AUTOMATION PRODUCTS GROUP, INC.

Operator's Manual

IRU-2xx4/3xx4 Series

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Automation Products Group, Inc.
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Table of Contents

• Warranty and Warranty Restrictions

APG warrants its products to be free from defects of material and workmanship and will, without charge, replace or repair any equipment found defective upon inspection at its factory, provided the equipment has been returned, transportation prepaid, within 18 months from date of shipment from factory.

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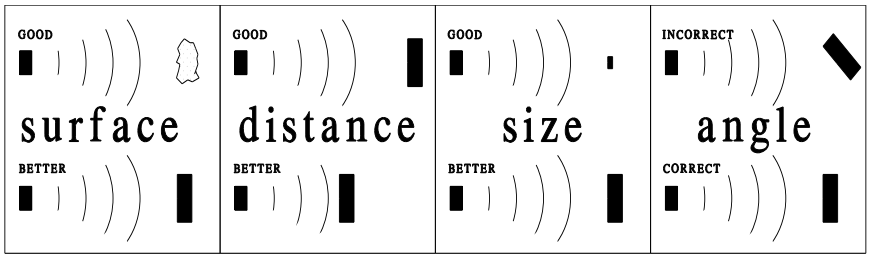
All associated equipment must be protected by properly rated electronic/ electrical protection devices. APG shall not be liable for any damage due to improper engineering or installation by the purchaser or third parties. Proper installation, operation and maintenance of the product becomes the responsibility of the user upon receipt of the product.

Returns and allowances must be authorized by APG in advance. APG will assign a Return Material Authorization (RMA) number which must appear on all related papers and the outside of the shipping carton. All returns are subject to the final review by APG. Returns are subject to restocking charges as determined by APG's "Credit Return Policy".

UNDERSTANDING ULTRASONICS

Ultrasonic sensors measure distance by using a transducer to send out ultrasonic bursts. Each burst contains a series of pulsed sound waves. The ultrasonic burst emits in the shape of a cone, reflects off the detected target, and is received by the transducer. The time required for this burst to travel to and from the target is measured and converted into a distance measurement by the sensor.

Ultrasonic sensing is affected by several factors including the target's surface, size, angle and the distance from the sensor. Environmental conditions such as temperature, humidity, gases, and pressure may also affect the measurement. APG sensors automatically compensate for most of these varied environments. The following considerations will help ensure the best possible sensing conditions.



SURFACE

The ideal target surface is hard and smooth. This surface will reflect a greater amount of signal than a soft, rough surface. A weak echo, which is the result of a small or soft object, will reduce the operating distance of the sensor and decrease its accuracy.

DISTANCE

The shorter the distance from the sensor to an object, the stronger the returning echo will be. Therefore, as the distance increases, the object requires better reflective characteristics to return a sufficient echo.

SIZE

A large object will have more surface to reflect the signal than a small one. The surface area recognized as the target is generally the portion closest to the sensor.

ANGLE

The inclination of the objects' surface facing the ultrasonic sensor affects the reflectivity of the object. The portion perpendicular to the sensor returns the echo. If the entire surface is at a great enough angle, the signal will be reflected away from the sensor and no echo will be detected.

DESCRIPTION

The IRU-2xx4/3xx4 is a low cost ultrasonic sensor used for non-contact measurement over a 1' to 35' range. RS-485 interface allows for convenient sensor communication. The sensor is encased in a sealed chemical resistant housing and has built in temperature compensation.

