaining a sample in this mode will be approximately twice what it is with background light elimination OFF.

If the sensor cannot detect a distinct peak in the camera data or the measurement is just beyond the end of the full scale range (but with the spot still on the camera near one end), the sensor will output zero distance. If there is no target in the measurement range and background light elimination is on, the sensor will generally put out zeros. However, if lighting conditions are changing rapidly or if background light elimination is off, a bright spot can be misinterpreted as the laser spot and generate a false distance reading when there is no target in range. Reducing the **Exposure Limit** can eliminate this problem in most cases.

2.2. Mechanical Dimensions

The following diagram shows the mechanical dimensions for the small AR700. For this unit, the rectangular window on the front contains both the laser exit port and the return light collection optics. In larger units the exit port and collection optics have separate windows. The sensor has two #4 (M3) clearance holes for mounting the sensor. The rear face of the sensor has the cable, the function button, the green "LASER ON" LED, and the function display LEDs. The cable is for power and all communication (serial, analog, limits, and laser enable). The housing of the sensor is anodized aluminum. The front windows and the housing parts are sealed, creating a dustproof, splash proof enclosure.



	AR700-0125, 0250, 0500, 1, 2, 4	AR700-6, 8	AR700-12, 16	AR700-24, 32
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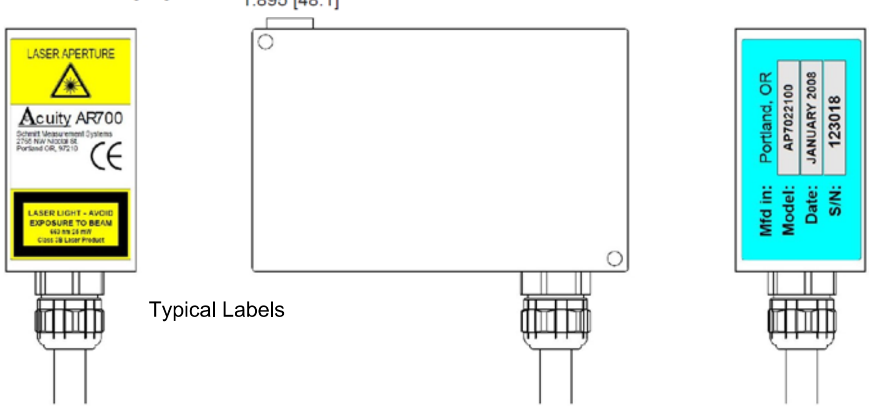
B	1.125 [28.6]	1.125 [28.6]	1.50 [38.2]	1.50 [38.2]
C	2.125 [54.0]	2.125 [54.0]	2.50 [63.5]	2.50 [63.5]
D1	3.020 [76.7]	4.970 [126.2]		
D2			3.05 [77.5]	5.55 [141]
D3			4.00 [101.6]	8.00 [203.2]
E	0.625 [15.9]	0.625 [15.9]	0.67 [17]	0.67 [17]
F	0.500 [12.7]	2.450 [62.2]	7.56 [192]	16.56 [420.6]



Typical Labels

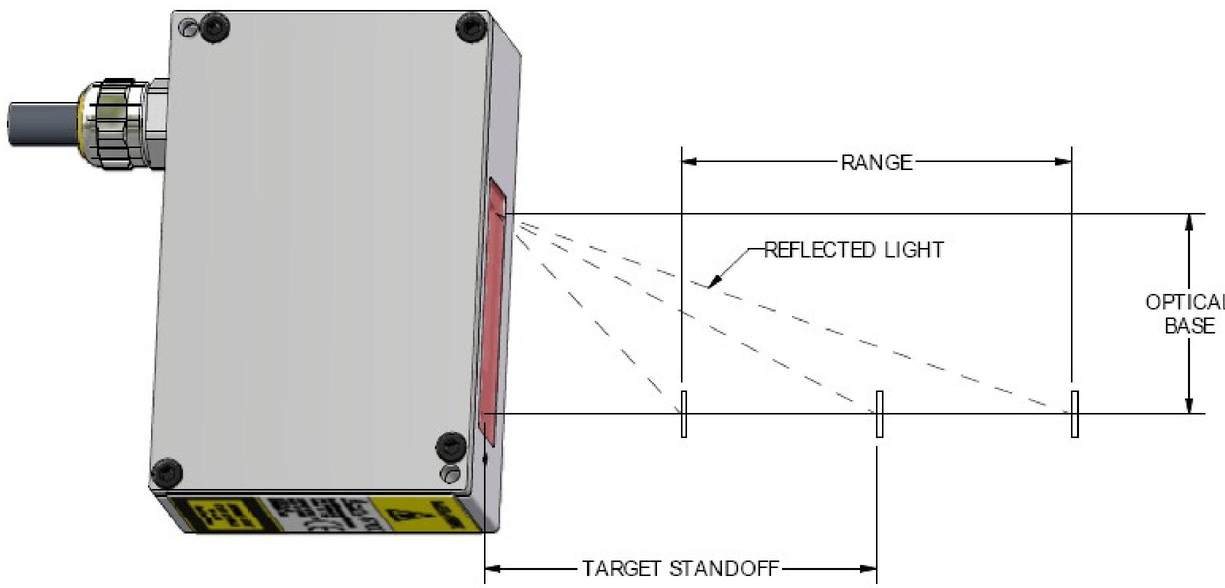
The Beam Attenuator is supplied for Class 3B sensor models. Rotate the beam attenuator to block the laser aperture as required in your system. The sensor will not operate correctly with the beam blocked.

2.3. Electrical Installation

The AR700 sensor's electrical connections are all provided through an attached cable. Included are power, input, output, communications, and shielding. The sensor is ON whenever power is applied to the cable. See Signal and Power Interface (section 4). Note that class 3B operation requires interlocks and other safety features that can be satisfied with the Interlock Box option.

2.4. Mechanical / Optical Installation

The AR700 sensor is typically installed by affixing the sensor to a machined bracket with bolts through the two mounting holes in the sensor. Their location is shown in the mechanical drawing above.



Laser light is emitted from the laser aperture, which is close to the "Laser Aperture" placard as shown. The laser beam then strikes the target at a position along its range. Some of the laser light reflected from the target is collected by the camera lens.

The Optical Base defines the distance from the laser aperture to the camera lens. The Optical Base and Optical Width define the area between the laser, target, and lens that must be kept clear throughout the full measurement range. This way the camera can always see the laser spot on the target, a requirement for the measurement process.

The "Range" is the sensor's full measurement range. This is the range over which the sensor's output distance measurement is calibrated.

The Target Standoff is the approximate distance from the sensor face to the midpoint of the measurement range. This is a non-calibrated distance that is used primarily for sensor selection and installation design.

2.5. Laser Safety

Caution: This laser device should not be aimed at the human eye. Installers of laser sensors should follow precautions set forth by ANSI Z136.1 Standard for the Safe Use of Lasers or by their local safety oversight organization. Be sure that the laser will not cause an eye hazard.

For Class 3B models:

Class 3B operation requires interlocks and other safety features that are not supplied with the AR700 sensor. It is the responsibility of the installer to ensure that the complete system meets all applicable safety standards for Class 3B laser products. This may include but not be limited to a beam attenuator, compliant power supply interlocks, external interlock switches, emission indicators, and user warning labels that may be required to be visible during use.

The AR700 Interlock Box option can be used to satisfy these requirements.

Use eyewear specifically designed to block laser light of the wavelength emitted by the sensor and through which the green “LASER ON” LED is visible.

Several lasers are used in the AR700 sensor models.

Wavelength (nm)	Power Limit (mW)	Safety Classification	Color
650	1	Class 2	Red
670	5	Class 3R	Red
660	25	Class 3B	Red

The laser safety classification reflects worst case situations. The laser is considered to be continuous, not pulsed. When the laser pulses in normal operation, the level of laser light does not increase.

The housing is sealed with tamper-resistant fasteners. Do not attempt to open the sensor. A higher level of laser light could be accessible inside.

2.6. Sensor Maintenance

The AR700 sensor requires little maintenance from the user. The sensor window(s) should be kept clean of dust buildup as a part of regular preventative maintenance. Use compressed air to blow dirt off the window or use delicate tissue wipes and a light solvent such as isopropyl alcohol or water. Avoid using pressurized water and do not use abrasive wipes on the optical glass. If your sensor does not function according to specifications, contact Schmitt Industries, Inc.

The housing is sealed with tamper-resistant fasteners. Do not attempt to open the sensor. It is not user serviceable. A higher level of laser light could be accessible inside. The accuracy of the unit will be degraded if the sensor is opened.

2.7. Sensor Service

The AR700 sensor has no user-serviceable parts. Refer all service questions to Schmitt Industries, Inc.

The housing is sealed with tamper-resistant fasteners Do not attempt to open the sensor. A higher level of laser light could be accessible inside. The accuracy of the unit will be degraded if the sensor is opened.

2.8. Environmental Materials

The AR700 is produced in compliance with the RoHS directive regarding reduction in the use of lead and other hazardous substances.

