AccuRange 4000

AccuRange High Speed Interface

AccuRange Line Scanner

User's Manual

Rev. 2.3
For use with AR4000 Rev. 20
January 25, 2000

Acuity Research Incorporated
3475 Edison Way, Unit P
Menlo Park, CA 94025
www.acuityresearch.com

Limited Warranty

Acuity Research makes the following limited warranties. These limited warranties extend to the original purchaser and to no other purchaser or transferee.

Limited One Year Parts and Labor Warranty

Acuity warrants this product and its parts against defects in materials or workmanship for a period of one year after the date of original retail purchase. During this period, Acuity will, at its option, repair or replace a defective product or part without charge to you.

Warranty Conditions

The above LIMITED WARRANTIES are subject to the following conditions:

1. Warranties extend only to products manufactured by Acuity.

2. Warranties extend only to defects in materials or workmanship as limited above. Warranties extend only to defects which occur during normal use and do not extend to damage to products or parts which results from alteration, repair, modification, faulty installation or service by anyone other than an authorized Acuity service center, damage to products or parts caused by accident, abuse, misuse or maintenance, mishandling, misapplication, or damage caused by acts of God.

3. You must retain your bill of sale or provide other proof of purchase.

4. Any replacement parts furnished at no cost to the purchaser in fulfillment of this warranty are warranted only for the unexpired portion of the original warranty.

ALL WARRANTIES REQUIRED TO BE IMPLIED BY STATE LAW ARE EXPRESSLY LIMITED TO THE DURATION OF THE LIMITED WARRANTIES SET FORTH ABOVE. Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. **WITH THE EXCEPTION OF ANY WARRANTIES REQUIRED TO BE IMPLIED BY STATE LAW AS HEREBY LIMITED, THE FOREGOING EXPRESS WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES.**

IN NO EVENT SHALL ACUITY BE LIABLE FOR SPECIAL, INCIDENTAL, CONSEQUENTIAL OR PUNITIVE DAMAGES, INCLUDING, WITHOUT LIMITATION, INJURY OR DAMAGE TO PERSONS OR OTHER PROPERTY, INCONVENIENCE, LOSS OF GOODWILL, LOST PROFITS OR REVENUE, LOSS OF USE OF THIS PRODUCT OR ANY ASSOCIATED EQUIPMENT, COST OF SUBSTITUTIVE EQUIPMENT DOWNTIME COSTS OR CLAIMS OF ANY PARTY DEALING WITH PURCHASER FOR SUCH DAMAGES, RESULTING FROM THE USE OF THIS PRODUCT OR FROM DEFECTS IN THIS PRODUCT, OR ARISING FROM BREACH OF WARRANTY OR CONTRACT, NEGLIGENCE OR ANY OTHER LEGAL THEORY. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation may not apply to you.

Procedures for Obtaining Warranty Service

1. Contact your Acuity distributor or call Acuity Research at (415) 369-6782 to obtain a return merchandise authorization (RMA) number within the applicable warranty period. Acuity will not accept any returned product without an RMA number.

2. Ship the product to Acuity, 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 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.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this device in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Table of Contents

1. INTRODUCTION 4

2. GENERAL DESCRIPTION 5

2.1 MECHANICAL DIMENSIONS 6

3. OPERATING GUIDELINES 7

4. SIGNAL AND POWER INTERFACE 8

4.1 8 WIRE POWER AND SIGNAL CABLE 8
4.1.1 POWER AND SIGNAL CABLE WIRE DESCRIPTIONS 8
4.2 POWER SUPPLIES AND SAFETY INTERLOCKS 10
4.2.1 LIR AND LV POWER SUPPLIES 10
4.2.2 IR INTERLOCK BOX 12

5. SERIAL INTERFACE SPECIFICATION 14

5.1 HARDWARE PORT 14
5.1.1 OUTPUT FLOW CONTROL 14
5.1.2 INPUT FLOW CONTROL 14

6. INSTALLATION 15

6.1 CABLING 15
6.1.1 STANDALONE CABLING 15
6.1.2 CONNECTION TO A HOST COMPUTER 15

7. INITIAL CHECKOUT 16

7.1 4000-LV 16
7.2 4000-LIR 16
7.2.1 VERIFYING OPERATION 16
7.3 TROUBLESHOOTING 16
7.3.1 SERIAL COMMUNICATIONS CHECK 17
7.3.2 RANGE OUTPUT CHECK 17
7.3.3 ANALOG OUTPUT CHECK 17
7.3.4 RANGE MEASUREMENT QUALITY CHECK 18

8. PERFORMANCE AND MEASUREMENT ACCURACY 19

8.1 DETECTOR THERMAL NOISE **20**
8.2 LASER DIODE NOISE **20**
8.3 MAXIMUM RANGE SPECIFICATION **20**
8.4 SAMPLING RESOLUTION **20**
8.5 OTHER FACTORS AFFECTING PERFORMANCE **21**
8.6 SENSOR LINEARITY **21**

9.0 SERIAL COMMUNICATIONS 22

9.1 OUTPUT DATA FORMATS **22**
9.1.1 ASCII DATA FORMAT, CALIBRATED DISTANCE ONLY 22
9.1.2 ASCII DATA FORMAT, LOW LEVEL SENSOR OUTPUTS ONLY 22
9.1.3 ASCII DATA FORMAT, DISTANCE PLUS LOW LEVEL SENSOR OUTPUTS 23
9.1.4 BINARY DATA FORMAT, CALIBRATED DISTANCE ONLY 23
9.1.5 BINARY DATA FORMAT, LOW LEVEL SENSOR OUTPUTS ONLY 23
9.1.6 BINARY DATA FORMAT, DISTANCE PLUS LOW LEVEL SENSOR OUTPUTS 23

10. CURRENT LOOP AND PULSE WIDTH OUTPUTS 24

10.1 PULSE WIDTH OUTPUT **24**
10.2 CURRENT LOOP OUTPUT **24**

11. SERIAL AND ANALOG OUTPUT PERFORMANCE SPECIFICATIONS 25

11.1 SAMPLE RATE **25**
11.2 RESOLUTION **26**

12. CONFIGURATION AND NON-VOLATILE STORAGE 27

12.1 EEPROM OPERATION **27**

13. ACCURANGE 4000 COMMAND SET 28

13.1 COMMAND QUICK REFERENCE **29**
13.2 COMMAND DESCRIPTIONS **32**

14. DATA SHEET: SUMMARY OF SPECIFICATIONS 40

15. ACCURANGE HIGH SPEED INTERFACE 43

15.1 GENERAL DESCRIPTION **43**
15.1 SENSOR CONFIGURATION AND SAMPLE RATE **44**
15.2 MOTOR POWER **44**
15.3 I/O CONNECTORS **45**
15.3.1 9 PIN POWER AND SIGNAL CONNECTOR P1 45
15.3.2 POWER AND SIGNAL CONNECTOR DESCRIPTION 45

15.3.3 25 PIN I/O CONNECTOR P2 46
15.3.4 P2 PIN DESCRIPTIONS 46
15.4 I/O PORT INTERFACE 49
15.4.1 PORT DESCRIPTIONS 50
15.5 SAMPLED DATA FORMAT 51
15.5.1 DESCRIPTION OF SAMPLED DATA FORMAT 52
15.6 INTERRUPT DRIVEN OPERATION 53
15.7 INTERFACE RESOLUTION AND SAMPLE RATES 53
15.8 INTERFACE INSTALLATION AND CHECKOUT 54
15.8.1 DIAGNOSTICS 54
15.9 HIGH SPEED INTERFACE DATA SHEET 55

16. ACCURANGE LINE SCANNER 58

16.1 GENERAL DESCRIPTION 58
16.2 SCANNER PERFORMANCE SPECIFICATIONS 58
16.3 SCANNER INSTALLATION AND USE 59
16.4 LINE SCANNER DATA SHEET 59

1. Introduction

This section is a guide to getting started with the AccuRange 4000 and this manual. The AR4000 has a number of configurable parameters, but many applications can use it in its default configuration.

The first sections of the manual that should be read are the General Description and the Operating Guidelines. After that Installation, with reference to the Signal and Power Interface section for specific cable descriptions, 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 interface.

To understand more about the format of the serial data, read the Serial Communications chapter. For details on the current loop and pulse width outputs, read the chapter titled Current Loop and Pulse Width Outputs.

For custom configuration, the AccuRange Command Set section provides information on setting up the AccuRange for specific application requirements. The remaining sections deal with specifics of the outputs and interfaces and with general performance characteristics of the sensor.

2. General Description

The AccuRange 4000 is a laser diode based distance measurement sensor for ranges up to 50 feet, with 0.1 inch accuracy. There are three models, the 4000-LV, 4000-LIR, and 4000-RET. The 4000-LV emits visible light (red, 670 nm wavelength), while the 4000-LIR and 4000-RET uses near infrared light (780 nm wavelength). The 4000-LIR is a Class IIIb laser product, available in power levels of 8 mW (standard), or up to 20 mW with the High Power Laser option. The 4000-LV is a Class IIIa laser product. The 4000-RET is a Class I eye safe product for use with retroreflective tape. The labels shown below appear on the AccuRange 4000-LV and 4000-LIR.

4000-LIR: Emitter: 780 nm IR laser diode
Optical power 20 milliwatts max.
Effective Range: 50 feet

4000-LV: Emitter: 670 nm red laser diode
Optical power: 5 milliwatts max.
Effective Range: 40 feet

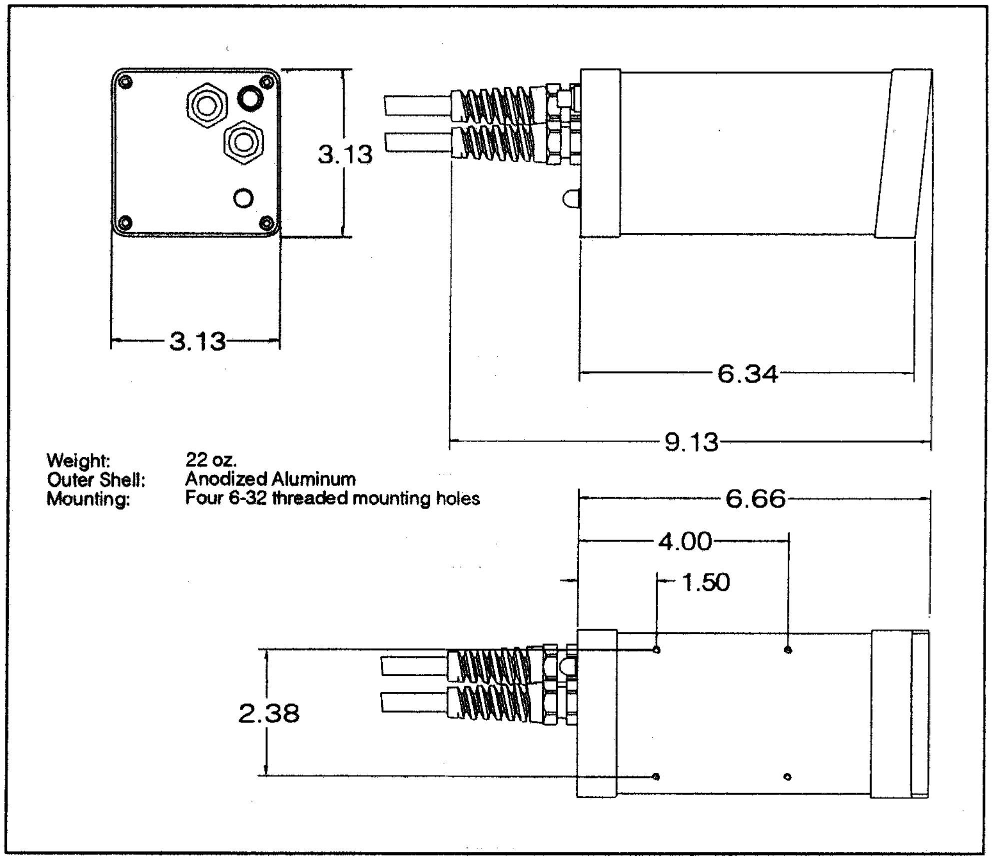
The 4000-LIR and 4000-RET have lower measurement noise and greater sensitivity and maximum range. The 4000-LV features visible light output. See the relevant descriptions in the Performance and Measurement Accuracy section for noise and range information. Custom configurations of the AccuRange 4000 are also possible.

The AccuRange 4000 operates by emitting a modulated, collimated beam of laser light and converting the distance to the target surface to an RS-232 or RS-422/485 output. The range may be read via the serial cable as digital data, or from the optional analog current loop output. A second cable supplies power to the AccuRange 4000 and brings out other signals, which include reflected signal strength, sensor temperature, and background light level. When configured for use with the AccuRange 4000 High-Speed Interface and host-resident calibration software, uncalibrated pulse-width modulated output is also available on this cable.

2.1 Mechanical Dimensions

Figure 1 shows the mechanical dimensions for the AccuRange. The laser beam is emitted from the center of the front panel, and the central 2.5 inch diameter of the front panel is a collector for return light. The bottom of the sensor has 4 blind holes which are threaded for 6-32 bolts for mounting the sensor. The back of the sensor has a switch for configuration and reset, LED, and two 6 foot cables. The first is for RS-232 communication, the second contains power and analog signals. The weight of the AccuRange 4000 is 22 ounces.

Figure 1. Mechanical Specifications



The outer case of the sensor is .125" aluminum. The acrylic front window and the back panel are sealed to the case, creating a watertight enclosure.

3. Operating Guidelines

Use protective eyewear whenever there is a risk of being exposed to the output beam of the 4000-LIR or 4000-LV. Use eyewear specifically designed to block laser radiation of the frequency used by the sensor.

Do not point the sensor at any person, particularly a person's eyes or face. Laser radiation can damage the eyes without sensation or warning.

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 case is exposed to direct sunlight for more than a minute or where the air temperature is more than 45°C (113°F). If the sensor is to be used in temperatures below 0°C (32°F), apply power to the heater power supply lines. This will allow the sensor to maintain a constant internal temperature, ensuring optimum operation.

Do not point the sensor at the sun or other intense heat sources. The sensor will operate when pointed at sunlit areas, although sensitivity is reduced. The optional optical filter is recommended for use on sunlit target areas.

Avoid excessive vibration and shocks. The sensor contains securely mounted but precisely aligned optical components. These components are isolated from the case with shock mounting, which protects them from all but severe shocks to the case.

Do not scratch the front face of the sensor, particularly in the central area. Keep the front face clean with a damp cotton cloth. The face is acrylic with an anti-abrasion coating. Avoid the use of cleaning solvents other than alcohol.

4. Signal and Power Interface

The 4000 has 2 cables. In the default configuration, the cable with the 9 pin connector is a standard RS-232 serial port. If the 4000 is ordered with the RS-422 option, this cable is used for that. The other cable is an 8 pin power/signal cable. If the 4000 is ordered with a power supply, the power/signal cable will pass through the power supply. All wires are passed through the power supply except the red, orange, and brown power lines which are connected only between the power supply and the sensor. Connection and termination according to the instructions is essential for correct sensor operation. Read the wire descriptions for connection information.

4.1 8 Wire Power and Signal Cable

The table below shows the wiring on systems ordered without power supplies. See the section on power supplies and safety interlocks for the wiring on systems ordered with power supplies.

Wire	Function	Direction
Red	Power, +5V (5-6V)	In
Black	Ground	
Orange	Heater Power, +5V (4.5-7V)	In
Brown	Heater Power Return	
Yellow	Temperature, 0-5 V	Out
Blue	Pulse Width Range	
	or Optional Current Loop Range	Out
Green	Ambient light signal, 0-5 V	Out
Purple	Amplitude signal, 0-5 V	Out
Shield	Ground at Supply End	

Power and Signal Cable Wiring

4.1.1 Power and Signal Cable Wire Descriptions

Line 1: +5V power at 300 milliamps. Maximum noise: 10 millivolts p-p.
Color: Red
Power supplies from 5 to 6 volts may be used. Higher voltages will result in excessive current drawn by the overvoltage protection circuitry and may cause permanent damage. Voltages less than 5.0 Volts at the cable end may result in inaccurate range readings.