SPECIFICATIONS

	IRU-2xx4	IRU-3xx4
Range:	1' to 25'	1.25' to 35'
Housing:	ABS or PVC	PVC
Outputs:	RS-485 & NPN	RS-485 & NPN
Supply Voltage:	12 to 28 VDC (24 VDC Recommended sensor performance is diminished if lower voltage applied)	12 to 28 VDC
Current Draw:	60 ma @ 24 VDC 2.0 Watts Max.	60ma @ 24VDC 2.0 Watts Max.
Transducer Type	Ceramic	Ceramic
Ratings	NEMA 4X	NEMA 4X
Sensor adjust	RS-485 interface	RS-485 interface
Operating temp.	-40 to 60 °C	-40 to 60 °C
Resolution	.1inches (2.5mm)	.1inches (2.5mm)
Accuracy	+/- 0.25% Range	+/- 0.25% Range
Temp. Comp.	Internal (thermistor located on transducer face)	Internal
Sample Rate	Programmable, 1 to 22 Hz	
Beam pattern	9 degrees off axis (when operating with high sensitivity)	
Cable	6 conductor, 22 gauge 6' length	

SETUP & OPERATION

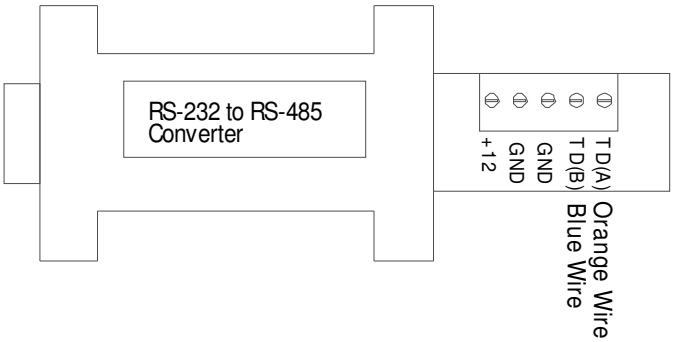
Wire the IRU-2XX4/3XX4 as described below.

Color	Description
Red	+ 12 - 24 VDC
Black	Ground
Orange	**T(+) or TD(A)**
Blue	**T(-) or TD(B)**
White	NPN (200 ma max)
Green	Clock Sync.

RS-485 COMMUNICATIONS DATA

All Communication to the sensor is in the following format:

Protocol	RS-485 2 wire
Speed	9600
Length	8 bits
Stop	1 bit
Parity	none
Echo	on



COMMAND PROTOCOL

A command must be sent to the sensor in order to obtain any information from the unit.

- All distances coming form the sensor will be in whole millimeters.
- The temperature is returned as a Celsius value with a 40° positive offset
- No negative numbers, decimal numbers or fractions are sent.

COMMAND STRUCTURE

All of the IRU-2XX4/3XX4 commands follow the format below.

Messages from the sensor

Start character	(AAh)
Sensor Number	as single byte value
Command Number	as single byte value
Data values	as double byte value
Stop character	(55h)
	6 bytes Total

Messages from the sensor

Start character	(66h)
Sensor Number	as single byte value
Command Number	as single byte value
Data value 0	as double byte value
Data value 1	as single byte value for returning distance and temperature if possible
Stop character	(99h)
	7 bytes total

MEMORY

There are two types of memory available in the IRU-2XX4/3XX4, E^2 and RAM. E^2 is nonvolatile and will retain the data if power to the sensor is lost or turned off. RAM is volatile and will not be retained without power. The number of WRITES available to E^2 is approximately 10,000. Prudent use of this function will allow a lifetime of use. The number of READS from E^2 is unlimited. If frequent parameter changes are anticipated or necessary, use the WRITE RAM functions to avoid "wearing out" the E^2 memory.

COMMAND LIST

COMMAND

01h) Read Sensor Number EE
02h) Write Sensor Number EE
03H) READ BANK NUMBER EE
04H) WRITE BANK NUMBER EE
05H) READ BLANKING EE
06H) WRITE BLANKING EE
07H) READ PULSES EE
08H) WRITE PULSES EE
09H) READ SENSITIVITY EE
0AH) WRITE SENSITIVITY EE
0BH) READ CALIBRATION EE
0CH) WRITE CALIBRATION EE
0DH) READ TEMPERATURE COMPENSATION
0EH) WRITE TEMPERATURE COMPENSATION
0FH) READ AVERAGE EE
10H) WRITE AVERAGE EE
11H) READ OUT OF RANGE SPAN EE
12H) WRITE OUT OF RANGE SPAN EE
13H) READ OUT OF RANGE COUNT EE
14H) WRITE OUT OF RANGE COUNT EE
15H) READ SAMPLE RATE EE
16H) WRITE SAMPLE RATE EE
17H) READ TRIP BEGIN
18H) WRITE TRIP BEGIN
19H) READ TRIP END
1AH) WRITE TRIP END
1BH) READ TRIP TYPE
1CH) WRITE TRIP TYPE
1DH) READ TRANSMIT OFF(0)/ON(1)
1EH) WRITE TRANSMIT OFF(0)/ON(1)
1FH) RESET PARAMETERS TO DEFAULTS
20H) START TRANSMIT SENSOR
21H) STOP TRANSMIT SENSOR
22H) START TRANSMIT BANK
23H) STOP TRANSMIT BANK
24H) DISTANCE AND TEMPERATURE READ