2.9. Sensor Specifications

Go to http://www.acuitylaser.com/AR700/sensor-technical-data.shtml

3. Installation and Checkout

3.1. Mounting

Mount the sensor in such a way that the unit is not twisted or warped. Using three hard points along the front and back edges or a slightly compliant mounting system are the best methods. Do not clamp or squeeze the sensor excessively. If the sensor is distorted, the sensitivity and accuracy may be affected.

3.2. Cabling

The AR700 has a multipurpose cable with solder tail wires. If the AR700 is ordered with a power supply, the sensor cable will be connected to the power supply. Connection and termination according to the instructions is essential for correct sensor operation. Read the wire descriptions for connection information.

3.2.1. Standalone Cabling

To use the AR700 without a serial connection to a host computer, the only connections necessary are the power and ground wires, the analog output wires, and optionally the limit output wires connecting to your data display, recording, or control equipment. See Signal and Power Interface (section 4) for wire connections. In its default configuration, the AR700 will begin measuring and transmitting measurement data on power-up.

In 4-20mA analog output mode, the best accuracy and linearity for the current loop is obtained with a 500-ohm load to current loop return at the measurement point, converting it to a voltage of 2-10V. The limit outputs can be used to indicate the analog output validity.

In 0-10V analog output mode, the best accuracy and linearity for the voltage output is obtained with a 10K-ohm load to the voltage output return at the measurement point. The limit outputs can be used to indicate the analog output validity.

In limits-only mode, one or both of the two limit output wires can be used to connect to control equipment. Using both wires allows the sensor measurement validity to be indicated.

3.2.2. Connection to a Host Computer

A 9-pin serial D-sub serial connector can be attached to the serial output wires to connect the AR700 directly to an IBM-PC compatible 9-pin serial port. Connect a 15 volt power supply to the power and ground lines of the sensor cable. See Signal and Power Interface (section 4) for wire connections. Only the power and ground need be connected for operation in addition to the serial interface. For testing use a terminal emulation program such as the Windows HyperTerminal, set to 9600 baud, 8 bits, no parity, 1 stop bit to communicate with a sensor in the default configuration.

3.3. Power On

Caution: be sure that the laser will not cause an eye hazard. Use eyewear specifically designed to block laser light of the wavelength used by the sensor. Use eyewear through which the green "LASER ON" LED is visible.

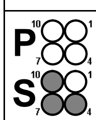
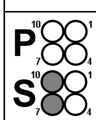
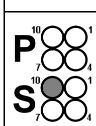
When power is applied some function display LEDs may flash briefly and go off. Then the "LASER ON" LED will come on and stay on. Then the laser beam will be emitted from the front laser aperture window. In most models the laser beam will be bright red, but some have invisible or nearly invisible laser light. The sensor will begin transmitting measurement readings as soon as the laser comes on.

3.4. Verifying Operation

In its default configuration, the AR700 transmits 5 samples per second at 9600 baud over the serial signals, and transmits measured distance over the current loop output at the same update rate. The current loop should put out 4 mA at the near end of the measurement range, and 20 mA at the far end. Check either, or both, signals to verify basic sensor operation.

3.5. Troubleshooting

The sensor can display simple error indications using its function display LEDs. Trouble shooting steps are shown below:

Symptom	Possible Cause	Correction
"LASER ON" LED never turns on	Power lines not connected Power lines reversed polarity Power supply voltage too low or too high	Check wire connections Check wire connections Check power supply voltage when loaded
No laser light and no sample data	Sampling is turned off Serial output is turned off Power supply voltage is too low Ambient light level is too high	Turn Sampling on Turn Serial Output mode on. Check power supply input voltage Reduce the ambient light level.
 Function display LEDs flash pattern P0S6	Configuration data lost	Press function button, default configuration is loaded
 Function display LEDs flash pattern P0S8	Calibration data lost	Call Schmitt Industries for instructions
 Function display LEDs flash pattern P0S10	Waiting for Class 3B laser to start	This time-out finishes in 5 seconds.

3.5.1. Serial Communications Check

If no information is received over the serial port, check the power supply and serial wire connections. The sensor may be in a configuration that prevents serial communication, such as being set at the wrong baud rate.

To reset the sensor to the default: Turn the power off, press the function button on the AR700, and turn the power on with the button held down. The function display LEDs should cycle through a pattern that illuminates each, one at a time. When the button is released, the sensor will reset to the default configuration (9600 baud, 8 bits, no parity, 1 stop bit), and should enable serial RS232 communication with the host system.

3.5.2. Sensor Output Check

If the sensor output value is in error, check that the sensor and target are stationary and stable, that the target is in the middle of the measurement range as an initial test distance, and that the laser beam is hitting the target.

The Zero-Point and Span-Point configuration settings may alter the values output by the sensor. Reset the sensor to the default to remove their effect.

The sensor may need to warm up for 5-10 minutes before reaching full accuracy. Leave it on for a few minutes and re-check the sensor accuracy.

4. Signal and Power Interface

The AR700 has a multipurpose cable (sensor cable) with solder tail wires. If the AR700 is ordered with a power supply, the sensor cable will be connected to the power supply. Connection and termination according to the instructions is essential for correct sensor operation. Read the wire descriptions for connection information.

4.1. Sensor Cable Wire Colors and Functions

The tables below shows the wiring on systems ordered without power supplies.

Wire	Function in All Modes
Red	Power Supply, +15V (15 VDC min to 24 VDC max)
Black	Ground - Power Supply Common Return
White	Laser Disable (connect to ground to disable)
Clear	(Shield) Ground at Supply End
Pink	Limit 1 Output (open collector NPN switch to ground)
Grey	Limit 2 Output (open collector NPN switch to ground)

The analog output wires can be used for 4-20 mA current output or 0-10V voltage output.

	Function in Selected Analog Mode	
Wire	**4-20mA**	**0-10V**
Orange	Current Loop Output	Voltage Output
Brown	Current Loop Return	Voltage Return

The serial communications wires can be used for RS232 or RS422.

	Function in Selected Serial Mode	
Wire	**RS232**	**RS422**
Yellow	RxD – Receive Data	RX– : Receive Data –
Green	TxD – Transmit Data	TX– : Transmit Data –
Blue	RTS – Request To Send	TX+ : Transmit Data +
Violet	CTS – Clear To Send	RX+ : Receive Data +

4.1.1. Power Supply (Black, Red)

The Black wire is the Power Supply Common return, also named Ground. It carries the return current for the power supply, the Limit Outputs, the Laser Enable, and the serial data signals. Note that the ground current for the Limit Outputs may be up to 100 mA each.

The Red wire is the Power Supply Input to the sensor. The sensor requires +15 VDC power at 120 mA to 200 mA (depending on the internal laser used). The sensor uses a surge of up to 350 mA at power on. The Analog Output uses an additional current up to 20 mA. The maximum ripple allowed on the supply is 100 mVpp.

Power supplies from 15 VDC to 24 VDC may be used. Higher voltages will result in excessive current drawn by the over-voltage protection circuitry and may cause permanent damage. Voltages less than 14 VDC may result in inaccurate measurement readings.

Class 3B laser operation requires interlocks and other safety features that can be satisfied with the Interlock Box option.

4.1.2. Shield (Clear)

The Clear wire is the cable and housing shield and is connected to ground inside the sensor. It should also be connected to ground at the power supply end of the cable.

4.1.3. Serial Communications (Green, Yellow, Blue, Violet)

A standard 9-pin D-SUB serial connector can be built to interface with an IBM or compatible computer using connection the pin out table below. The RS422 pin-out shown is not a standard. This pin-out is not compatible with the AR600.

Pin #	DCE RS232 Function (PC compatible)	Signal Direction	Wire Color	RS422 Function (not PC compatible)
1	Data Carrier Detect (DCD)	To Computer	N/C	
2	Transmitted Data	To Computer	Green (TXD/TX-)	TX-
3	Received Data	From Computer	Yellow (RXD/RX-)	RX-
4	DTE Ready	From Computer	N/C	
5	GND	Reference	Black (COM)	Reference
6	DCE Ready	To Computer	N/C	
7	Clear To Send (Optional)	From Computer	Violet (CTS/RX+)	RX+
8	Request To Send (Optional)	To Computer	Blue (RTS/TX+)	TX+
9	Ring Detect	To Computer	N/C	

RS232 and RS422 modes are compatible with the associated ANSI standards.

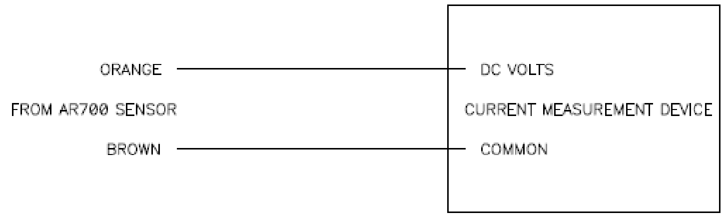
See Serial Interface Operation (section 5) for more information.

4.1.4. Analog Output (Brown, Orange)

The Brown wire is the return signal for the Analog Output. It is connected to ground inside the sensor and should not be connected to ground outside the sensor. Inadvertently connecting it to ground may cause a reduction in accuracy of the analog output, especially in voltage mode.