Line 2: Ground
Color: Black
Return for the 5V supply.

Line 3: Heater Power, 5 to 7 volts at 0-2 amperes, temperature dependent.

Color: Orange

Heater power and return may be optionally connected to supply power for temperature regulation within the sensor. The current drawn by the heater power circuitry depends on the difference between the ambient temperature and the hold temperature for which the sensor is configured. It may be as high as 2 amperes in extreme cases. The sensor power and ground lines should only be connected to the heater power and ground at the source of a low impedance power supply, to prevent high heater current from causing significant voltage drops in the supply lines for the sensor electronics. This line should be left disconnected if heater power is not used.

Line 4: Heater Power Return
Color: Brown

Return for the optional heater power. If heater power is used, connect to the sensor electronics ground at the power supply. This line should be left disconnected if heater power is not used.

Line 5: Temperature output: 0 to 4 volts. 5 mA max.
Color: Yellow

The temperature output is a linear indication of internal sensor temperature. This may be used to monitor the internal temperature and to make range corrections due to changes in temperature, although the temperature dependence of the indicated range is typically small. The temperature output will change approximately 29 millivolts for each 1° F change in sensor temperature, and should read about 2.5 volts when the sensor is at 85° F. This output should be left open when not in use.

Line 6: Pulse Width Range Signal: Pulse width square wave
OR: Optional Current Loop Range Output: 4-20 milliamps, 10 V max output
Color: Blue

In the standard AccuRange 4000 configuration, this output provides an uncalibrated measure of range. The period of the pulse is the sample interval for which the sensor has been configured with the Sample Rate command. The duration of the low portion of the pulse is proportional to measured range, scaled by the sample rate and maximum range for which the sensor is configured. See the Current Loop and Pulse Width Outputs section for details. The pulse width signal is used by the AccuRange High-Speed Interface to make range measurements at high sample rates. It may be timed by sampling hardware to determine indicated (uncalibrated) range.

If the sensor was ordered with the optional current loop output, this line will deliver a current proportional to the measured range. The zero range current, offset of the zero range point, and the span (point of full scale output) may be set using the appropriate commands. If calibrated output mode is enabled, the output will be the actual distance to the target. Otherwise, the output will be the raw sensor range, uncompensated for temperature, signal strength, and other effects. Best accuracy is obtained by loading the line with a 500 ohm resistor to ground at the measurement point.

Line 7: Ambient light output: 0 to 4 volts. 5 mA max.
Color: Green

This output provides a measure of the total optical energy received by the sensor, which is a combination of external illumination and the laser beam energy. This may be used to make range corrections due to changes in ambient light levels at the target location, although range dependence on ambient light is small unless high ambient light levels such as sunlight are encountered. This output should be left open when not in use.

Line 8: Amplitude output: 0 to 4 volts. 5 mA max.
Color: Purple
This output provides a measure of the strength of the signal received by the sensor,
the amount of output laser light reflected back and collected by the sensor. This may be used to make corrections to variations in the range reading caused by changes in reflectance of the target. This output should be left open when not in use.

Outer shield: Not connected. Should be grounded at supply end.

4.2 Power Supplies and Safety Interlocks

4.2.1 LIR and LV Power Supplies

The optional AC to DC power supplies for the AccuRange 4000-LV and 4000-LIR supply operating power and temperature stabilization heater power to the sensors. They are housed in NEMA-4 polycarbonate enclosures and are permanently attached to the AccuRange 4000 power/signal cable, with 6 feet of cable between the sensor and power supply. An additional 4 feet of cable extends beyond the power supply for reading the sensor’s optional current loop and other outputs.

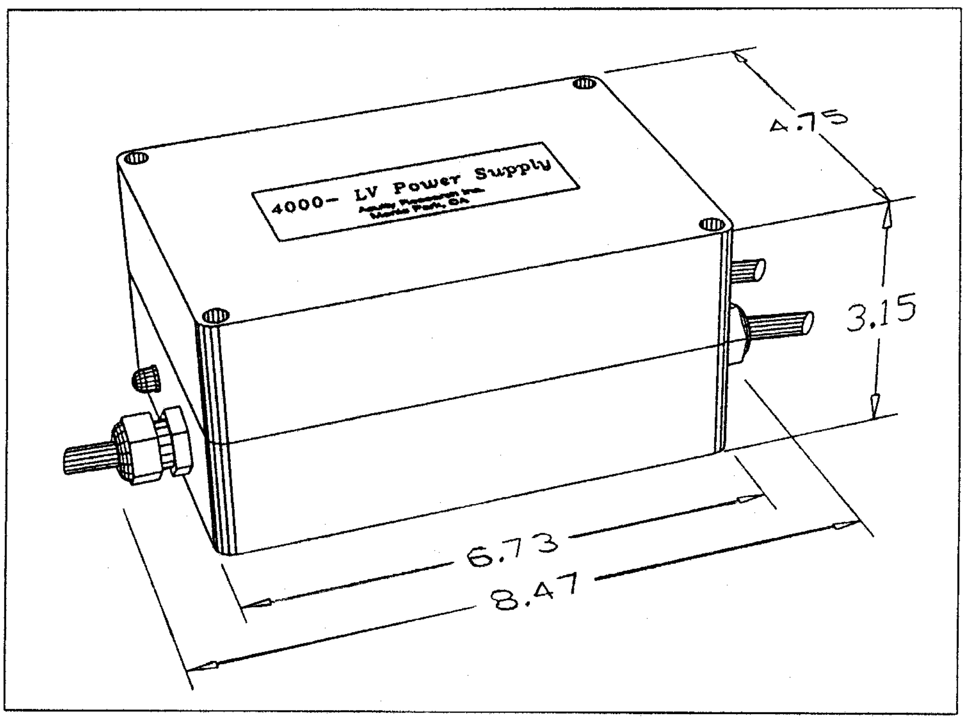
The LIR Power Supply also includes the keyswitch and interlock jack required for CFR certification for Class IIIb lasers. In the LIR Power Supply the keyswitch and interlock jack located inside the box must be turned on and installed to complete the laser power supply circuit.

To access the switch and jack, remove the four screws in the power supply case and lift the top half of the case. When the circuit is complete, the indicator lamp on the box will light, and power is applied to the sensor. After a 5 second delay, the 4000-LIR laser will come on.

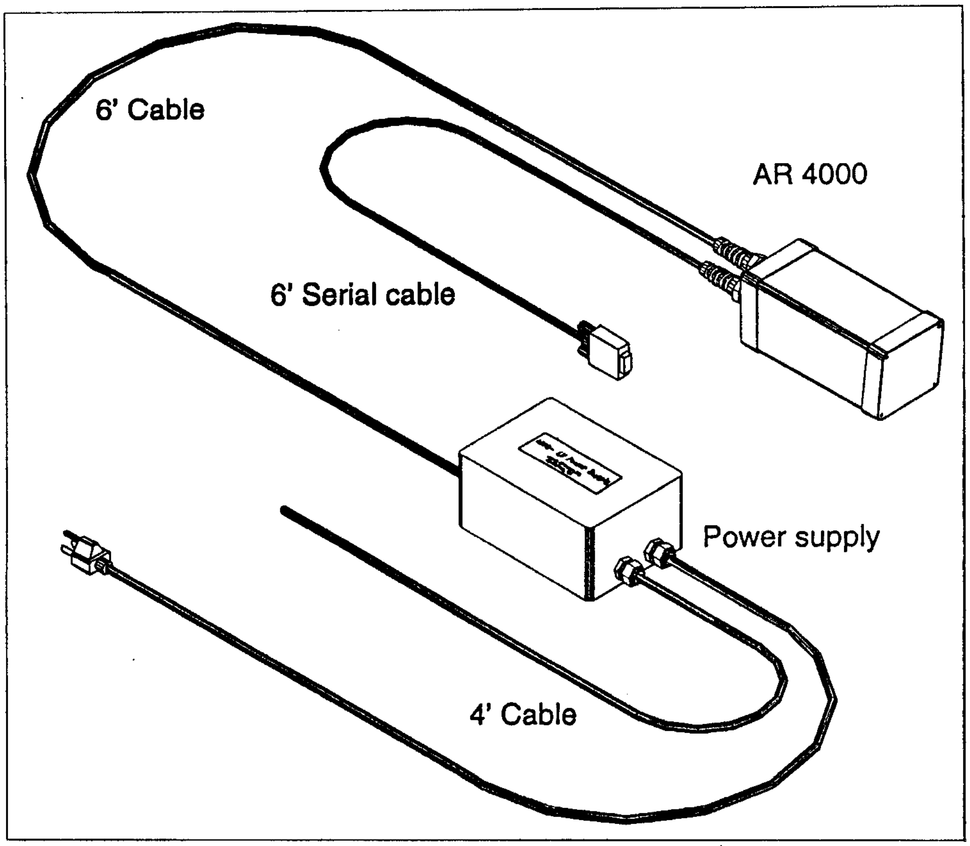
The wiring for the 8 line power and signal cable extending from the power supplies is the same as for the AccuRange 4000LV and LIR, except that the 5 volt power and heater lines, and the heater return line, are not connected. The table below shows the wiring for the 8 wire cable extending from the LIR and LV power supply boxes.

Wire	Function	Direction
Red	No Connection	
Black	Ground	
Orange	No Connection	In
Brown	No Connection	
Yellow	Temperature, 0/5 Volt	Out
Blue	Pulse Width Range	
	or Optional Current Loop Range	Out
Green	Ambient light signal, 0-5 V	Out
Purple	Amplitude signal, 0-5 V	Out
Shield	No Connection	

LIR and LV Power Supply Signal Cable Wiring



LIR and LV Power Supply Dimensions

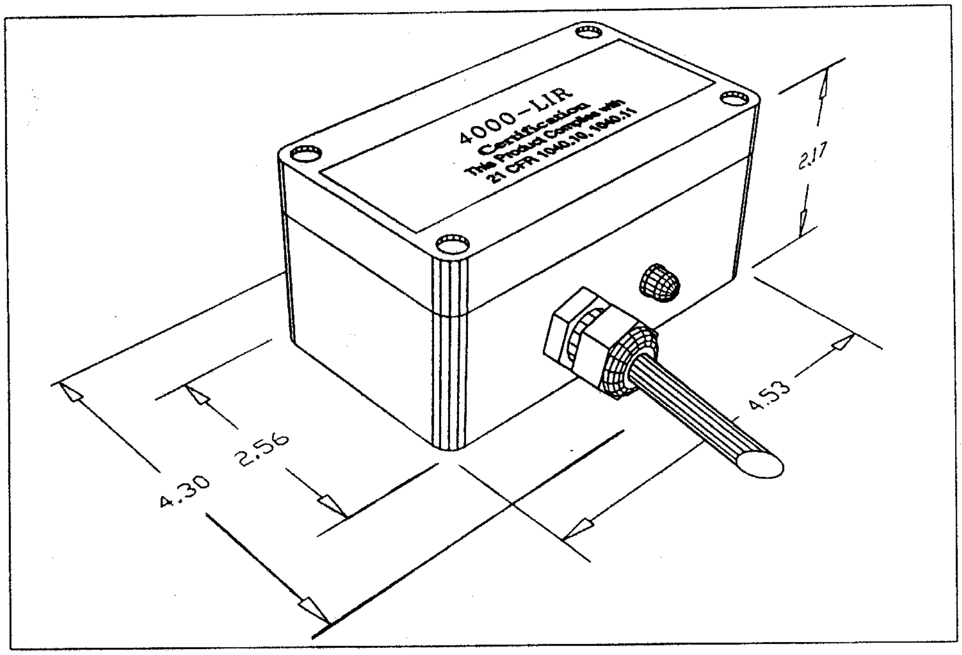


4000 LIR and LV With Power Supply

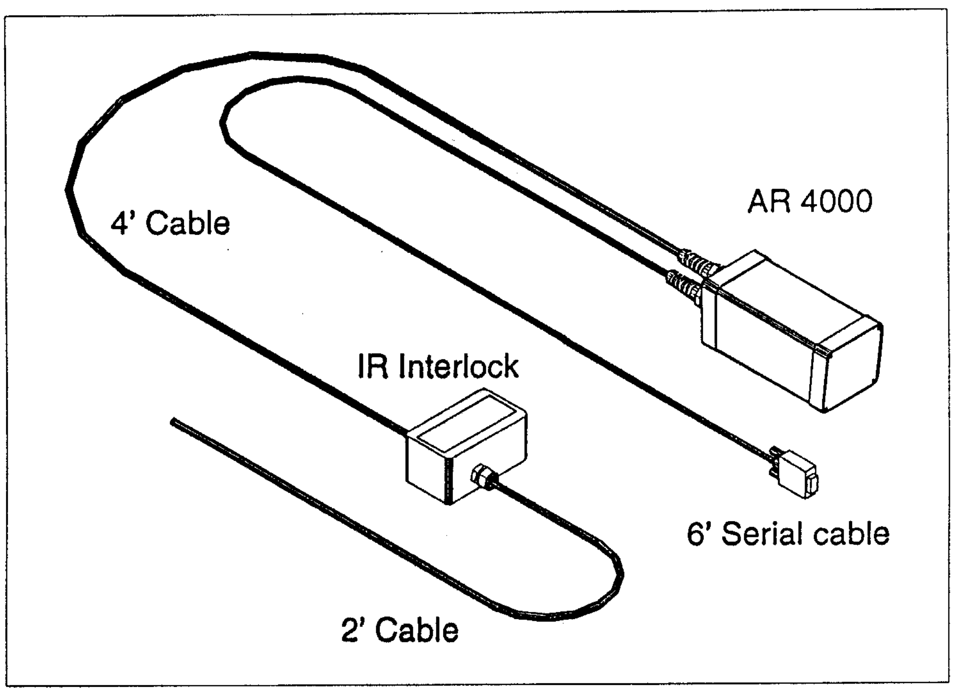
4.2.1 IR Interlock Box

The IR Interlock box contains the same keyswitch and removable jack as the IR Power Supply. To access the switch and jack, remove the four screws in the power supply case and lift the top half of the case.

All of the lines in the AccuRange Power and Signal cable are connected straight through, except that the red power line passes through the keyswitch and jack before powering the laser. Removing either the key or the jack or turning off the key breaks the sensor power circuit. When the circuit is complete, the indicator lamp on the box will light, and power is applied to the sensor. After a 5 second delay, the 4000-LIR laser will come on.



IR Interlock Box Mechanical Dimensions



4000 LIR with Interlock Box

5. Serial Interface Specification

5.1 Hardware Port

The default serial port in the AccuRange 4000 is a standard RS-232 port, which can be connected to an IBM or compatible 9 pin serial port. If the 422/485 option is ordered, the serial cable contains the wire pairs for point-to-point full duplex RS-422 communication. Data can be transferred at any of several baud rates, in binary or ASCII format.

Pin #	RS-232 Function	RS-422 Function
1	CTS	TxData-
2	TxData	TxData+
3	RxData	RxData+
4	DTR	RxData-
5	GND	GND
6	DSR (Connected to CTS)	NC
7	NC	NC
8	NC	NC
9	NC	NC

RS-232 and RS-422 Serial Port Wiring

5.1.1 Output Flow Control

If configured for RS-232, The interface board responds to two types of flow control: Ctrl-S/Ctrl-Q and hardware CTS/DTR. If configured for RS422, only Ctrl-S/Ctrl Q can be used, since wire pairs for CTS-DTR are not included. The interface will always stop transmission if Ctrl-S is received, and will resume when Ctrl-Q is received. RS-232 interface response to the DTR flow control input is controlled by the Flow Control configuration parameter. If flow control is enabled and the host computer sets DTR false, the sensor will stop transmitting. If flow control is disabled, DTR will be ignored. If output is suspended in the middle of a sample, the remainder of the sample will be transmitted when DTR is asserted by the host, but subsequent samples may be lost.

