

Acuity[®]

AR100™ Super Compact Laser Sensor

User's Manual



For use with AR100™ Super Compact Triangulation Sensor
January 15, 2021

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User's Manual for the
AR100™ Series Laser Sensor
Rev.1.3.1

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1. Introduction

This section is a guide to getting started with the AR100 and this manual. The AR100 has a number of configurable parameters, but many applications can use the sensor in its default factory configuration. This manual contains information for a variety of AR100 sensor configurations that can be ordered from Acuity. Your specific AR100 model may not have all interfaces and functions described in this manual.

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 Alarm 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
 - Alarm Output Operation – alarm settings
 - Performance Optimization – Sample Rate, Background Elimination, Exposure control
 - AR100 Command Set – explains all commands for customizing the application

1.1 General Overview

The AR100 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, communications interface, and laser diode option. Models vary in range from 10 to 500 mm. Interface options include RS232, RS485, 4-20mA, and 0-10V.

The accuracy is generally specified with a linearity of about +/- 0.05% of the range.

A variety of configuration settings can be selected via the serial port. The complete list of settings is found in the AR100 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. Several other configurable parameters enhance the performance. Sampling may be turned on and off. It can even be triggered using an input signal wire or a serial command.

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.

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

Do not operate the sensor in areas Where: the sensor case is exposed to direct sunlight for extended periods or Where: the air temperature is more than 50°C (122°F) or less than -10°C (-14°F).

Don't allow fast temperature variations during sensor operation.

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

Do not operate the sensor if the lens is fogged or dirty.

Do not scratch the lenses on the front face of the sensor. Keep the lenses clean with expert optical procedures. The lenses are glass with an anti-reflection coating. Avoid the use of organic cleaning solvents.

Do not touch the lenses with bare fingers. The oils are very difficult to remove.

Operate only with DC supply voltages between 9 and 36 volts.

1.2 Definition of Terms

Sensor – The complete AR100 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. For the AR100, it is visible (Red or Blue) radiation.

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

Base Distance – The distance from the face of the laser to the start of the measurement window (range).

1.3 Quick Start Instructions

This will get the sensor running in its factory default configuration.

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

1.3.1 Mounting

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 is not obstructed. Use a piece of paper such as a business card to insert into the beam to use as a measurement target. The laser should be aimed at a target such that the distance from the reference point to the target can be measured.

Mount the sensor in such a way that the case is not twisted or warped. The AR100 can be screwed on using two fastening screws $\phi 2.8$. The fastening screws are not included in the scope of delivery.

Attach the cable(s) 8-pin connector to the plug(s) on the rear of the sensor.

Connect the red (Supply +) and brown (Ground) wires of the sensor cable to a 9 to 36 volt DC power supply (or use the power supply if the sensor came with one).

1.3.2 Serial Data Wires

The serial connection is required to set up a unit for operation. If not using the Acuity Connectivity kit which includes a serial cable, the customer must make their own D-sub 9 serial connector

1.3.2.1 RS232 serial

Connect the RS232 wires to a 9 pin D-SUB male connector that can be plugged into a COM port of a PC (RS232): Gray (Ground) to pin 5, Green (Transmit) to pin 2, and Yellow (Receive) to pin 3. See section 0.

Use the Demo and Configuration Software (see Section 9) to connect to the sensor via the serial port and get distance measurements.

1.3.2.2 RS485 serial

Connect the RS485 wires to a RS485 adapter connected to a PC COM port Gray (Ground) to pin 5, Green (Data+) to pin 2, and Yellow (Data -) to pin 3. See section 0.

Follow the same instructions for RS232 serial above.

1.3.3 Analog Output Signals

Quick suggestion: connect a DVM (digital volt meter) to the wires: Gray to Common, Blue to mA input. Type QA. The output is a 4-20mA current loop from 0 to the maximum range. The meter should read near 4 mA when a target is placed in the laser beam near 0 mm and 20 mA near the end of the range

2. General Description

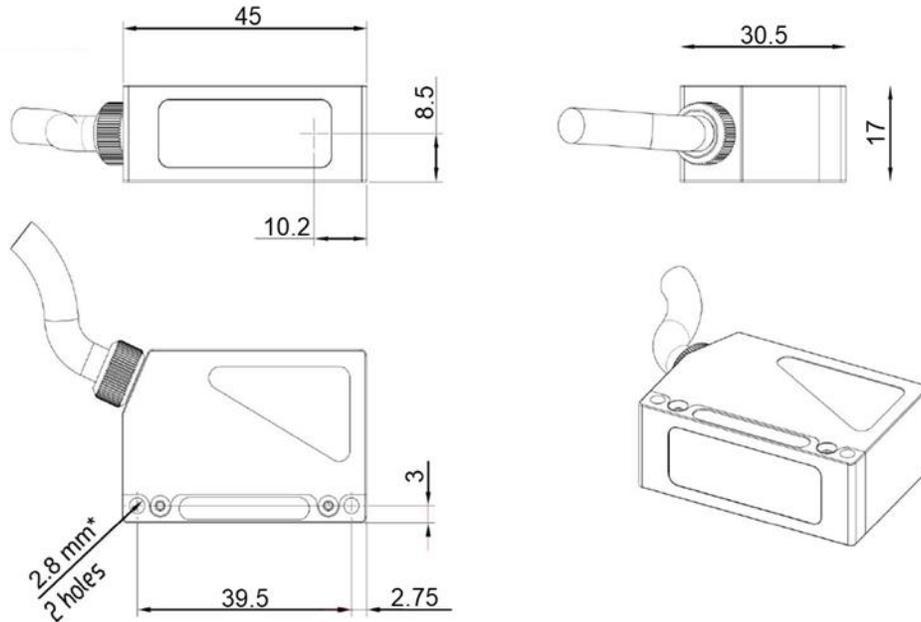
The AR100 is an ultra-compact laser diode-based distance measurement sensor with available ranges covering 10 to 500 mm. Consult the AR100 data sheet for exact model range availabilities. The accuracy is generally specified with an absolute linearity of +/- 0.05% of the range with a resolution of 0.01% of the span for ranges up to the 250 mm model, and an absolute linearity of +/- 0.10% of the span with a resolution of 0.02% of the span for the 500 mm range model. Linearity will vary depending on sample averaging, temperature, target stability and surface reflectivity of the target surface. The AR100 laser sensors can be ordered with a variety of red or blue laser diodes and a variety of data interfaces. The sensor can be triggered externally and also has logic outputs to trigger alarms, etc.

2.1 Principles of Operation

The AR100 uses laser triangulation principles to measure distance. The laser beam is projected from the housing's aperture and shines on a target surface, where it creates a small spot. From there, the laser light is scattered in all directions for diffuse surfaces (mirrors reflect the light specularly). A collection lens is located behind a window in the sensor. It collects a portion of the reflected light, which is focused on a CMOS detector array. The linear position of this reflected spot is converted to an electrical signal which is proportional to the target distance relative to the sensor. The position is processed and communicated via serial, analog, or digital interfaces.

2.2 Mechanical Dimensions

The following diagram shows the mechanical dimensions for the AR100. The sensor's housing is made of anodized aluminum. The front panel of the housing has a glass window. The housing also contains mounting holes. The cable is mounted on the sensor without connector.

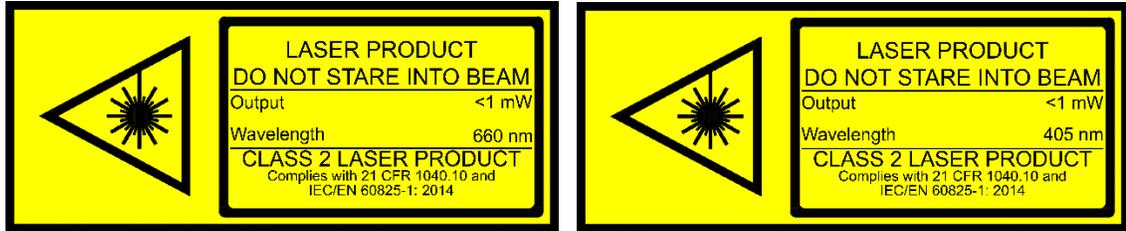


2.3 Installation

The AR100 sensor unit is typically installed by affixing the sensor to a machined bracket with bolts through the two mounting holes on the side of the sensor. Their location is shown in the mechanical drawing in the previous section. Note that the zero point is NOT the glass window, but instead a distance from the glass window called the **base distance**. Most brackets will have adjustment capabilities so the AR100's laser can be aimed in X, Y and Z coordinates.