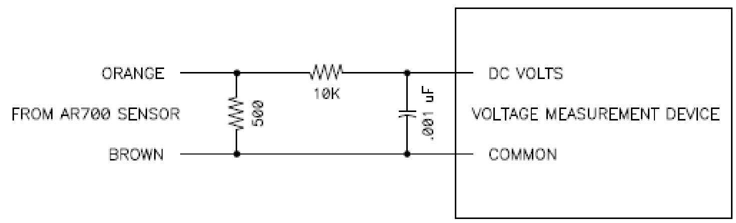
4.1.4.1. 4-20 mA Current Loop Output (Orange)

In Current Loop mode the Orange wire delivers a current proportional to the measured distance.



The best conversion to voltage is obtained by connecting a 500-ohm load resistor (1/4 Watt minimum) between the orange and brown wires at the measurement point. This gives a 2 volt to 10 volt output range.

See Analog Output Operation (section 6) for mode selection and scaling options.



The sensor may be connected directly to a meter or a filter may be inserted to reduce noise. The filter shown will pass the signal at full speed (nearly 10000 samples per second). To filter better at slower speeds, use a 0.01 uF capacitor (1000 samples per second) or a 0.1 uF capacitor (100 samples per second).

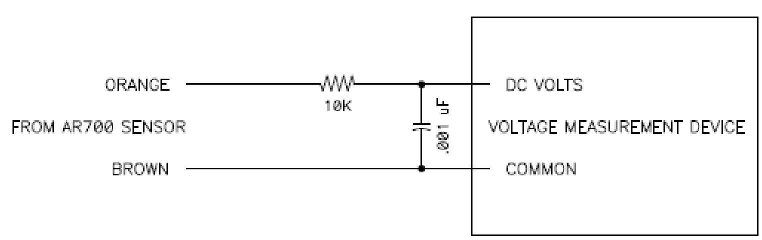
4.1.4.2. 0 – 10 V Voltage Output (Orange)

In Voltage mode the Orange wire delivers a voltage proportional to the measured distance. A load resistance of 10K-ohms or more may be connected between the orange and brown wires in this mode.

Note that the output voltage does not go all the way to zero but the output is linear from about 10 mV (at position = 0) to 10 V.

See Analog Output Operation (section 6) for mode selection and scaling options.

The sensor may be connected directly to a meter or a filter may be inserted to reduce noise. The filter shown will pass the signal at full speed (nearly 10000 samples per second). To filter better at slower speeds, use a 0.01 uF capacitor (1000 samples per second) or a 0.1 uF capacitor (100 samples per second).



4.1.5. Limit Outputs (Pink, Gray)

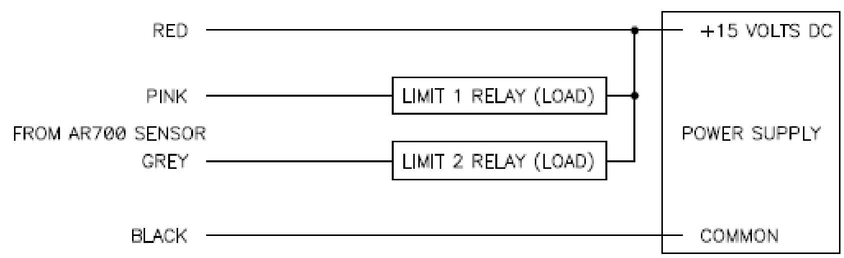
The Pink wire is the Limit 1 Output.

The Gray wire is the Limit 2 Output.

See Limit Output Operation (section 7) for operation options and details.

Each Limit Output is an open collector NPN transistor switch to Ground. When a Limit Output is not active, its output will be high impedance and no current will flow through it. When a Limit Output is active (On) it can sink up to 100mA of current. A current limiting circuit will cause the transistor to turn off in the case of a current overload. The transistor will remain off until the sensor's measurement conditions cause it to turn off and then back on again.

The load for each output should be connected to the Power Supply (Red wire). The voltage on these wires must not exceed the limits of the Power Supply connection voltages (red and black wires), or excessive current may flow into the sensor and cause damage.



4.1.6. Laser Disable and Trigger (White)

The White wire is the Laser Disable input. Connecting it to Ground (black wire) will disable the laser (turn it off). It is normally left unconnected to enable the laser.

If this input will be controlled by an operator from more than two meters from the sensor, then an emission indicator near the operator control area may be necessary to comply with laser safety regulations.

This signal can be driven by a switch, an open collector transistor, or by TTL or 3 to 5 volt CMOS level signals. This signal must be held in one state for at least 70 µs in order to guarantee that the state is recognized. A low signal (0 volt state) disables the laser. A high state (3 to 5 volts) enables the laser.

Additionally this input can be used to trigger a single measurements in the sensor. If the Sampling Control is set to HARDWARE TRIGGER mode then a single sample will be measured each time this signal transitions from low to high. The measurement will begin within 70 µs of the transition. Note that the Laser Disable input signal must remain 'enabled' (signal state high) until the sample is acquired or the laser will turn off and disable the sensor's ability to sample. A mechanical switch is not recommended for triggering unless the switch has excellent 'bounce' characteristics.

For the fastest possible trigger speed, use an open collector transistor and use a trigger pulse that goes low (0 volt state) for 70 µs and remains high the rest of the time. Use BLE OFF (L2), Rate Priority (P2), and limit the exposure. 4500 samples per second can be achieved in this way if the target is close and highly reflective enough to operate with an exposure limit of M33 and a Sample interval of S21.

See Performance Optimization (section 8) for more about Sampling Control.

4.2. Other Interfaces

Terminal block connections can be provided for user connections.

4.2.1. Optional Interface Kit with Serial Cable and Power Supply

The Acuity AR700 Interface Kit (p/n AQ7000001) provides an interface box with terminal block connections, a serial cable for connecting to a PC, and a Power Supply.

One terminal block in the interface box connects to the AR700 sensor. A second terminal block allows user access to all other connections as needed.

A standard 9-pin D-SUB serial connector is provided in the interface box. It provides the pin-out described in the Serial Communications subsection, above. In addition, it ties pins 4 (DTE Ready), 6 (DCE Ready,) and 1 (DCD) together, a standard connection used with a PC. A standard 9-pin cable is supplied to connect the interface box to a PC.

The interface box has a jack to accept the plug from a standard 15V Power Supply, also supplied with the Interface Kit.

4.2.2. Interlock Box

The Interlock Box option may be added to sensors with a Class 3B lasers in order to provide some of the safety features required for compliance with laser regulations.

It provides the same features as the Interface Kit and also includes a beam attenuator, a key switch, a laser interlock connector, and a second laser emission indicator.

4.2.3. OEM Models (Class 3B without Interlock Box)

A Class 3B sensor that doesn't have the Interlock Box option is for use only as a component for incorporation into a system that must include all applicable safety components prior to use. It is the responsibility of the installer to ensure that the complete system meets all applicable safety standards for Class 3B laser products. This may include but not be limited to a beam attenuator, compliant power supply interlocks and safety switches, emission indicators and user warning labels that may be required to be visible during use.

5. Serial Interface Operation

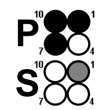
5.1. Serial Hardware Interface

The serial port hardware mode can operate in RS232 or RS422 mode. The hardware mode can not be selected using a serial command and must be selected through the use of the function button. The default serial port mode is RS232. In RS422 terminated mode, the serial port is set for full-duplex transmission with an internal 120 ohm termination connected between the receiver pair's wires. In RS422 unterminated mode, the serial port is set for full-duplex transmission and the 120 ohm termination is not connected.

5.1.1. Serial Communication Mode (RS232, RS422)

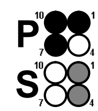
The Serial Communication Mode command is used to set the hardware communication mode used by the sensor. It can only be set using the function button. See Function Button Command Operation (section 10.3) for instructions.

5.1.1.1. RS232 (function button parameter 9, setting 1 [default]



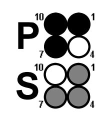
This command sets the serial communications mode to RS232 using four signals, TX, RX, CTS, and RTS.

5.1.1.2. RS422 (function button parameter 9, setting 2)



This command sets the serial communications mode to RS422 with no termination provided. Two signal pairs (TX and RX) use four wires. CTS and RTS are not available.

5.1.1.3. RS422 Terminated (function button parameter 9, setting 3)



This command sets the serial communications mode to RS422 with and internal 120 Ohm termination on RX. Two signal pairs (TX and RX) use four wires. CTS and RTS are not available.

5.1.2. Baud Rate (B)

The Baud Rate is selectable via the function button. Although changing the Baud Rate using the serial port is also allowed, it requires the host device to change its own Baud Rate after commanding the sensor to change.

The following Baud Rates are provided (with corresponding serial command):

300	`B1`
1200	`B2`
2400	`B3`
4800	`B4`
9600	`B5` (default)
19200	`B6`
38400	`B7`
57600	`B8`
115200	`B9`
230400	`B0`

5.1.3. Serial Output Flow Control (T)

The Serial Flow Control command is used to select the serial output flow control mode.

Whenever sampling is enabled the measurement, analog output, and limit output operations continue, even though serial output flow may be stopped.

5.1.3.1. Output Flow Control OFF (T2[default])

In this mode waiting characters are always transmitted.

