USER'S MANUAL

RoLine 11X0

Version 4.11.2.3

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This product is designated for use solely as a component and as such it does not comply with the standards relating to laser products specified in U.S. FDA CFR Title 21 Part 1040.

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1 Laser Safety

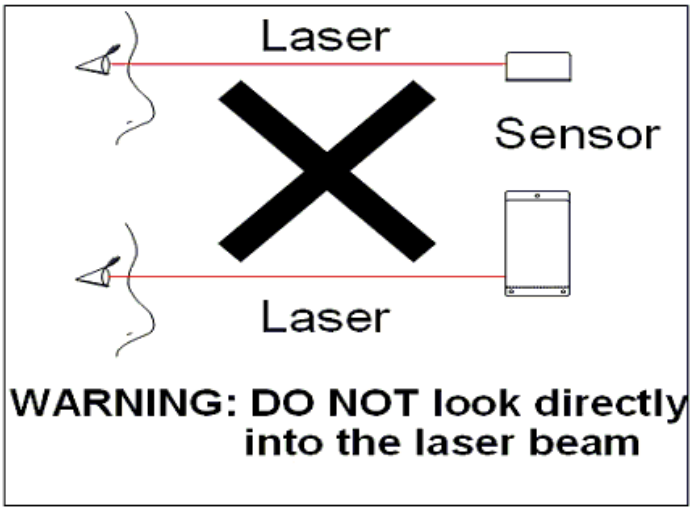
1.1 General Information

The laser light sources used in LMI Sensors are semiconductor lasers emitting visible light.

LMI Laser Sensors have a 2/II, 3R/IIIa or 3B/IIIb classification depending on model.

Class 2/II and 3R/IIIa sensors are referred to as “products” indicating that they fully comply with the standards relating to laser products specified in IEC 60825-1 and U.S. FDA CFR Title 21 Part 1040 except for deviations pursuant to Laser Notice No. 50, dated July 26, 2001.

Class 3B/IIIb sensors are sold only to qualified OEM’s as “components” for incorporation into their own equipment. The sensors do not incorporate safety items which the OEM is required to provide in their own equipment (e.g. remote interlocks, key control). As such these sensors do not fully comply with the standards relating to laser products specified in IEC 60825-1 and FDA CFR Title 21 Part 1040.



Caution! Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

1. **International Standard IEC 60825-1 (2001-08) Consolidated edition**, Safety of laser products – Part 1: Equipment classification, requirements and user's guide
2. **Technical Report TR 60825-10**, safety of laser products – Part 10. Application guidelines and explanatory notes to IEC 60825-1
3. **Laser Notice No. 50**, FDA and CDRH http://www.fda.gov/cdrh/rad-health.html

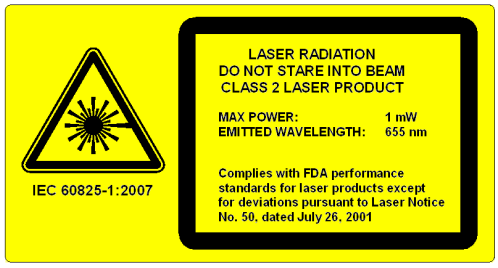
1.2 Laser Classification

1.2.1 Laser Classes

Class 2/II laser products:

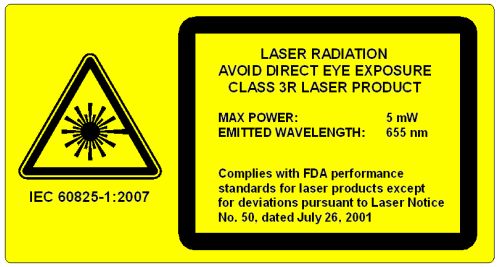
Class 2/II laser products would not cause permanent damage to the eye under reasonably foreseeable conditions of operation, provided that any exposure can be terminated by the blink reflex (assumed to take 0.25 sec). Because classification assumes the blink reflex, the wavelength of light must be in the visible range (400 nm to 700 nm). The Maximum Permissible Exposure (MPE) for visible radiation for 0.25 second is 25 Watt per square meter, which is equivalent to 1 mW entering an aperture of 7 mm diameter (the assumed size of the pupil).

Labels reprinted here are examples relevant to the laser classes. For detailed specifications observe the label on your laser sensor



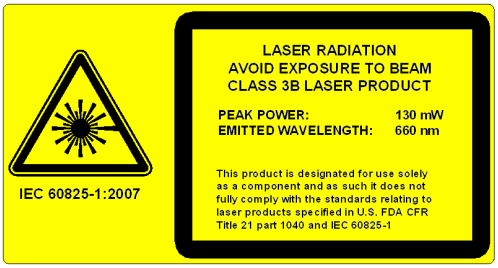
Class 3R/IIIa laser products:

Class 3R/IIIa laser products emit radiation where direct intrabeam viewing is potentially hazardous, but the risk is lower than for 3B/IIIb lasers. Fewer manufacturing requirements and control measures for users apply than for 3B/IIIb lasers.



Class 3B/IIIb laser components:

Class 3B/IIIb components are unsafe for eye exposure. Usually only ocular protection would be required. Diffuse reflections are safe if viewed for less than 10 seconds.



1.2.2 User Precautions & OEM Responsibilities

The specific user precautions as specified in IEC 60825-1 and FDA CFR Title 21 Part 1040 are:

Requirements	Class 2/II	Class 3R/3a	Class 3B/3b
Remote interlock	Not required	Not required	**Required****
Key control	Not required	Not required	**Required**** Cannot remove key when in use
Power-On delays	Not required	Not required	**Required****
Beam attenuator	Not required	Not required	**Required****
Emission indicator	Not required	Not required	**Required****
Warning signs	Not required	Not required	**Required****
Beam path	Not required	Terminate beam at useful length	Terminate beam at useful length
Specular reflection	Not required	Prevent unintentional reflections	Prevent unintentional reflections
Eye protection	Not required	Not required	Required under special conditions
Laser safety officer	Not required	Not required	Required
Training	Not required	Required for operator and maintenance personnel	Required for operator and maintenance personnel

LMI Class 3B/IIIb laser components do not incorporate the safety items indicated by asterisks ** in the table above. These items must be added and completed by the OEM in the system design.

1.2.3 Class 3B/IIIb OEM Responsibilities

LMI Technologies has filed reports with the FDA to assist the OEM in achieving certification of their laser products. The OEM can reference these reports by an accession number that will be provided upon request.

Detailed descriptions of the safety items that must be added to the OEM design are listed below:

Remote Interlock

A remote interlock connection must be present in Class IIIB laser systems. This permits remote switches to be attached in serial with the keylock switch on the controls. The deactivation of any remote switches must prevent power from being supplied to any lasers.

Key Control

A key operated master control to the lasers that prevents any power from being supplied to the lasers while in the OFF position. The key can be removable in the OFF position but the switch must not allow the key to be removed from the lock while in the ON position.

Power-On Delays

A delay circuit is required that illuminates warning indicators for a short period of time prior to supplying power to the lasers.

Beam Attenuators

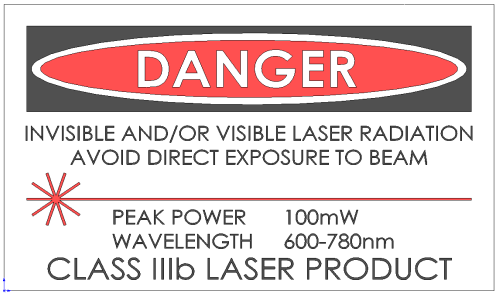
A permanently attached method of preventing human access to the laser radiation other than switches, power connectors or key control must be employed. On some LMI laser sensors, the beam attenuator is supplied with the sensor as an integrated mechanical shutter.

Emission Indicator

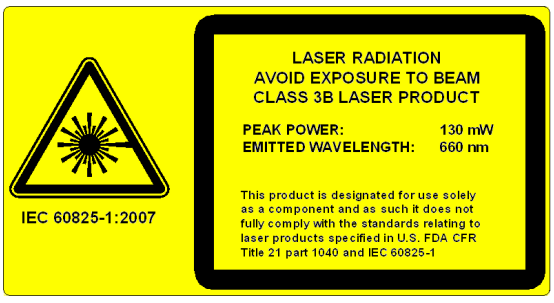
It is required that the controls that operate the sensors incorporate a visible or audible indicator when power is applied and the lasers are operating. If distance (>2 m between sensor and controls) or mounting of sensors intervenes with observation of these indicators, a second power-on indicator should be mounted at some readily observable position. When mounting the warning indicators, it is important not to mount them in a location that would require human exposure to the laser emissions.

Warning Signs

Laser warning signs must be located in the vicinity of the sensor such that they will be readily observed. Examples of laser warning signs are:



FDA Example



IEC Example

1.3 Requirements for Laser Systems Sold or Used In the USA

The OEM's laser system which incorporates laser components or laser products manufactured by LMI Technologies requires certification by the FDA.

It is the responsibility of the OEM to achieve and maintain this certification.

OEM's are advised to obtain the information booklet *Regulations for the Administration and Enforcement of the Radiation Control for Health and Safety Act of 1968*: HHS Publication FDA 88-8035.

This publication, containing the full details of laser safety requirements, can be obtained directly from the FDA, or downloaded from their website at http://www.fda.gov/cdrh.