5.1.2 Input Flow Control

The sensor does not transmit Ctrl-S/Ctrl-Q. In the RS-232 configuration, if the input buffer is in danger of overflowing, the CTS line will be brought false. To assure no loss of command string data, the host system should respond to this signal if transmitting command strings of more than 10 bytes, or allow 0.1 seconds between commands for command completion. The Flow Control configuration parameter has no effect on the interface's assertion of CTS.

6. Installation

6.1 Cabling

6.1.1 Standalone Cabling

To use the AccuRange 4000 without a serial connection to a host computer, the only connections necessary are the power and ground lines, and the pulse width or current loop signal connection to your data display or recording equipment. See the Signal and Power Interface for wire connections. In its default configuration, the AccuRange 4000 will begin measuring and transmitting range on power-up (following a 6 second laser power-on delay for the 4000-LIR).

Depending on the configuration ordered, the range output line will have either the current loop or pulse width output on it. The best accuracy and linearity for the current loop is obtained with a 500 ohm load to ground at the measurement point.

The signal strength, background light, sensor temperature, and/or the optional current loop range output may be connected to analog input hardware. Use of a temperature stabilization power supply is also recommended for maximum accuracy. If you want to use temperature stabilization, attach the heater power lines to a 5 volt supply.

The AR4000 requires at least 5 volts for sensor power, so if the same supply is used for the sensor power as for the heater power, make sure that the lines are connected together at the supply. Tying them together at a distance from the supply may cause voltage drops in the power lines due to the heavy currents (up to 4A in cold conditions) drawn by the heaters.

6.1.2 Connection to a Host Computer

Unless ordered with the RS-422 option, the cable with the 9 pin connector is the RS-232 serial connection to the sensor. This may be directly connected to an IBM-PC compatible serial port. Connect a 5 to 6 volt power supply to the power and ground lines of the Power/Signal cable. See the Signal and Power Interface for wire connections. Only the power and ground need be connected for operation with the serial interface. Temperature stabilization power may also be connected, as described above. For testing use a terminal emulation program such as the Windows terminal, set to 9600 baud, 8 bits, no parity, 1 stop bit. Sensors configured with the RS-422 option behave identically in software, and any of several commercially available RS-22 cards may be used to support the sensor on a PC communcations port.

7. Initial Checkout

7.1 4000-LV

When power is applied the green LED on the back panel should flash briefly and then stay on, and a bright red beam should be emitted from the center of the front aperture. The sensor should give reasonable range information immediately, although it will take 5-10 minutes for the internal temperature and range readings to stabilize fully.

7.2 4000-LIR

When power is applied the green LED on the back panel should come on. After approximately 6 seconds, the LED will flash briefly and the laser will come on. The beam will be invisible or just barely visible. Use an IR viewing card in the path of the beam for viewing. The sensor should give reasonable range information after the 6 second delay has passed and the laser turns on, although it will take 5-10 minutes for the range readings to stabilize fully.

7.2.1 Verifying Operation

In its default configuration, the 4000 transmits 5 samples per second at 9600 baud over the serial line, and transmits measured distance over the current loop output (if installed) with the same update rate. The frequency of the pulse width output will be higher: See the Pulse Width Output section. The current loop should put out 4 mA at zero range, and 20 mA at 650 inches. Check either or both of these signals to verify basic sensor operation.

7.3 Troubleshooting

If the LED does not come on, then blink once and stay on, check the power supply wiring. If the laser does not come on (after 6 seconds for the 4000-LIR), or the LED blinks rapidly (several times a second) check the power supply voltage. If the LED blinks continuously about once a second after power-up, the EEPROM has lost its configuration and/or calibration data. Pressing the switch will allow power-up to continue, but configuration information and measurement accuracy may have been affected. Messages will be transmitted over the serial port describing the failure (see the section on Configuration and Non-Volatile Storage). Configuration information may be restored by re-entering the desired configuration. Contact Acuity in the event of calibration data loss.

In the event of slightly low voltage from the power supply, the sensor will stop transmitting data and the LED will blink rapidly (several times a second) until the power supply level is restored.

If the power supply falls below 5 volts for more than 100 microceconds, the sensor will be reset to avoid unreliable operation that could damage it. If this occurs, the quality of the power supply and its ability to provide a constant voltage when there is noise on the AC line. If the power supply output voltage can be increased to 5.5 volts, this may provide enough margin to prevent resets, unless the supply has very poor line regulation.

7.3.1 Serial Communications Check

If no information is received over the serial port, check the power supply and serial cable connection. The sensor may in a configuration that prevents serial communication, such as being set at the wrong baud rate. Turn the power off, press the button on the back panel of the 4000, and turn the power on with the button held down. The LED should stay off until the button is released, and then flash briefly (after a 5 second pause on the 4000-LIR). This will reset the sensor to the factory default configuration (9600 baud, 8 bits, no parity, 1 stop bit), and should enable serial communication with the host system.

If no serial data is being received and the LED is blinking several times a second, the power supply voltage is low. It should be at least 5.0 volts at the end of the 6 foot sensor cable.

7.3.2 Range Output Check

If the range output is in error, check that the sensor and target are stationary and stable, that the target is about 8 feet from the sensor as an initial test range, and that the beam is hitting the target. The sensor may need to warm up before reaching full accuracy: leave it on for a few minutes and re-check the range accuracy.

One way to check the basic ranging operation of a sensor configured with pulse width output is with an oscilloscope. Check the waveform on the pulse width output. It should be a square wave swinging from 0.4 to 0.9 volts, with at rise/fall time of about 20 nanoseconds. The duration of the low portion of this signal should increase as the distance to the target surface increases. The signal repeats approximately 200 times per second at low sample rate settings, depending on the maximum range configured. For high sample rate settings, the signal will repeat once per sample interval.

7.3.3 Analog Output Check

The analog signal outputs can be tested with a voltmeter or oscilloscope. Each should be between 0 and 5 volts. Amplitude should change as the target is moved, or as the target color changed. The ambient light output will also change, to a lesser degree. Pointing the sensor at a brightly lit surface should raise the ambient light output. Temperature should rise gradually for the first 15 minutes or so from a cold start, or more rapidly if the heater power is applied.

7.3.4 Range Measurement Quality Check

The quality of a range measurement depends on many variables, some of which are discussed in the section on performance and measurement accuracy. Generally, the quality of the signal can be measured by taking a set of samples of a stationary target over a fixed time interval and computing the standard deviation of that set of samples. For example, a set of 10 samples taken at a 100 Hz sampling rate over a total elapsed interval of 0.1 second on a stationary white target at a range of 8 meters can be expected to have a standard deviation of about .02 in. for the 4000-LIR and .08 in. for the 4000-LV. Note that sampling much faster than 100 Hz will result in greater standard deviations due to detector thermal noise effects, and sampling over much longer intervals will result in larger deviations due to long term drift.

8. Performance and Measurement Accuracy

This chapter is a general discussion of factors that affect the sensor's performance and is intended as background information to help with demanding applications. It is not needed for basic installation and configuration.

The 4000-LIR and 4000-LV will detect diffuse reflections from objects of any color with the greatest sensitivity falling at about 8 feet, although short distances right up to the front face of the sensor can be measured. If the sensor is configured with the close focus optics options, the greatest sensitivity will be 3 to 4 feet from the sensor unless adjustments have been made for a specific application. The sensor has no trouble picking up walls, floors, carpets, and even surfaces such as CRT screens from almost any angle. Shiny surfaces such as glossy plastic or paint can be more difficult to detect, depending on the angle at which the beam hits them.

The 4000-RET will detect only returns from retroreflective materials or mirror-like surfaces, including glass. Retroreflective tape can be detected over incidence angles of about +/- 40 degrees, while mirror surfaces must be oriented to reflect the beam back into the sensor to allow detection.

The sensor is calibrated with the temperature control active and set to 95^{o} F. Lower laser settings and operation at other temperatures may reduce the accuracy of the measurements taken.

There are three types of noise that will affect the measurement accuracy in different ways. They are described below, but each has a range of sample rates at which it is the predominant source of noise. Figure 2 shows the accuracy limit imposed by each type of noise for a given sample rate. The first type is detector thermal noise, which originates in the signal detection photodiode, and is proportional to the square root of the sample rate. The second type is laser diode noise, and the third type of "noise" is the resolution limitation imposed by the sampling method. Detector thermal noise is not a factor with the 4000-RET, as the signal from the retroreflector is strong even at the eye safe power level.

The vertical scale in Figure 2 is the attainable accuracy, while the horizontal scale is sample rate. Each line represents a different constraint on accuracy due to noise or sampling resolution. For any sample rate, the highest line at that rate represents the limiting factor and the attainable accuracy. At low sampling rates (below 10,000 samples per second) the limiting factor is the laser diode noise, shown as a horizontal line. At higher sampling rates the limiting factor becomes the detector thermal noise, shown as the curved line proportional to the square root of the sample rate. At the highest sampling rates, the sampling resolution becomes a factor, and the diagonal line shown in Figure 2 represents the limitations of the AR4000 sampling resolution with a maximum range of 30 feet.

8.1 Detector Thermal Noise

Range measurement accuracy at high sample rates is limited by thermal noise in the sensors' detector. Typically, a range measurement will be made by timing a number of cycles of the output. The greater the number of cycles timed, the better the averaging or filtering of this noise will be. Without going into the theory of noise power and noise bandwidth, the effect is that the standard deviation of the measurement error increases proportionally with the square root of the signal bandwidth, or in this case the sample rate. The noise in this sensor is 0.0005 in/($Hz^{1/2}$). Multiplying this value by the square root of sample rate will give the rms. noise value (approximately the same as the standard deviation) for the measurement. Thus a sample rate of 10,000 Hz gives readings with a standard deviation of about .05 inches.

8.2 Laser Diode Noise

There is another source of measurement error that needs to be considered when taking high accuracy measurements, caused by noise in the laser diode. This noise is characterized by random changes in the range reading that tend to increase as the time over which the readings are taken increases, when the sensor and target are stationary. This becomes noticeable over times of about 0.3 seconds or more, and increases up to times of several hours. The standard deviation of this drift is about 0.01 in. at 1 second, and .05 in. at 10 hours for the IR version and up to .1" in 10 hours for the visible model. Much of this noise shifts to higher frequencies (up to several kilohertz) if the target is moving or vibrating, even slowly. This fact can be used to filter out this noise if low frequency sampling is being done on a moving target. The motion effectively dithers the range reading, and an average value can be obtained that is more accurate than is possible if the target is stationary.

8.3 Maximum Range Specification

One of the configuration options for the AccuRange 4000 is the maximum range expected. This is to allow the sensor to obtain readings with the best possible resolution and accuracy. Internally, the time required to take a single sample depends on the distance being measured and the resolution used to take the measurement, If the ranges are known to be short, better resolution and accuracy at high sample rates may be obtained by reducing the maximum range. For most applications the default of 650 inches should be adequate. If you are measuring ranges greater than this, or ranges much shorter in situations where maximum resolution and high sample rates are required, your maximum should be specified using the Set Maximum Range command.

8.4 Sampling Resolution

The diagonal line shown in Figure 2 is an accuracy limit due to sampling resolution, assuming that the ranges to be measured are 30 feet or less. This becomes the limiting constraint above 15,000 samples/second. For ranges up to

60 feet, the limitation would be a similar line with twice the slope. This is due to the fact that longer ranges make more time to resolve to the same precision.

8.5 Other Factors Affecting Performance

In addition to noise, there are other factors that affect the indicated range output. The most significant of these is the amplitude of the return signal, or the reflectivity of the target. Indicated range can vary as much as 3 inches between very weak signals and very strong ones. The sensor has a signal strength output, which is an analog signal that ranges from 0 to 4 volts and is approximately logarithmic with received light intensity. The calibrated output compensates for varying reflectivity. The amplitude output can also be used to create grayscale images of objects over which the beam is scanned, and to determine whether a signal is valid or too weak to be reliable.

Temperature and the ambient light level also affect the measurement slightly. Analog temperature and ambient light outputs allow these effects to be compensated for in software, but typically they are not significant unless the sensor is used in an environment where they vary widely.

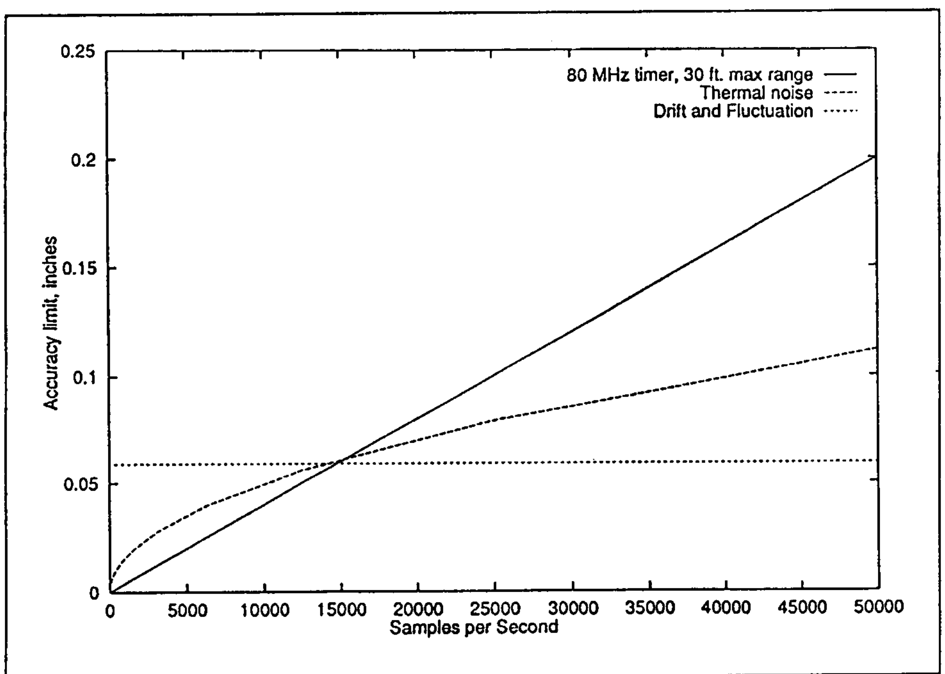


Figure 2. Attainable Accuracy vs. Sample Rate

8.6 Sensor Linearity

If the sensor is being operated in uncalibrated output mode, the nonlinearity of the sensor must be considered to accurately obtain actual distance from the indicated range. The sensor's calibrated output compensates for nonlinearity, but since this varies from sensor to sensor it must be individually measured and accounted for when operating the sensor in uncalibrated mode.

9.0 Serial Communications

9.1 Output Data Formats

Data is transmitted from the AccuRange 4000 as 8 data bits with no parity and 1 stop bit. The data sent may consist of calibrated distance readings, uncalibrated sensor data, or both together in each sample. Data may be sent in ASCII or binary format. Thus there are 6 data format combinations that can be transmitted by the 4000: ASCII calibrated only (the default), ASCII uncalibrated only, ASCII calibrated plus uncalibrated, binary calibrated only, binary uncalibrated only, and binary calibrated plus uncalibrated.

If calibrated output is enabled, the range information is the measured distance obtained by the sensor's internal calibration process. This is then transmitted as ASCII characters or binary bytes, depending on whether the ASCII or binary mode has been selected. In binary, all multibyte range and distance measurements are transmitted most significant byte first.