2.4 Laser Safety

The sensors make use of a c.w. 660 nm (or 405 nm, 450 nm) wavelength semiconductor laser. The maximum output power is 0.95 mW. The sensors belong to laser safety class 2. The following warning label is placed on the sensor body:



The following safety measures should be taken while operating the sensor:

- Do not disassemble the sensor;
- Avoid staring into the laser beam.

2.5 Sensor Maintenance

The AR100 sensor and module require little maintenance from the user. The sensor lens should be kept clean of dust buildup as a part of regular preventative maintenance. Use compressed air to blow dirt off the windows or use delicate tissue wipes. Do not use any organic cleaning solvents on the sensor. If your sensor does not function according to specifications, contact Schmitt Industries, Inc. Do not attempt to loosen any screws or open the sensor housing.

2.6 Sensor Service

The AR100 sensor is not user-serviceable. Refer all service questions to Schmitt Industries, Inc. Do not attempt to loosen any screws or open the sensor housing.

2.7 Sensor Specifications

Units in mm unless noted.

Model AR100		-10	-25	-50	-100	-250	-500	
Base distance X, mm (in.)		20 (0.79)	20 (0.79)	30 (1.18)	55 (2.17)	65 (2.56)	105 (4.13)	
Range, mm		10 (0.39)	25 (0.98)	50 (1.97)	100 (3.97)	250 (9.87)	500 (19.69)	
Linearity, %		±0.05 % of the Full-Scale range					±0.10 %	
Resolution, %		0.01 % of the Full-Scale range (for digital output)					0.02%	
Temperature drift		0.02% range/°C						
Maximal sampling rate, Hz		9,400 Hz						
Light source		Red semiconductor laser, 660 nm wavelength or UV semiconductor laser 405 nm wavelength (BLUE version)						
Output power, mW		≤1						
Laser safety Class		2 (IEC60825-1)						
Output Interface	Digital	RS232 (max. 460.8 kbit/s) or RS485 (max. 460.8 kbit/s)						
	Analog	4 ... 20 mA (load ≤ 500 Ohm) or 0-10 Volts						
Trigger input		2.4 - 24 V (CMOS, TTL)						
Logical output		Programmed functions, NPN: 100 mA max; 40 V max for output						
Power supply, V		24 (9-36) Volts						
Power consumption, W		1.5-2.0 Watts						
Environmental Resistance	Enclosure rating	IP67						
	Vibration	20g/10 - 1000Hz, 6 hours, for each of XYZ axes						
	Shock	30 g / 6 ms						
	Operation temperature, °C	-10 - +50 °C						
	Permissible Ambient light, lx	10,000						
	Relative humidity	5-95% (no condensation)						
	Storage temperature	-20 - +60, °C						
Housing material		aluminum, glass windows						
Weight (without cable)		40 grams						
Size, mm (in.)		17x45x30.5 (0.67x1.77x1.2)						

Note: Specifications may change with future revisions.

3. Installation and Checkout

3.1 Mounting

Mount the sensor in such a way that the case not twisted or warped. Do not clamp or squeeze the sensor case excessively. If the case is distorted, the sensitivity and accuracy of the sensor may be affected.

3.2 Cabling for sensor unit

The AR100 sensor has a multipurpose cable with 8 conductors (included).

The standard cable is LiYCY (TP) a flexible, overall shielded, PVC twisted-pair data transmission cable for use in flexible and stationary applications under low mechanical stress with free movement without any tensile stress, loads or forced movements in dry, damp and wet conditions. The twisted pair construction reduces interference (crosstalk) within the cable while the tinned copper braid shield offers optimum protection from electrical and electromagnetic interference. The AR100 is not suggested for outdoor use.

The standard cable length is 5m in length. Longer cable lengths are available upon request. Connection according to the instructions is essential for correct sensor operation. Read the wire descriptions in Section 4.1 for connection information.

3.3 Standalone Cabling

To use the AR100 sensor unit 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 alarm output wire connecting to your data display, recording, or control equipment. See Signal and Power Interface (section 4) for wire connections. In its default configuration, the AR100 should stream measurement distances 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. To reduce noise, it is recommended to install RC (resistor-capacitor) filter before the measuring instrument. The filter capacitor value is indicated (in section 4.4) for maximum sampling frequency of the sensor (9.4 kHz) and this value increases in proportion to the frequency reduction. An out-of-range current indicates a sensor measurement error.

The alarm output wire can be used to connect to control equipment.

3.3.1 Serial Connection to a Host Computer

The simplest way to connect the AR100 sensor to a PC for initial configuration or regular distance measuring is with the use of an Acuity Connectivity Kit. This is a sealed connection box which contains terminal blocks for each wire lead. It also has an AC power supply and a 2m RS232 serial cable for connection to a PC. There is also a version that includes a serial-to-USB connector. Without the Acuity connectivity kit, the user must connect a DB9 plug to the cable using the directions below.

Each AR100 is configured for either RS232 **or** RS485 serial communications. Please be sure to confirm the serial communication standard used by the control system you intend to use before ordering. If you have an AR100 with the incorrect standard for your application, a third-party converter will be necessary.

RS232: An AR100 with the RS232 option can be wired directly to a 9-pin D-sub serial connector using the table below.

Wire Color	Function	DB9 pin #
Gray	Ground	5
Green	TxD / Data+	2
Yellow	RxD / Data -	3

To connect the AR100 this way to a modern PC, you will likely need a serial to USB converter. Acuity recommends using a converter that contains an FTDI chip. Contact Acuity for this option.

RS485: To wire an AR100 with the RS485 option to a 9-pin serial connector, please refer to the wire functionality chart in section 4 for details.

3.4 Power On

Connect a power supply to the power and ground lines of the sensor cable. The AR100 can operate with a power supply supplying 9-36 volts. Acuity recommends a 15 or 24 volt power supply. 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.

When power is applied the laser beam will be emitted from the round sensor window.

3.4.1 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 or is in a polling mode.

Use the Demo and Configuration Software to restore the unit to factory defaults. Otherwise, the **04h** command will restore factory defaults to the device.

3.4.2 Sensor Output Check

If the sensor output value is in error, check that the sensor and target are stationary and stable and that the laser beam is hitting the target.

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

4.1 Sensor Cable, Wire Colors and Functions

The AR100 sensor includes a hardwired cable (sensor cable) with solder tail wires. Connection according to the instructions is essential for correct sensor operation. Read the wire descriptions for connection information.

The table below shows the wiring on systems ordered without a power supply.

Wire	Function in All Modes
White	Trigger Input
Brown	Ground (Power)
Green	TxD (Data +)
Yellow	RxD (Data -)
Gray	Ground (Signal common)
Pink	Logic Output (programmable)
Blue	Analog output (current loop / voltage)
Red	Power, Voltage in

4.2 Power Supply (Red, Brown)

The Brown wire is the Power Supply Common return, also named Ground. It carries the return current for the power supply.

The Red wire is the Power Supply Input to the sensor. The sensor requires +9 - 36 VDC power and consumes 1.5 – 2 Watts of power (< 250mA draw) depending on the sensor's configuration.

Power supplies from 9 VDC to 36 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 9 VDC may result in inaccurate measurement readings or non-functionality.

4.3 RS232 / RS485 Serial Comm. (Green, Yellow)

Your sensor is configured with either RS232 or RS485 communications

See Serial Interface Operation (section 5) for information on commands and data. The maximum baud rate is 921.6 KBaud for both RS232 and RS485.