5.1.3.2. Hardware Output Flow Control (T1)

This mode uses the RS232 control signal CTS. In this mode the sensor will not transmit any characters if the CTS signal is not active. It will immediately begin transmitting any waiting characters when CTS becomes active. Hardware flow control is not operational in RS422 mode.

This mode responds on a character by character basis.

5.1.3.3. Soft Output Flow Control (T3)

In this mode the sensor responds to software flow control characters (Ctrl-S and Ctrl-Q). It will stop the flow of serial sample data after Ctrl-S is received. The sensor will resume the flow after Ctrl-Q is received. Non sample data information will be transmitted regardless of the flow control characters (Show Version command, for example).

This mode stops the transmission of complete samples. Once the first character of a sample is transmitted, all the characters of the sample will transmit.

5.1.4. Input Flow Control

The sensor provides hardware input flow control in RS232 mode using the RTS signal, which is set active to indicate that the sensor is able to receive at least two more characters. Hardware flow control is not operational in RS422 mode.

The sensor does not transmit software flow control characters (Ctrl-S and Ctrl-Q). If the host is transmitting command sequences that are more than 10 bytes in length, pause for 0.1 seconds between commands.

5.2. Serial Data Output (A, N)

The Serial Data Format, units, and offsets modes are selectable using the Serial Output Control command. Serial data is transmitted from the AR700 as 8 data bits with no parity and 1 stop bit. The sample data sent represents calibrated distance readings.

Available units are Native (0 to 50000), English, Metric, and Short (0 to 16378).

Output Formats are ASCII, 3 byte binary, and 2 byte binary.

Adjustable offset modes are Unbiased, Zero-Based, and Offset-Based.

5.2.1. Serial Output Off (A3)

In this mode no serial data is transmitted. Analog and Limit Outputs continue to function.

5.2.2. ASCII Native Format (A0, A4, A7)

Native is the format used for many commands (Z, J, K, U) and it is also provided as an output format. Native has valid measurement values between 0 and 50000, inclusive. The output is up to five digits followed by <CR><LF> (Carriage Return and Line Feed characters) that represent a measured distance computed as:

Distance = <Range> * value / 50000 (<Range> is the sensor's numeric Range)

Errors are represented by values over 50000:

Error	Native Units value
1 - Target too near	50001<CR><LF>
2 - Target not seen	50002<CR><LF>
3 - Target too far	50003<CR><LF>
4 - Laser Off	50004<CR><LF>

5.2.3. ASCII Distance

In these modes, each sample consists of a string of characters as follows: optional minus sign (see Offset-Based Output – section 5.2.6.3), up to 7 distance digits plus a decimal point (depending on model range – section 5.2.3.4), and followed by <CR><LF>, for a maximum of 10 characters including <CR><LF> characters. Leading zeros are not transmitted except a single zero prior to the decimal point. The maximum number of characters is dependent on the sensor's <Range> and the measurement units selected. Output formats are as follows:

5.2.3.1. Error Modes (Q1[default], Q2, Q3)

Three user selectable modes of error indication can be set for ASCII distance formats by the Error Report Mode command:

Q1	code	'E' + Error + <CR><LF>	E1<CR><LF>
Q2	plus	'+' + ErrorValue + <CR><LF>	+5.0001<CR><LF>
Q3	natural	ErrorValue + <CR><LF>	5.0001<CR><LF>

Error values are indicated by out-of-range distances (see Native Format – section 5.2.2). The numeric error codes are coded as:

ErrorValue = <Range> * (50000 + Error) / 50000

Any numeric output value inclusive of 0.0000 and <Range> is a valid distance measurement. For a 1" sensor 1.00000 is a valid output and 1.00006 represents error 3 (too far). For the same sensor in metric 25.4000 is a valid output and 25.4015 represents error 3. Examples in the sub-sections below represent the output from a 5 inch range sensor for clarity.

5.2.3.2. ASCII English (A1[default], A5, A8)

Error codes for English units (inches) are as follows (AR700-0.500 model):

Error	Q1 (default) 'Code' mode	Q2 '+' mode	Q3 natural mode
1 - Target too near	E1<CR><LF>	+0.50001<CR><LF>	0.50001<CR><LF>
2 - Target not seen	E2<CR><LF>	+0.50002<CR><LF>	0.50002<CR><LF>
3 - Target too far	E3<CR><LF>	+0.50003<CR><LF>	0.50003<CR><LF>
4 - Laser Off	E4<CR><LF>	+0.50004<CR><LF>	0.50004<CR><LF>

5.2.3.3. ASCII Metric (A2, A6, A9)

Error codes for Metric units (mm) are as follows (AR700-0.500 model):

Error	Q1 (default) 'Code' mode	Q2 '+' mode	Q3 natural mode
1 - Target too near	E1<CR><LF>	+12.7003<CR><LF>	12.7003<CR><LF>
2 - Target not seen	E2<CR><LF>	+12.7005<CR><LF>	12.7005<CR><LF>
3 - Target too far	E3<CR><LF>	+12.7008<CR><LF>	12.7008<CR><LF>
4 - Laser Off	E4<CR><LF>	+12.7010<CR><LF>	12.7010<CR><LF>

5.2.3.4. English and Metric Output Formats

Sensor Range	English	Metric	(Metric Range)
0.125 in:	-0.xxxxxx in	-x.xxxxx mm	3.17500 mm
0.250 in:	-0.xxxxxx in	-x.xxxxx mm	6.35000 mm
0.500 in:	-0.xxxxx in	-xx.xxxx mm	12.7000 mm
1.0 in:	-x.xxxxx in	-xx.xxxx mm	25.4000 mm
2.0 in:	-x.xxxxx in	-xx.xxxx mm	50.8000 mm
4.0 in:	-x.xxxxx in	-xxx.xxx mm	101.600 mm
6.0 in:	-x.xxxxx in	-xxx.xxx mm	152.400 mm
8.0 in:	-x.xxxxx in	-xxx.xxx mm	203.200 mm
12.0 in:	-xx.xxxx in	-xxx.xxx mm	304.800 mm
16.0 in:	-xx.xxxx in	-xxx.xxx mm	406.400 mm
24.0 in:	-xx.xxxx in	-xxx.xxx mm	609.600 mm
32.0 in:	-xx.xxxx in	-xxx.xxx mm	812.800 mm
50.0 in:	-xx.xxx in	-xxxx.xx mm	1270.00 mm

5.2.4. 3-Byte Binary Data format (N0, N2)

LH<FF>

In this mode, each sample data output consists of 3 bytes representing a value in Native Units: a low byte (L), a high byte (H), and a termination byte (<FF>). The low byte has a value of 0 to 255. The high byte has a value of 0 to 195. The termination byte always has a value of 255. For synchronizing, note that the termination byte (always 255) immediately follows the high byte (never 255). To convert the two bytes to an output value, use the following equation:

Bin3out = H * 256 + L.   Distance = Range * Bin3out / 50000

Just as in Native mode, valid measurements are indicated by values between 0 and 50000, inclusive. Errors are represented by values over 50000:

Error	value
1 - Target too near	50001<CR><LF>
2 - Target not seen	50002<CR><LF>
3 - Target too far	50003<CR><LF>
4 - Laser Off	50004<CR><LF>

Offset-Based Zero-Point output is not available in binary mode (no negative numbers).

5.2.5. 2-Byte Binary Data format (N1, N3)

LH

In this mode, each sample data output consists of 2 bytes: a low byte (L) and a high byte (H). The low byte has a value of 0 to 127. The high byte has a value of 128 to 255. For synchronizing, note that the bigger value (H) always follows the smaller value (L). To convert the two bytes to an output value, use the following equation:

Bin2out = (H – 128) * 128 + L.   Distance = Range * Bin2out / 16378   (except errors)
Note: Native = 50000 * Bin2out / 16378   (except errors)

In this mode valid measurements are indicated by values between 0 and 16378, inclusive. Errors are represented by values over 16378:

Error	value
1 - Target too near	16379<CR><LF>
2 - Target not seen	16380<CR><LF>
3 - Target too far	16381<CR><LF>
4 - Laser Off	16382<CR><LF>

Offset-Based Zero-Point output is not available in binary mode (no negative numbers).

5.2.6. Zero-Point (Z) – Span-Point (U)

NOTE: The Zero-Point (Z) and Span-Point (U) parameters may also affect the Analog Output.

The location of the Zero-Point may be changed with the Zero-Point command (Z). The direction of increasing output serial values from the Zero-Point may be reversed by issuing the Span-Point command (U) with a value smaller than that used in the Zero-Point command.

Example:		
	Z25000	Set Zero-Point to middle of range (0 to 50000).
	Z/	Set Zero-Point to current location.
	U12500	Set Span-Point at 1/4 of range.

Z represents the Zero-Point Value   U represents the Span-Point value

5.2.6.1. Unbiased Output Units (A7, A8, A9, N2, N3)

This mode reports the distance without applying the Zero-Point value. The Zero-Point value can still be applied to the analog output.

Measurement	Z = 20000, U > 20000	Z = 20000, U < 20000
(below)	50001	50001
10	10	10
19990	19990	19990
20000	20000	20000
20010	20010	20010
49990	49990	49990
(above)	50003	50003

5.2.6.2. Zero-Based Output Units (A0, A1[default], A2, N0, N1)

This mode reports the distance as positive from the Zero-Point value (zero) up to the limit of the sensor. No negative values are transmitted.