PARAMETERS

The **Parameters** (E) command displays the current settings of the sensor. The following is an example of a parameter report from the IRU-2XX4/3XX4.

PARAMETERS MENU	Min.	Max.
Distance Sensor Number EE	0	9
Bank Number EE	0	9
Blanking EE	152	7620
Pulses EE	0	20
Sensitivity EE	0	100
Calibration EE	0100	1999 (0 .100 to 1.999)
Temp. Compensation	0	1
Average EE	1	10
Out of Range Span EE	0	7620
Out of Range Count EE	0	250
Sample Rate EE	23	1000
Trip point begin	0	7620
Trip point end	0	7620
Trip point type	0	7
Sensor Transmit	0	1 (0 = OFF, 1 = ON)

The IRU-2XX4/3XX4 will display the distance to a target in millimeters.

DISTANCE SENSOR

To request the Distance and temperature from sensor number 1, send:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
24h	Command	24h	Command
00h	Data (not used)	##h	Distance (High Byte)
00h	Data (not used)	##h	Distance (Low Byte)
55h	End Byte	##h	Temperature
		99h	Stop Byte

SENSOR NUMBER

Up to 10 sensors may be attached to the same communication and power line. Each sensor is then assigned a unique number. ***Each sensor must have a unique Sensor Number***. Sensor Numbers are assigned one at a time as the sensors are placed on line. When assigning these values, ensure that only the desired sensor is connected to the RS-485 line.

With only one sensor connected to the RS-485 communication lines, assign a sensor number to a sensor by using the following steps.

1. Determine the present sensor number by reading the sensor number:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
01h	Command	01h	Command
00h	Data (not used)	01h	Sensor # (High Byte)
00h	Data (not used)	00h	NA (Low Byte)
55h	End Byte	00h	NA
		99h	Stop Byte

2. Program New sensor number, Example Change from #1 to #0:

Send	
AAh	Start Byte
01h,	Sensor Number
02h	Command
00h	Data
00h	Data (Not Apply)
55h	End Byte

BANK NUMBER

There are 10 banks (0-9) available for sensor assignment and up to 10 sensors may be assigned to any 1 bank. However, this system will support a maximum of 10 sensors and each sensor must have a unique Sensor Number. Banks allow a number of sensors to be controlled simultaneously.

Assign a Bank Number by,

Send		
AAh	Start Byte	
01h,	Sensor Number	
03h	Command	
02h	Data	Bank number 2
00h	Data (not used)	
55h	End Byte	

BLANKING

Blanking allows the sensor to ignore all echoes returned before this distance. There is a minimum distance to which this can be set which is 152 millimeters. This distance (or time) allows the ceramic in the transducer to stop vibrating after it has transmitted a series of pules.

To read the current setting for the blanking in the sensor:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
05h	Command	05h	Command
00h	Data (not used)	##h	Blanking (High Byte)
00h	Data (not used)	##h	Blanking (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To send a new Blanking distance use the command structure:

Send	
AAh	Start Byte
01h,	Sensor Number
06h	Command
00h	Data (High Byte)
00h	Data (Low Byte)
55h	End Byte

Example: Suppose the sensor is mounted in a position that were a partial structure is located 600 mm from the sensor head. The desired detection range is from 650 mm to 2100 mm . Setting the blanking at 620mm would allow the sensor to ignore the structure and monitor the desired detection area.