RS232: RS232 is normally used for shorter distances of communications and slower data rates. RS232 allows only one transmitter and one receiver per network. A standard 9-pin D-SUB RS232 serial female connector can be built to interface with a PC or a serial to USB converter using connection the pins below.

Color	Pin on DSUB 9 connector	Function
Green	2	Transmit data from sensor
Yellow	3	Receive data to sensor
Gray	3	Signal ground reference
N / C	1, 4, 6	DCD, DTE, DCE – These three signals can be tied together to satisfy some PC signal requirements for hardware handshake.
N / C	7, 8	CTS, RTS – These two signals can be tied together to satisfy some PC signal requirements for hardware handshake.

RS485: RS485 is normally used for longer distances of communications and faster data rates. Multiple devices can share one line because RS485 is multi-drop. If you do not have a computer or controller or PLC that supports RS485 communications, it may be necessary to use a commercial RS485 to RS232 converter.

4.4 Analog Output (Blue, Grey)

Your sensor is configured with either 4-20mA current loop or 0-10V voltage analog output.

The Grey 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. The analog signal for distance is a 4-20 mA current loop or 0-10V signal.

In Current Loop / Voltage Blue wire delivers a current (or voltage for sensor ordered with Voltage output) proportional to the measured distance. The resolution is characterized by a 16-bit digital-to-analog converter.

4.4.1 Current Loop

The current loop connection scheme is shown in the Figure 1. The value of load resistor should not be higher than 500 Ohms. To reduce noise, it is recommended to install an RC (resistor / capacitor) filter before the measuring instrument. The filter capacitor value is indicated for maximum sampling frequency of the sensor (9.4 kHz) and this value increases in proportion to the frequency reduction.

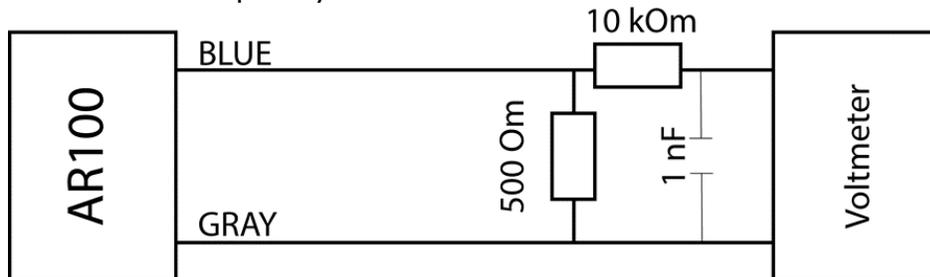


Figure 1 Wiring Diagram for Current Loop output

4.4.2 Voltage Output

The voltage output connection scheme is shown in the. To reduce noise, it is recommended to install an RC (resistor / capacitor) filter before the measuring instrument. The filter capacitor value is indicated for maximum sampling frequency of the sensor (9.4 kHz) and this value increases in proportion to the frequency reduction.

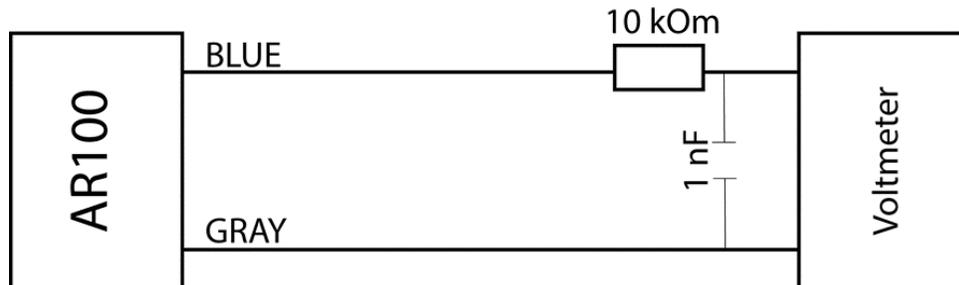


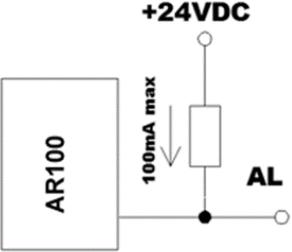
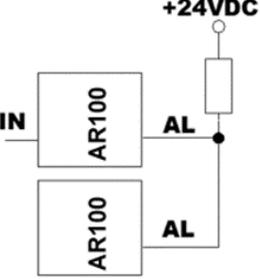
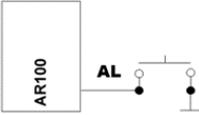
Figure 2 Wiring Diagram for Voltage output

4.5 Logic Outputs (Pink, Grey)

The Pink wire is a multi-purpose logic output / interface that can operate in eight distinct modes. The functionality can be configured according to the instructions in section 7 . Functions include distance alarms, multi-sensor synchronization, setting of Zero Point via hardware control, encoder input, and control of the laser ON / OFF state.

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

The Logic Output is an open collector NPN transistor switch to the Ground for Signal (Grey). When the Alarm Output is not active, its output will be high impedance and no current will flow through it. When the Alarm Output is active (On) it can source up to 100mA of current. The voltage on the Alarm wire must not exceed 24 VDC.

Distance Alarms	Multi-sensor Synchronization	Zero point set / Laser On / Off control
		
<p>Figure 3 Wiring Diagram for Distance Alarms</p>	<p>Figure 4 Wiring Diagram for Multi-sensor synchronization</p>	<p>Figure 5 Wiring Diagram for Zero point control and Laser On / Off</p>

5. Serial Interface Operation

This section refers to serial communication protocols for both the Sensor and Module versions of the AR100.

5.1 Binary Communications Protocol and Syntax

Serial port communication is required to configure the AR100 for operation. The easiest way to communicate is by using a PC with an RS232 communication port and a terminal emulation program that uses hexadecimal binary format. The factory default baud rate is 9600 bits/second.

Through these serial interfaces measurement data can be obtained by two methods:

By single requests

- Automatic streaming data
- The serial data transmission byte has the following format:

1 start-bit	8 data bits	1 even bit	1 stop-bit
-------------	-------------	------------	------------

The communications protocol is formed by communication sessions (commands), which are only initiated by the 'master' (PC, controller). There are two kinds of sessions with such structures:

1. "request", ["message"] – ["answer"], square brackets include optional elements
2. "request" – "data stream" – ["request"].

5.1.1 Request

"Request" (INC) – is a two-byte message, which fully controls the communication session and can be transmitted by the 'master.' The 'request' message is the only one of all messages in a session Where: the most significant bit is set at 0, therefore, it serves to synchronize the beginning of the session. In addition, it contains the device address (ADR), code of request (COD) and optional message [MSG].

"Request" format:

Byte	Bits								Description
	7	6	5	4	3	2	1	0	
0	0	ADR							Network address
1	1	0	0	0	COD			Code of request	
2	1	0	0	0	MSG[0] lo			Lower tetrad of the 0 th byte	
3	1	0	0	0	MSG[0] hi			Higher tetrad of the 0 th byte	
4	1	0	0	0	MSG[1] lo			Lower tetrad of the 1 st byte	
5	1	0	0	0	MSG[1] hi			Higher tetrad of the 1 st byte	
...				

5.1.2 Answer

An 'answer' is a data burst that can be transmitted by a 'slave' during the course of the session.

All messages with an 'answer' burst contain 1 in the most significant digit. The data in a message is transferred in nibbles (aka: "tetrads"). When a byte is transmitted, the lower tetrad goes first, and then follows the higher tetrad. When multi-byte values are transferred, the transmission begins with lower byte.

When 'answer' is transmitted, the message contains:

- SB-bit, characterizes the updating of the result. If SB is equal to "1" this means that the sensor has updated the measurement result in the buffer, if SB is equal to "0" - then non-updated result has been transmitted (subject to sampling period). SB=0 when parameters transmit;
- Two additional bits of cyclic binary batch counter (CNT). Bit values in the batch counter are identical for all transmissions of one batch. The value of batch counter is incremented by the sending of each burst and is used for formation (assembly) of batches or bursts as well as for control of batch losses in receiving data streams.