If uncalibrated mode is selected, the data transmitted by the sensor consists of a raw (uncorrected) range reading in sensor count units, the reflected signal strength, background light level, and sensor temperature. The size of the sensor count units in uncalibrated mode will depend on the maximum range and sample rate specified.

If both calibrated and uncalibrated outputs are enabled, the calibrated data is transmitted first, followed by the uncalibrated information. Each combination is detailed below.

The location of the zero point may be changed for either calibrated or uncalibrated output with the Set Zero Point command. The direction of increasing output serial values from the zero point may be reversed by issuing the Set Span command with a distance closer than that used in a previously issued Set Zero Point command.

9.1.1 ASCII Data format, Calibrated Distance Only

[DD]D.DD<CR><LF>
In this configuration, each sample consists of a string of characters as follows: 4 to 6 distance followed by <CR><LF>. characters (possible values from 0.00 to 999.99 inches in 1/100ths of an inch in English output, or 0 to 99999 mm metric) Values enclosed in [] will not appear if they consist only of leading zeros.

9.1.2 ASCII Data format, Low Level Sensor Outputs Only

[RRRRRR]R<TAB>[SSS]S<TAB>[AAA]A<TAB>[TTT]T<CR><LF>

In this configuration, each sample consists of characters as follows: 1 to 7 range characters (possible values from 0 to 4.19 million, decimal format), SPACE, 1 to 4 signal strength characters (0 to 1023), SPACE, 1 to 4 ambient light level characters (0 to 1023), SPACE, 1 to 4 sensor temperature characters (0 to 1500 in 0.1^{o}F per unit), <CR><LF>.

9.1.3 ASCII Data format, Distance plus Low Level Sensor Outputs

[DD]D.DD<TAB>[RRRRRR]R<TAB>[SSS]S<TAB>[AAA]A<TAB>[TTT]T<CR><LF>

In this configuration, each sample consists of characters as follows: 4 to 6 distance characters (possible values from 0.00 to 999.99 inches or 0 to 99999 mm), TAB, 1 to 7 range characters (possible values from 0 to 4.19 million), SPACE, 1 to 4 signal strength characters (0 to 1023), SPACE, 1 to 4 ambient light level characters (0 to 1021), SPACE, 1 to 4 sensor temperature characters (0.1^{o}F per unit), <CR><LF>. Values enclosed in [] will not appear if they consist only of leading zeros.

9.1.4 Binary Data format, Calibrated Distance Only

DD<FF>

In this configuration, each sample consists of 3 bytes: 2 distance bytes representing the range in 1/100ths of an inch in English output, or mm in metric ouput, followed by one byte with value FF Hex for framing. The maximum value of the distance word is FEFF Hex, to prevent framing ambiguity. The distance is transmitted low byte first. Synchronization should be performed by halting the serial output and then restarting it after flushing the serial input to the host, or by verifying that only one byte in 3 is of value 0xFF.

9.1.5 Binary Data format, Low Level Sensor Outputs Only

RRRSAT<FF><FF>

In this configuration, each sample consists of 8 bytes as follows: 3 range bytes, 1 signal strength byte, 1 ambient light level byte, 1 sensor temperature byte (0 to 255 in units of 0.5 ^{o}F), and two bytes with value 255 (Hex FF) for framing. The range is transmitted high byte first.

9.1.6 Binary Data format, Distance Plus Low Level Sensor Outputs

DDRRRSAT<FF><FF>

In this configuration, each sample consists of 10 bytes as follows: 2 distance bytes representing range in units of 1/100 of an inch or in mm, 3 range bytes, 1 signal strength byte, 1 ambient light level byte, 1 sensor temperature byte, and two bytes with value 255 (Hex FF) for framing. The maximum value of the distance word is FEFF Hex, to prevent framing ambiguity. The distance is transmitted low byte first. The uncalibrated range is transmitted high byte first.

10. Current Loop and Pulse Width Outputs

One of the lines in the power/signal cable, not used in the base configuration, carries the optional current loop output or, if the sensor is configured for use with a High Speed Interface, the same line will have an uncalibrated pulse width output signal.

10.1 Pulse Width Output

If the AccuRange 4000 is configured for use with a High Speed Interface, this output provides an uncalibrated measure of range. The period of the pulse is the sample interval for which the sensor has been configured with the Sample Rate command. The high level of the pulse is about 0.9 volts, and the low level is about 0.4 volts. The duration of the low portion of the pulse is proportional to measured range, scaled by the sample rate and maximum range for which the sensor is configured.

The pulse width output is actually a direct indication of the range as measured by the sensor electronics, before any firmware averaging or calibration. The scaling of the pulse width output depends on the sample rate and the maximum anticipated range for which the sensor is configured. The pulse will repeat once per sample interval down to a sample rate of about 200 samples per second. At lower sample rates the pulse will repeat one or more times per sample.

The width of the low portion of the pulse is proportional to range plus a constant offset: Zero range does not give zero pulse width. The pulse duration is also scaled each time a new Sample Rate or Maximum Range command is issued. The scaling is by factors of 2, and is set so that pulses will complete before the start of the next sample, but will take up most of the pulse period when measuring a distance at maximum range. Therefore, the max. range and sample time should be set before using the pulse width output, as changing them may re-scale it.

10.2 Current Loop Output

If the sensor was ordered with the optional current loop output, this line will deliver a current proportional to the measured range. The zero range current, offset of the zero range point (the starting distance), and the span (point of full scale output) may be set. See the Set Zero Point and Set Span Commands. Either calibrated or uncalibrated range may be selected for this output. If calibrated output mode is enabled, the output will be the actual distance to the target. Otherwise, the output will be the indicated sensor range, uncompensated for temperature, signal strength, and other effects.

In the default configuration, the current output is updated 5 times per second. This may be increased or reduced with the Set Sample Rate Command, using either the pushbutton on the back of the sensor or the ‘S’ command over the serial port.

Best accuracy and noise immunity is obtained by loading the line with a 500 ohm resistor to ground at the measurement point. The default configuration is for calibrated output, with the zero current set to 4 milliamps, the zero point at zero distance, and the span at 650 inches.

The minimum current loop span is approximately 9 inches. Attempts to set a smaller span will result in a span of about 9 inches.

The direction of increasing current output can be reversed by setting the span to a value closer that the previously set zero point.

The current loop output is a single line: The return portion of the “loop” is through ground.

11. Serial and Analog Output Performance Specifications

11.1 Sample rate

Maximum of 770 samples per second for calibrated output, 3300 samples per second for uncalibrated output. The sample rate is programmable to any rate below this, down to one sample per 10 seconds, with a resolution of 1 microsecond. Valid arguments for the sample rate command are 20 (microseconds per sample) to 9999999 (microseconds per sample).

Sample rate has a slightly different meaning for serial output and for the optional current loop output. For serial output, one sequence of characters is transmitted at each sample interval. The sample rate may be limited by the time required to obtain and calibrate a range measurement in calibrated output mode. It may also be limited by the time required to transmit each sample at the specified baud rate. If the baud rate is the limiting factor, data will be transmitted continuously. For calibrated output, the maximum sample rate is 1400 microseconds per sample if only the serial output is enabled.

For current loop output, the current transmitted is updated once per sample interval up to the limits of the sensor’s sample rate capability. If a low sample rate is specified the resolution of the output will be 1 part in 4000 over 0 to 20 milliamps, the limit of the output converter. If only the current loop output is enabled, the maximum obtainable sample rate is 1300 microseconds per sample.

If both the serial and current loop outputs are enabled, the maximum output rate is 1500 microseconds per sample for calibrated output.

For uncalibrated output, the maximum serial output rate is 400 microseconds per sample, and the maximum current loop update rate is 300 microseconds per sample.

11.2 Resolution

Range resolution is limited by the sample rate selected and the maximum range to be measured. Specifying faster sample rates or longer maximum ranges will result in poorer resolution. Calibrated range output is always transmitted in units of .01 inches. However, resolution will show up as “steps” in the output values transmitted by the sensor. For the current loop output, resolution may also be limited by the resolution of the digital to analog converter used. This may become noticeable for large span settings, since the inherent sensor resolution for low sample rates is better than 1 part in 10,000. The table below shows the resolution that will be obtained for a variety of sample rate and maximum distance settings.

Maximum Attainable Sample Rates, samples/second

Resolution, inches	Range 6 Feet	30 Feet	55 Feet
.0062	2304	677	390
.0125	4609	1355	781
.0250	9218	2711	1562
.0500	18346	5422	3125
.1000	36873	10845	6250
.2000	50000	21691	12500
.4000	50000	43382	25000
.8000	50000	50000	50000

Current loop output is generated with a resolution of 1 part in 4000, and is linear with respect to measured range to 1 part in 1000. Selectable zero and span allow full resolution over any distance span.

Sensor amplitude, ambient light, and temperature are 10 bit samples and are internally updated at the same frequency as the range measurement up to 10,000 samples per second.

12. Configuration and Non-Volatile Storage

12.1 EEPROM Operation

The AccuRange 4000 stores its configuration settings in non-volatile memory (EEPROM). Factory configuration values are stored in the EEPROM upon shipment and may be restored at any time using the Reset Configuration command, or by holding the push-button down while powering up the interface.

The configuration commands do not automatically store the changes to the EEPROM. The Write command is used to make these changes permanent. The Write command stores all configuration information, so it can be used once after making several changes. The Read command is used to restore the values from EEPROM and will overwrite any changes not saved with the Write command.

If the interface is unable to read the configuration data on power up or when the READ command is used, the message “EEPROM VALUES INVALID”. is sent over the serial port as the present baud rate, or at 9600 baud if the failure occurs on power-up. This will happen if the data has been corrupted due to a power failure during EEPROM write or some other reason. The sensor will then halt, with the indicator lamp flashing, until the switch is pressed. When operation continues, the sensor will be configured with the factory default settings.

The Write command should not be issued repeatedly under computer control in the course of normal operation, since the EEPROM’s expected lifetime is 100,000 data changes.

Calibration data is also stored in the EEPROM, but cannot be changed by user commands. If the calibration data becomes corrupted, the message “EEPROM CALIBRATION DATA READ FAILED” is sent over the serial port. The sensor will then halt, with the indicator lamp flashing, until the switch is pressed. When operation continues, the calibrated range output will likely be incorrect, and sensor operation will be impaired. Contact Acuity for assistance.

13. AccuRange 4000 Command Set

All configuration of the sensor may be done via commands sent over the serial port or by using the push-button switch and acknowledgment LED on the back panel. The serial port commands are ASCII commands that may be entered under computer control or from the keyboard of a terminal connected to the port. Configuration information may be stored in nonvolatile EEPROM with the Write command, and is then retained through power cycling.

Each ASCII command is one character, which for some commands must be followed by one or more parameter value characters. Multiple commands may be grouped together in a single serial transmission, as there are no terminator characters used, but sending more than 10 characters without pauses at high baud rates may result in loss of input if the CTS serial line signal is not respected.

Commands such as Set Sample rate have parameters that may be variable length. A command is accepted and executed when any character other that a digit (‘0’-’9’) is received, or when the maximum acceptable length of the command is reached.

Example: To execute a set sample rate command: S50<CR> or S0000050 or S50F100<CR>. The last example also sets the maximum range to be measured. Any character that is not a valid command or a numeric parameter is ignored and will have no effect other than to terminate numeric parameter entry. It is advisable to always terminate single commands or the last command in a sequence with a character such as <CR> or ‘.’ to ensure immediate command execution regardless of the length of numeric parameters entered.

All commands sent over the serial line are alphanumeric ASCII characters, allowing terminal keyboard entry. Command characters may be upper or lower case.

To enter commands with the switch and LED on the interface, press and hold the switch. The LED will go out for one second, and then will flash once per second as long as the switch is held. Hold it for the number of flashes given as the input switch code for that command. If a parameter is required, release the switch briefly as the command code flash count is reached (until the LED comes on after being released), then press and hold the switch for the number of flashes as required by the parameter value. The switch may be released any time after the start of a flash, before the next one starts. After the switch is released and the command entry is complete, the LED will flash in acknowledgment for a number of flashes equal to the total in the command, with a hesitation between the command and parameter. Commands take effect after the acknowledgment flashes.

Remember to make the changes permanent with the Write command (9 flashes) if desired, before turning off the power.
Example: To set the baud rate to 2400 baud, press and hold the push-button and wait for the LED to go out and then flash 10 times. Release the button. The LED will stay out, indicating that a parameter value should be entered. Press and hold

the button until the LED has flashed 4 times. Release the button. The LED will flash 10 times, pause, flash 4 times, and the baud rate will be set to 2400.

13.1 Command Quick Reference

One byte commands are shown below as ASCII Code:<Commandcharacter>.
Multiple byte commands are shown as:
ASCII Code: <Commandcharacter:> <<Parametername>>.

If the command may also be entered using the push-button, the number of LED flashes for that command is also given below.

Bracketed numeric parameters [...] are optional. Omitting an optional numeric parameter will set the value to the present internally measured value of that parameter. When using the switch and LED to enter commands, many optional parameters may only be set to their present values, since high resolution entry is not possible with the switch as an input device.

Default settings are for the factory configuration.

The notation (Serial Entry Only) indicates that the command cannot be given using the pushbutton on the back of the sensor.

Command Name	Length	Command Code	Default Setting
Set Sample Interval	3-8 bytes	ASCII Code: S<Interval> (20 <= Interval <= 9999999) Input switch code: 8<Rate Code>	5 samples/second (S200000)
Set Maximum Range	1-6 bytes	ASCII Code: F [<MaxRange>] (0 <= MaxRange <= 99999) Input switch code: 5	650 inches
Set Zero Point (Calibrated)	1-6 bytes	ASCII Code: Z[<ZeroPoint>] (0<=ZeroPoint <= 99999) Input Switch code:1	Zero range
Set Zero Point (Uncalibrated)	1-8 bytes	ASCII Code: Y[<ZeroPoint>] (0<=ZeroPoint <= 9999999) Input Switch code:16	

Command Name	Length	Command Code	Default Setting
Laser Power On	1 byte	ASCII Code: H Input switch code: 6	Laser on
Laser Power Off	1 byte	ASCII Code: L Input switch code: 7	
Enable Serial Data Output	2 bytes	ASCII Code: A<Mode> (Mode: 1=English, 2=low level, 3=flowctl, 4=Metric(mm)) Input switch code:11 <Mode>	English output enabled, uncalibrated outputs disabled, flowctl disabled
Disable Serial Data Output	2 bytes	ASCII Code: T<Mode> (Mode: 1=calibrated, 2=low level, 3=flowctl, 4=Metric(mm)) Input switch code: 12<Mode>	English output enabled, uncalibrated outputs disabled, flowctl disabled
Set Baud Rate	2 bytes	ASCII Code: B<Baud Rate Code> 1=300, 2=600, 3=1200, 4=2400, 5=4800, 6=9600, 7=19200, 8=38400, 9=76800 Input switch code: 10<Baud rate Code>	9600 baud
Set Serial Output to ASCII (Serial Entry Only)	1 byte	ASCII Code: D	ASCII Output
Set Serial Output to Binary (Serial Entry Only)	1 byte	ASCII Code: N	
Set Analog Zero Current	1-5 bytes	ASCII Code: J[<Current Output>] (Current Output, microamps) Input Switch Code: 3<Operation Code> Operation Code: 1:Set to 0. 2:Set to present current.	4 milliamps
Set Span	1-8 bytes	ASCII code: U[<Span] (0<=Span<=9999999) Input switch code:2	650 inches
Set Analog Output Mode	2 bytes	ASCII Code: X[<Mode>] (Mode:1=calibrated, 2=uncalibrated, 3=off) Input switch code:4	Calibrated Output

Command Name	Length	Command Code	Default Setting
Read Configuration Data From EEPROM	1 byte	ASCII Code: R Input Switch Code:18	
Write Configuration Data To EEPROM	1 byte	ASCII Code: W1234 Input Switch Code:9	
Reset Configuration to Factory Defaults	1 byte	ASCII Code: I Input Switch Code:15	
Set Temperature Hold Level	1-3 bytes	ASCII Code: C[<Temp To Hold>] (Temp. To Hold: 32-99 in ^{o}F). Input Switch code:13	95^{o}F
Take Single Sample (Serial Entry Only)	2 bytes	ASCII code: E[<Cal/Uncal.] (1=calibrated, 2=uncalibrated, 3=both)	
Set Minimum Valid Amplitude	1-4 bytes	ASCII Code: P[Amplitude] Input Switch Code: 17	0
Set Maximum Valid Amplitude	1-4 bytes	ASCII Code: M[Amplitude] Input Switch Code: 18	1023 (ASCII fmt) 0FFH (Binary fmt)
Show Version Number	4 bytes	ASCII Code: V1234	

13.2 Command Descriptions

The notation (Serial Entry Only) indicates that the command cannot be given using the pushbutton on the back of the sensor.