PULSES

Pulses is used to control output power of the sensor. Each burst from the sensor contains a number of pulses. More pulses equate to more power and fewer pulses to less power. *Caution: More power may not always be best as more pulses can create more echoes and may result in false readings.*

To read the pulses in a sensor, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
07h	Command	07h	Command
00h	Data (not used)	##h	Pulses(High Byte)
00h	Data (not used)	##h	NA (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the pulses in the sensor to 9 , use the command structure:

Send		
AAh	Start Byte	
01h,	Sensor Number	
08h	Command	
09h	Data	9 pulses
00h	Data (not used)	
55h	End Byte	

SENSITIVITY

Sensitivity controls the gain of the receive circuit. High values will amplify the return pulse enabling the sensor to detect weak signals. *Caution: High sensitivity setting increases the chance for the sensor to detect unwanted objects, which can decrease the reliability of the output.*

To read the Sensitivity in a sensor, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
09h	Command	09h	Command
00h	Data (not used)	##h	Sensitivity (High Byte)
00h	Data (not used)	##h	NA (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the Sensitivity in the sensor to 80%, use the command structure;

Send		
AAh	Start Byte	
01h,	Sensor Number	
0Ah	Command	
50h	Data	80 decimal = 50 hex
00h	Data (not used)	
55h	End Byte	

CALIBRATION

Calibration The IRU-2XX4/3XX4 must be calibrated if a familiar reading is desired. The software is designed so that a calibration factor of 1000 will yield units that represent inches, feet and meters. Variations of the speed of sound in different atmospheres may yield readings which slightly differ from actual measured values. If this is unacceptable, vary the Calibration factor to "dial in" the exact number desired.

Acceptable values for this parameter range from 0100 to 1999

If a certain distance to a target is known and the sensor is not outputting the desired reading, use the following formula to obtain the desired reading.

New Calibration Factor = (Desired Distance Reading x Old Calibration Factor) / Sensor Distance Reading.

Example: Suppose a target is 5.50 feet from the face of the sensor. The sensor has a calibration factor of 1000 and is yields a Distance Reading of 5.65 ft.

Calculate the new Calibration Factor by:
New Calibration Factor = (5.50 x 1000) / 5.65 = 0973.

To read the calibration factor in a sensor, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
0Bh	Command	0Bh	Command
00h	Data (not used)	03h	Calibration (High Byte)
00h	Data (not used)	E8h	Calibration (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the calibration factor in a sensor, use the command structure;

Send		
AAh	Start Byte	
01h,	Sensor Number	
0Ch	Command	
03h	Data (not used)	0973 D = 3CD
CDh	Data (not used)	
55h	End Byte	

TEMPERATURE COMPENSATION

Temperature Compensation allows the operator to enable or disable temperature compensation. When this feature is enabled, the IRU-2XX4/3XX4 will make adjustments for variations in temperature, which affects the speed of sound. This will produce a more exact output.

To Read the Temperature Compensation in a sensor, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
0Dh	Command	0Dh	Command
00h	Data (not used)	00h	Temp. Comp. (High Byte)
00h	Data (not used)	00h	NA(Low Byte)
55h	End Byte	00h	NA
		99h	Stop Byte

To change the Temperature Compensation in the sensor from OFF to ON, use the command structure;

Send		
AAh	Start Byte	
01h,	Sensor Number	
0Eh	Command	
01h	Data	Change to 1 for temp. Compensation ON
00h	Data (not used)	
55h	End Byte	

AVERAGE

Average: The sensor will average the number of samples set in the Average Parameter. Each qualified sample is placed into a buffer and averaged with the previous samples to generate a steady output. A qualified sample is one that falls within the boundaries set in the Out of Range Span Parameter.