Measurement	Z = 20000, U > 20000	Z = 20000, U < 20000
(below)	50001	50001
10	50001	19990
19990	50001	10
20000	0	0
20010	10	50003
49990	29990	50003
(above)	50003	50003

5.2.6.3. Offset-Based Output Units (A4, A5, A6)

This mode reports the signed distance from the Zero-Point value (up to the limit of the sensor. This mode is not available in binary modes (no negative numbers).

Measurement	Z = 20000, U > 20000	Z = 20000, U< 20000
(below)	50001	50001
10	-19990	19990
19990	-10	10
20000	0	0
20010	10	-10
49990	29990	-29990
(above)	50003	50003

6. Analog Output Operation (X)

The analog output uses two wires not used in the basic configuration. The output is Orange and the return is Brown. The return wire is connected to ground inside the sensor and should not be connected to ground outside the sensor. Three modes, Voltage, Current Loop, or Off may be selected with the Analog Output Control command.

The analog output is updated with each sample measured. The analog output can keep up with the sensor's fastest measurement rate.

The analog output is not updated (does not change) if a sample is not determined to be valid and within the sensor's measurement range.

6.1. Analog Output Off (X5)

In this mode no analog output is generated on the analog output wires.

6.2. Current Loop Output (X1[default], X3)

In 4-20mA analog mode, the analog output will deliver a current which increases linearly from 4 mA at the Zero-Point to 20 mA at the Span-Point.

Best accuracy and noise immunity is obtained by connecting a 500 Ohm resistor to the current return wire at the measurement point. The default configuration is for calibrated output, with the Zero-Point at zero (Z0), and the Span-Point at full scale (U50000).

6.3. Voltage Output (X2, X4)

In 0-10V voltage mode, the analog output will deliver a voltage which increases linearly from 0V at the Zero-Point to 10V at the Span-Point.

Best accuracy and noise immunity is obtained by connecting a 10K Ohm resistor to the voltage return wire at the measurement point. The default configuration is for calibrated output, with the Zero-Point at zero (Z0), and the Span-Point at full scale (U50000).

6.4. Zero-Point (Z) – Span-Point (U)

NOTE: The Zero-Point (Z) and Span-Point (U) parameters may also affect the Serial Output.

The location of the Zero-Point may be changed with the Zero-Point command (Z). The direction of increasing output serial values from the Zero-Point may be reversed by issuing the Span-Point command (U) with a value smaller than that used in the Zero-Point command.

Example:	**`Z25000`**	Set Zero-Point to middle of range (0 to 50000).
	`Z/`	Set Zero-Point to current location.
	`U12500`	Set Span-Point at 1/4 of range.

Z represents the Zero-Point Value U represents the Span-Point value

6.4.1. Unbiased Analog Output (X3, X4)

Unbiased mode ignores the Zero-Point and Span-Point settings. The analog voltage (X4) or current (X3) output is at a minimum at the near end of the measurement range and a maximum at the far end of the measurement range.

Measurement	Z and U = don't care
(below)	(no change)
10	0.012 V, 4.003 mA
19990	4.014 V, 10.397 mA
20000	4.016 V, 10.400 mA
20010	4.018 V, 10.403 mA
49990	9.998 V, 19.997 mA
(above)	(no change)

6.4.2. Zero-Span Biased Output (X1, X2)

The Zero-Point (Z - the measurement distance of the minimum analog output), and the Span-Point (U - the measurement distance of full-scale analog output) may be set anywhere within the measurement range of the sensor. See Zero-Point and Span-Point (section 5.2.6). The minimum distance between Zero-Point and Span-Point is 5% of the full sensor range. Attempts to set a smaller span will be scaled such that the full analog output range will represent 5% of the sensor range. Note that the full scale value may not be generated if its required location is outside the sensor's range. Example ZP=49000 and SP=50000. 5% of range (5% of 50000) is 2500. Actual ZP=49000 and the effective SP=51500. Since the sensor can never measure past 50000, the analog output would never go above 40% of full scale (50000 is 40% of the way from 49000 to 51500).

Setting the Span-Point to a value lower than the Zero-Point will reverse the direction of increasing output.

Measurement	Z = 20000, U = 50000	Z = 40000, U = 20000
(below)	(no change)	(no change)
10	0.010 V, 4.000 mA	10.000 V, 20.000 mA
20000	0.010 V, 4.000 mA	10.000 V, 20.000 mA
20010	0.013 V, 4.005 mA	9.995 V, 19.992 mA
30010	3.343 V, 9.339 mA	5.000 V, 11.992 mA
49990	9.997 V, 19.995 mA	0.010 V, 4.000 mA
(above)	(no change)	(no change)

7. Limit Output Operation (J, K)

The limit outputs use two wires not used in the basic configuration.

Limit 1:	Pink	Associated with Parameter J and the Limit 1 command
Limit 2:	Grey	Associated with Parameter K and the Limit 2 command

The limit outputs are updated with each sample measured. The limit outputs can keep up with the sensor's fastest measurement rate.

Example:	`J25000`	Set Limit 1 to middle of range (0 to 50000).
	`J/`	Set Limit 1 to current location.
	`K12500`	Set Limit 2 at 1/4 of range.

The limit outputs are set based on the sensor reading in Native units. Note that 'valid' measurements include values that the sensor detects out of range and an invalid measurement is one for which the sensor cannot determine position.

7.1. Limit Switches both OFF between limits, inclusive (J<K)

This mode is determined by the J parameter having a value less than the K parameter.

Limit 1 is ON for a measurement that is invalid or <J (including below range).
Limit 1 is OFF for a measurement that is valid and >=J (including above range).
Limit 2 is ON for a measurement that is invalid or >K (including above range).
Limit 2 is OFF for a measurement that is valid and <=K (including below range).

This mode is default (J=0, K=50000).

7.2. Limit Switches both ON between limits, inclusive (J>K)

This mode is determined by the J parameter having a value greater than the K parameter.

Limit 1 is ON for a measurement that is valid and <=J (including below range).
Limit 1 is OFF for a measurement that is invalid or >J (including above range).
Limit 2 is ON for a measurement that is valid and >=K (including above range).
Limit 2 is OFF for a measurement that is invalid or <K (including below range).

7.3. Limit Output Toggle (J=K) for Analog Output Timing

This mode is determined by the J parameter having a value equal to the K parameter. The Limit outputs change at the same time the analog output changes.

If J=K<=30000 then Limit 1 is OFF for any valid measurement and ON if invalid.
If J=K>30000 then Limit 1 is ON for any valid measurement and OFF if invalid.
Limit 2 toggles from ON to OFF or OFF to ON for every sample, valid or invalid.

8. Performance Optimization

8.1. Sample Definition

A Sample consists of one or more scan cycles. A scan cycle is performed in the sensor by scanning its camera. Scan cycles are performed continuously and as fast as possible in the sensor and then reported at the Sample Rate. If more than one scan cycle is performed during a Sample Period, then the results of those cycles are averaged, allowing slower sample rates to be less noisy.

Note that there is not a direct time correlation between scan cycles and samples. One or more scan cycles take place and are averaged within a sample period, but the exact time of those scan cycles are not known within the sample period.

Samples are not completed at an exact rate, but at an average rate with a small amount of fluctuation. The fluctuation is on the order of 30 microseconds, so it would only make a noticeable difference at very high sample rates.

8.2. Sample Interval (S)

The Sample Interval command (S) controls the maximum average Sample Rate. Its parameter has a resolution and units of 5 µs (micro seconds). The command accepts parameter values from S0 to S999999. Note that any value below S22 is taken as S21 (maximum rate is about 9434 samples per second). The sample frequency and period are calculated as:

Sample Rate = 200000 / S (samples per second)
Sample Period = 5 * S (microseconds per sample)

The minimum sample rate is 200000 / 999999 = 0.5 samples per second.

Example: `S40/` Sets the sample rate to 5000 per second (200000/40).

The maximum possible sample rates are limited by the sensor internal processes.

Two configuration settings can limit the actual or maximum sample rate.

8.2.1. Background Light Elimination (BLE) (L)

BLE (or Background Light Elimination) is controlled by the Background Light Elimination Mode command (L).

8.2.1.1. BLE ON (L1[default])

When BLE mode is ON the sensor scans its camera two times per scan cycle, once with the laser off and once with the laser on. The two scans are subtracted to enhance the laser image and reduce the background image.

The maximum sample rate with BLE ON is about 4717 samples per second (S<43).

8.2.1.2. BLE OFF (L2)

When BLE mode is OFF the sensor scans the camera once per scan cycle and processes the image. This can be done at twice the speed as with BLE ON because the camera is scanned half as often per scan cycle.

The maximum sample rate with BLE OFF is 9433 samples per second (S<22).

8.2.1.3. ROAD PROFILING (L3 – Default in Road Profiler Models (section 1.5))

This is the mode of operation is allowed only in Road Profiler models. This mode behaves as if BLE is OFF (section 8.2.1.2) and forces RATE Priority (section 8.2.2.2). It is described in detail in section 1.5. An attempt to set this mode in a standard (non-RP) model will be ignored.