Set Sample Interval 2-8 bytes ASCII Code: S <Interval>
(20 <= Interval <= 9999999)
Default: 200000 (5 Samples/second) Input switch code: 8<Sample Rate Code>

Applies to serial and current loop output. When invoked as the “S” command over the serial port, sets the output rate of the sensor to the specified sample interval in microseconds. Interval must be 7 characters or less. Leading zeros may be included. Samples will not be sent unless corresponding output is enabled. For serial data, if the interval is less than the time required to transmit the data at the selected baud rate, samples will be sent continuously. Maximum rate will be limited by processor capacity when producing calibrated output.

To set with the pushbutton: The sample rate may be set to 1, 10, 100, or 1000 samples per second. The command code is 8, followed by the sample rate code. Allowed sample rate code values and resultant sample rates are:

Sample Rate Code	**Sample Rate**
1	1000 samples/second (1000 microsec/sample)
2	100 samples/second (10000 microsec/sample)
3	10 samples/second (100000 microsec/sample)
4	1 sample/second (1000000 microsec/sample)

Set Maximum Range 1-6 bytes ASCII Code: F [<Max Range>]
(0 <= Max Range <= 99999)
Default: 650 inches Input switch code: 5

Specifies the maximum range the sensor will be expected to measure, in inches, or to the presently measured distance if no numeric parameter is entered or the pushbutton is used. Setting this value to a short distance allows maximum resolution to be obtained for higher sample rates. See the section on resolution in the Serial and Analog Output Performance chapter. It is suggested that for sample rates above 1000 samples per second, this value be set as low as the maximum expected range allows.

Note: The maximum range cannot be set to a value greater than its present value with the pushbutton. The sensor will not properly measure distances beyond the maximum range setting, so attempting to set the maximum range to a greater value will give unpredictable results. The serial port may be used to set a long maximum range, and then the pushbutton used to set a closer value.

Set Zero Point (Calibrated) 1-6 bytes
ASCII Code: Z[<Zero Point>]
(0 <= Zero Point <= 99999)
Default: 0 inches
Input switch code: 1

Applies to serial and current loop outputs. Sets the zero point for the serial and analog current outputs to the value specified. If English output mode is enabled, the distance should be entered in 1/100ths of an inch. If metric output is enabled, the distance should be entered in millimeters. If no numeric parameter is entered or the pushbutton is used to enter this command the zero point will be set to the presently measured range. The sensor should be operating and pointed at a stationary target to use the latter technique. Note: The zero point may be set for either the calibrated output or the low level sensor output, but setting one will reset the other to zero. The sensor can be made to reverse the direction of increasing distance values for the serial and current loop outputs by setting the zero point and then using the U (Set Span) command with a closer location specified (See the Set Span command).

Set Zero Point (Uncalibrated) 1-8 bytes
ASCII Code: Y[<Zero Point>]
(0 <= Zero Point <= 9999999)
Default: Zero counts
Input switch code: 16

Applies to serial and current loop outputs. Sets the zero point for the serial and analog current outputs to the value specified in the present uncalibrated operating resolution of the sensor, or to the presently measured range if no numeric parameter is entered or the pushbutton is used to enter this command. The physical location of this point will depend on the sample rate and maximum range settings, and is in the same units as are in effect when the command is issued. The sensor should be operating and pointed at a stationary target to use the latter technique. Note: The zero point may be set for either the calibrated output or the low level sensor output, but setting one will reset the other to zero.

Set Span 1-8 bytes ASCII Code: U[<Span>]
(0 <= Span <= 9999999)

Default: 650 inches
(undefined in uncalibrated mode) Input switch code: 2

Set the point at which the current loop output is set to its maximum value. If the span is set to a distance which is less than a previously set zero point, the sensor output values will increase as the target point moves closer from the zero point to the span point. Other than causing this reversal of direction in the serial data, this command does not affect the serial output. If English output mode is enabled, the distance should be entered in 1/100ths of an inch. If metric output is enabled, the distance should be entered in millimeters. If no numeric parameter is entered or the pushbutton is used to enter this command, the distance at which the full scale level is output will be set to the presently measured range. If a parameter is entered, it is interpreted as the absolute distance from the sensor, not the distance from the zero point.

The sensor should be operating and pointed at a stationary target to set the span to the presently measured range. Note that if the zero point is subsequently changed with Set Zero Point, the full scale range position will change by the same amount, so that the span is preserved. Generally, the span should be set after the zero point.

Set Analog Output Mode 2 bytes ASCII Code: X[<Type>]
(Type:1=Calibrated,2=Uncalibrated, 3=off)

Default: Calibrated, if current loop installed. Input switch code: 4

Selects whether the current loop output will be based on the calibrated distance or on the direct, uncalibrated sensor output, or turned off. Note that any changes to the zero point and the analog span are dependent on the output type enabled. Therefore, this command should be used to select the desired output type prior to setting the zero and span locations.

If the current loop output is enabled, a current between the zero current level and 20 milliamps will be transmitted out the current loop line. The zero reading current may be set anywhere from 0 to 20 milliamps with the Set Zero Current Command, and the Zero Point and Span commands may be used to set the distances at which minimum and maximum current occur. This command has no effect if the Current Loop option is not installed other than to reduce the maximum sample rate, and should be left set to Off.

Laser Power On 1 byte ASCII Code: H
Input switch code: 6

Factory Default: Laser on.

Turns the laser on. For both the 4000-LIR and 4000-LV, this command turns the laser on within 50 microseconds of reception.

Laser Power Off	1 byte	ASCII Code: L Input switch code: 7

Factory Default: Laser on.

Turns the laser off. For both the 4000-LIR and 4000-LV, this command turns the laser off within 50 microseconds of reception.

Enable Serial Data Output	2 bytes	ASCII Code: A <Mode> Input switch code: 11 <Mode>

Default: English calibrated output enabled, Low level internal sensor data (uncalibrated) output disabled, flow control disabled.

Enables serial output transmission. Either or both of calibrated distance and internal sensor information may be transmitted at every sample time. Calibrated distance may be ouput in either inches or millimeters. If only calibrated output is enabled, the serial data stream consists only of actual distance measurements, in either ASCII or binary format. If only internal sensor information is enabled, the output stream contains only the uncalibrated range in internal sensor units, along with the signal strength, ambient light level, and sensor temperature. If both types of output are enabled, the calibrated distance is followed by the sensor information.

Calibrated distance measurements are corrected for signal strength and temperature with the AccuRange 4000 internal calibration algorithm. Calibrated output is the form typically used, unless the amplitude and other information is also required.

See the Output Data Formats section for a detailed description of the possible output formats, in ASCII or Binary. For high sample rates, disable any unused output mode. Disable both serial modes to halt serial output and improve the update rate of the current loop output.

RS-232 flow control is also enabled with this command. See the section on Flow Control.

Mode Value	Output Enabled
“1” or 1	Serial Calibrated Output in Inches
“2” or 2	Serial Uncalibrated
“3” or 3	Flow Control
“4” or 4	Serial Calibrated Output in Millimeters

If any serial output is enabled, and flow control is disabled or the DTR input is asserted, sample data is transmitted over the serial line at the selected sample rate and baud rate, in ASCII or binary as specified with the Set ASCII and Set Binary commands. If flow control is enabled, the state of the DTR input on the serial connector is monitored and output is suspended if the signal is false.

Disable Serial Data Output	2 bytes	ASCII Code: T <Mode> Input switch code: 12 <Mode>

Factory Default: English calibrated output enabled, Low level internal sensor data output disabled, flow control disabled.

Disables the serial output data mode specified by the parameter. See the Enable Serial Data Output command. For high sample rates, disable all unused output modes. Flow control may also be disabled with this command.

Set Baud Rate	2 bytes	ASCII Code: B <Baud Code>
Default: 9600 Baud (Baud Code 6)		Input switch code: 10 <Baud Code>

Sets the baud rate to the specified value, as given by the following table. Note that if the baud rate combined with the number of bytes sent per sample (as determined by the output format: ASCII or Binary, Calibrated or Uncalibrated) exceeds the selected sample time, data will be transmitted continuously.

Baud Code (button or ASCII)	Baud Rate
1 or “1”	300
2 or “2”	600
3 or “3”	1200
4 or “4”	2400
5 or “5”	4800
6 or “6”	9600
7 or “7”	19200
8 or “8”	38400

Set Analog Zero Current 6 bytes ASCII Code: J [<Currentlevel>]
Input Switch Code: 3<Option Code>
(Option Code = 1, 2)
Factory Default: 4 milliamps

Sets the current that the analog output will deliver when the measured distance is less than or equal to the zero point as set by the Set Zero Point command. If the current drops below this level, the interface has experienced a hardware failure. The level may be set from 0 to full scale (20 mA).

When invoked by serial line, this command sets the zero current to the level specified, in microamps, or to the present current output level if no numeric parameter is entered. A value of 4000 will set it to 4 milliamps.

When invoked by push-button, there are 2 zero current setting options. They are:

Button Option Code 1: Set Zero Current to Zero milliamps. If the range is less than or equal to the zero point as set by the Zero command, the current loop output will be zero. To see the current go to zero upon using this command, use the Zero Point command first, and then point the sensor at a closer target and use this command. Setting the zero current to a level below its present value with the button must be done in 2 steps. The first is this step. The second is to use Set Zero Current to Present Reading.

Button Option Code 2: Set Zero Current to Present Reading. The zero current value is set to the present current level being output. To use this command, first use the Set Zero Current to Zero command, above. Then point the sensor at a target at a range which causes the desired zero current to be output and use this command.

Read Configuration Data From EEPROM 1 byte ASCII Code: R
Input Switch Code: 18

Reads the configuration from the EEPROM and makes it the current configuration. It may be used to restore the power-up configuration if a temporary change has been made with any of the configuration commands, and those changes have not been written to the EEPROM. This command is executed automatically upon power on.

Write Configuration Data To EEPROM 1 byte ASCII Code: W1234
Input Switch Code: 9

Sets the power up state of all configuration options to their present values. The configuration is immediately preserved and automatically becomes the new power up default. The argument “1234” is required to prevent accidental writes during power up. Factory defaults may be restored at any time with the Reset Configuration to Factory Defaults command.

Reset Configuration to Factory Defaults	1 byte	ASCII Code: I Input Switch Code: 15

Restores the operating configuration to the original factory defaults. May be used if the present state is unknown or inconvenient. This reconfiguration is NOT saved to EEPROM: The Write command must then be used to make this initialization permanent. The configuration may also be set to the factory settings by holding the push-button down on power up. The LED will stay off until the button is released, and the factory configuration will be loaded.

Set Serial Output to ASCII (Serial Entry Only)	1 byte	ASCII Code: D

Factory Default: ASCII

Sets the serial output format to ASCII, allowing it to be read on a terminal. See the Output Data Formats section for a detailed description of the serial data stream in ASCII format.

Set Serial Output to Binary (Serial Entry Only)	1 byte	ASCII Code: N

Factory Default: ASCII

Sets the serial output format to binary. See the Output Data Formats section for a detailed description of the serial data stream in binary format.

Set Temperature Hold Level	1-3 bytes	ASCII Code: C[<Temp. To Hold>] (Temp. To Hold: 32-99 in ^{o}F) Input Switch Code: 13

Factory Default: 95^{o}F

If power is applied to the temperature control power supply lines, the temperature will be maintained at this temperature or higher in the AccuRange 4000. On power up, the time to reach the target temperature is approximately 30 seconds/^{o}F temperature difference. Only heating capability exists, so the temperature may rise above this level if the ambient temperature is high. If this command is given with the push-button or without parameters, the present temperature is used as the temperature to hold.

Take Single Sample (Serial Entry Only)	2 bytes	ASCII Code: E[<Cal/Uncal.] (1=Calibrated, 2=Uncalibrated, 3=Both)

Turns on the laser, waits approximately 100 microseconds for the laser output to stabilize, takes a sample, turns the laser off, and sends the sample results over the serial port. If the parameter value is 1, calibrated distance is sent. If the parameter value is 2, uncalibrated range and other sensor data is sent. If the value is 3, both are sent. Note that the laser is turned off after this command, even if it was previously on.

Set Minimum Valid Amplitude 1-4 bytes ASCII Code: P[Amplitude]
Input Switch Code: 17

Factory Default: 0 (Distance output calculated for all amplitudes)

Sets the amplitude (signal strength) below which the calibrated distance output from the serial port and current loop will be zero. This may be used to detect and prevent what would be inaccurate readings resulting from low signal strength. If no parameter is entered or the switch is used to issue this command, the presently measured amplitude is used as the threshold value. Values from 0 to 999 may be entered. The amplitude of a range measurement is part of the sensor data which may be sent over the serial port using the Enable Serial Data Output command (Command “A2”).

Set Maximum Valid Amplitude 1-4 bytes ASCII Code: M[Amplitude]
Input Switch Code: 18

Factory Default: 1023 (Distance output calculated for all amplitudes)

Sets the amplitude (signal strength) ABOVE which the calibrated distance output from the serial port and current loop will be zero. This may be used to detect and prevent what would be inaccurate readings resulting from sensor overload. If no parameter is entered or the switch is used to issue this command, the presently measured amplitude is used as the threshold value. Values from 0 to 999 may be entered. The amplitude of a range measurement is part of the sensor data which may be sent over the serial port using the Enable Serial Data Output command (Command “A2”).

Show Version Number 4 bytes ASCII Code: V1234
(Serial Entry Only)

The characters V1234 entered in sequence will cause the firmware revision number of the sensor to be output. If data is being output when this command is used, the version number will appear between samples. The argument “1234” is required to prevent accidental output during data transmission.

14. Data Sheet: Summary of Specifications

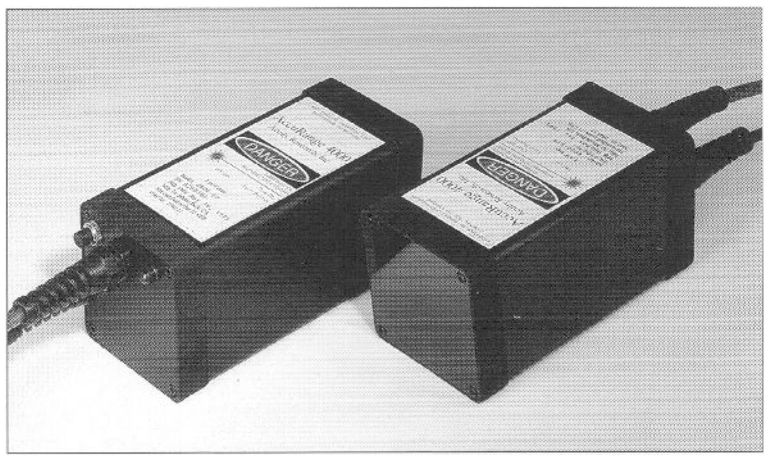
The following 2 pages are a reproduction of the data sheet for the AccuRange 4000, which lists interface specifications, requirements and characteristics of the sensor.