To Read the number of samples being averaged in a sensor, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
0Fh	Command	0Fh	Command
00h	Data (not used)	##h	Average (High Byte)
00h	Data (not used)	##h	NA (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the average to 7 in the sensor, use the command structure;

Send		
AAh	Start Byte	
01h,	Sensor Number	
10h	Command	
07h	Data	Number of samples to average
00h	Data (not used)	
55h	End Byte	

OUT OF RANGE SPAN

Out of Range Span The Out of Range Span was designed to eliminate extraneous signals and noise. This Span or window changes with the distance of the average distance reading. This window will allow only readings that fall within its limits. If the target is suddenly changed outside of the window limits, the sensor will wait until a number or echoes specified in the Out of Range Count are received within a new window before updating the output reading.

To Read the Out of Range Span in a sensor, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
11h	Command	11h	Command
00h	Data (not used)	##h	Span (High Byte)
00h	Data (not used)	##h	Span (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the Out of Range Span in the sensor to 304 mm, use the command structure;

Send	
AAh	Start Byte
01h,	Sensor Number
12h	Command
01h	Data 304 decimal = 130h
30h	Data
55h	End Byte

OUT OF RANGE COUNT

Out Range Count : indicates the number of consecutive samples outside the Out of Range Span that would need to be detected before the sensor recognizes them as legitimate samples. For example, with the Out of Range Span set at 300mm, the sensor detecting a distance at 1,520mm and the OUT OF RANGE COUNT set to 10, and a target entered the detection area of the sensor at a distance less than 1,220mm or greater than 1,820mm, the target would need to be present long enough for the sensor to receive 10 samples before the sensor would recognize the target. If the target were in the detection area of the sensor for only 9 samples, the sensor would retain the 1,520mm distance reading.

To Read the Out of Range Count in a sensor, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
13h	Command	13h	Command
00h	Data (not used)	##h	Out of range (High Byte)
00h	Data (not used)	##h	NA (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the Out of Range Count to 10 in the sensor, use the command structure;

Send		
AAh	Start Byte	
01h,	Sensor Number	
14h	Command	
0Ah	Data	10 decimal = A hex
00h	Data (not used)	
55h	End Byte	

SAMPLE RATE

Sample Rate is used to control the burst rate. The number entered in this field represents the number of milliseconds between each burst.

To Read the Sample Rate in a sensor, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
15h	Command	15h	Command
00h	Data (not used)	##h	Sample Rate (High Byte)
00h	Data (not used)	##h	Sample Rate (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the Sample Rate to 80 msec in the sensor, use the command structure;

Send		
AAh	Start Byte	
01h,	Sensor Number	
16h	Command	
00h	Data (high byte)	80 decimal = 50 hexadecimal
50h	Data (low byte)	
55h	End Byte	

TRIP POINT SETTINGS

The IRU-2XX4/3XX4 has a programmable NPN trip point that is fully programmable for 'BEGIN' and 'END' points and 'TYPE' of operation. (see page 20) The zero point of distance will be at the transducer, the relay trip points is programmed in millimeters.

DESCRIPTION	PARAMETERS	EXPLANATION
Begin Trip	Units = millimeters Default =	Sets the begin point of Trip
End Trip	Units = millimeters Default =	Sets the end point of Trip
Trip Type	Range = 0 - 7 0 - near 1 - exclusive 2 - hysteresis near 3 - far 4 - inclusive 5 - hysteresis far 6 - disable Default = 0	Selects the type of function Trip will perform. (See Page 20)

To read the Begin Trip Distance in sensor number 1 , use the command structure:

Send		Receive	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
17h	Command	17h	Command
00h	Data (not used)	##h	Distance (High Byte)
00h	Data (not used)	##h	Distance (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the Begin trip distance in sensor number 1 to 900mm, use the command structure;

Send	
AAh	Start Byte
01h,	Sensor Number
18h	Command
03h	Data (high byte) 900 mm decimal = 384h
84h	Data (low byte)
55h	End Byte

To read the End Trip Distance in sensor number 1 , use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
19h	Command	19h	Command
00h	Data (not used)	##h	Distance (High Byte)
00h	Data (not used)	##h	Distance (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the Begin trip distance in sensor number 1 to 1200mm, use the command structure;