8.2.2. Sample Exposure and Priority (P)

Each scan cycle (camera scan) is checked for the correct exposure. The sensor controls the exposure by varying the strength of the laser beam and the camera's shutter time. For optimal speed performance, the laser power is increased before the shutter time is increased.

Shorter exposure times generally occur with more reflective targets, measurements that are closer to a sensor (shorter range), and with higher power lasers. Longer exposure times generally occur with less reflective targets, measurements that are farther from a sensor (longer range), and with lower power lasers.

Note that because each exposure is based on what the camera saw on the previous scan cycle, there can be a delay of several scan cycles in acquiring the correct exposure. If the reflectance characteristics of the target are changing rapidly, then the required exposure is constantly changing and correcting. For fast changing targets (position or texture) the quality of the measurement will be reduced.

When the exposure time is greater than the requested sample period (S command) then the priority command determines how the camera's shutter time is calculated.

8.2.2.1. Quality sets Priority (P1[default])

In this mode the sample rate may be slowed down from the programmed value in order to attain the optimum shutter time. If the sample rate is slowed, then that rate is uncontrolled.

8.2.2.2. Rate sets Priority (P2 – forced in Road Profiler Modes (section 1.5))

In this mode the shutter time is limited in order to guarantee the programmed sample rate. If the exposure is too low, then the sample quality (accuracy) may be reduced. If the shutter time is limited in this mode, then there will only be only one scan cycle per sample (no averaging).

8.2.2.3. Exposure Limit (M – limited in Road Profiler Modes (section 1.5))

When the sensors camera doesn't 'see' a laser spot on a target, then it increases the exposure in order to try to see one. If there is no target within range, then the exposure can be increased to just over 0.1 second. Once a target comes into range, it may take the sensor a very long time (up to 0.5 seconds) to get the correct exposure. Also under this condition it is easy for a background point of light to be interpreted as a laser spot.

The Exposure Limit command is provided in order to significantly reduce both of these effects. It can be manually set from M0 to M80, but it is not easy to understand the effect of the value of the parameter:

ExposureLimit = MaxExposure * 2 (0.25 * (M – 80)). Note that MaxExposure is in units of time * laser power.

However, it is easy to have it acquire a value automatically. Get the least reflective target material that is to be used in an application and position it at the far end of the range such that it is getting a good measurement. Issue the M command without a parameter and it will set the Exposure Limit for about 1.5 times the exposure required at the measured location. This value will be sufficient for most applications. To see what value has been set, use the Show Version command (V1234) to display all of the current parameter settings. Once the approximate M value is known, a slightly different one can be used if adjustment is necessary.

8.3. Sampling Control (H, E)

The sensor is able to sample the distance using measurement scans on a continual basis.

Whenever sampling is on, the sensor continually updates the limit outputs. If an analog output is enabled, then it is updated with each sample. If serial data is on, then it is updated with each sample.

Sampling may be turned off as needed.

8.3.1. Sampling On – Laser On (H1)

In this mode sampling is on continuously. The laser is on. Enabled outputs are updated at the sample rate.

8.3.2. Sampling Off – Laser Off (H2)

In this mode sampling is off. There is no output. The laser is off. The camera does not track the exposure. This mode is used for measuring single samples, but without the laser being on continuously.

8.3.3. Sampling Off – Laser On (H3)

In this mode sampling is off. There is no output. The laser is on so that the sensor's camera can keep the exposure up to date.

This mode is useful when single samples will be commanded but the target reflectivity or position may change significantly between each sample.

8.3.4. Hardware Trigger Mode – Laser Off (H4)

In this mode sampling is off. There is no output. The laser is off. The Laser Disable input is used to trigger a single sample measurement each time the signal changes from 'disabled' to 'enabled'. The camera does not track the exposure.

This mode is useful for synchronizing single samples with a hardware input signal. Single samples can also be requested by command in this mode.

Note that the Laser Disable input signal must remain 'enabled' until the sample is acquired or the laser will turn off and disable the sensor's ability to sample.

8.3.5. Measure Single Sample (E)

This command is normally used when sampling is off. It causes a single sample to be measured and outputs to be generated (analog, limit, and serial).

This command is ignored if sampling is on.

This command does not change any configuration settings.

Note: Sending the E command while a sample is in progress will cause a new sample to follow.

8.3.6. High Speed Sampling Tips

High speed sampling can be hindered by several things.

- The sensor gives no indication if the specified sample rate is not being met.
- Targets that are dark and/or distant require longer exposure times to obtain good samples, making higher speeds more difficult to attain.
- With BLE ON (L1) the exposure time required is double that needed with BLE OFF (L2), and will reduce the sampling speed by up to 50%.
- Priority must be set to Rate (P2) to assure sampling takes place at the specified rate.

8.3.7. High Speed Single Sample Tips

The speed of single sample operation is further hindered. Several operations that are overlapped during normal operation must be performed in sequence during single sample operation, particularly at high speed.

The maximum exposure time for single sampling is controlled by the S command as if the sensor were in continuous sampling mode.

The single sample rate can be increased slightly by using the exposure limit command (M) to reduce the exposure. Note that reducing the exposure can also reduce the signal quality.

- Use commands S21, L2, and P2 to get the fastest rate.
- Use M34 to get a maximum rate of about 4500 samples per second.
- Reducing the value to M13 will not make a significant difference in sample speed.
- From M12 to M2 the maximum rate may increase slightly. At M2 the rate may exceed 5200 samples per second, but the low exposure may result in no sample signal.
- At M40 the maximum single sample rate is about 3450.
- Above M40 the M command is no longer influencing an increase in the single sample rate.

8.4. Measurement Resolution

The sensor output data was described in the sections on Serial Data Output and Analog Output, where the resolution is defined in terms of how many digits are calculated for the results.

This section discusses measurement resolution: How much does the target need to move before a reliable distance change appears in the measurement.

A target material that is smooth and opaque, such as an enamel painted surface, will measure more reliably than a rough or porous surface such as paper or anodized aluminum.

This function is dependent on the measurement quality and the sample period and is related to noise and sample quality. In general, the resolution will improve as the square root of the number of scan cycles averaged. The number of cycles averaged is generally proportional to the sample period. Rate priority mode can reduce the resolution if it reduces the signal quality in order to increase the rate. Once the sensor is controlling the exposure time, the target reflectance and distance affect the resolution. Then the number of scan cycles averaged can increase proportionally to the target reflectance. Note that target reflectance refers to the amount of laser light scattered in the direction of the sensor's lens. A mirror can be highly reflective, but it can reflect nearly all the light away from the lens and have a very low reflectance to the sensor. A flat black surface can appear to have a much higher reflectance to the sensor than the mirror. The number of scan cycles averaged will decrease as the square of the distance from the sensor's lens to the target.

That being said, the sensor with default settings should have a resolution of 1 part in 20000 for a diffuse white target normal to the laser at the middle of the sensor's range.

8.5. Serial Data Rate

Serial data is transmitted from the AR700 at a variety of formats and baud rates. The time it takes to transmit a measurement is highly dependent on the format and baud rate. The amount of time can be computed as:

TransmitTime (in seconds) = 10 * (Number of characters) / (Baud Rate)

If a typical sensor sends 9 characters per sample at a default baud rate of 9600, this equates to about 94 ms per sample, or about 107 samples per second (1 / TransmitTime). The AR700 sensor is capable of generating samples at more than 800 times that rate, over 9400 samples per second. At a baud rate of 230400, the nine character samples can be transmitted at only 2560 samples per second. Even using 3-byte binary mode only gets the rate up to 7680 samples per second. Only by using 2-byte binary mode at 230400 baud can the sensor transmit the serial data at the full measurement rate of the sensor.

If the serial data rate is faster than the sample rate, then a single sample is transmitted serially for each sample measured.

When the serial data rate can't keep up with the sample rate, the actual sample rate continues without delay, but the serial sample rate is reduced by skipping samples. Once a sample has finished being transmitted, the most recent new sample is used for the next serial output.

9. Nonvolatile Memory Storage

The AR700 stores its configuration settings and calibration information in electronically erasable non-volatile memory.

9.1. Calibration

The calibration information is specific to the sensor, and cannot be changed by the user.

If the sensor cannot validate the calibration information when the sensor is turned on, then the function display LEDs will flash code 08 and the sensor will continuously transmit the following message at 9600 baud using RS232 communication mode:

"CALIBRATION DATA CORRUPTED, RELOAD"

The sensor cannot be used if the calibration data is not valid. Contact the factory for return instructions.

9.2. Configuration

9.2.1. Default Configuration

Default configuration values are stored for the configuration settings when the sensor is shipped, and the default configuration settings may be restored at any time using the Default command. The easiest way is to hold the function button down and then apply power to the sensor. Once the function display LEDs start sequencing, release the button and the configuration will be set to the default settings.

If the sensor cannot validate the configuration information when the sensor is turned on, then the function display LEDs will flash code 06 and the sensor will continuously transmit the following message at 9600 baud (default) using RS232 communication mode (default):

"SAVED SETTINGS INVALID - USING DEFAULT"

Pushing the function button will stop the light from flashing, stop the error message from transmitting, and will start the sensor using the default configuration. The sensor can also send this message as the result of the Read Configuration Data command with configuration data that is not valid.