AccuRange 4000 by Acuity RESEARCH

The AccuRange 4000 is an optical distance measurement sensor with a useful range of zero to 50 feet for most diffuse reflective surfaces, with an eye safe version available for use with reflective tape. It operates by emitting a collimated laser beam that is reflected from the target surface and collected by the sensor. The sensor is suitable for a wide variety of distance measurement applications that demand high accuracy and fast response times.

Key Features

- Zero to 50 feet operating range for most surfaces.
- 0.1 in (2.5mm) accuracy, 0.02 in (0.5mm) short-term repeatability. Digital output in inches or mm.
- Optional RS-485/422, 4-20 mA current loop, and pulse width outputs. RS-232 serial output standard.
- Reflected signal amplitude output for grayscale images.
- Fast response time: 50 KHz maximum sample rate.
- Lightweight, compact, low power design.
- Tightly collimated output beam for small spot size.
- Three output beam configurations available: Visible, infrared, or eye safe infrared for reflective tape targets.
- Ideally suited to level and position measurement, machine vision, autonomous vehicle navigation, and 3D imaging applications.



AccuRange 4000 Technical Specifications

Standard Configurations

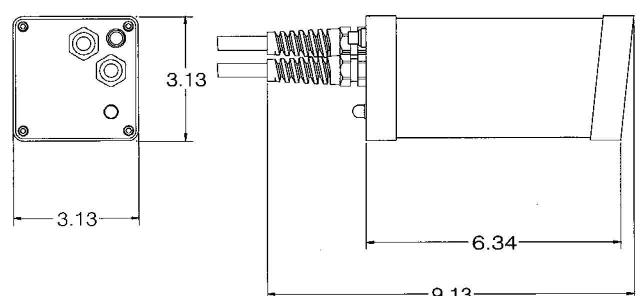
4000-LIR: Emitter: 780 nm
IR laser diode
Optical power:
8 milliwatts max.
Effective Range:
50 feet
Optional 20mW max.

4000-LV: Emitter: 670 nm
Visible red laser diode
Optical power:
5 milliwatts max.
Effective Range:
40 feet

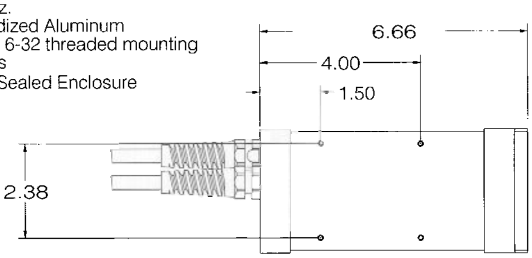
4000-RET: Emitter: 780 nm
IR laser diode
Optical power:
130 microwatts max.
Effective Range:
50 ft cal, 150 ft uncalib.

**Class I
Eye Safe
Laser Product**

Mechanical



Weight: 22 oz.
Outer Shell: Anodized Aluminum
Mounting: Four 6-32 threaded mounting holes
NEMA 4 / IP65 Sealed Enclosure



Of these configurations, the 4000-RET and 4000-LIR have the lower measurement noise, greater sensitivity and maximum range. The 4000-LV features visible light output. See the relevant specifications. Custom configurations are also possible.

Interface

Power

Sensor Power: +5 Volts (+5V min, +6V max) @ 400 mA
Heater Power: +5 Volts (+5V min, +6V max) @ 4 A, temperature dependent. May be used to stabilize sensor temperature in low-temperature environments.

Power and Signal Cable

Color	Function	Direction
Red	Power	In
Black	Ground	
Orange	Heater Power	In
Brown	Heater Return	
Yellow	Temperature	Out
Blue	Pulse or Current	Out
Green	Ambient Light	Out
Purple	Amplitude	Out

Data and Communications

Serial Interface

RS-232 serial output or optional RS-485 or 422 on a 9-pin PC-compatible cable. Output may be in an internally calibrated distance format with a resolution of .01" or 1mm, or in an uncalibrated format which includes uncompensated range and signal strength, background light, and sensor temperature.

Data Formats

ASCII Mode:

Calibrated Output: 3-6 bytes.
Distance 0 to 650 inches in units of .01"
CR,LF terminated
Low Level Outputs: 9-24 bytes
CR,LF terminated

Binary Mode:

Calibrated Output: 3 bytes.
Distance 0 to 650 inches in units of .01"
FF terminated
Low Level Outputs: 8 bytes
FFFF terminated

Device Configuration via AccuRange Command Set

Baud Rate: 300-38400 baud*
Sample Rate
ASCII or Binary Output
Maximum Range *
Reversible scale direction
Laser On/Off*
Zero Point Set
Current Loop Zero, Span*
Current Loop Mode (Off/Calibrated/Uncalibrated)*
Serial Mode (Off/Calibrated/Uncalibrated)*
Take Single Sample

* May also be set without serial communication, using pushbutton/LED interface.

Optional Pulse Width Output

Uncalibrated range output: 18 to 50000 samples/sec
0.5V peak to peak square wave signal

Supplementary Voltage Outputs

Analog voltage signals: Standard on the power/signal cable. Voltage outputs are 0-5 volt analog levels indicating target signal strength, background illumination, and sensor temperature.

The pulse width and voltage outputs are typcially used for external calibration at sample rates above 1000/second.

Optional 4-20 mA Current Loop

Replaces pulse width output on the power/signal cable.
Calibrated output to 1 KHz or high-speed uncalibrated output to 3 KHz
Adjustable zero and span points
Adjustable zero current: 4 mA default

Operating Temperature: 0 - 113°F.

Performance

Two forms of output are available from the sensor. Calibrated output is distance in units of .01". Calibration compensates for sensor temperature and target reflectance, and is performed in the sensor. The sample rate for calibrated output is limited to 1 KHz. For higher speed output, the uncalibrated serial outputs or pulse width and voltage signals may be used.

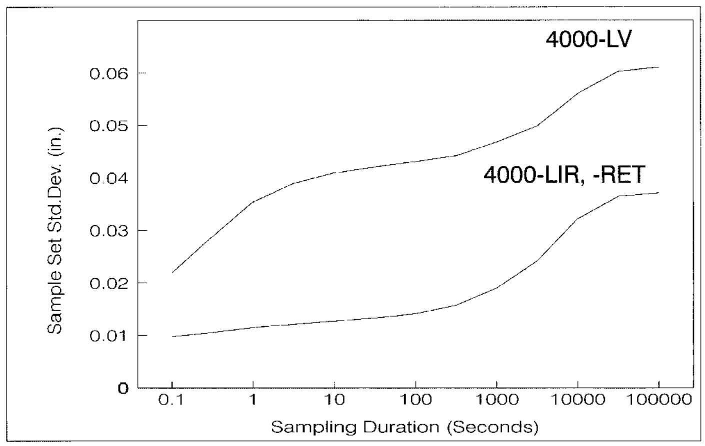
Useable Range

4000-LIR: 0 to 54 feet (calibrated)[1]
4000-RET: 0 to 54 feet (calibrated)
4000-LV : 0 to 40 feet (calibrated)[1]
0 to 150 feet (uncalibrated, with reflective target)

Short Term Measurement Noise

.0005 inches / $\sqrt{Hz}$
(all samples within 0.3 sec.)

Long Term Drift



Standard deviation of measurement error (drift) vs. time

Calibrated Absolute Accuracy

Standard Deviation of Range Error:
4000-LIR and 4000-RET: .1"
4000- LV: .3"

Range Signal Response Time

< 1 sample for all sample rates

Amplitude, Ambient Light, and Temperature Outputs

Analog signals, 0-5 Volts
Response Times (except temperature): 20 microseconds
Amplitude: Logarithmic signal
Ambient (Background) Light: Linear signal
Temperature: Linear 0-140°F. (31.3 millivolts/degree)

Optical

Laser Beam Diameter: 0.1"
Laser Beam Divergence: 0.5 milliradians
Return Light Collection Aperture Diameter: 2.5"

The AccuRange High Speed Interface is also available, with sample rates to 50,000 samples/second for all AccuRange 4000 outputs.

Note 1: To 85% diffuse reflectance target.
US Patent # 5,309,212

Acuity Research, Inc. 3475 Edison Way #P Menlo Park, CA 94025 (650) 369-6782 Fax (650) 369-6785

15. AccuRange High Speed Interface

15.1 General Description

The AccuRange High Speed Interface is an interface board that takes samples from the AccuRange 4000 optical rangefinder. Two models are available. One model plugs into an IBM-PC or compatible ISA or EISA bus. The other model is PC/104 compatible. Samples come over the bus in an 8 byte format that includes a 19 bit range value and 1 byte values for signal strength, ambient light, and sensor internal temperature as well as status and general purpose input bits. These inputs, along with external enable/disable control of sampling, allow precise synchronization with external events.

The ISA/EISA board has an IBM PC form factor, and will fit in a half-length PC ISA slot. The PC/104 board conforms to the PC/104 specification for a 16-bit stackthrough module. Data is transferred over an 8 bit I/O port, with the address selected with on-board jumpers.

The interface board operates by measuring the range-dependent pulse width output of the AccuRange 4000. To use the 4000 with the High Speed Interface, the Current Loop option must not be installed in the sensor. Each pulse on the pulse width output is timed on the Interface board by a timer with a clock rate of 80 MHz. The sample rate of the interface is therefore controlled by the sample rate for which the 4000 is configured. Since the pulse width output can be set to repeat at up to 50 KHz, that is the maximum sample rate of the interface.

The data collected by the high speed interface is not scaled or calibrated in any way. It can be used to create calibrated distance output using software modules and tables supplied with the interface or though user-written algorithms. The data can be used to calculate distance as each sample is collected, although the more typical application will collect a batch of samples and create distance readings from the entire group after high-speed collection is finished.

Other features of the interface include memory buffer empty, half full, and overflow status indicators, external sample start/stop control, and three general purpose input bits that allow synchronous recording of events while sampling.

The board can also be ordered with power control circuitry for two small motors. This is not full servo control, but it allows motor power to be programmed. If the motors have encoders, the encoders may be sampled with the sensor data to provide position information in the sample stream in scanning systems. Each motor can be driven with up to 2 amps at 12 to 48 volts. Power for the motors must be supplied to the board, where it is pulse-width modulated (ISA/EISA model only) or DC level controlled (depending on the configuration ordered) according to the programmed power level.

15.1 Sensor Configuration and Sample Rate

When using the High Speed Interface, all configuration of the 4000 is done via the serial port, or push-button interface, just as it would be when using the sensor without the High Speed Interface. The communication path from the 4000 to the High Speed Interface is a one-way data path only; the sensor cannot be configured through the Interface. Since the sample rate of the Interface is controlled by the rate of the pulse width output of the 4000, using the Set Sample Interval command over the serial port will set the sample rate for the Interface, with one limitation. The lowest rate at which the internal sampling and therefore the pulse width output of the sensor can operate is 31 samples per second (32 milliseconds per sample). Setting lower sample rates will not reduce the pulse width output frequency or the sample rate of the Interface.

To obtain the slowest possible sample rate from the High Speed Interface and the maximum resolution per sample, use the serial interface to configure the 4000 for a maximum expected range of 9950 inches, and then set the sample rate. Setting the maximum range to shorter distances (including the default setting) may cause the pulse width to repeat at higher frequencies than the sample rate set, depending on the maximum expected range and sample rate specified. For short maximum range settings, the pulse frequency will be about 5 Khz for sample rates below that.

The maximum sample rate is 50,000 samples per second (20 microseconds/sample).

15.2 Motor Power

The AccuRange High Speed Interface can be ordered with two motor power control and encoder reading channels. Each motor may be set to one of 64 software controlled power levels via commands to the board. If the motors have encoders which are connected to the encoder inputs, two 8-bit values from the encoders are decoded and inserted into the data stream, giving the position of each motor, modulo 256. If the encoders provide index pulses, these can be applied to two of the general purpose input lines and used to determine the absolute positions of the motors. See the description of the 25 pin I/O connector for encoder connection details.

If motors are to be driven by the power amplifier on the board, the motors and motor power must be connected to P2. Motor 1 should be connected between pins 14 and 16, and motor 2 between pins 1 and 2. A separate power supply is required to drive the motors. Connect the motor power supply to pin 3 and the power supply ground to pin 15.

The ISA/EISA model Motor control can be ordered in either of 2 configurations. The first is pulse-width modulation and is suitable for driving D.C. brush motors at up to 2 amps at 48 volts. The other configuration is variable voltage control, and is suitable for small motors and brushless D.C. motors with embedded electronics and steady-state power levels up to 5 watts (36 Volts max) per motor. Pulse width modulation tends to be more power efficient, while variable voltage control is suitable for smaller motors or brushless motors.

With pulse-width control, motor direction can be reversed by switching the motor connections, or through software control of the motor power. There is no software direction control with variable voltage control.

The PC/104 model is available in only the variable voltage control configuration.

15.3 I/O Connectors

There are 2 connectors on the High Speed Interface. The 9 pin connector supplies power and receives signals from the AccuRange 4000. The 25 pin connector is used for powering the motors and reading the motor encoders, general purpose inputs, and sample control input.

15.3.1 9 Pin Power and Signal Connector P1

Pin	4000 Wire	Function	Direction
1	Red	Power, +5V (5-6V)	Out
2	Black	Ground	
3	Orange	Heater Power, +5V (4.5-7V)	Out
4	Brown	Heater Power Return	
5	Yellow	Temperature, 0-5 V	In
6	Blue	Pulse Width Range Signal	In
7	Green	Ambient light signal, 0-5 V	In
8	Purple	Amplitude signal, 0-5 V	In

P1: Power and Signal Connector Wiring

15.3.2 Power and Signal Connector Description

The line descriptions for P1 are the same as the descriptions of the power and signal lines in the AccuRange 4000 Power and Signal Cable Wire Description section. Pins 1-4 supply sensor power and sensor heater power and ground lines. The remaining lines are inputs for the signals from the AccuRange 4000. Pins 5, 7, and 8 are the inputs for the analog signals, with 2K impedance. Pin 6 is the input for the pulse width range signal.

15.3.3 25 Pin I/O Connector P2

P2 includes general purpose input lines, a sample start/stop control line, quadrature encoder input lines, and power for encoders or other applications.

Top Row			Bottom Row		
Pin	**Function**	**Direction**	**Pin**	**Function**	**Direction**
1	Motor 2 Control	Out	14	Motor 1 Control	Out
2	Motor 2 Return	Out	15	Motor Power Ground	
3	Motor Power Supply	In	16	Motor 1 Return	Out
4	No Connection		17	No Connection	
5	+5V Power, 100 mA.	Out	18	+5V Power, 100 mA	Out
6	Ground		19	Motor 2 Encoder Ch A	In
7	Ground		20	Motor 2 Encoder Ch B	In
8	Ground		21	Motor 1 Encoder Ch A	In
9	Ground		22	Motor 1 Encoder Ch B	In
10	Ground		23	No Connection	
11	No Connection		24	General Purpose Input 1/ Encoder 1 Index Pulse	In
12	Start/Stop Sample Ctrl	In	25	General Purpose Input 3	In
13	General Purpose Input 2/ Encoder 2 Index Pulse	In			

P2: I/O Connector

15.3.4 P2 Pin Descriptions

Pin 1: Motor 2 Control

If used, motor 2 should be connected between this pin and pin 2. If the pulse width motor control option was ordered (ISA/EISA model only), this pin and pin 2 will drive motor 2 with a 20 KHz pulse width signal, as set through software commands. If the variable voltage motor control option was ordered, the output voltage level is varied as commanded.