Send		
AAh	Start Byte	
01h,	Sensor Number	
1Ah	Command	
04h	Data (high byte)	1,200 mm decimal = 4B0h
B0h	Data (low byte)	
55h	End Byte	

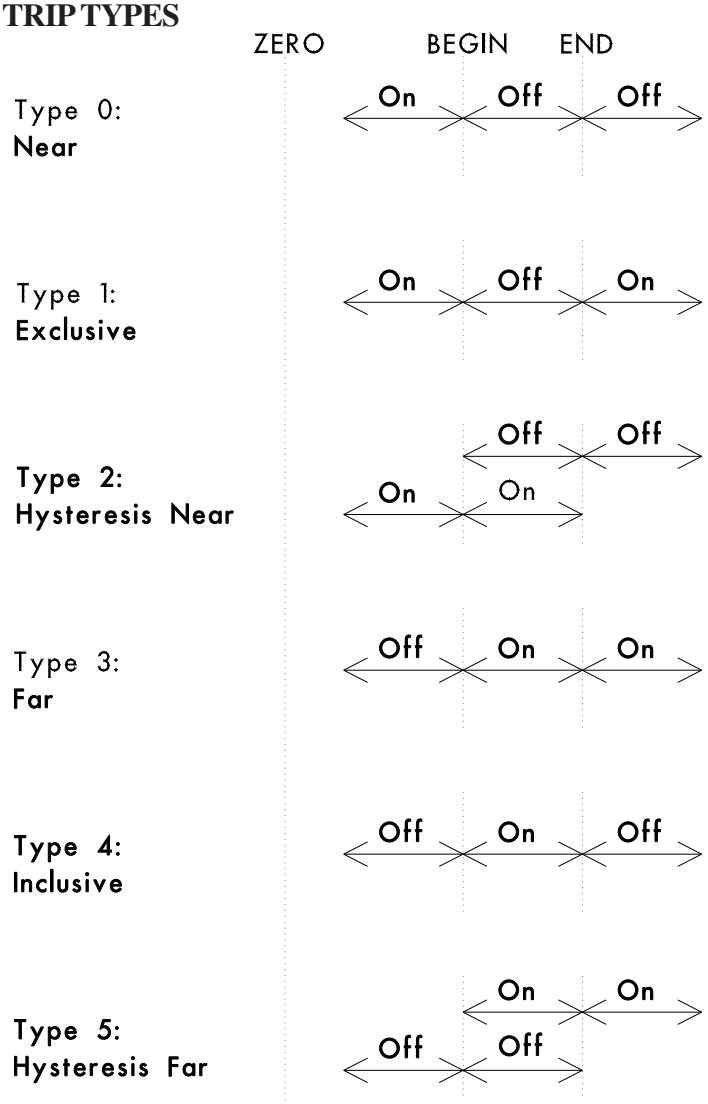
To read the Trip Type in sensor number 1 , use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
1Bh	Command	1Bh	Command
00h	Data (not used)	##h	Trip Type (High Byte)
00h	Data (not used)	##h	NA (Low Byte)
55h	End Byte	##h	NA
		99h	Stop Byte

To change the Trip Type in sensor number 1 to 4, use the command structure;

Send	
AAh	Start Byte
01h,	Sensor Number
1Ch	Command
04h	Data
84h	NA
55h	End Byte

TRIP TYPES



Type 6:
Trip Point Disable

NOTE: The Zero line represents the face of the sensor.

CONTINUOUS TRANSMIT

The IRU-2XX4/3XX4 can operate in two different modes:
(0) Control mode were the sensor will begin and end transmitting when it receives a begin or end transmit or bank command.
(1) Continuous transmit mode were the sensor will transmit as long as it has power.
To read the mode the sensor number 1 is operating in, use the command structure:

Send		**Receive**	
AAh	Start Byte	66h	Start Byte
01h,	Sensor Number	01h	Sensor Number
1Dh	Command	1Dh	Command
00h	Data (not used)	00h	Operating mode
00h	Data (not used)	00h	NA
55h	End Byte	00h	NA
		99h	Stop Byte