1.4 RoLine 11X0 Laser Safety Specification

Laser Classification:	3B/IIIb laser component
Peak Power:	130mW
Emitted Wavelength:	660nm

2 Proper Handling and Precautions

2.1 System Installation

2.1.1 Component Grounding

All sensors should be grounded to the earth/chassis through their housing. For sensors with through-hole mounts, this can be accomplished by using star washers on the mounting bolts. The star washers must cut through the powder coating to provide electrical conductivity from the mounting hardware to the sensor housing. For sensors with tapped hole mounts, conductive hardware must to be used between the sensor and the frame. This must be checked with a multi-meter by ensuring electrical continuity between the frame and the connector housing on the sensor. It is imperative that the scan frame or chassis that the sensor is mounted to is connected to earth ground.

Master networking products should have the housing connected to earth ground. This can be accomplished using star washers on the mounting holes or through the earth ground connection located on the rear of the Master 1200 and 2400. FireSync Networking products should be installed inside electrical cabinets that are suitably grounded to earth ground.

2.1.2 Shielded Cable

LMI Technologies recommends the use of shielded cables in all environments to ensure isolation from electrical noise. The shield should be electrically connected to both the sensor housing through the connector housing and to the electrical box containing either the Master (network systems) or the power supply (standalone sensors).

LMI Technologies supplies both shielded FireSync cordsets and shielded FireSync cable for building cordset.

2.1.3 Power Supply

The user must provide a suitable +48VDC power supply for the system capable of handling an infinite capacitive load. These power supplies must be isolated such that DC ground is NOT tied to AC ground. The power supply should be of a suitable capacity for the size of the system.

LMI Technologies recommends the Phoenix Contact QUINT series of power supplies.

2.1.4 Uninterruptible Power Supply (UPS)

To maximize the life of the sensor, LMI Technologies recommends the use of an on-line double-conversion UPS whenever the quality of the electrical supply to the system is poor. This includes but is not limited to when the electrical supply:

- contains high frequency noise (due to other electronics, electic motors or other factors)
- is prone to “brown-out” conditions or large voltage fluctuations
- is prone to electrical surges or spikes due other components or electrical storms.

LMI Technologies recommends the Tripp Lite SU2200RTXL2UA UPS.

2.1.5 Installation Environment

To prevent damage to LMI 3D sensors and ensure reliable operation, avoid installing the sensor in locations:

- that are humid, dusty, or poorly ventilated
- with a high temperature such as a place exposed to direct sunlight
- where there are flammable or corrosive gases
- where the unit may be directly subjected to vibration or impact
- water, oil, or chemicals may splash onto the unit
- where static electricity is easily generated

2.2 Temperature and Humidity

LMI 3D Sensors are rated for operation between 0- 50℃, and 25-85% Relative Humidy (non-condensing).

2.3 Maintenance

LMI 3D sensors are high-precision optical instruments. To ensure the highest accuracy is achieved in all measurements, the windows on the front of the sensor should be kept clean and clear of debris.

Use dry, clean air to remove dust or other dirt particles. If dirt remains, clean the windows carefully with a soft, lint-free cloth using an ammonia based cleaner. Ensure that no residue is left on the windows after cleaning.

2.4 Laser Lifetime

LMI Technologies uses semiconductor lasers in their 3D measurement sensors. To maximize the lifespan of the sensor it is recommended to turn off the laser by stopping the sensor whenever it is not in use.

2.5 Avoid Flash Writes (Standalone Sensors only)

Operation parameters for standalone sensors are stored with flash memory inside the sensor. Flash has an expected lifetime of 100,000 writes. Avoid frequent or unnecessary write commands to the sensor to maximize the lifetime of the sensor.

3 Getting Started

Warning! RoLine 11x0 sensors are class 3B/IIIb components. Please read Section 1: Laser Safety above, and institute the necessary safety precautions before turning these sensors on.

This section provides a brief introduction to the RoLine 11x0 family, which includes the RoLine 1130, RoLine 1140 and RoLine 1145 sensors. It identifies the components supplied by LMI Technologies, and the additional components required to get a basic system up and running. This is followed by instructions on how to connect these components together, and how to install and run our client software to acquire basic profile data.

More detailed information is given in the sections that follow this "Getting Started" guide.

3.1 Components

LMI Technologies provides RoLine sensors. External peripherals such as power supply and host computer must be provided by the User.

3.1.1 Sensors

Model	Description
RoLine 1130	• Full Profile / Bridge Value over Ethernet
RoLine 1140	• Full Profile / Bridge Value over Ethernet • Bridge Value over Selcom Serial
RoLine 1145	• Full Profile / Bridge Value over Ethernet • Bridge value over Selcom Serial • Power over Selcom Serial Connector • Laser Safety

3.1.2 Host Computer

The user must also provide a suitable host computer. This must be equipped with a 100Mbit Ethernet port to communicate with a standalone FireSync sensor. The Client Interface to the sensor is OS independent. However, this computer must run Windows XP to install and run our FireSync Client demonstration application.

3.2 Connections

LMI Technologies does not supply the cord-sets required to connect to the RoLine 11X0. Instead, cord-set drawings are provided and can be found at the Sensor's Support Center:

http://partners.sensorsthatsee.com/

These drawings can be used, as reference, to manufacture custom length cord-sets for a user's particular application. The following summarizes the necessary connections required for proper communication between the sensor and the host.

3.2.1 Sensor to Host

The following table is a summary of the connections available on the RoLine 11X0. Note that the connections are dependent on the particular model of the sensor.

Connector	Total Pins	Cord-set Drawing	Applicable Model	General Description
FireSync®	14	30644	1130/1140/1145	Used to receive power, transmit data over Ethernet.
Sync Pulse	4	30645	1130	Used to transmit an opto-isolated pulse used for triggering/synchronizing external devices (sync pulse).
Selcom Serial	12	30668	1140	Used to transmit bridge values over the Selcom serial protocol. Also transmit sync pulse.
Selcom Serial + Power	12	30703	1145	Used to transmit bridge values over Selcom serial protocol. Also provides connections for power, laser safety, and sync pulse.

Before powering up the sensor, please be sure to check the following:

1. RoLine 1145 Power Connection Warning:
    a. Apply power to the sensor either through the M12 (Selcom+Power), or the M16 (FireSync®) connector; NEVER BOTH.
    b. If using the M12 (Selcom) connector for power, ensure the M16 protection cap is securely fastened to avoid accidental shorts.
2. The +48VDC power supply, used to power the sensor, must be isolated from AC ground. This means that AC ground cannot be tied to DC ground.

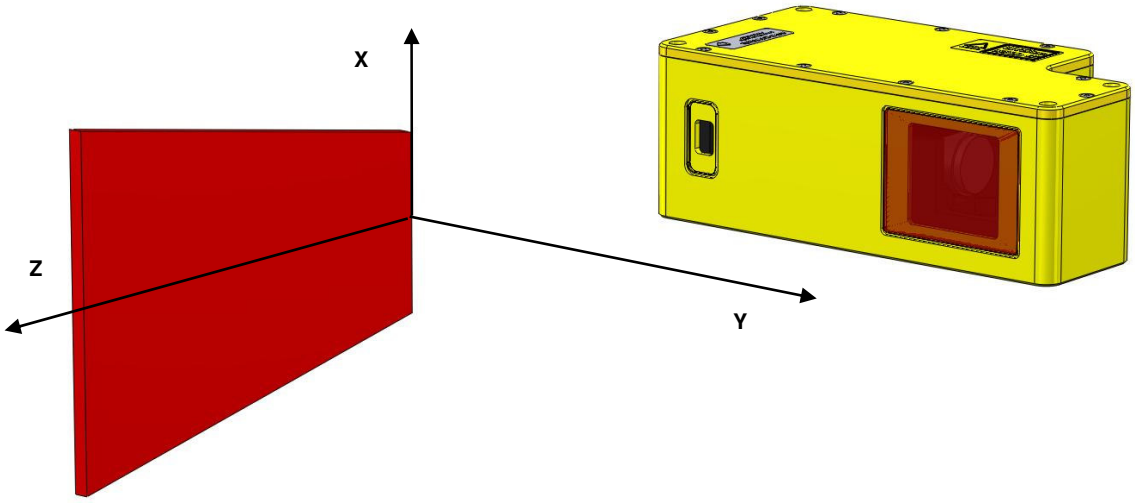
3.2.2 Safety Interlock

The Safety Interlock signal allows the user to turn on and off the laser in the sensors without disrupting power to the sensor. A laser safety control signal must be provided to the sensor to enable the laser, which then allows the sensor to properly function.

To enable the laser safety control, apply between +12V and +48V across the laser safety +/- connection.

3.3 Coordinate Definitions

Throughout this document and software interface, displacements are represented in x-, y- and/or z-coordinates. The coordinates are defined thus:



Axis	Definition
x	Field of view (along the laser line)
y	Field of view (axis of motion or axis of time)
z	Range from a sensor to the object being scanned.