Pin 2: Motor 2 Return.

If used, motor 2 should be connected between this pin and pin 1.

Pin 3: Motor Power.

The external power supply for the motors should be applied to this line, at +12 to +48 Volts, depending on the motor used. The line may draw up to 2 amps.

Pin 4: No Connection.

Pin 5: +5V power output.

Primarily intended as power for the motor 1 encoder, but it may be used to drive other hardware, up to 100 mA maximum.

Pins 6-10: Ground

May be used as ground for encoders or other hardware powered by +5V on pins 5 and 18.

Pin 11: No Connection.

Pin 12: Start/Stop Sample Control Input.

When high, this input enables sampling and samples will be taken until the on-board buffer is full. When pulled low, sampling will stop. Samples are always completed, so that a full 8 byte sample is always buffered. This line is pulled up with an on-board 10Kohm resistor, so sampling is enabled when the input is left open. The first sample following resumption of sampling after stopping the sampling will not contain valid data, and must be read and discarded.

Pin 13: General purpose input bit 2 / Motor 2 index pulse input.

This may be used to sample external signals. The value of the bit will is included in the sampled data stream. This may be used to sample motor encoder index pulses or other events in order to synchronize the sample data with the event. The signal is latched so that any high signal of 500 nanoseconds or longer during a sample interval will appear as a high level in at least one sample. If the input is high across a sampling interval boundary, it will appear in 2 consecutive samples. This is intended for use with encoder index pulses.

Pin 14: Motor 1 Control.

If used, motor 1 should be connected between this pin and pin 14. If the pulse width motor control option was ordered (ISA/EISA model only), this pin and pin 14 will drive motor 1 with a 20 KHz pulse width signal, as set through software commands. If the variable voltage motor control option was ordered, the output voltage level is varied as commanded.

Pin 15: Motor Power Ground.

The external power supply ground for the motors should be connected to this pin.

Pin 16: Motor 1 Ground.

If used, motor 2 should be connected between this pin and pin 16.

Pin 17: No Connection.

Pin 18: +5V power.

Primarily intended as power for the motor 2 encoder, but it may be used to drive other hardware, up to 100 milliamps maximum.

Pin 19: Motor 2 Encoder Channel A.

If the motor control option is installed on the board, this input is decoded with pin 20 as a quadrature encoder signal from motor 2. The input should be a TTL-level signal and may switch at up to 1.5 Mhz. The encoder positions are converted to 8 bit position values that ate included in the data stream. Each transition of pins 19 or 20 causes an up or down count in the position, so each quadrature cycle is effectively multiplied by 4 for the best possible resolution.

Pin 20: Motor 2 Encoder Channel B.

If the motor control option is installed on the board, this input is decoded with pin 19 as a quadrature encoder signal from motor 2. The input should be a TTL-level signal and may switch at up to 1.5 Mhz.

Pin 21: Motor 1 Encoder Channel A.

If the motor control option is installed on the board, this input is decoded with pin 22 as a quadrature encoder signal from motor 1. The input should be a TTL-level signal and may switch at up to 1.5 Mhz. The encoder positions are converted to 8 bit position values that are included in the data stream. Each transition of pins 21 or 22 causes an up or down count in the position, so each quadrature cycle is effectively multiplied by 4 for the best possible resolution.

Pin 22: Motor 1 Encoder Channel B.

If the motor control option is installed on the board, this input is decoded with pin 21 as a quadrature encoder signal from motor 1. The input should be a TTL-level signal and may switch at up to 1.5 Mhz.

Pin 23: No Connection.

Pin 24: General purpose input bit 1 / Motor 1 index pulse input.

This may be used to sample external signals. The value of the bit will is included in the sampled data stream. This may be used to sample motor encoder index pulses or other events in order to synchronize the sample data with the event. The signal is latched high so that any high signal of 500 nanoseconds or longer during a sample interval will appear as a high level in at least one sample. If the input is high across a sampling interval boundary, it will appear in 2 consecutive samples. This is intended for use with encoder index pulses.

Pin 25: General purpose input bit 3.

This may be used to sample external signals. The value of the bit will be inverted and inserted into the sample data stream. This may be used to sample events in order to synchronize the sample data with the event. Note: the bit is INVERTED and NOT LATCHED, so if the event does not last for at least one sample interval it may be missed.

15.4 I/O Port Interface

The High Speed Interface is accessed as a set of I/O ports on the ISA or PC/104 bus. The board occupies a group of 8 contiguous port address locations starting at the address determined by the port address jumper J1.

	Jumpers				**Address**
ISA/EISA Model:	**J1-4**	**J1-3**	**J1-2**	**J1-1**	
PC/104 Model:	**JMP-4**	**JMP-3**	**JMP-2**	**JMP-1**	
	off	off	off	off	000Hex
	off	off	off	on	040Hex
	off	off	on	off	080Hex
	off	off	on	on	0C0Hex
	off	on	off	off	100Hex
	off	on	off	on	140Hex
	off	on	on	off	180Hex
	off	on	on	on	1C0Hex
	on	off	off	off	200Hex Default
	on	off	off	on	240Hex
	on	off	on	off	280Hex
	on	off	on	on	2C0Hex
	on	on	off	off	300Hex
	on	on	off	on	340Hex
	on	on	on	off	380Hex
	on	on	on	on	3C0Hex

Port Address Base Jumper Map

Within the 8 byte address space occupied by the board, locations 0-3 are used. They are addressed as offsets from the base address selected by the jumpers. For example, if address 280 Hex is selected as the base, the port addresses for the board are 280H, 281H, 282H, and 283H.

Any one of 16 locations between 0 Hex and 3C0 Hex may be selected for the port base. Choose a location from the table below that does not interfere with other peripherals in your system.

Offset from Base Address	Access	Function
0	Read-Write	Read: Sample Data Write: Send Command
1	Read Only	Buffer Status
2	Write Only	Motor 1 Power and Direction
3	Write Only	Motor 2 Power and Direction
4-7	Repeat Functions of ports 0-3	

I/O Port Address Map

15.4.1 Port Descriptions

Port 0 Data	Read: Sensor Data (see Sampled Data Format Section)		
	Write: Command value:	0 = Clear Buffer Full Flag	
		3 = Reset Board	
Port 1 Data	Read: Buffer Status:	Bit 0 = 0: No data available	
		Bit 0 = 1: Data available	
		Bit 1 = 0: Buffer Less Than Half Full	
		Bit 1 = 1: Buffer At Least Half Full	
	Port 2 Data Write:	Bits 0-5:	Motor 1 Power Level
		Bit 7:	Motor 1 Direction
	Port 3 Data Write:	Bits 0-5:	Motor 2 Power Level
		Bit 7:	Motor 2 Direction

I/O Port Data Definition

Port 0: The base address + 0 is a read/write port. When read, it gives the next byte in the data stream. If the memory buffer is empty, this byte will be meaningless. It is not possible to tell from the data content whether the byte is valid data or not.

There are 2 possible ways to determine whether the data is good. Bit 0 of the status port (offset 1) may be read and tested. A 1 indicates that the next byte read from the data port will be valid data. The other method is to test bit 1 of the status port. A 1 here indicates that the buffer is half full. A group of bytes half the size of the buffer may then be read before there is any danger of the buffer being empty.

Writing to port 0 sends a command to the board. The command code is contained in the lower 2 bits of the byte written. The 2 commands are as follows:

Clear Buffer Overflow Flag: Writing a byte with bits 0 and 1 clear will clear the buffer overflow flag in the data stream. See the Sampled Data Format section for further description of this flag.

Board Reset: Writing a byte to port 0 with bits 0 and 1 set resets the interface board. This clears the buffer overflow flag and empties the data buffer. The next byte following a reset will be the first byte of an 8 byte sample. The first sample following a Reset will not contain reliable data, so it should be read and discarded. The Reset command also clears the encoder counters, resetting them to 0.

Port 1: The base address + 1 is a read only port. Only the lower 2 bits have meaning. If bit 0 is clear, there is no data available at port 0 for reading. Reading port 0 should be avoided until port 1 bit 0 reads as 1, since the byte read may or may not be a valid data byte: The next byte could arrive in the buffer between reading the status byte and reading the data byte. Port 1 bit 1 is a half-full status bit. If this bit is set, a stream of bytes equal to half the length of the buffer may be read without checking the status port. Standard buffer sizes are 2K bytes and 16K bytes.

Port 2: The base address + 2 is a write only port. The lower 6 bits of the byte written are the power level for motor 1. A value of 0 is off, and 63 is full power. Bit 6 is unused. The high bit (bit 7) is the direction, which is effective only with the pulse width motor driver configuration (ISA/EISA model only). The direction bit has no effect if the board is configured with variable voltage motor drivers.

Port 3: The base address + 3 is a write only port. The lower 6 bits of the byte written are the power level for motor 2. A value of 0 is off, and 63 is full power. Bit 6 is unused. The high bit (bit 7) is the direction, which is effective only with the pulse width motor driver configuration (ISA/EISA model only). The direction bit has no effect if the board is configured with variable voltage motor drivers.

15.5 Sampled Data Format

The interface board collects 8 bytes/sample in a sequential stream. Reading from the port at offset 0 will read the next byte in the data stream, if it is available (See I/O Interface section, above). When reading from the board, multiples of 8 bytes should be read to ensure that a complete sample is obtained. If memory buffer overflow occurs, the board will always drop complete samples, so that synchronization is not lost. If a software board reset command is issued, the next byte read will be the first byte of a complete sample, and unread and partially read samples will be lost.

In general the values for amplitude and ambient light level, will correspond closely to the values from the 4000’s serial interface, with the ASCII format serial data being 4 times the High Speed Interface values for amplitude and ambient light. However, the values will not match exactly, and the calibration software supplied for use with the High Speed Interface must be used with the values obtained from the High Speed Interface, not serial data. The temperature and range have different scale factors from the serial data and must be scaled using algorithms found in the software supplied with the interface.

Byte 0:	Amplitude Sample	
Byte 1:	Ambient Light Sample	
Byte 2:	Internal Temperature	
Byte 3:		
	Bits 7-5:	3 Least significant bits of range (bits 0, 1, 2)
	Bit 4:	Always Zero
	Bit 3:	Data Lost: Buffer Overflow
	Bit 2:	Input 3
	Bit 1:	Input 2 / Motor 2 Index
	Bit 0:	Input 1 / Motor 1 Index
Byte 4:	Range bits 3-10	
Byte 5:	Range bits 11-18	
Byte 6:	Motor 1 Encoder Position	
Byte 7:	Motor 2 Encoder Position	

Sampled Data Format

15.5.1 Description of Sampled Data Format

Amplitude: 8-bit sample of the AccuRange logarithmic signal strength output. The sample represents the amplitude of the modulated signal sensed by the detector. The amplitude sample is taken in the first 10 microseconds of the data sample interval.

Ambient Light: 8-bit sample of the AccuRange ambient light output. The sample represents the ambient or background light sensed by the detector. It will also register the light transmitted by the sensor, so changing range signal strengths will affect this reading somewhat. The ambient light sample is taken in the first 10 microseconds of the data sample interval.

Internal temperature: 8-bit sample of the AccuRange internal temperature. The temperature is sampled in the first 10 microseconds of the data sample interval.

Range: 19-bit value proportional to the distance to the object being ranged, within the uncalibrated linearity of the AccuRange 4000. The lowest 3 bits appear in sample byte 3, and the upper 16 bits in bytes 4 and 5.

Buffer overflow indicator: 1 bit indicating whether a memory buffer overflow occurred and 1 or more samples were lost just prior to the first sample in which the flag is set. Once an overflow occurs, this bit will stay set until a Reset Buffer Overflow Flag or Reset Interface Board command is given or a power cycle occurs. Samples with the overflow flag set may contain inaccurate range data and should be discarded. Since the overflow flag is stored with the buffered data, resetting the flag will not become evident in the data until the data in the buffer has been read, or the buffer has been cleared with a board reset command. Note that if the buffer is full when the Reset Buffer Overflow Flag command is given, it will simply be set again immediately.

Inputs 1, 2, 3: 3 general purpose input lines, CMOS logic levels. These may be used to determine the exact times of external events relative to the samples taken. Inputs 1 and 2 are latched high. Input 3 is inverting and not latched. See the Pin Descriptions for more detail.

Motor 1 Encoder Position: 8-bit sample of the position of motor encoder 1, if the motor control option is installed and a motor encoder is attached to the P2 motor 1 encoder inputs. The position will wrap to 0 after reaching 255.

Motor 2 Encoder Position: 8-bit sample of the position of motor encoder 2, if the motor control option is installed and a motor encoder is attached to the P2 motor 2 encoder inputs. The position will wrap to 0 after reaching 255.

15.6 Interrupt Driven Operation

The interface board may be jumpered to generate an interrupt when the on-board data buffer is half full. One jumper pair in Jumper J2 may be closed to activate the corresponding interrupt, as shown below. The interrupt can only be cleared by reading samples until the buffer is less than half full or by issuing a Reset command to the board.

Jumper Pair		**Interrupt Enabled**
ISA/EISA	**PC/104**	
J2-1	JMP2-6	IRQ 3
J2-2	JMP2-5	IRQ 4
J2-3	JMP2-4	IRQ 5
J2-4	JMP2-3	IRQ 6
J2-5	JMP2-2	IRQ 7
J2-6	JMP2-1	IRQ 9

J2 - Interrupt Enable Jumper

15.7 Interface Resolution and Sample Rates

The resolution for the high speed interface is 33% better than the resolution of the sensor data transmitted over the serial port or current loop, and the maximum possible sample rate is much higher, since the serial and current loop output rates are limited by the 4000’s on-board processor. The sample rate and maximum expected range should be set as described earlier in this manual.

At relatively low sample rates, the 4000 sets a higher internal rate and averages multiple samples for best resolution. Since the high speed interface sample rate is the same as this internal rate, setting a combination of low sample rate and short maximum range will result in a higher than expected high speed interface sample rate. The slowest sample period with a max range setting of 650 inches is about 2250 microseconds, or 440 Hz, and rises to 5.4 Khz (185 microseconds) with a max range setting of 1 inch. To obtain a lower sample rate, set the max range to a larger value, and then set the sample rate desired, or for best accuracy sample at the higher rate and average multiple samples in software.

Maximum Attainable Sample Rates, samples/second

Resolution,	Range		
inches	6 Feet	30 Feet	50 Feet
.0047	2304	677	390
.0094	4609	1355	781
.0188	9218	2711	1562
.0375	18346	5422	3125
.0750	36873	10845	6250
.1500	50000	21691	12500
.3000	50000	43382	25000
.6000	50000	50000	50000

15.8 Interface Installation and Checkout

After selecting a port address base that does not conflict with other peripheral cards in your computer; install the ISA/EISA board in any PC ISA or EISA slot, or install the PC/104 board into a PC/104 stack. Attach the AccuRange 4000 Power and Signal cable to the 9 pin connector. Turn on the computer power. Check out the operation of the AccuRange 4000 as described in the Initial Checkout section.

15.8.1 Diagnostics

Install the ISA/EISA High Speed Interface in an ISA bus slot, or install the PC/104 board into a PC/104 stack, connect the sensor to the interface board and to a serial port on the computer.

If the sensor's LED does not come on, check the connection of the sensor to the interface. The serial connection to the sensor may be tested separately using a program such as the Windows terminal to observe sensor output and send commands. If the sensor does not respond to serial communications, check the serial port connection.

After installing the board and connecting the AccuRange sensor, run the demo/diagnostic software supplied with the board, following the instructions in the README.TXT file with the software.