To change the operating mode in sensor number 1 to transmitting all of the time, use the command structure;

Send	
AAh	Start Byte
01h,	Sensor Number
1Eh	Command
01h	Data
00h	NA
55h	End Byte

START TRANSMIT SENSOR

Start Transmit Sensor allows the user to identify a sensor and have it start transmitting. This command controls a single sensor.
To have sensor number 1 begin transmitting, use the command structure;

Send	
AAh	Start Byte
01h,	Sensor Number
20h	Command
00h	NA
00h	NA
55h	End Byte

STOP TRANSMIT SENSOR

Stop Transmit Sensor allows the user to identify a sensor and have it start transmitting. This command controls a single sensor.
To have sensor number 1 stop transmitting, use the command structure;

Send	
AAh	Start Byte
01h,	Sensor Number
21h	Command
01h	NA
00h	NA
55h	End Byte

START TRANSMIT BANK

Start Transmit Bank allows the user to identify a bank of sensors and have them start transmitting. This command controls up to 10 sensors providing they are all assigned to the same bank.
To have Bank number 1 begin transmitting, use the command structure;

Send	
AAh	Start Byte
00h,	NA
22h	Command
01h	Bank Number)
00h	NA
55h	End Byte

STOP TRANSMIT BANK

Stop Transmit Bank (e) allows the user to identify a bank of sensors and have them stop transmitting. This command controls up to 10 sensors providing they are all assigned to the same bank.
To have Bank number 1 stop transmitting, use the command structure;

Send	
AAh	Start Byte
00h,	NA
23h	Command
01h	Bank Number
00h	NA
55h	End Byte

RESET PARAMETERS

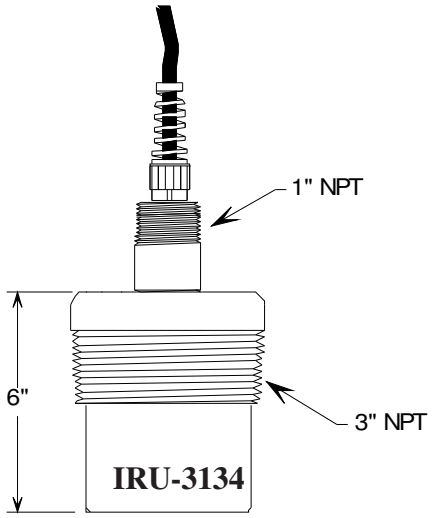
Reset allows the user to reset the parameters in a particular sensor to the factory defaults.

To reset the parameters in sensor number 1, use the command structure:

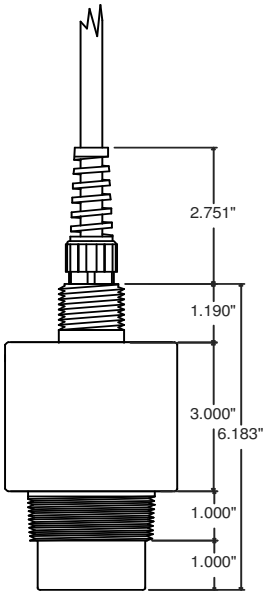
Send	
AAh	Start Byte
01h,	Sensor Number
1Fh	Command
00h	NA
00h	NA
55h	End Byte

MOUNTING

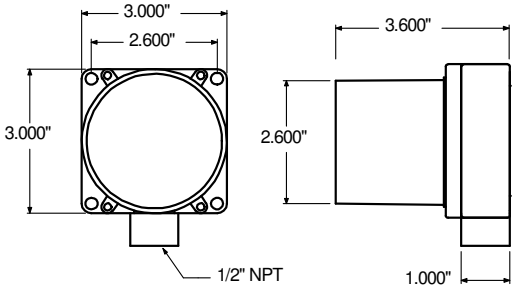
When mounting any ultrasonic sensor, alignment is critical. Ensure the face of the transducer is parallel to the target. A misalignment of a few degrees can affect the accuracy and reliability of the sensor.



IRU-3134



IRU-2124



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