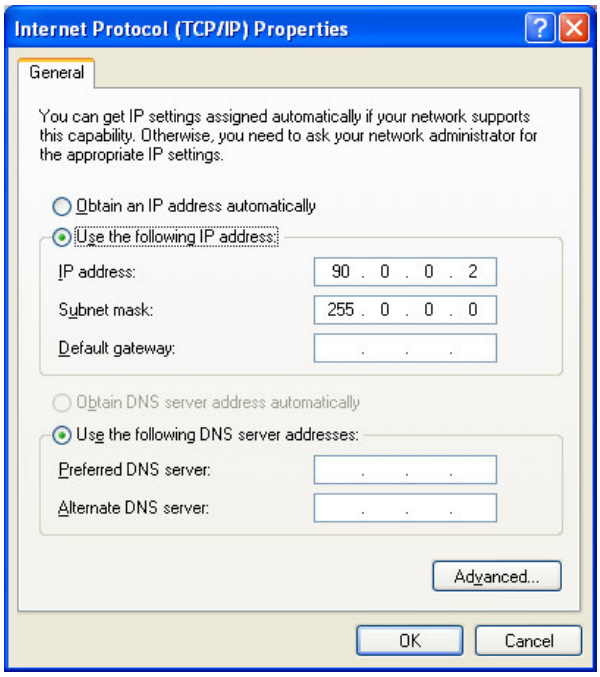
3.4 FireSync Client (Basic)

FireSync Client is a software application that can be used to set up, demonstrate, or diagnose problems with the RoLine 11x0 sensor. The following sections describe how to use FireSync Client to configure the RoLine 11x0 sensor. For a detailed description of the FireSync Client application, see the section entitled *FireSync Client (Complete)* in the *Software* chapter of this manual.

3.4.1 Installation

The FireSync Client application is available for Windows XP, and can be downloaded from the LMI Technologies support website. To begin, download the software and install it on a suitable client machine. The client machine should have an Ethernet adaptor that can be configured for a static IP address and that supports 1000 Mb/s operation.

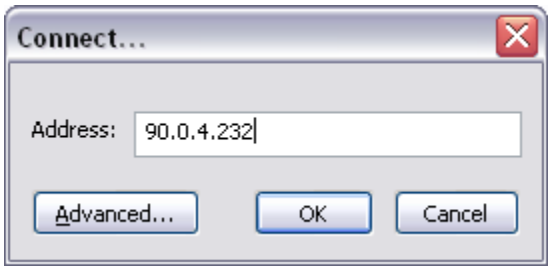
The RoLine 11x0 sensor typically ships with the address 90.0.x.x. Set the client machine to an available address on the same subnet (e.g. 90.0.0.2) and then connect a suitable cable from the client machine to the RoLine sensor.



3.4.2 Connection

After starting FireSync Client (kClient.exe), use the lightning (left-most) icon in the toolbar to display the Connect… dialog. To connect to the RoLine 11x0 sensor, enter its IP address, and then click OK.

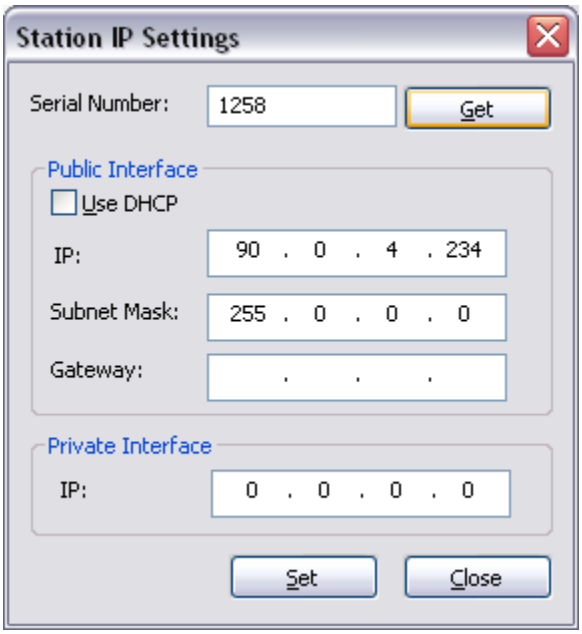
The default IP address of RoLine11x0 is typically set to 90.0.x.x, where the last two fields are dependent on the sensor's serial number. As an example, a sensor's serial number is 1256. In hexadecimal, the serial number becomes 0x04E8. Its most significant byte (0x04 = 4) becomes the third number of the IP address, and its least significant byte (0xE8 = 232) becomes the forth number of the IP address. Hence, the sensor's IP address becomes 90.0.4.232.



RoLine 11x0's network settings can be retrieved or set using the FireSync Client (connection is not needed). To retrieve network settings, select *Server->Station IP Settings…* from the menu item. Enter the serial number of the sensor and press "*Get*". The network information should show up. To configure the network settings, go to menu item *Server->Station IP Settings…*, enter the serial number and the desired network

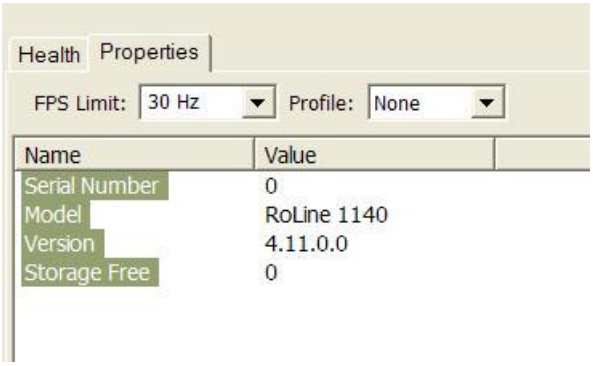
configuration and press "*Set*". The sensor is then automatically reset, after which the new IP settings will be in effect.

Please note that the DHCP flag for the public interface and the private address are not supported for the RoLine 11x0 at the present.



3.4.3 Check Firmware Version

To check the version of the firmware running in the connected sensor, click on the Properties tab in the visualization area.



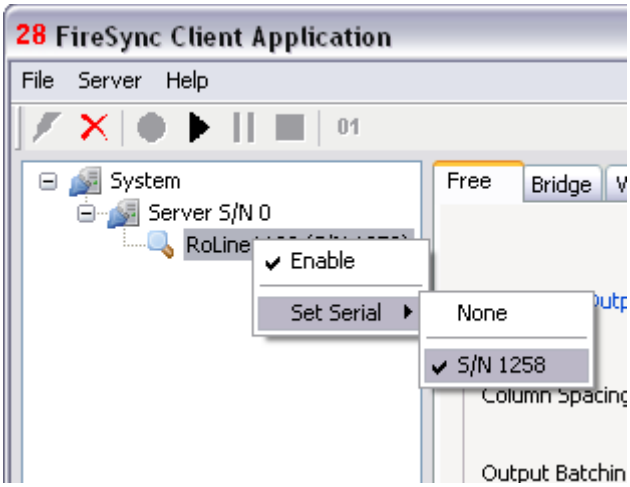
3.4.4 Firmware Update

To perform a Firmware update, first make sure that the FireSync Client is connected to the sensor. Click on the *Server S/N#* node in the device tree, and then select *Server->Upgrade...* from the menu. When prompted, select a firmware update file (supplied by LMI) and click the *Perform Upgrade* button. When the upgrade is completed, close the *Upgrade* dialog box. The server and sensors will reboot automatically.

Once the sensor reboots, restart the FireSync Client and then reconnect to the sensor.

3.4.5 Sensor Setup

The RoLine 11x0 device tree is shown in the left panel of the FireSync Client. Once the RoLine 11x0 is connected, the sensor is listed in the FireSync Client's device tree. If the serial number is not assigned in the FireSync Client, right-click the device tree node to assign a serial number.



3.4.6 Sensor Data

To view live laser profile data from a sensor, click on the sensor's node in the device tree, and the select the *Free* tab. Press the Play button in the FireSync Client toolbar. The Range visualization tab will display live laser profile measurements. This display can be used in conjunction with a stationary or moving target to verify that laser profiling is operating correctly.

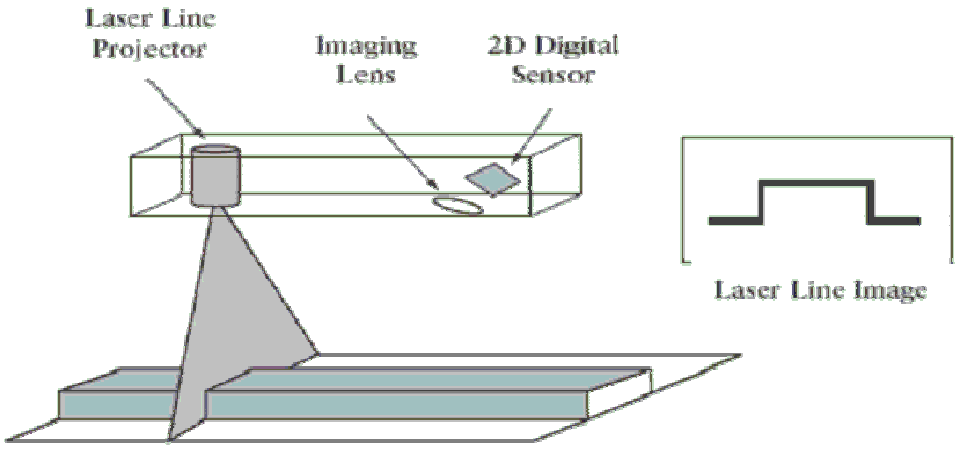
4 Product Overview

4.1 Introduction

The RoLine 11x0 is the new-generation, high-speed, high-density 3D profile scanning system for road or inertial profiling. The sensors are based on LMI's field-proven FireSync platform, which provides a synchronized, scalable, distributed vision processing architecture for building reliable, high performance systems. High reliability and simple, rapid installation are achieved with a single cable for power and data.