The following is the format of two 'response' data bursts for transmission of a byte:

Byte	Bits								Description
	7	6	5	4	3	2	1	0	
0	1	SB	CNT		MSG[0] lo				Lower tetrad of the 0 th byte
1	1	SB	CNT		MSG[0] hi				Higher tetrad of the 0 th byte
2	1	SB	CNT		MSG[1] lo				Lower tetrad of the 1 st byte
3	1	SB	CNT		MSG[1] hi				Higher tetrad of the 1 st byte
...				

All values are given in binary form. The Base distance and range are given in millimeters. The value of the result transmitted by a sensor (D) is so normalized that 4000h (16384) corresponds to a full range of the sensor (S in mm), therefore, the result in millimeters is obtained by the following formula:

$$X=D*S/16384 \text{ (mm)} \quad (1).$$

On special request (**05h**), the current result can be latched in the output buffer where it will be stored unchanged up to the moment of arrival of request for data transfer. This request can be sent simultaneously to all sensors in the net in the broadcast mode in order to synchronize data pickup from all sensors.

To issue requests with sizes greater than one byte, set the high byte 'session' then send the low byte request 'session'.

Refer to Section 10 for a list of all requests and parameters.

5.1.3 Data Stream

'Data stream' is an infinite sequence of data bursts or batches transmitted from 'slave' to 'master', which can be interrupted by a new request. In transmission of the 'data stream' one of the 'slaves' fully holds data transfer channel, therefore, when 'master' produces any new request sent to any address, the data streaming process is stopped. Also, there is a special request to stop data streaming.

5.1.4 Saving to Non-Volatile (FLASH) Memory

When adjusting parameter values, all changes are discarded when the AR100 is powered OFF unless a command is made to save these changes to the FLASH memory.

To save any changes to the FLASH memory, input 0 for binary parameter **04h**. This must be done every time a save is desired.

5.1.5 Recover AR100 Factory Settings

To recover all factory settings, input 1 for binary parameter **04h**.

5.2 ASCII Communications Protocol

There is now an option to switch the AR100's output to an ASCII based format that may make the data easier to read for those using only a terminal emulator to operate the laser. The AR100 is set by default to binary output.

The output can be changed to ASCII output using binary parameter **8Ah**.

- Value "0" is binary communications.
- Value "1" is ASCII communications.

Once the output is changed ASCII request codes can be entered by typing the code and desired value (when necessary) and pressing enter. In subsequent chapters, ASCII request codes will be written in the form of [code]x where "x" is the desired value (Example: code Ax determines whether analog output is on or off. A1 turns analog on, and A0 turns analog off.)

To change the output back to binary, use the ASCII command "**PRT**"

5.2.1 Saving to Non-Volatile (FLASH) Memory

To save any changes to the FLASH memory, use ASCII command **W0**.

5.2.2 Recover AR100 Factory Settings

To recover all factory settings, use ASCII command **W1**.

Note: This will not return the laser to binary communications.

6. Analog Output Operation

AR100 sensors can be ordered with either 4-20mA or 0-10 V analog outputs. The analog outputs use the same two wires. Please refer to Section 4.4 for connection details.

The analog output is updated with each sample measured. The analog output will deliver a current which increases linearly from 4 mA (or 0 volts) at the range beginning point to 20 mA (10 volts) at the range end point.

6.1 Analog Output ON (Binary: 01h; ASCII: Ax)

Default Value: 1 – Analog Output ON

The analog output can be toggled ON / OFF.

The binary parameter (**01h**) and ASCII command (**Ax**) use values 1 or 0 for ON and OFF, respectively.

Note: If a sensor is not configured with an analog interface, the value will always be set to 0 despite any attempts to change it.

6.2 Analog Output Mode (Binary: 02h bit R; ASCII: TAx)

Default Value: 0 – Window Mode

The analog output can be operated in two modes, "Window Mode" or "Full Mode".

The binary parameter (**02h bit R**) and ASCII command (**TAx**) use values 0 or 1 for Window Mode or Full Mode, respectively.

Window Mode – Value: 0 – The entire range of the analog output is scaled within the selected window. Outside the window, the analog output is "0".

Full Mode – Value: 1 – The entire range of the analog output is scaled within the selected window. Outside the selected window, the whole range of the analog output is automatically scaled onto the whole operating range of the sensor.

6.3 Analog Output Working Range (Binary: 0Ch, 0Dh, 0Eh, 0Fh; ASCII: none)

Default Value [Beginning of Range]: 0

Default Value [End of Range]: 16384

Resolution of the analog output can be increased by adjusting the window size and location within the measurement span. The analog signal will be scaled within this window only. This can only be changed in binary mode.

If the beginning of the range of the analog signal is set at a higher value than the end value of the range, this will change the direction of rise of the analog signal.

Parameters to set the Beginning of the Analog Range (0V or 4mA):

0Ch – Value range: 0 to 16384 – Low byte for the beginning of the analog output range.

0Dh – Value range: 0 to 16384 – High byte for the beginning of the analog output range.

Parameters to set the End of the Analog Range (10V or 20mA):

0Eh – Value range: 0 to 16384 – Low byte for the end of the analog output range.

0Fh – Value range: 0 to 16384 – High byte for the end of the analog output range.

7. Logic Interface(s) Operation

All AR100 sensors include a multi-purpose logic line. See the wiring description in section 4.5.

7.1 Binary Communication (02h bits M2, M1, and M0)

Default Value: 000 – Distance Alarm Mode

When the laser is set to binary communication, this line can be set to one of the eight **modes** defined by the M bits of parameter 02h

Distance Alarm Mode: To activate this mode from another, set bits M2, M1, and M0 to **000**. The output value is 0 when the measured distance is out of the range or selected window (see Analog Window in section 6.3).

Synchronization Mode: The synchronization mode makes it possible to synchronize measurement sample times of two and more sensors. Synchronization is achieved by tying together the trigger input lines of multiple sensors and also the logic output lines of the sensor. Synchronization is a valuable feature for thickness measurements using opposing laser sensors so that measurements are captured at exactly the same instant. There are two modes:

- **'Master' mode:**
 - Activate this mode by setting bits M2, M1, and M0 to **111**.
- **'Slave' mode:**
 - Activate this mode by setting bits M2, M1, and M0 to **001**.

Hardware Zero Set Mode (Tare function): Activate this mode by setting bits M2, M1, and M0 to **010**. When the Logic Interface wire is grounded, the currently measured distance is assigned as the zero point and subsequent measurements are now relative to this location within the span.

Laser Disable Mode: Activate this mode by setting bits M2, M1, and M0 to **011**. When the Logic Interface wire is grounded, the laser is ON. When the switch is removed from ground, the laser is OFF. This controls only the laser diode and not power to the sensor itself.

Encoder Mode: Activate this mode by setting bits M2, M1, and M0 to **100**. In this mode, the Trigger Input (White) and Logic Interface (Pink) wires work as inputs for a quadrature encoder signal, and if an encoder is connected to these lines, measurements will be synchronized with the encoder.

Input Mode (Ethernet models only): Activate this mode by setting bits M2, M1, and M0 to **101**. In this mode, The Logic Interface line state is transmitted in the status word of an Ethernet packet.

Ethernet Packet Counter Reset Mode (Ethernet models only): Activate this mode by setting bits M2, M1, and M0 to **110**. In this mode, connecting the Logic Interface wire to ground will reset the Ethernet packet counter.

7.2 ASCII Communication (TLx)

Default Value: 0 – Distance Alarm Mode

When the laser is set to ASCII communication, the Logic Interface line can be set to one of four modes using the command **TLx**:

Distance Alarm Mode: This is the default logic output. To activate this mode from another, use command **TLO**. The output value is 0 when the measured distance is out of the range or selected window (see Analog Window in section 6.3).

Mutual Synchronization Mode: Activate this mode by using command **TL1**. Unlike with binary communication mode, the laser cannot be specifically set as 'master' or 'slave' in ASCII communication mode, but like in binary communication mode, synchronization mode makes it possible to synchronize measurement sample times of two and more sensors. Synchronization is achieved by tying together the trigger input lines of multiple sensors and also the logic output lines of the sensor.