If the motor control option is not installed, the encoder tests will not succeed. If you have not connected the input lines and external sample control line to 0/5 volt signals, the tests of those lines will not succeed. All other tests should succeed.

If the one or more of the Interface tests fail, check that the port address as selected by J1 (ISA/EISA model), or JMP1 (PC/104 model) matches the port address you give the diagnostic software. Also make sure that no other boards in the computer system are using the address group selected by J1 (ISA/EISA model), or JMP1 (PC/104 model). Verify that the serial port the sensor is connected to is the port number you give the diagnostic software. Check that the sensor’s serial port is configured for 9600 baud.

If the sensor stability tests fail, check that the laser comes on during those tests and that the sensor is pointed a white target 1 to 2 yards from the sensor.

15.9 High Speed Interface Data Sheet

The following two pages are a reproduction of the data sheet for the AccuRange High Speed Interface, which lists specifications, requirements and characteristics of the board.

AccuRange High Speed Interface

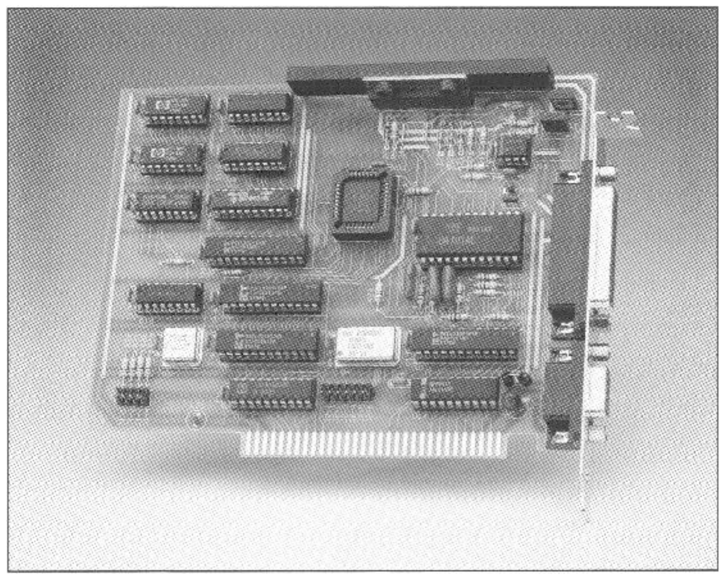
by Acuity RESEARCH

PC-104 VERSION NOW AVAILABLE

The AccuRange™ High Speed Interface can be used to increase the sample rate capability of Acuity Research's line of AccuRange sensors, using any PC-compatible computer. It can sample all the AccuRange outputs at up to 50,000 times per second and buffer the data for reading by the host computer. The High Speed Interface can also be used to control the AccuRange Line Scanner. For a full description of the AccuRange 4000 and AccuRange Line Scanner, see the corresponding data sheets.

Key Features

- Sample rates to 50,000 samples per second.
- Samples AccuRange distance, amplitude, ambient light, and temperature outputs.
- Supplies 8-byte samples over the standard PC ISA bus.
- 2K or optional 16K byte buffer for sample data onboard.
- Buffer empty, half-full, and overflow indicators, and half-full interrupt.
- Start/stop sampling control input.
- 3 general purpose input data lines for event recording.
- Improved resolution and higher sample rate capability than the AccuRange 4000 alone.
- Supplies power to the AccuRange sensor.
- Optional motor power control and shaft encoder reading capability.



AccuRange High Speed Interface Technical Specifications

Mechanical and Power

Form Factor
IBM-PC ISA bus, half-length board, 6.25 by 4.75 inches

Power Requirements: +5V @ 500 ma
Includes power for AccuRange sensor

AccuRange 4000 Interface

The AccuRange High Speed Interface measures the duration of the pulse width output of the AccuRange 4000. Setting sample rate and all other configuration of the 4000 is done through the serial interface on the 4000, over a computer serial port (not included on the High Speed Interface). Signal strength, ambient light, and sensor temperature are also sampled. For maximum accuracy, calibration to obtain actual distance then occurs in software on the host computer.

P1: DB-9 power and signal connector

Pin	Function	Direction
1	Power, +5V (5V min, 6V max)	Out
2	Ground	
3	Heater Power, 4.5 to 6.0 V	Out
4	Heater Power Ground	
5	Temperature signal, 0-5V	In
6	Pulse Width Range Signal	In
7	Ambient light signal, 0-5V	In
8	Amplitude signal, 0-5V	In
9	No Connection	
Shield	Ground	

Amplitude, Ambient Light, and Temperature Inputs

Analog signals, 0-5V: 8 bit samples
Response times:
One sample period, as programmed

General Purpose Inputs & Motor Control

General Purpose Inputs

3 general purpose input bits.

Input lines 1, 2: Latched high, non-inverting.
Minimum pulse width to guarantee latching: 500 ns.

Input line 3: Not latched, inverting.

Inputs 1 and 2 may be used to detect the index pulse on motor encoders, or for other purposes. They will latch any high signal for one sample interval, so that the signal will appear as a 1 in the data stream for the sample during which the signal ocurred.

Optional Motor Control

The AccuRange High Speed Interface can be ordered with two pulse-width modulated power control channels, or with two variable-current motor control outputs.

Maximum Motor Power

Pulse-width control:	2A @ 48V.
Variable-current control:	0.5A @ 24V.
Motor power control resolution:	1 part in 64.

A separate power supply is required to drive the motors. With the pulse-width drivers, motor direction may also be controlled.

Encoder Readers

Two 8-bit motor encoder readers.
Inputs: 2-channel quadrature from motor encoders.
Outputs: 8 bit motor positions inserted in sensor data stream.

P2: I/O Connector

Pin	Function	Direction
1	Motor 2 Control	Out
2	Motor 2 Return	Out
3	Motor Power	In
4	No Connection	
5	+5V Power, 100 mA	Out
6	Ground	
7	Ground	
8	Ground	
9	Ground	
10	Ground	
11	No Connection	
12	Start / Stop Sample Control	In
13	Input 2 / Encoder 2 Index Pulse	In
14	Motor 1 Control	Out
15	Motor Power Ground	
16	Motor 1 Return	
17	No Connection	
18	+5V Power, 100 mA	Out
19	Motor 2 Encoder Channel A	In
20	Motor 2 Encoder Channel B	In
21	Motor 1 Encoder Channel A	In
22	Motor 1 Encoder Channel B	In
23	No Connection	
24	Input 1 / Encoder 1Index Pulse	In
25	Input 3	In

Bus/Software Interface

Data Bus Width: 8 bits

Port Addressing

Four jumpers control the I/O port address space of the board, which may be configured to start at any of 16 locations between 0 Hex and 3C0 Hex. The board occupies 8 locations starting at the selected base.

Port 0:	Read:	Sensor Data
	Write:	Send Command
Port 1:	Read Only:	Buffer Status
Port 2:	Write Only:	Motor 1 Power, Direction
Port 3:	Write Only:	Motor 2 Power, Direction
Ports 4-7:	Repeat Functions of ports 0-3.	

Command Set Summary

There are 2 software commands that can be executed by writing to Port 0:

Reset Board - Flush memory buffer, reset encoder counts to zero.
Clear buffer overflow flag.

Buffer Status: Port 1
Bit 0: Sensor data available on port 0.
Bit 1: Buffer at least half full.

Half Full Interrupt

The half full signal may be jumpered onto an interrupt line to generate an interrupt when the buffer is half full. To clear the interrupt, the buffer must be read until less than half full, or the board must be reset.

Interrupts available: IRQ lines 3, 4, 5, 7, 9

Sampled Data Format

Sample size: 8 bytes/sample, in a sequential stream. The range sample is 19 bits. All other data are 1 byte or 1 bit fields.

Byte 0: Amplitude Sample
Byte 1: Ambient Light Sample
Byte 2: Temperature Sample
Byte 3: Bits 7-5: 3 Range bits 0-2
Bit 4: Always 0
Bit 3: Data Lost: Buffer Overflow
Bit 2: Input 3
Bit 1: Input 2 / Motor 2 Index
Bit 0: Input 1/ Motor 1 Index
Byte 4: Range Bits 3-10
Byte 5: Range Bits 11-18
Byte 6: Motor 1 Encoder Position
Byte 7: Motor 2 Encoder Position

Motor Power Control

Power and direction for the motors is controlled by writing to ports 2 and 3.

Motor 1 Power:	Lower 6 bits of port 2
Motor 1 DIrection:	High bit of port 2
Motor 2 Power:	Lower 6 bits of port 3
Motor 2 DIrection:	High bit of port 3

16. AccuRange Line Scanner

16.1 General Description

The AccuRange Line Scanner consists of a motor with encoder and a mirror mounted on the motor. The mirror is machined from aluminum and coated with protected silver for high reflectance for both the 4000-LV and 4000-LIR. The mirror is encased in a cylindrical sleeve which together with the mirror forms a balanced system for minimum vibration when rotating.

The mirror deflects the outgoing beam from the sensor 90 degrees, and sweeps it through 360 degrees as the mirror rotates. Returning light is deflected off the mirror back into the sensor. The mirror surface is sized to match the collection aperture of the sensor.

Sensor and scanner are mounted on a flat plate that holds the mirror in the proper location relative to the sensor. The plate causes a blind spot of about 60 degrees of arc.

The line scanner is intended to be primarily used as a constant-speed scanner, although it is possible to control the position of the mirror through software to create a point-to-point scanner.

16.2 Scanner Performance Specifications

Mirror Reflectance: 96%. Total losses are 8% for the outgoing and return light together. This results in a slight reduction in sensitivity, which is not usually noticeable.

Maximum Motor Speed: 2600 R.P.M. Custom configurations with larger motors for higher speed are possible. This speed should not be exceeded. even though it is possible to do so with high motor power supply voltages and/or motor power settings.

Encoder: 2000 quadrature counts per revolution. 0/5 Volt levels, 2 channels plus index pulse.

Speed and Power Consumption: Motor speed at different voltages is shown below. This is the typical speed with power applied directly to the motor. If the scanner is controlled through the High Speed Interface, the motor speed will depend on the power level for which the motor is programmed.

Applied Voltage	Scanner Speed	Scanner Current
5.0	1050 rpm	45 mA
10.0	2100 rpm	90 mA
12.0	2600 rpm	110 mA

Typical Scanner Speed and Power

16.3 Scanner Installation and Use

If the scanner was ordered and delivered with an AccuRange 4000, the sensor will be mounted together with the scanner. If they were ordered separately, the sensor should be mounted so that the beam aligns with the motor axis, both in position and angle. If the scanner is ordered with the High Speed Interface, the motor encoder comes connected to the appropriate pins from the interface connector. For connection to other encoder readers, the encoder pinout is shown below.

Pin	Connector Wire Color	Function
1	Black (left side of encoder, viewed from top)	Ground
2	Blue	Index Pulse
3	White	Channel A
4	Red	Vcc (+5 Volts)
5	Brown	Channel B

Encoder Pinout

The index pulse is a brief pulse lasting 1/1000 of a revolution, occurring once per revolution. Channels A and B are standard quadrature signals, 50% duty cycle square waves, 90 degrees out of phase.

Do not attempt to remove the encoder from the motor. Encoder alignment is critical and will be lost. If necessary, the mirror can be removed from the motor shaft by loosening the two set screws holding the mirror sleeve to the shaft, but increased vibration at high motor speeds may result after reinstallation.

The mirror should be kept clean and free of excessive dust, fingerprints, etc. It may be cleaned with a soft cloth and alcohol or water.

16.4 Line Scanner Data Sheet

The following page is a reproduction of the data sheet for the AccuRange Line Scanner, which lists the specifications, and characteristics of the scanner.

AccuRange Line Scanner

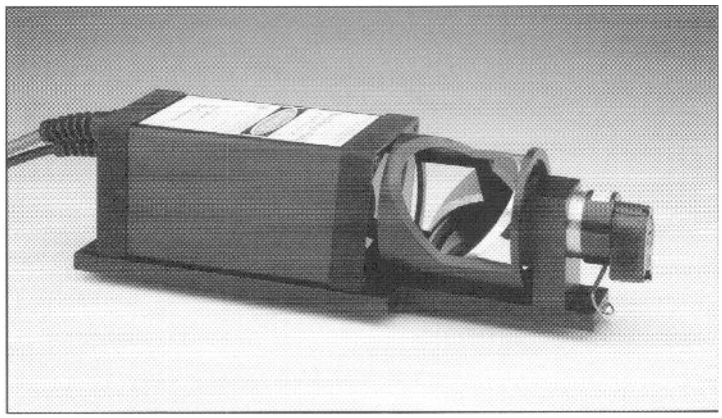
by Acuity RESEARCH

NOW AVAILABLE WITH 4096 COUNT ENCODER

The AccuRange™ Line Scanner can be used with the AccuRange 4000 to scan and collect distance data over a full circle. The scanner consists of a balanced, rotating mirror and motor with position encoder, and mounting hardware for use with the AccuRange 4000. The scanner deflects the AccuRange beam 90°, sweeping it through a full circle as it rotates. For a full description of the AccuRange 4000 and AccuRange High Speed Interface, see the corresponding data sheets.

Key Features

- Scan rates up to 2600 lines per minute.
- Scanning mirror sweeps laser beam through 360° and returns reflected light to AccuRange 4000.
- 96% optical reflectance for maximum sensitivity.
- Compact, lightweight assembly with AccuRange 4000.
- May be used with AccuRange 4000 or AccuRange 4000 and AccuRange High Speed Interface.
- Motor encoder with 2000 position counts/revolution and index pulse.



AccuRange Line Scanner Technical Specifications

Weights

Rotating Mirror:	6.5 oz.
Mirror and motor:	14 oz.
Full Assembly with AccuRange 4000 (including mounting platform):	3.5 lb.

Mirror Reflectance 96%, 670 to 800 nm laser wavelengths

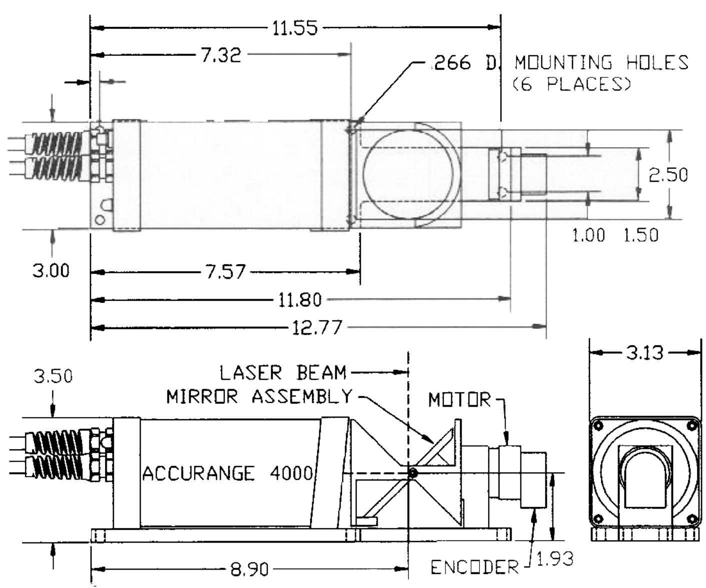
Clear angle of scan with standard mount: 300 degrees
Other mounting configurations available.

Speed and power consumption

Applied Voltage	Scanner Speed	Scanner Current
5V	1050 rpm	45 mA
10V	2100 rpm	90 mA
12V	2600 rpm	110 mA

Encoder

Counts per revolution:	2000
Output: 3 channels	2 quadrature plus index pulse
Output Levels:	0/5 volts



Line Scanner shown with AccuRange 4000

Acuity Research, Inc. 3475 Edison Way # P Menlo Park, CA 94025 (650) 369-6782 Fax (650) 369-6785