4.2 Measurement Principles

The RoLine 11x0 sensors function on the principle of structured light triangulation. A semiconductor laser with special optics projects fan of light onto the target. A digital



camera mounted at an angle to the laser plane acquires images of the light pattern created on the target. These images contain the basic information needed to compute distances to the target.

4.3 High Scan Rates

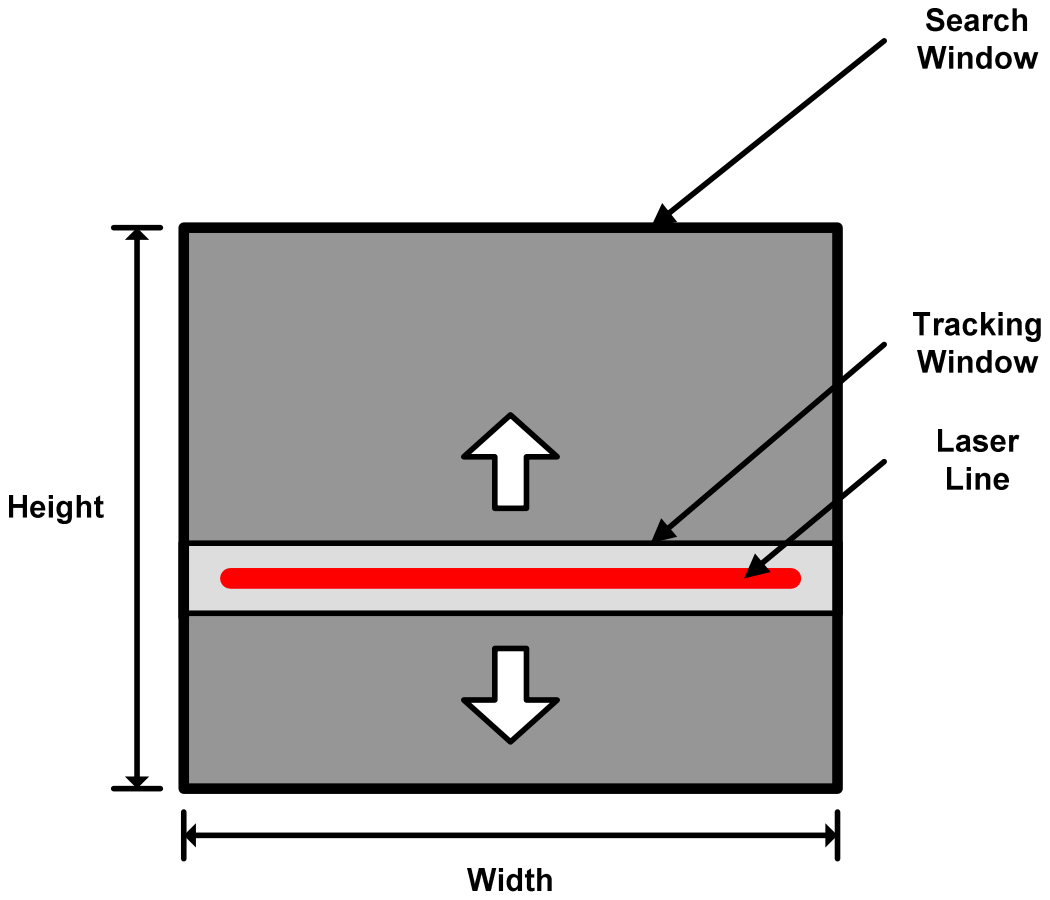
The RoLine 11x0 sensor uses a laser line tracking algorithm to provide scan rates up to 3000 Hz. Please refer to section 3.6 for a more detailed explanation.

4.4 Ambient Light Immunity and Dark Asphalt Performance

The sensor maintains excellent dark asphalt performance and ambient light immunity. More specifically, the sensor achieves dark asphalt sensitivity equivalent to level 18 on the Kodak gray scale chart.

4.5 Laser Line Tracking Algorithm

In normal operation, the RoLine 11x0 uses a laser line tracking algorithm to optimize sensor's speed. For scanning, the algorithm dynamically switches between two imager window sizes: a large and a small window labeled "search window" and "tracking window", respectively. See the following diagram.

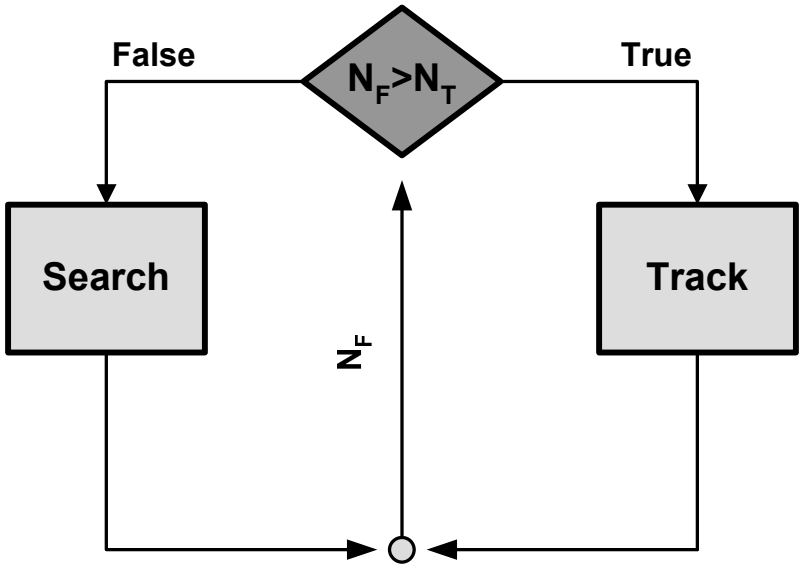


The algorithm consists of two states: searching and tracking. In the searching state, the larger search window is used to locate the laser line within the full range of the sensor. In the tracking state, the smaller tracking window is used to follow the laser line within a smaller range of the sensor. During tracking, the algorithm dynamically positions the tracking window such that the laser line remains centered. Due to the smaller window used, tracking can operate at higher speeds. If the tracking window loses the laser line, the algorithm switches back to searching to reacquire the line. Searching is slower than tracking since the search window needs to cover a larger area of the imager. Once the laser line is found in the searching state, the algorithm switches back to tracking and continues to output ranges at higher speed.

The following table summarizes the tracking and searching states of the laser line tracking algorithm. Please note that the sync pulse always remains at 3000 Hz.

Algorithm State	**Description**
Tracking	• Sensor speed = 3000 Hz • 1 sync pulse per profile data • Tracking window
Searching	• Sensor speed = 750 Hz • 4 sync pulses per profile data • Search window
Disabled	• Sensor speed = 428.5 Hz • 7 sync pulses per profile data • Search window

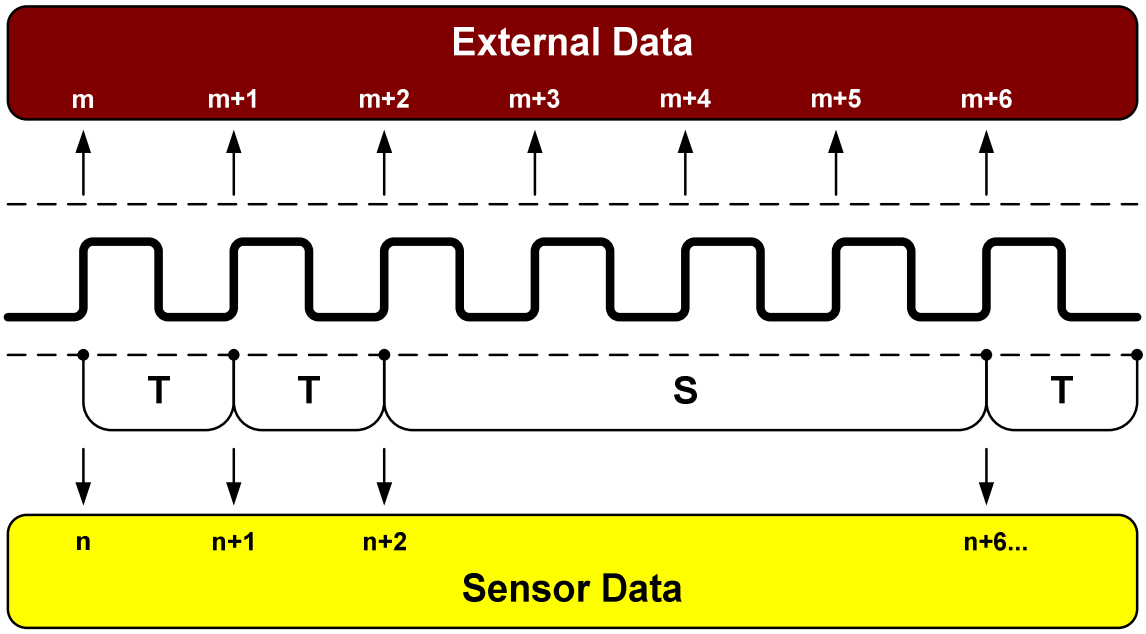
Algorithmically, searching is triggered when the number of laser points found, N_F is less than the minimum threshold of laser points required, N_T (see figure below). In practice, such an event can occur if there is excessive tilting of the sensor, an instantaneous step change in the road that exceeds 10mm within one 3000 Hz frame period (worse case), or an occlusion of the laser line due to deep cracks.