Hardware Zero Set Mode (Tare function): Activate this mode by using command **TL2**. When the Logic Interface wire is grounded, the currently measured distance is assigned as the zero point and subsequent measurements are now relative to this location within the span.

Laser Disable Mode: Activate this mode by using command **TL3**. When the Logic Interface wire is grounded, the laser is ON. When the switch is removed from ground, the laser is OFF. This controls only the laser diode and not power to the sensor itself.

8. Performance Optimization

This section describes how to configure the AR100 sensor for best use in your particular application.

8.1 Baud Rate (Binary: 04h; ASCII: Bxxx)

Default Value: 4 – 9600 bit/s (baud)

The AR100 automatically begins measuring and outputting distance measurements to the analog and serial lines when powered-up. The default baud rate is 9600 bit/s.

Users may select among several baud rates that will optimize the sensors' speed or accuracy performances over a serial connection.

The binary parameter (**04h**) and ASCII command (**Bxxx**) can use values from 1 – 192. This specifies the data transfer rate in multiples of 2400. The default value is 4 (9600 bit/s).

8.2 Laser ON/OFF (Binary: 00h; ASCII: Ox)

Default Value: 1 - ON

This serial function toggles the laser ON or OFF. The default setting is ON. Note that there exists a hardware Logic line which can control the laser's state as well. See Laser Disable feature in section 7.

The binary parameter (**00h**) and ASCII command (**Ox**) use values 1 or 0 for ON or OFF, respectively.

8.3 Network Address (Binary: 03h; ASCII: none)

Default Value: 1

This parameter defines the network address of the sensor equipped with RS485 interface. The factory default value is 1. This parameter cannot be edited using an ASCII command.

Network data communications protocols assume the presence of a 'master' in the network, which can be AR100 set to 'master' mode (see section 7.1), a computer, or other information-gathering device, and from 1 to 127 'slaves' (AR100 Series sensors) which support the protocol.

Each 'slave' is assigned a unique network identification code – a device address. The address is used to form requests or inquiries all over the network. Each slave receives inquiries containing its unique address as well as '0' address which is broadcast-oriented and can be used for formation of generic commands, for example, for simultaneous latching of values of all sensors and for working with only one sensor (with both RS232 port and RS485 port).

Parameter **03h** can be assigned values from 1 – 127.

8.4 Zero Point (Binary: 17h, 18h; ASCII: Zxxxxx)

Default Value: 0

This parameter allows the user to set a zero point within the sensor's measurement span. The factory default value for the zero point is the beginning of the measurement span. Note that users can also set the zero point through hardware controls. See Zero Point in section 7.

Binary Parameters:

- **17h** – LOW byte of the Zero Point
- **18h** – HIGH byte of the Zero Point

ASCII Command:

- **Zxxxxx** – Where **xxxxx** is the Zero Point

The above values can be set within a range of 0 to 16384. This is the range of the absolute coordinate system of the AR100 sensor.

8.5 Sampling Mode (Binary: 02h bit S; ASCII: TSx)

Default Value: 0 - Time Sampling

The AR100 has two sampling modes, Time or Trigger Sampling. The factory default setting is Time Sampling.

The sensor must be in Data Stream Mode. The binary parameter (**02h bit S**) and the ASCII command (**TSx**) use the same values.

Time Sampling – Value: 0 – When selected, the sensor automatically transmits the measurement result via serial interface in accordance with selected sampling period.

Trigger Sampling – Value: 1 – When selected, the sensor transmits the measurement result when an external synchronization input (see section 4.5) is switched. This takes the division factor set into account. See Sampling Period section 8.6.

8.6 Sampling Period (Binary: 08h, 09h; ASCII: Sxxxxx)

Default Value: 5000

If the *Time* sampling mode is selected, the 'sampling period' parameter determines the time interval over which the sensor will automatically transmit the measurement result. The time interval value is set in increments of 1 μ s. For example, for the parameter value equal to 100, data are transmitted through bit-serial interface with a period of 100 μ s.

If the *Trigger* sampling mode is selected, the 'sampling period' parameter determines the division factor for the external synchronization input. For example, for the parameter value equal to 100, data are transmitted through bit-serial interface when each 100th synchronizing pulse arrives at trigger input of the sensor.

Binary Parameters:

08h – Low byte for the sampling period.

09h – High byte of sampling period.

ASCII Command:

Sxxxxx – Where **xxxxx** is the sampling period.

Value ranges:

- In *Time* sampling mode: 10 to 65535. The time interval in increments of 1 μ s with which sensor automatically communicates of results on streaming request (priority of sampling = 0)
- In *Trigger* sampling mode: 1 to 65535, divider ratio of trigger input with which sensor automatically communicates of result on streaming request (priority of sampling = 1)

Note 1: It should be noted that the 'sampling mode' and 'sampling period' parameters control only the transmission of data. The sensor operation algorithm is built so that measurements are taken at a maximum possible rate determined by the integration time period, the measurement results are sent to buffer and stored therein until a new result arrives. The above-mentioned parameters determine the method of the read-out of the result from the buffer.

Note 2: If the bit-serial interface is used to receive the result, the time required for data transmission at a selected data transmission rate should be taken into account in the case Where: small sampling period intervals are used. If the transmission time exceeds the sampling period, it is *this* time that will determine the data transmission rate.

8.6.1 Output Rate

The sensor's output rate (OR) depends on the selected Baud rate (BR) of serial interface and is calculated by the following formula:

$$OR = 1 / (44/BR + 1 * 10^{-5}) \text{ Hz.}$$

For example, for BR=460800 b/s, Output Rate = 9.4 kHz

8.7 Maximum Integration Time (Binary: 0Ah, 0Bh; ASCII: Exxxx)

Default Value: 3200

The intensity of the reflected laser radiation varies with target surface characteristics (color, texture, etc.) and ambient lighting conditions. The laser's output power and the integration time (like camera shutter time) of the CMOS detector array are automatically adjusted to achieve maximum measurement accuracy.

The Maximum Integration Time parameter specifies a maximum allowable integration time limit. If the radiation intensity received by the sensor is so small that no reasonable result is obtained within the time of integration equal to the limiting value, the sensor transmits a zero value.

Binary Parameters:

0Ah – Low byte for maximum integration time.

0Bh – High byte for maximum integration time.

ASCII Command:

Exxxx – Where **xxxx** is the maximum integration time.

Value ranges:

2 to 3200. This value specifies the limiting integration time for the CMOS array in increments of 1 μ s.

The measurement frequency depends on the integration time of the receiving array. Maximum frequency (9.4 kHz) is achieved for the integration time $\leq 106 \mu$ s (minimum possible integration time is 0.1 μ s). As the integration time exceeds 106 μ s, the resulting update time increases proportionally.

Increasing this parameter may improve the sensor's ability to measure to low-reflecting targets at the cost of decreased speed and possible increased effects of ambient light on measurement accuracy. Decreasing the parameter's value increases measurement frequency, but may decrease measurement accuracy.

8.8 Results Lock (Binary: 10h; ASCII: Dxxx)

Default Value: 1 – 5ms

If the sensor does not "see" the target surface or if a new measurement cannot be received, a zero value is transferred. The Results Lock parameter sets a time limit during which the sensor transfers the last valid result instead of a zero value. The factory default value is 5 ms.

The binary parameter (**10h**) and the ASCII command (**Dxxxx**) both use a value range of 0 to 255 . It specifies the time interval in increments of 5 ms.

8.9 Results Averaging Mode (Binary: 02h bit A; ASCII: TMx)

Default Value: 0 – Averaging over a Number of Results

This parameter defines one of the two methods of averaging of measurement results implemented directly in the sensor: Averaging over a Number of Results or Time Averaging. The factory default setting is for Averaging over a Number of Results.