The default settings described in this manual are the "standard" default settings. Custom default settings may be generated by special factory order.

9.2.2. Write Configuration Data Command (W1234)

The commands used to change the configuration do not automatically store the changes to the nonvolatile memory. The Write Configuration Data command must be used to make these changes permanent. The Write Configuration Data command stores all of the current configuration settings, so it can be used after making several changes.

The Write command should not be issued repeatedly under computer control, since the nonvolatile memory expected lifetime is 1,000,000 writes.

9.2.3. Read Configuration Data Command (R)

The Read Configuration Data command is used to restore the saved configuration from nonvolatile memory, and will immediately replace the sensor's configuration settings.

9.2.4. Initialize Configuration Data Command (I – Except Serial)

This Initialize Configuration Data command is used to immediately restore the default configuration setting, EXCEPT for the Serial port communication mode and baud rate. The Write Configuration Data command must be used to save these settings permanently.

9.2.5. Initialize Configuration Data Command (Q8)

This Initialize Configuration Data command is used to immediately restore the complete default configuration setting. The Write Configuration Data command must be used to save these settings permanently.

9.2.6. Show Version, Configuration Command (V1234)

This command causes the current configuration settings and other information about the sensor to be transmitted out the serial port.

If sampling is on, use a data capture program to save the information in a file for viewing. Sampling can be turned off (H2) to keep the information from scrolling off the screen, but that changes the sampling mode that is displayed by the command.

The following is sample output from the command:

```
AR700-0.500 Rev 0.10 - Copyright 2007-2008, Schmitt Industries, Inc.
Zero Point: 0
Span Point: 50000
Sample Interval: 40000
Analog Output Mode: Zero Based Current
Background Light Elimination: On
Sampling Mode: On
Serial Mode: RS232
Baud Rate: 9600
Output Data: Zero Based English
Error Mode: Code
Sample Priority: Rate
Serial Output Flow Control: Off
Limit 1: 0
Limit 2: 50000
Exposure Limit: 80
Class 3B: NO
Serial Number: 000001
```

In addition to the configuration settings, the output contains the sensor's model (Road Profiler and Range), firmware revision, serial number, and information on whether the laser is class 3B.

9.2.7. Show Version Command (V1235)

This command causes the model, firmware version, and serial number of the sensor to be transmitted out the serial port.

10. AR700 Command Set

The AR700 commands are used to operate the sensor, change the sensor's configuration, or check the configuration. There are two different means provided to command the sensor, although their capabilities doesn't completely overlap.

- Commands may be sent over the serial port. The serial commands provide the best resolution for most settings, but can't be used to set the Serial Communications Mode (RS232, RS422, etc). The serial commands use ASCII characters and any device that can communicate over a serial port may send the commands.
- Commands may be entered manually by using the function button and the function display LEDs. The function button provides limited resolution, but is required for setting the Serial Communications Mode.

Configuration settings may be retained through power cycling with the Write command (see Nonvolatile Memory Storage – section 9).

10.1. 'Current Status' Commands (Z, U, J, K, M)

Several commands may be used to acquire the current location or current exposure as the command's parameter value. When using these commands, make sure the target is stable and the sensor is actively measuring the target (sampling is not off, etc.) to ensure that a valid measurement is acquired for the command.

10.2. Serial Command Operation

The sensor is always receptive to serial commands. Once a command is recognized as complete, it is executed immediately.

10.2.1. Serial Command Communications

Serial commands may only be processed when the serial port characteristics match the serial communications mode and baud rate.

Use the function button to set the Serial Communications Mode (RS232 or RS422).

Although the baud rate may be set using the serial commands, it may be easier to set the baud rate using the function button.

10.2.2. Serial Command Format

ASCII commands have a general form of a command letter, an optional parameter value made of up to 6 numeric digits, and may optionally have a terminating character.

Each command letter represents a different command. The letter is not case sensitive. It may be upper or lower case.

Some commands do not have parameters. They are executed as soon as the letter is received.

The remaining commands may be followed by a parameter value made of up to six numeric digits. The maximum number of digits depends on the individual command. For some commands the parameter is optional.

Commands with incorrect parameters are ignored.

The following all send a valid Sample Interval command with parameter = 50:

```
S50/        (Terminating character [slash] after only 2 of 6 digits entered.)
s000050     (Executed automatically after 6th digit entered.)
S50A2       (The 'A' command [Serial Output Control] terminates the 'S' command.)
```

10.2.3. Serial Command Execution

Each command is executed when it is recognized as complete. There is no specific termination character. Commands are completed in the following ways:

- When the maximum number of parameter digits is received. Note that for some commands the maximum number of digits is zero and the command letter itself is the complete command.
- When a non numeric character is received. This may be a new command letter or some other character such as a period, slash, space, or Carriage Return (<CR>).

It is advisable to terminate a command if uncertain as to whether is has been terminated. Use a character such as period, slash, space, or <CR> to ensure immediate command execution. Extra characters of this type have no ill effects.

When a command is executed, it is first evaluated. If the parameter is valid the command execution is completed. A command with an invalid command is ignored.

Commands are executed in the order received. A command's execution is completed before the next command is evaluated.

10.2.4. Serial Command Response

There is no acknowledgement character from the sensor when a command is received, evaluated, or executed. If the command is a valid it will be executed. If the command is not valid it is ignored.

All commands interrupt the sampling process momentarily when they are executed. In some cases this is negligible. Commands that change non-volatile memory may take up to 100 ms to complete. Commands that alter the sampling mode cause a restart of sampling.

Multiple commands may be grouped together in a single transmission. However, sending more than 10 characters in a single transmission at high baud rates may result in loss of characters.

In RS232 mode, the sensor always uses the RTS signal to indicate when there is a danger of losing characters. Enable hardware flow control on the sending system to avoid the loss of characters. The sensor does not send software flow control characters.

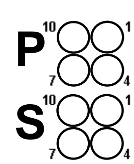
Note that a special response is returned for the V command.

10.3. Function Button Command Operation

The function button is used in conjunction with the function display LEDs in order to display or change many of the configuration settings (or parameter settings).

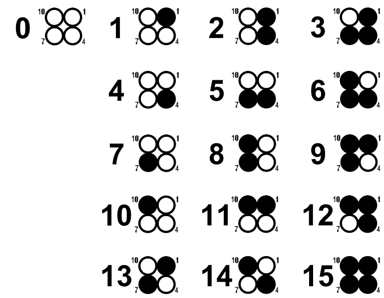
10.3.1. Function Display LEDs

There is only one button on the sensor, the function button. Below the function button are the function display LEDs. They are organized as two sets of four LEDs. The LEDs marked P represent the function **P**arameter and the LEDs marked S represent the parameter **S**etting.



10.3.2. Function Display LED codes

Each set of LEDs has 16 different combinations in which the LEDs can be illuminated to represent numbers. They are shown here (black dot = ON). Note that the LEDs are illuminated in groups in a clockwise direction. The first illuminated LED is next to a number (1, 4, 7, or 10). Add 1 to this number for each extra illuminated LED. For example, number 8 has #7 as the first illuminated LED (going clockwise) plus one more is 8. 13, 14 and 15 don't fit this rule, but the illumination patterns shown represent the indicated values.



10.3.3. Function Button: Displaying a Parameter

Normally all function display LEDs are off and the "LASER ON" LED is on indicating normal operation. There is no parameter number zero. This condition indicates that the function display is idle, no parameters are displayed.

Each momentary push of the function button (less than one second) will advance the display to the next parameter. All parameters can be viewed in increasing order, one at a time. After the last parameter, a momentary push of the function button cycles the display back off.

For each parameter displayed, the setting for that parameter is displayed on the setting LEDs.

The setting LEDs will display 0 (all off) if the parameter's current setting does not match one of the possible selections available from the function button. For example, there are nearly a million possible settings for the Sample Interval parameter, but only fifteen possible setting values are available from the function button.

If a parameter has been displayed for ten seconds without a push of the function button, then the function display will return to idle. The LEDs will go off.

10.3.4. Function Button: Changing a Setting

The function button can be used to change the setting of a displayed parameter. While the parameter is being displayed, the setting LEDs do not flash. Push and hold the function button for at least one second. The next available setting for that parameter will flash continuously on the setting LEDs. Note that the parameter LEDs continue to display the parameter value and do not flash.

A value flashing on the setting LEDs indicates an available setting value, not the current setting value.

Each momentary push of the function button (less than one second) will advance the setting LEDs to display the next available setting value (again, flashing). After the last available setting is displayed, a momentary push of the function button cycles the setting LEDs back to displaying the current setting (not flashing).

When the desired selection is flashing, push and hold the function button for at least one second. The selection will become active and the settings LEDs will stop flashing and display the current setting for the parameter, normally the one selected.

Some parameter settings are functions and not settings, so the display will not show the function that was activated, but instead revert to the current parameter setting.

If a setting has been flashing for ten seconds without a push of the function button, then the function display will return to displaying the current setting (not flashing).