Road testing shows that searching is typically triggered by the latter (i.e. bridge transitions). Since there can be undesired results near deep cracks and erroneous road features, the RoLine 11x0 puts a label to indicate whether the data is derived from a tracking or a search window. It is recommended that only track data be used for most accurate measurement.

4.6 Data Synchronization with External Devices

The RoLine 11x0 outputs an opto-isolated 3000 Hz pulse, called “sync pulse,” that can be used to trigger or synchronize external devices, such as accelerometers. Synchronization between sensor data and external data (accelerometer data) is made possible because the rising edge of the sync pulse coincides with the start of a sensor’s scan via LMI’s FireSync® technology. In addition, the sensor data is tagged with an index, called “sync index,” that keeps count of the number of sync pulse that has transmitted since the sensor starts. By counting the number of sync pulses (m) and matching it with the sync index (n) from the received sensor data, the external data can be synchronized with the sensor data. The figure below illustrates how data synchronization can be achieved. Notice that the synchronization method is still valid even if the sensor goes into “searching (S)” or “tracking (T)”.



4.7 Bridging Algorithm

In addition to outputting raw profile data, the RoLine 11X0 can also output a single, processed range value known as the “Bridge Value”. The bridge value can be delivered via Ethernet or Selcom Serial; depending on RoLine model. The following section describes how the bridge value is calculated.

The bridging algorithm, in essence, is a filtered average of a laser line profile. More specifically, the algorithm first compensates for profile tilt.

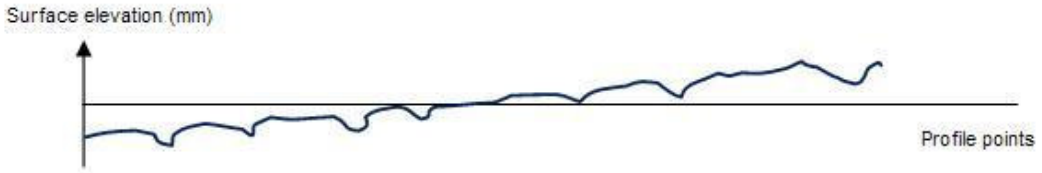


Figure 3.7.1: Raw Laser Line Profile

Figure 3.7.2: Laser Line Profile corrected for tilt.

The bridging algorithm uses the center of the profile as the rotational point for tilt compensation.

These corrected profile points are then sorted from the highest reading to the lowest range, for filtering. Users can adjust algorithm parameters “window skip” and “window size” to filter out the highest and lowest profile readings, respectively. By adjusting these parameters the user can remove unwanted road features (i.e. rocks, cracks, tining valleys, etc) to get an accurate representation of the tire to road interface.

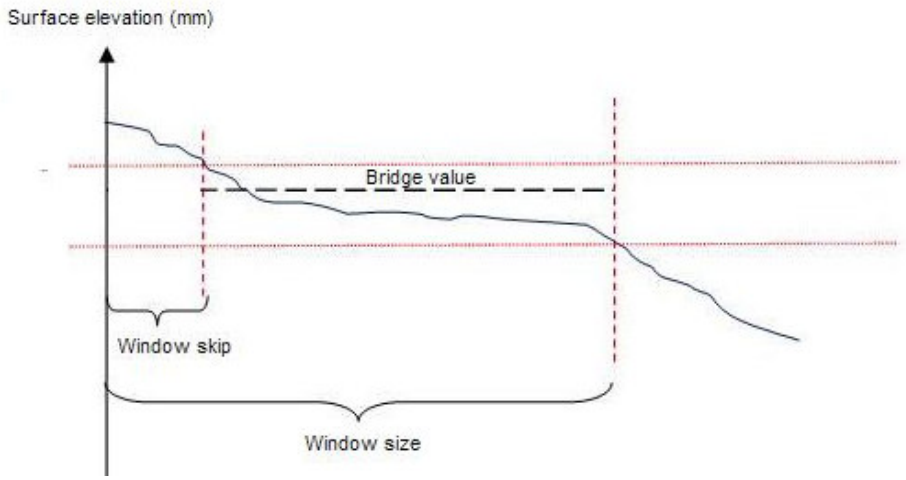


Figure 3.7.3: Sorted Profile Points and Bridge Algorithm Parameters

Finally, the average of the remaining readings is calculated to give what is referred to as the “bridge value”.

The following input parameters configure the bridging algorithm:

Window size	The number of profile points sorting from the most elevated point of the profile used in the bridging calculation.
Window skip	The number of profile points sorting from the most elevated point of the profile to be excluded in the bridging algorithm.
Window invalid	The maximum allowable invalid profile points in a profile. If this threshold is violated the algorithm returns an “INVALID” bridge value.

4.8 Bridge Value via Selcom Serial

For the RoLine 114X models, the user has the option to use the sensor’s RS485 Selcom Serial synchronous interface to receive bridged values from the sensor.

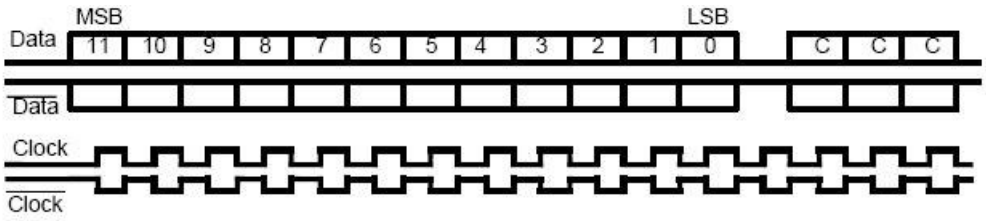
The Selcom Serial output consists of a clock and data signal. The serial clock frequency can be set to 96 kHz or 512 kHz, and is only running when data is being transmitted. Serial data is valid on the rising edge of the Selcom clock and is output MSB first followed by control bits for a total of 16 bits of information per frame.

The time elapsed between the camera exposure and the delivery of the corresponding range data is fixed to 3.4 milliseconds.

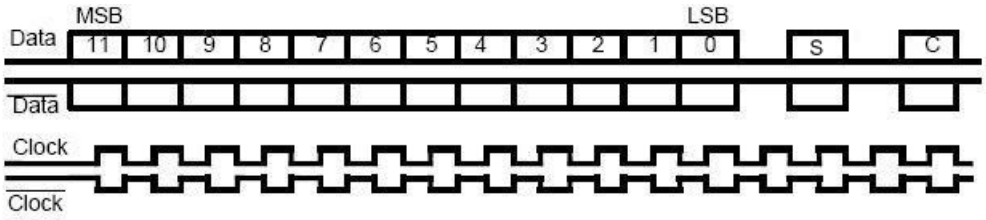
Depending on the application, users can choose one of four possible bit formats for the serial data output. MSB is the most significant data bit, LSB is the least significant data bit, C indicates whether the data is invalid (invalid = high), and S indicates whether the data is acquired in search mode or track mode (search mode = high).

Method	
0	12 bit data SLS Mode
1	12 bit data with Search/Track bit
2	14 bit data
3	14 bit data with Search/Track bit

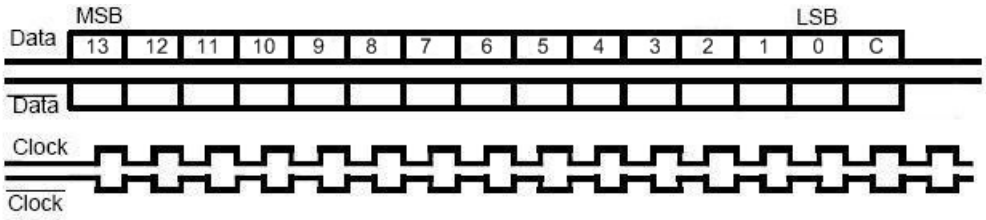
Method 0 – 12 bit data:



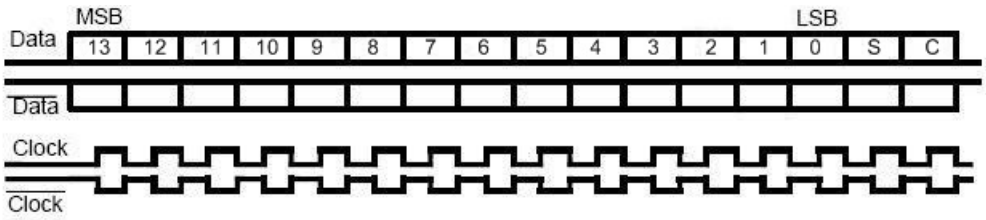
Method 1 – 12 bit data with Search/Track bit



Method 2 – 14 bit data



Method 3 – 14 bit data with Search/Track bit



When delivered via Selcom Serial, the bridged values are scaled according to the number of serial bits used to cover the 200mm measurement range. The 12-bit output

would break the 200mm measurement range into 4096 increments (0.0488mm/bit), and the 14-bit output would break the measurement range into 16384 increments (0.0122mm/bit). The bridged values are relative to the sensor's clearance distance.