The binary parameter (**02h bit A**) and the ASCII command (**TMx**) both use two values, 0 or 1, representing one of two modes:

Averaging over a Number of Results – Value: 0 – When selected, a sliding average is calculated and transmitted to the sensor's outputs

Time averaging – Value: 1 – When selected, the measurement results are averaged over a time interval

8.9.1 Averaging Configuration (Binary: 06h; ASCII: Gxxx)

Default Value: 1 – No Averaging

Depending on the selected averaging mode (Number or Time), this parameter controls either the number of results to be averaged or the time for averaging.

Averaging can reduce noise or occasional spikes in the output of the sensor caused by inaccurate readings in dynamic applications.

Averaging over a number of results does not affect the data update in the sensor output buffer. However, in case of Time Averaging, data in the output buffer are updated at a rate equal to the averaging period.

The binary parameter (**06h**) and the ASCII command (**Gxxx**) both use a value range of 1 to 127. This is either the *number of samples* or *length of time (in seconds)* depending on the selected averaging mode.

9. Demo and Configuration Software

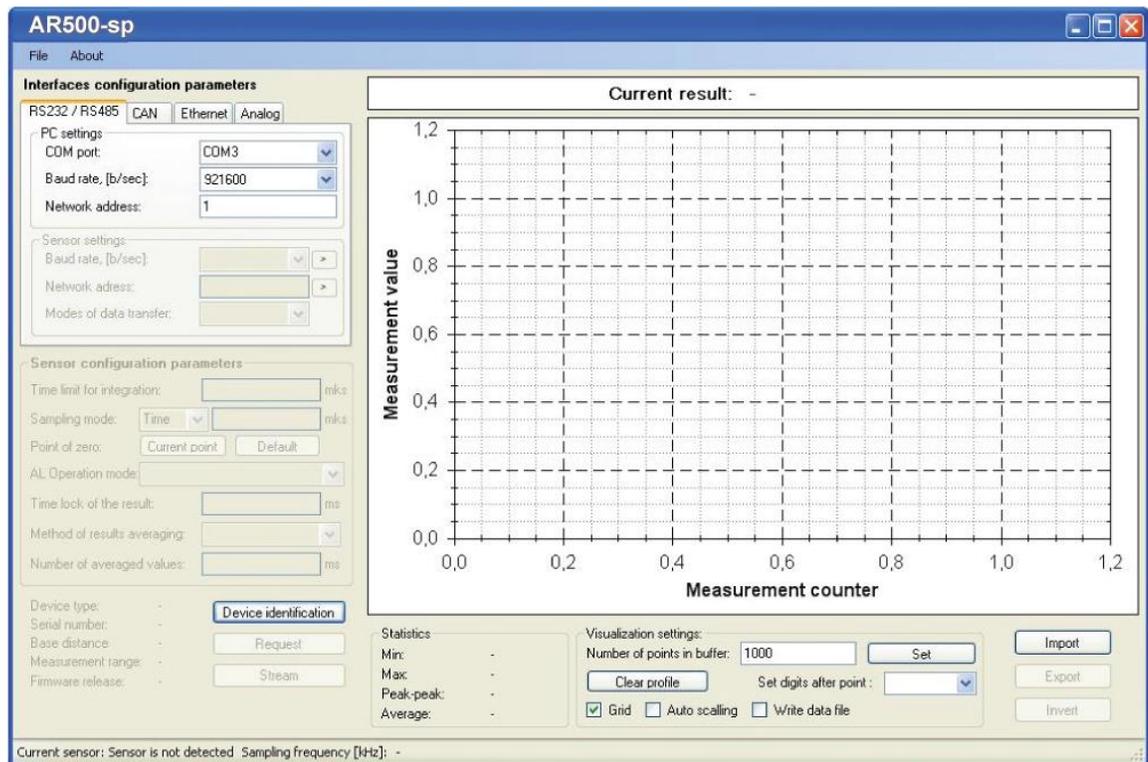
The AR100-SP software is intended for making simple serial (or Ethernet, if ordered) connections to the AR100 for demonstration purposes and configuration of the many sensor parameters. It is also possible to archive measurement data to a file using this software.

9.1 Program Setup

Start file AR100setup.exe and follow the instructions for the installation wizard.

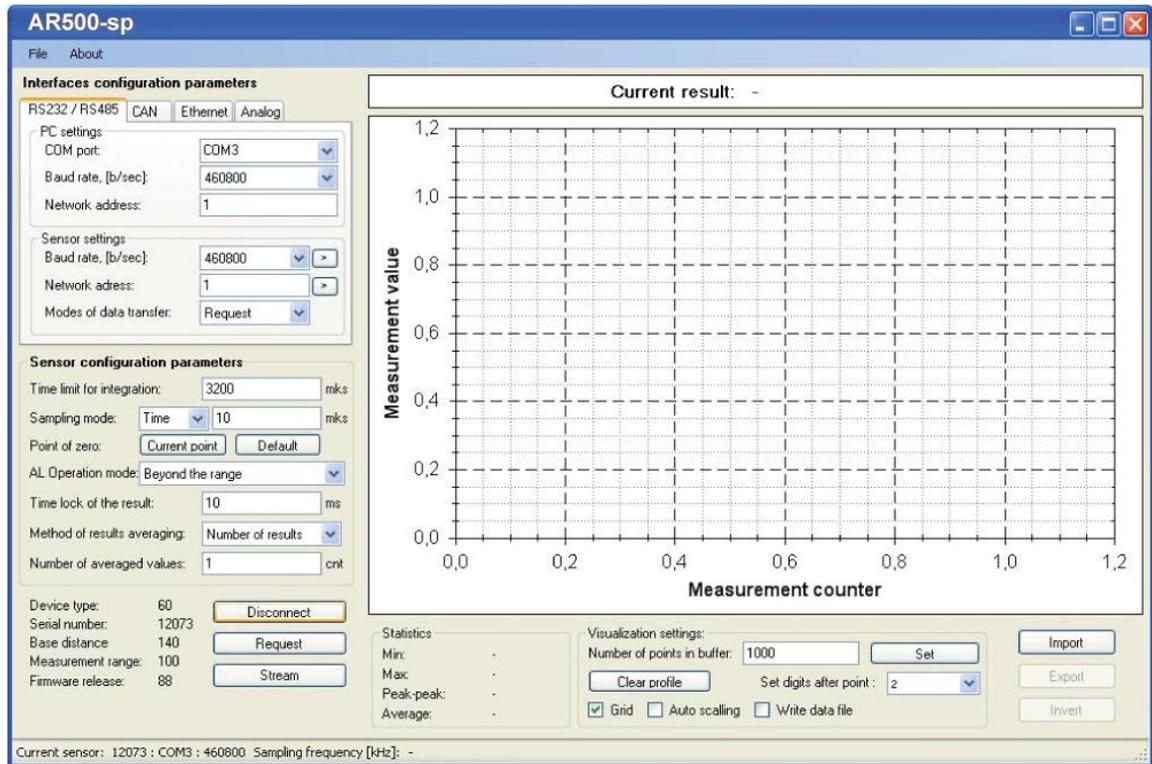
9.2 Connecting to the sensor (RS232/RS485)

Once the program is started, the pop-up window appears:

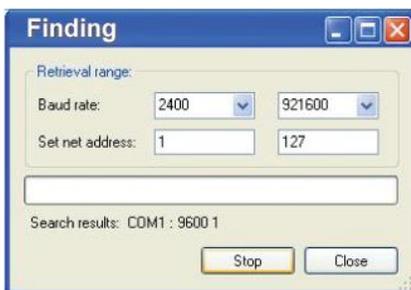


In the RS232/RS485 tab, select the COM-port Where: the sensor is connected. If using a USB to RS232 adapter, look at your computer's hardware profile to determine the assigned COM port. Select the Baud rate noting that the factory default is set to 9600 baud. Select the sensor network address, if necessary. Press the **Device identification** button.

If the selected parameters correspond to the parameters of the sensor interface, the program will identify the sensor, read and display its configuration parameters:



If connection a connection cannot be established, a prompt will appear asking to make an automatic search for the sensor.



To start search, press the **Yes** button and a configuration window will appear Where: it will be necessary to set the search range for the baud rate and the network addresses. When set, press the **Search** button.