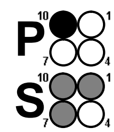
10.3.5. Function Display Error Codes

The function display error codes will display by flashing all LEDs. Typical error codes have the parameter LEDs all off, so they don't flash while the setting LEDs flash. Common codes are shown in the Troubleshooting section.

10.4. Saving the Configuration

Any configuration changes will not be saved unless a Write Configuration Data command is issued before turning off the power. This can be done using either serial communications or the function button.

The serial command is "W1234".



The function button is parameter 10 setting 9. Push the function button (10 times) until parameter 10 is displayed on the parameter LEDs. Push and hold the function button until the setting LEDs flash. Push the function button several times until the setting LEDs flash the code for "9". Push and hold the function button until the setting LEDs stop flashing. The configuration is saved.

11. Serial Command Quick Reference

The maximum number of digits is shown. Example: Snnnnnn indicates 6 digits maximum.

AR-700 Configuration Data Settings (Serial)			Function Button Parameter	Default
Command Name	Serial Command	Serial Code / Function		
Sample Interval	Snnnnnn	21 = Interval = 999999 (5μs increments) (f = 200,000/S)	3	S40000 (5Hz)
Zero-Point	Z	(none) Saves present location as Zero-Point	1	Z0
	Znnnnn	0 = Zero-Point = 50000 (where 50000 = full scale)		
Sampling Control	Hn	1 = On – continuous output – laser is on 2 = Off – laser is off (no output) 3 = Off – laser is on (no output, but tracks exposure) 4 = Hardware Trigger Mode – laser is off (no output)	6	H1 (On)
Serial Flow Control	Tn	1 = On: Hardware (Any chars Transmit only if CTS is true) 2 = Off (Always transmit) 3 = On: Software (CTRL-S stops sample output, CTRL-Q allows)	8	T2 (Off)
Serial Output Control	An	0 = Zero Based Native (0-50000) (Zero-Point Subtracted, negatives = 0) 1 = Zero Based English Units 2 = Zero Based Metric Units 3 = Off 4 = Offset Based Native (Zero-Point subtracted, negatives reported) 5 = Offset Based English 6 = Offset Based Metric 7 = Unbiased Native (Zero-Point ignored) 8 = Unbiased English 9 = Unbiased Metric	11	A1 (in)
	Nn	0 = Zero Based 3-Byte Binary 1 = Zero Based 2-Byte Binary 2 = Unbiased 3-Byte Binary 3 = Unbiased 2-Byte Binary		
Baud Rate	Bn	1 = 300, 2 = 1200, 3 = 2400, 4 = 4800, 5 = 9600, 6 = 19200, 7 = 38400, 8 = 57600. 9 = 115200, 0 = 230400	7	B5 (9600)
Span-Point	U	(none) Saves present location as Span-Point	2	U50000 (Full)
	Unnnnn	0 = Span = 50000 (where 50000 = full scale)		
Limit 1	J	(none) Saves present location as Limit 1	13	J0
	Jnnnnn	0 = Limit 1 = 50000 (where 50000 = full scale) if J=K then {toggle limit2, limit1: if J>30000 then ON else OFF = GOOD}		
Limit 2	K	(none) Saves present location as Limit 2	14	K50000
	Knnnnn	0 = Limit 2 = 50000 (where 50000 = full scale) if J=K then {toggle limit2, limit1: if J>30000 then ON else OFF = GOOD}		
Analog Output Control	Xn	1 = Zero-Span Based Current Loop (4 - 20 ma) 2 = Zero-Span Based Voltage (0 – 10 V) 3 = Unbiased Current Loop (4 - 20 ma) 4 = Unbiased Voltage (0 – 10 V) 5 = Off	4	X1 (Cur Loop)
Background Light Elimination Mode	Ln	1 = On (Difference of alternate sample with laser on/off) 2 = Off (Laser is on for every sample) 3 = RP (Selects Road Profile Mode – In RP version only – default in RP)	5	L1 (On) L3 (RP)
Sample Priority	Pn	1 = Sample Quality has priority over sample rate 2 = Sample Rate has priority over sample quality (Forced in RP mode)	12	P2 (Rate)
Error Report Mode	Qn	1 = Send Error Code (E1..E5) 2 = Send '+' prefix to output value (above range limit) 3 = Send output value (above range limit, the only binary error mode)	10	Q1 (Code)
Read Configuration Data	R	(none) Restores saved settings (also done at power on)	10	-
Write Configuration Data	Wnnnn	1234 = Save the current settings	10	-
Initialize Configuration Data	I Q8	(none) Restore Default, excluding Serial Communications and Baud Rate Restore Default, including Serial Communications and Baud Rate	10	-
Take Single Sample	E	(none) Valid when Sample Mode is not On (not H1)	-	-
Show Version, Configuration	Vnnnn	1234 = Send the current version and configuration (Response is very long) 1235 = Send the Model, version, and serial number (Short response)	-	-
Exposure Limit	M	(none) uses current exposure x 1.5 as Max Exposure	15	M80 (MAX)
	Mnn	0 <= nn <= 80; use MAX x 2**(0.25 * (nn-80)) as Max Exposure		
Serial Communication Mode	-		9	1 (RS232)

12. Function Button Command Quick Reference

Command Name	Serial Command	AR-700 Configuration Data Settings (Function Buttons): Function Button Parameter	Function Button Setting (**X**), *Special Function Codes	Default
Sample Interval	S	3	1 = S40, 2 = S100, 3 = S400, 4 = S1000, 5 = S4000, 6 = S10000, **7** = S40000, 8= S100000, 9 = 400000, 10 = S999999 (5 µs increments, F=200000/S)	7 (5Hz)
Zero-Point	Z	1	1 = Uses present location as Zero-Point **2** = 0, 3 = 10000, 4 = 20000, 5 = 30000, 6 = 40000, 7 = 50000	2 (0)
Sampling Control	H	6	**1** = On – continuous output – laser is on 2 = Off – laser is off 3 = Off – laser is on 4 = Hardware Trigger Mode – laser is off (no output)	1 (On)
Serial Flow Control	T	8	1 = Hardware (transmit character disable by CTS) **2** = Off (transmit not disabled) 3 = Software (transmit sample disabled by CTRL-S, enabled by CTRL-Q)	2 (Off)
Serial Output Control	A	11	10 = Zero Based Native **1** = Zero Based English Units 2 = Zero Based Metric Units 3 = Off 4 = Offset Based 5 = Offset Based English 6 = Offset Based Metric 7 = Unbiased Native 8 = Unbiased English 9 = Unbiased Metric	1 (inch)
	N		11 = Zero Based 3-Byte Binary 12 = Zero Based 2-Byte Binary 13 = Unbiased 3-Byte Binary 14 = Unbiased 2-Byte Binary	
Baud Rate	B	7	1 = 300, 2 = 1200, 3 = 2400, 4 = 4800, **5** = 9600, 6 = 19200, 7 = 38400, 8 = 57600, 9 = 115200 10 = 230400	5 (9600)
Span-Point	U	2	1 = Uses present location as Span-Point 2 = 0, 3 = 10000, 4 = 20000, 5 = 30000, 6 = 40000, **7** = 50000	7 (50000)
Limit 1	J	13	1 = Uses present location as Limit 1 **2** = 0, 3 = 10000, 4 = 20000, 5 = 30000, 6 = 40000, 7 = 50000	2 (0)
Limit 2	K	14	1 = Uses present location as Limit 2 2 = 0, 3 = 10000, 4 = 20000, 5 = 30000, 6 = 40000, **7** = 50000	7 (50000)
Analog Output Control	X	4	**1** = Zero-Span Based Current Loop (4 - 20 ma) 2 = Zero-Span Based Voltage (0 – 10 V) 3 = Unbiased Current Loop (4 - 20 ma) 4 = Unbiased Voltage (0 – 10 V) 5 = Off	1 (Cur Loop)
Background Light Elimination	L	5	**1** = On 2 = Off 3 = RP (Road Profile version only – default in RP version)	1 (On) 3 (RP)
Sample Priority	P	12	1 = Quality 2 = Rate (Forced in Road Profile mode)	2 (Rate)
Error Report Mode	Q	10	**1** = Codes (E1..E5) 2 = Send '+' prefix to values (above range limit) 3 = Send output value (above range limit, the only binary error mode)	1 (Code)
Read Configuration Data	R	10	*6 = Restore saved settings	-
Write Configuration Data	W	10	*9 = Save the current settings	-
Initialize Configuration Data	I Q8	10	*7 = Restore Default, excluding Serial Communications and Baud Rate *8 = Restore Default, including Serial Communications and Baud Rate	-
Take Single Sample	E	-	n/a	-
Show Version, Configuration	V	-	n/a	-
Exposure Limit	M	15	15 = uses current exposure * 1.5 as Max Exposure nn = 6***X**-4 (**X**:nn -> 1:2, 2:8, 3:13, 4:20, 5:26, … 13:74, **14**:80)	14 (80)
Serial Communication Mode	-	9	**1** = RS232, 2 = RS422, 3 = RS422 Terminated	1 (RS232)

13. Command Index

See the two quick reference chapters (sections 11 and 12) for programming reference (not operation).

All commands and their interactions are described in detail in the operation section appropriate for each command.