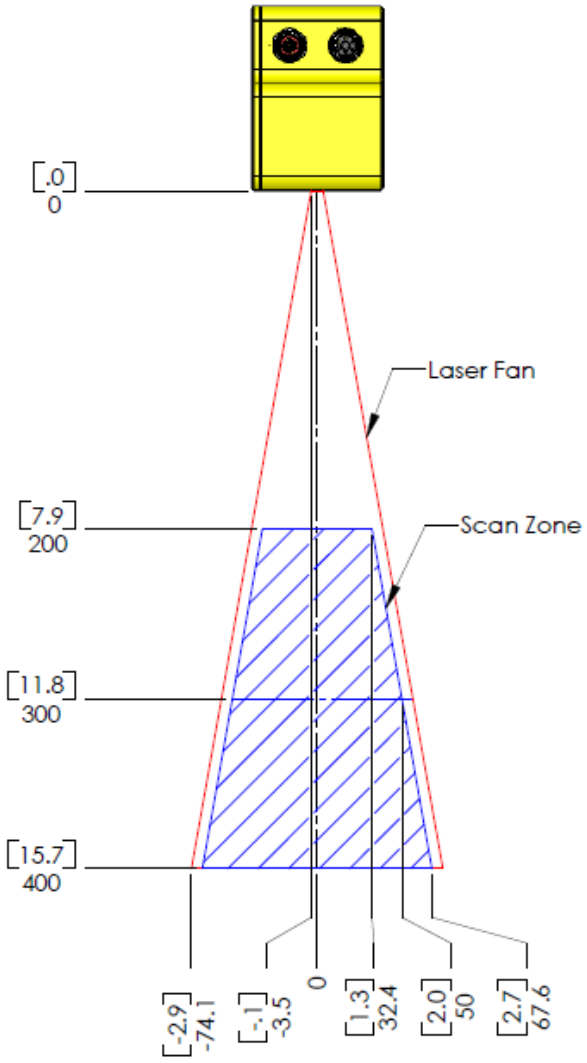
5 Sensor

The RoLine 11x0 is a 3 kHz sensor capable of outputting both full profile and bridged value data. This section presents sensor specific RoLine 11x0 information.

5.1 Specifications

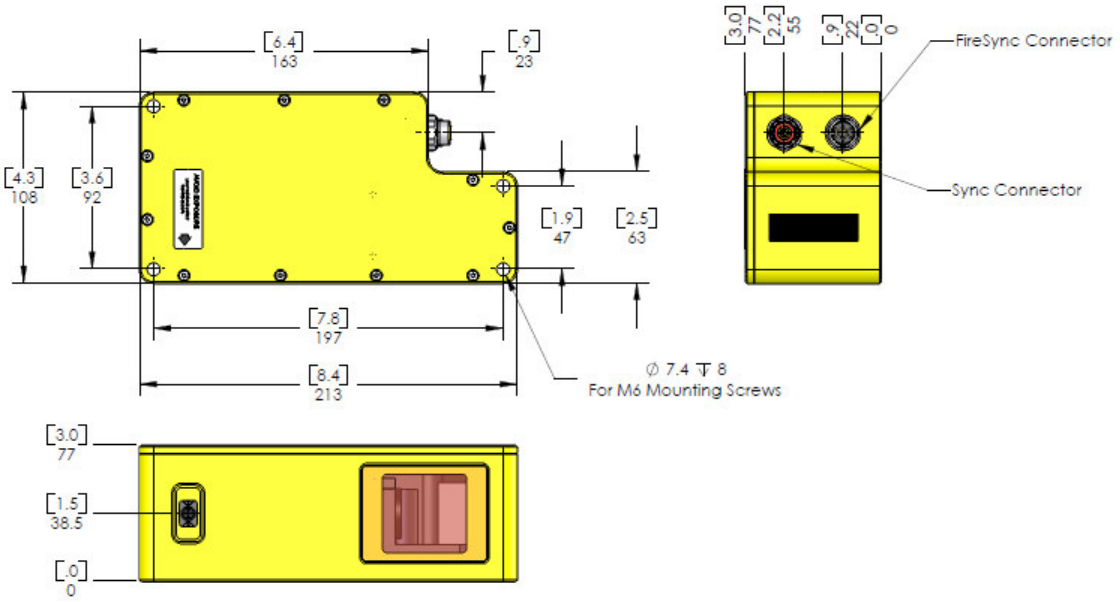
Operating Temperature	0 – 50 °C	32 – 122 °F
Voltage Requirement	48 VDC ± 10%	
Maximum Current	400 mA	
Housing	IP67, Powder Coated, Aluminum	
Weight	1.80 kg	4.00 lb
Laser Line Width (Mid Range)	1mm	

5.2 Scan Zone



Clearance Distance (CD)	200 mm	7.9 in
Measurement Range (MR)	200 mm	7.9 in
Field of View (FOV) @ CD	65 mm	2.6 in
Field of View (FOV) @ CD+MR/2	100 mm	4.0 in
Field of View (FOV) @ CD+MR	135 mm	5.4 in

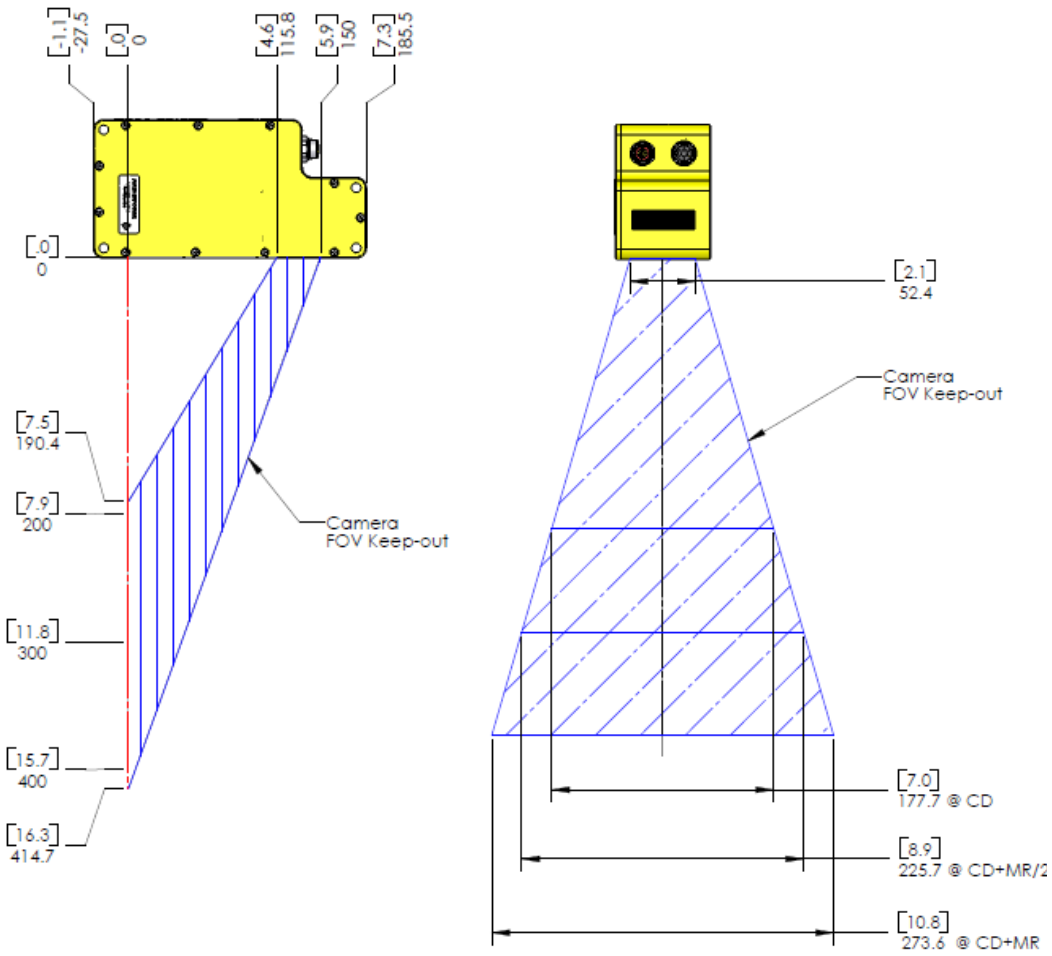
5.3 Dimensions



The sensor should be mounted with appropriate length M6 fasteners. Moreover, the **sensor should be grounded to the earth/chassis.** This can be accomplished by using star washers on the four M6 mounting holes. The star washers should cut through the powder coating to provide electrical conductivity from the mounting hardware to the sensor housing. This can be checked with a multi-meter. Also note that the laser fan is emitted through the clear window and that the camera is located behind the red tinted window. When mounting the sensor, ensure that there are no obstructions between the camera window and the scan zone.

5.4 FOV Envelope

The following drawings detail regions in front of the sensor that should be kept free of obstructions. These regions envelope the laser fan projection and the camera view of the scan zone.


[-1.1]
-27.5
[0]
0
[4.6]
115.8
[5.9]
150
[7.3]
185.5
[0]
0
[7.5]
190.4
[7.9]
200
[11.8]
300
[15.7]
400
[16.3]
414.7
Camera
FOV Keep-out
[2.1]
52.4
Camera
FOV Keep-out
[7.0]
177.7 @ CD
[8.9]
225.7 @ CD+MR/2
[10.8]
273.6 @ CD+MR

6 Software

This section describes the software interfaces to the RoLine 11x0 sensor, including the FireSync Client user interface, settings file format and message formats.