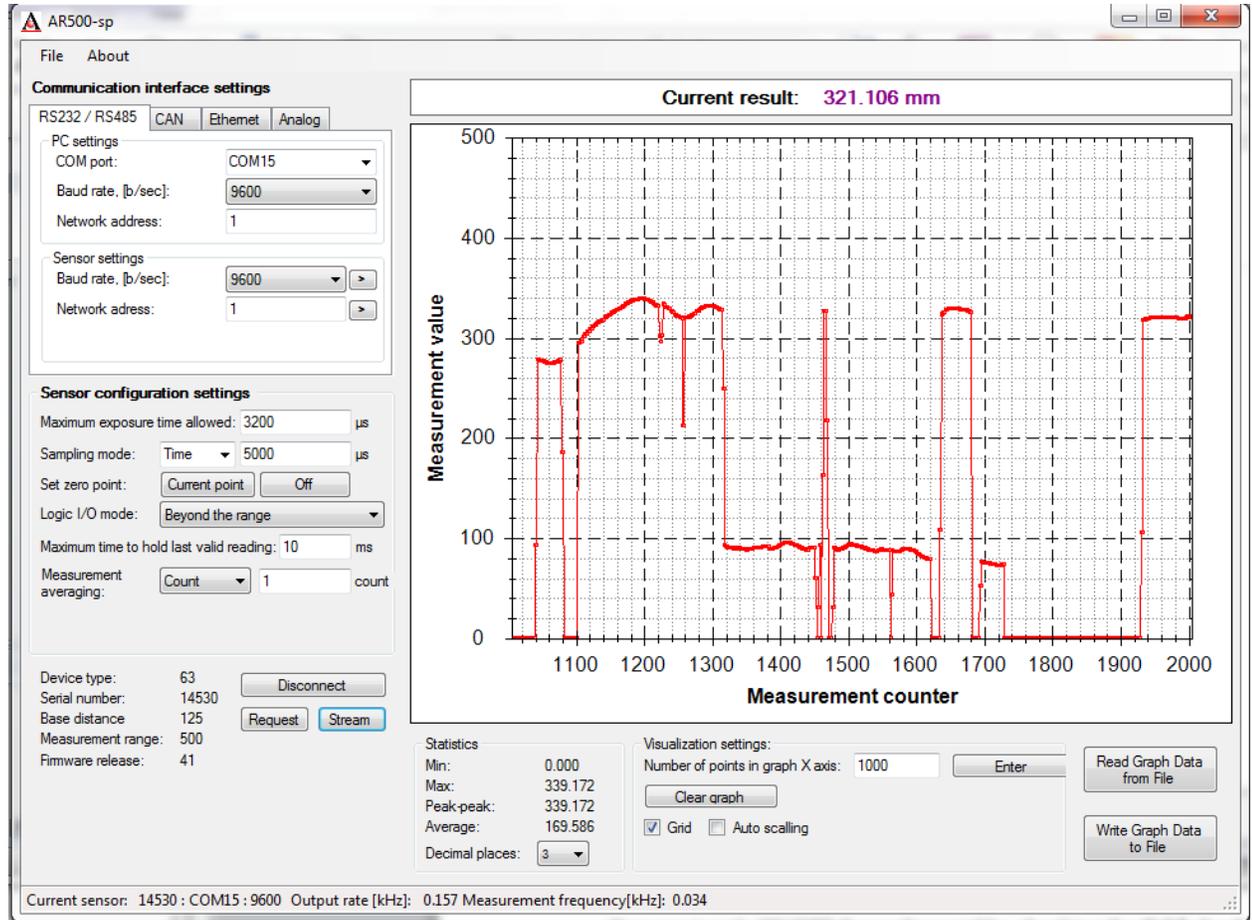
The program will perform automatic search of the sensor by searching over possible rates, network addresses and COM-ports of PC.

9.3 Sensor Operation

Once the sensor is successfully identified, check its operability by placing a target in the path of the laser and within the sensor's working range. Press the **Request** button to obtain a single measurement on the *Current Result* indicator at the top of the screen.

Note: The pressing of the **Request** button executes 06h request

Pressing the **Stream** button will switch the sensor to the data stream transmission mode (**07h** request code).



Move the target object and observe changes in the distance readings. The status line in the lower part of the window will show current data transmission and refreshing rates. Press the **Stop** button (**Stream** becomes **Stop**) to stop data transmission (08h request code)

9.4 Display and Archiving of Data

Measurement results are displayed in digitally and in chart form while stored in the PC memory. The number of points displayed along the X axis can be set in the Number of points in buffer window. Y axis scaling can be set by the Auto scaling function.

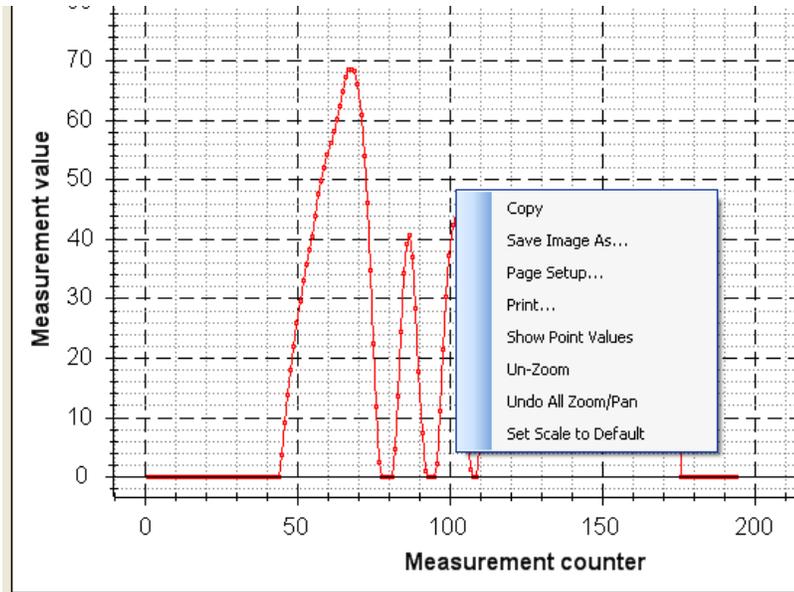
One can toggle ON/OFF the scaling grid by checking the **Grid** checkbox.

One can select the number of significant digits to the measurement result in the **Decimal place** pull-down menu.

To archive received data to a file, select the **Write Graph Data to File** checkbox. Streaming data must be stopped to write graph data to a file.

Note: the number of points displayed on the chart depends on PC speed and becomes smaller in proportion to the data transmission rate. After the stream is stopped by using the **Stop** button, the graph will display all received data.

To manipulate the chart image, right mouse click on the chart to reveal the corresponding menu:

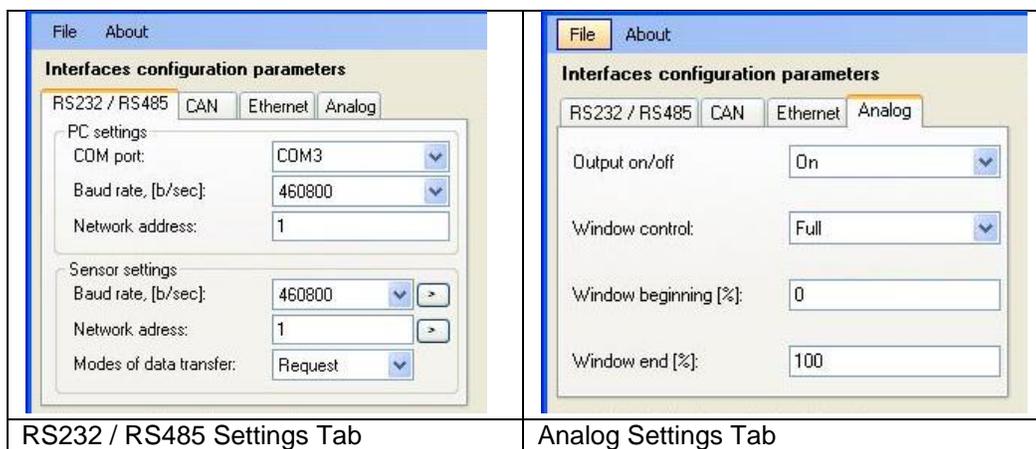


Additionally, one can manipulate the chart image, press the mouse wheel for movement or rotating the mouse wheel for zooming capabilities.