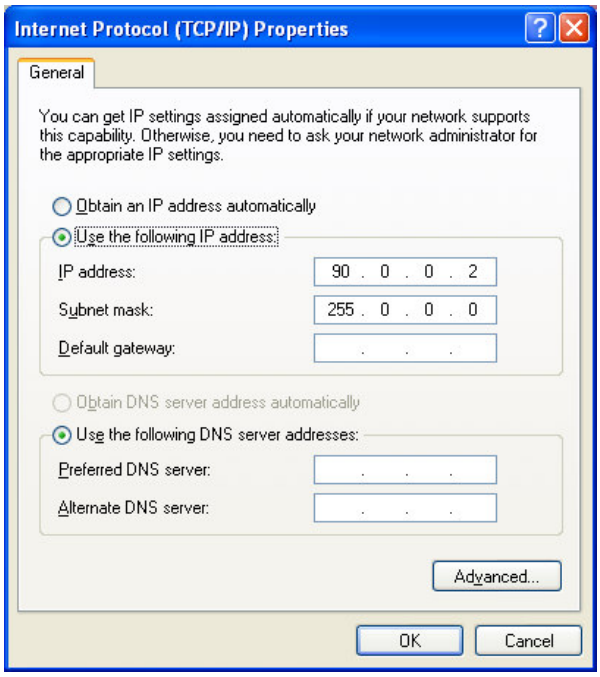
6.1 FireSync Client (Complete)

FireSync Client is a software application that can be used to setup, demonstrate, or diagnose problems with the RoLine 11X0 sensor. The following sections describe how to setup and use the various FireSync Client features.

6.1.1 Installation

The FireSync Client application is available for Windows XP, and can be downloaded from the LMI Technologies support website. To begin, download the software and install it on a suitable client machine. The client machine should have an Ethernet adaptor that can be configured for a static IP address and that supports 1000 Mb/s operation.

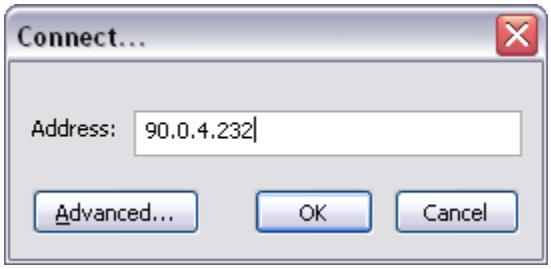
The RoLine 11x0 sensor typically ships with the address 90.0.x.x. Set the client machine to an available address on the same subnet (e.g. 90.0.0.2) and then connect a suitable cable from the client machine to the RoLine sensor.



6.1.2 Connection

After starting FireSync Client (kClient.exe), use the lightning (left-most) icon in the toolbar to display the Connect… dialog. To connect to the RoLine 11x0 sensor, enter its IP address, and then click OK.

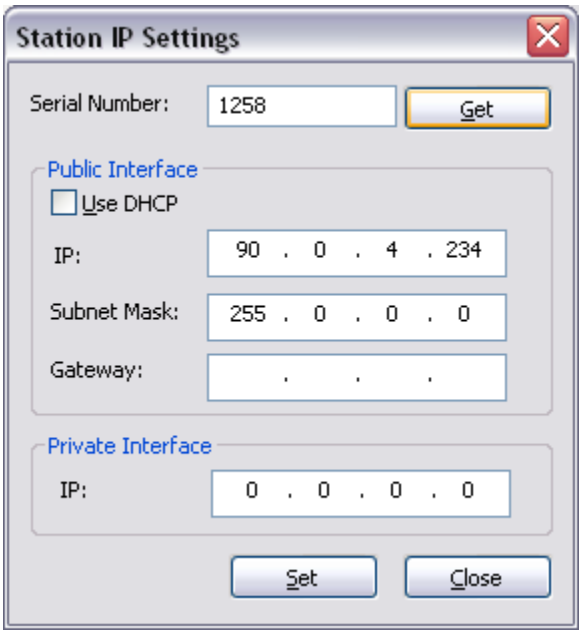
The default IP address of RoLine11x0 is typically set to 90.0.x.x, where the last two fields are dependent on the sensor's serial number. As an example, a sensor's serial number is 1256. In hexadecimal, the serial number becomes 0x04E8. Its most significant byte (0x04 = 4) becomes the third number of the IP address, and its least significant byte (0xE8 = 232) becomes the forth number of the IP address. Hence, the sensor's IP address becomes 90.0.4.232.



RoLine 11x0's network settings can be retrieved or set using the FireSync Client (connection is not needed). To retrieve network settings, select *Server->Station IP Settings…* from the menu item. Enter the serial number of the sensor and press "*Get*". The network information should show up. To configure the network settings, go to menu item *Server->Station IP Settings…*, enter the serial number and the desired network

configuration and press "*Set*". The sensor is then automatically reset, after which the new IP settings will be in effect.

Please note that the DHCP flag for the public interface and the private address are not supported for the RoLine 11x0 at the present.



6.1.3 Check Firmware Version

To check the version of the firmware running in the connected sensor, click on the Properties tab in the visualization area.

6.1.4 Firmware Update

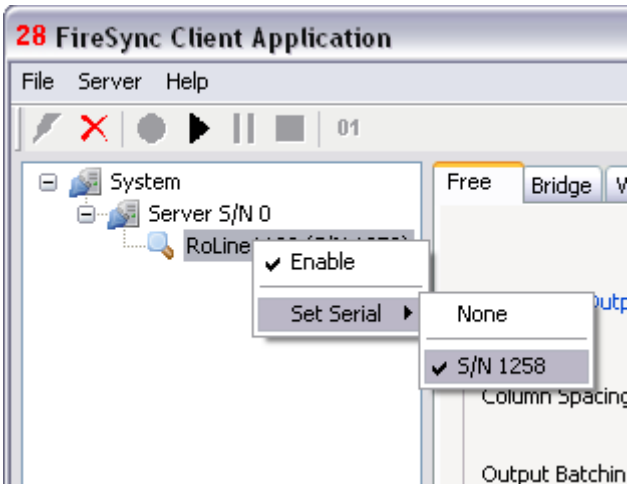
To perform a Firmware update, first make sure that the FireSync Client is connected to the sensor. Click on the *Server S/N#* node in the device tree, then select *Server-*

>Upgrade... from the menu. When prompted, select a firmware update file (supplied by LMI) and click the *Perform Upgrade* button. When the upgrade is completed, close the *Upgrade* dialog box. The server and sensors will reboot automatically.

Once the sensor reboots, restart the FireSync Client and then reconnect to the sensor.

6.1.5 Sensor Setup

The RoLine 11x0 device tree is shown in the left panel of the FireSync Client. Once the RoLine 11x0 is connected, the sensor is listed in the FireSync Client's device tree. If the serial number is not assigned in the FireSync Client, right-click the device tree node to assign a serial number.



6.1.6 Sensor Tabs

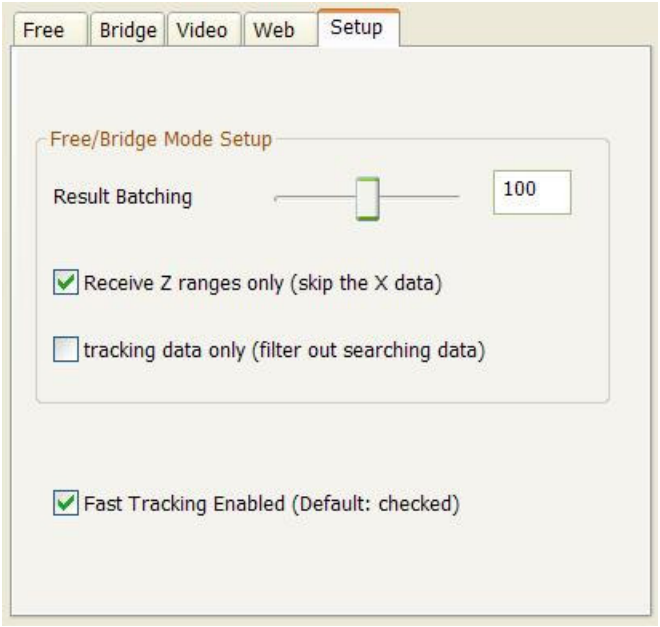
A variety of RoLine 11x0 features are accessible via clicking on one of five available sensor tabs in the middle panel of the FireSync Client.

Note that it is not possible to change the FireSync Client's options during data streaming. To change options, the user must ensure that the sensor is not streaming data.

6.1.6.1 Setup Tab

The Setup tab contains sensor configurations that apply to Free mode and Bridge mode.

Please note that no visualization is associated with the Setup tab.