9.5 Setting and Saving Sensor Parameters

9.5.1 Setting Parameters

Configuring is only accomplished through RS232 or RS485 interfaces. Setting of parameters for all (optional) interfaces can be done using the respective tabs on the Interfaces configuration parameters panel. Setting of all configuration parameters of the sensor is possible with the help of the respective panel (Sensor configuration parameters):



9.5.2 Saving Parameters

After setting one or more parameters as required, users must *write* them into the sensor memory. Write parameter by clicking **File > Write parameters** or by clicking the  button.

Be sure to perform testing of the sensor operation with the new parameters. Once satisfied, it is necessary to store the new parameters in *nonvolatile memory* by clicking **File > Write to flash**. This procedure saves the parameters so that upon powering-up in the future will cause the sensor to default to your new configuration and not factory default configuration.

9.5.3 Saving and Writing a Group of Parameters

Parameters of the sensor can be saved to a file on your computer. This is done by selecting **File > Write** parameters set and saving the file in the window offered.

To open a group of parameters from a file, select **File > Sensor parameters sets** and select the file required. This function is convenient for writing identical parameters to several sensors. After loading the parameters follow the instructions above for saving the parameters to non-volatile memory.

9.6 Factory Reset

To restore the sensor's factory default parameters, use **File > Restore defaults**. This recalls the factory settings to the interface. It will also be necessary to save the parameters as described above.

10. Serial Command Quick Reference

10.1 Binary Communications Reference

Request code	Description	Message (size in bytes)	Answer (size in bytes)
1h	Device identification	—	- device type (1) - firmware release (1) - serial number (2) - base distance (2) - range (2)
2h	Reading of parameter	- parameter code (1)	- parameter value (1)
3h	Writing of parameter	- parameter code (1) - parameter value (1)	—
4h	Storing current parameters to FLASH-memory	- constant AAh (1)	- constant AAh (1)
4h	Recovery of parameter default values in FLASH-memory	- constant 69h (1)	- constant 69h (1)
5h	Latching of current result	—	—
6h	Inquiring of result	—	- result (2)
7h	Inquiring of a stream of results	—	- stream of results (2)
8h	Stop data streaming	—	—

Parameter Code	Description	Values
00h	Sensor ON/OFF	0 - laser OFF, sensor in power save mode 1 - laser ON, measurements are taken (default);
01h	Analog output ON/OFF	0 - analog output OFF 1 - analog output ON (default) Note: If a sensor has no analog output, this bit will remain as 0 despite all attempts to change it.
02h	Averaging, sampling and logic output control	x, M2, A, C, M1, M0, R, S – control byte which determines the mode of operation. bit M2:M1:M0 (AL mode): 000 - out of range indication modes (default) 001 - 'slave' mode (mutual synchronization) 010 - hardware zero set mode 011 - laser disable mode 100 - encoder mode 101 - input mode (Ethernet enabled models) 110 - Ethernet packets counter reset mode 111 - 'master' mode (mutual synchronization) bit A (averaging mode): 0 - averaging over number of results (default) 1 - averaging over time bit C is not used bit R (analog output mode): 0 - window mode (default)

		<p>1 - full range mode</p> <p>bit S (sampling mode):</p> <p>0 – time sampling (default)</p> <p>1 – trigger sampling</p> <p>bit x is not used</p>
03h	Network address	1 - 127 (default: 1)
04h	Rate of data transfer through serial port	1 - 192, (default: 4) specifies data transfer rate in increments of 2400 baud; (e.g., 4 means $4 \times 2400 = 9600$ baud) Note: max baud rate = 921600
05h	Reserved for future use	
06h	Number of averaged values	1 - 128, (default: 1)
07h	Reserved for future use	
08h	Lower byte of the sampling period	1) 10 - 65535, (default: 5000)
09h	Higher byte of the sampling period	<p>When laser is set to Time Sampling mode (02h bit S) this is the time interval (in increments of 1 μs)</p> <p>2) 10 - 65535, (default: 5000)</p> <p>When laser is set to Trigger Sampling mode (02h bit S) this is the division for the external synchronization input</p> <p>Note: See section 8.6 for further explanation</p>
0Ah	Lower byte of maximum integration time	2 - 3200, (default: 3200) specifies the limiting time of integration by CMOS-array (in increments of 1 μ s)
0Bh	Higher byte of maximum integration time	
0Ch	Lower byte for the beginning of analog output range	0 - 16383, (default: 0)
0Dh	Higher byte for the beginning of analog output range	
0Eh	Lower byte for the end of analog output range	0 - 16383, (default: 16383)
0Fh	Higher byte for the end of analog output range	
10h	Time lock of result	0 - 255, (default: 1) Specifies time interval the sensor will output last valid result in increments of 5 ms
11 - 16h	Reserved for future use	
17h	Lower zero point	0 - 16383, (default: 0) specifies zero point within sensor's measurement span
18h	Higher byte zero point	
19 - 1Ch	Reserved for future use	
20 - 29h	Reserved for CAN interface	
89h	Autostart of stream at power on (delayed 20 seconds)	0 - Autostart OFF (default) 1 - Autostart ON
8Ah	Serial communication protocol	0 - Binary protocol (default) 1 - ASCII protocol

10.2 ASCII Communications Reference

The following are the command codes for the ASCII protocol. When entering a request code, it should be followed by the CR and LF codes in your terminal emulator. Each answer will also be followed by CR and LF codes.

Request code	Name	Description	Answer
PRT	Change data format	After entering this command, the sensor will give an ASCII answer then change its data format to binary.	OK
V	Device Identification	Sensor will report information about itself	<ul style="list-style-type: none"> - device type (Ex. 603) - firmware version (Ex. 40) - serial number (Ex. 19999) - base distance (Ex. 125) - measurement range (Ex. 500) <p>Note: 603 is an internal designation for the AR100</p>

The following codes all return "OK" when entered except Rx, which will just change the units of the output measurements upon being entered.

Request Code	Description	x values
Wx	Save and recovery	0 - save current parameters to non-volatile memory 1 - recover default parameters (Note: this will not change the communication protocol)
Rx	Measurement units	0 - native increments (0 – 16384) 1 - millimeters 2 - inches
Ox	Sensor ON/OFF	0 - laser OFF 1 - laser ON (default)
Ax	Analog output ON/OFF	0 - analog OFF 1 - analog ON (default)
TMx	Averaging mode	0 – averaging over number of results (default) 1 – time averaging
TLx	Logic interface mode	0 – out of range indication mode (default) 1 – mutual synchronization mode 2 – hardware zero set mode 3 – laser disable mode
TAx	Analog output mode	0 – window mode (default) 1 – full range mode
TSx	Sampling mode	0 – time sampling (default) 1 – trigger sampling
Bxxx	Serial communication rate	1 – 192 (default: 4) specifies data transfer rate in increments of 2400 baud; (e.g., 4 means 4 × 2400 = 9600baud) Note: max baud rate = 921600
Gxxx	Number of values averaged	1 – 128 (default: 1)

Sxxxxx	Sampling period	<p>1) 10 - 65535, (default: 5000) When laser is set to Time Sampling mode (TSx) this is the time interval (in increments of 1 μs)</p> <p>2) 10 - 65535, (default: 5000) When laser is set to Trigger Sampling mode (TSx) this is the division for the external synchronization input</p> <p>Note: See section 8.6 for further explanation</p>
Exxxx	Maximum integration time	2 - 3200, (default: 3200) specifies the limiting time of integration by CMOS-array (in increments of 1 μ s)
Dxxx	Time lock of result	0 - 255, (default: 1) Specifies time interval the sensor will output last valid result in increments of 5 ms
Zxxxxx	Zero point	0 - 16383, (default: 0) specifies zero point within sensor's measurement span