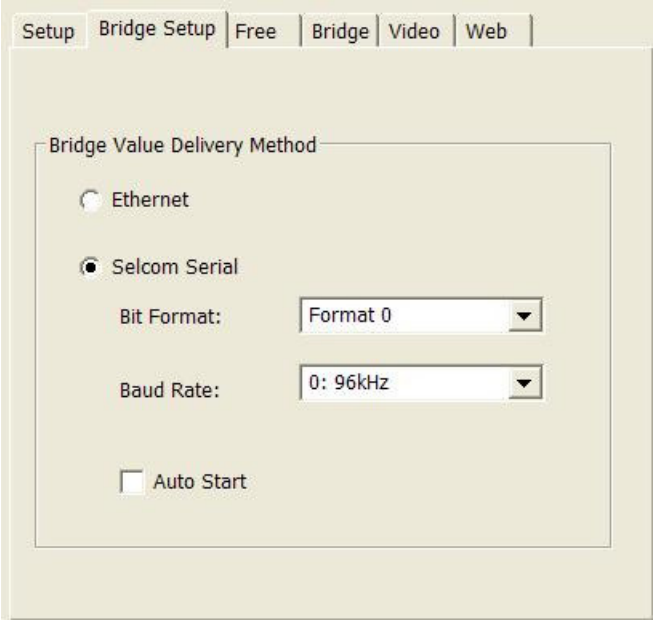


Result Batching	The number of profiles batched together in a single message. Set between 1-200. Note: Due to the high speed of the sensor, it is recommended that this value be set to a high value (ie. 100)
Receive Z ranges Only	Enable this option to configure the sensor to only send out Z-range values in Free mode profile data. Disable this option to configure the sensor to send both Z- and X-range values in Free mode profile data.
Tracking Data Only	Enable this option so that the Client only display/record range data acquired with the tracking window. Disable this option to send all data.
Fast Tracking Enabled	Enable this option to enable laser line tracking. When this is enabled, the sensor will run at the faster speed (maximum 3000Hz). Disable this option to utilize the sensor's full field of view. The sensor will then run at a slower fixed speed (428.5Hz). Refer to Laser Line Tracking Algorithm section for details. **Note: This option should be enabled for normal operation.**

6.1.6.2 Bridge Setup

The Bridge Advanced tab allows users to configure whether to use Ethernet/FireSync or Selcom Serial to deliver bridged values for the RoLine 1140 and 1145. These options are grayed out for the RoLine 1130.

Note that no visualization is associated with this tab.

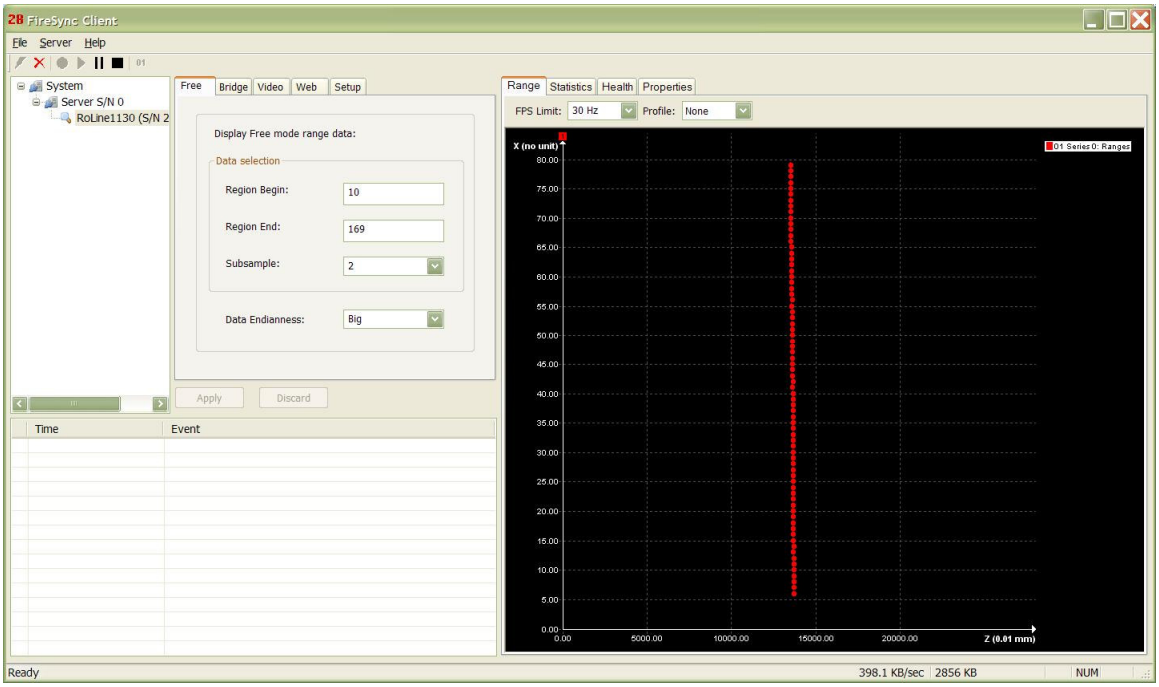


Ethernet output		Bridged value will be delivered in the FireSync kHost protocol via Ethernet. The bridged value will be displayed in the Bridge tab's visualization.
Selcom Serial output		Bridged value will be delivered via selcom serial. If this option is selected, the bridged value will not be displayed in kClient.
	Bit Format	Select one of four possible bit arrangements
	Baud Rate	Select 0 to set the Selcom clock speed to 96kHz, or 1 to set the Selcom clock speed to 512kHz
	Auto Start	Enables or disables the auto-starting option. If auto-start is enabled, sensor will automatically start when the sensor is power cycled. Note that there is a 30 second delay before the sensor actually starts emitting laser light after the sensor restarts. Note that when Auto Start is enabled, the selected delivery method is ignored. Bridged value is transmitted via selcom serial using the pre-selected bit format.

6.1.6.3 Free Tab

When selected, this tab enables *Free* mode. (Explained in section 5.2.2.2).

After selecting the *Free* tab, press the *Play* button (black triangle) in the toolbar to observe the incoming raw profile data from the sensor.



In this mode, users may specify the size of the imager window from which the profile data is computed. By adjusting RegionBegin, RegionEnd and Subsample, users can select where the data is computed within the imager window.

The number of points being outputted is defined:

N = (RegionEnd – RegionBegin + 1) /Subsample

Please ensure that the inputs are such that N is smaller than or equal to 150.

Data Selection		
	RegionBegin	Must be set between 0 and RegionEnd.
	RegionEnd	Must be set between RegionBegin and 199.
	Subsample	Subsample the profile data along the x-axis. This can be set to 1, 2, 4 or 8.
Endianness		Define the endianness (little or big) of the profile data.

Note that ranges are reported in units of 0.01mm, and the range values (z values) are relative to the sensor's clearance distance.

6.1.6.4 Bridge Tab

The *Bridge* tab allows users to configure how the bridged value is calculated. When selected, this tab enables *Bridge* mode. (Explained in the Bridging Algorithm section). .

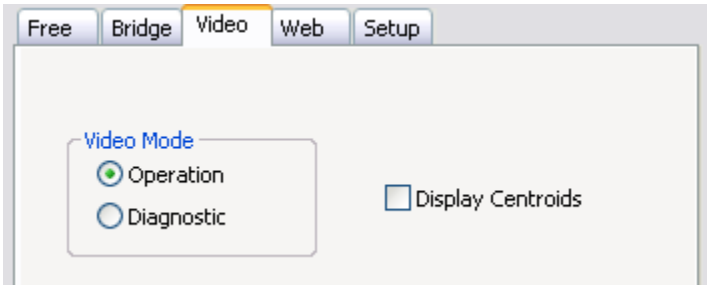
After selecting the *Bridge* tab, press the *Play* button (black triangle) in the toolbar to display the bridged value.

Window size	The number of profile points sorting from the most elevated point of the profile used in the bridging calculation. This should be set to an integer between 0 and 196.
Window skip	The number of profile points sorting from the most elevated point of the profile to be excluded in the bridging algorithm. This should be set to an integer between 0 and 196. It should also be set smaller than Window size.
Window invalid	The maximum tolerance regarding the number of invalid profile points in a profile. This should be set to an integer between 0 (lowest tolerance) and 196 (maximum tolerance).
Normalize Profile	Enables or disables the compensation for lateral tilt of the scanned surface.

6.1.6.5 Video Tab

The *Video* tab contains settings that configure how video is displayed. When selected, this tab enables *Video* mode, which can be used for diagnostics analysis.

After selecting the *Video* tab, press the *Play* button (black triangle) in the toolbar, and observe the incoming video images from the camera. To zoom in or view the profile of the video, right-click on the image display and select from the available options.

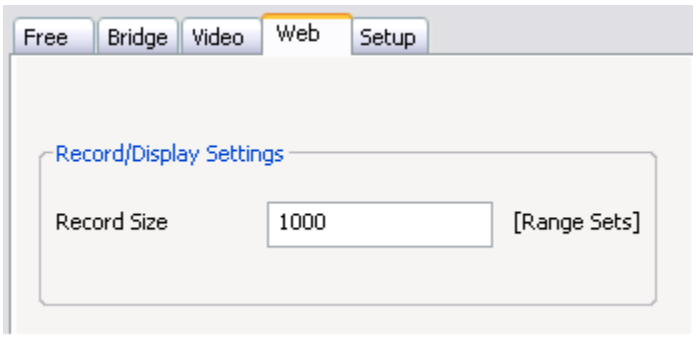


Video Mode	When Operation is selected, the streaming video shows how the laser line tracking algorithm functions by dynamically positioning the smaller tracking window based on the laser line's position. When Diagnostic is selected, the streaming video shows the relative position of the laser within the full window.
Display Centroids	Enable to overlay laser spot data on top of video

6.1.6.6 Web Tab

The *Web* tab contains settings that provide another way (other than the Free tab) to record or display Full Profile data. When selected, this tab enables *Free* mode.

After selecting the *Web* tab, press the *Play* button (black triangle) in the toolbar to view the range data, or press the Record button (red circle) to record the raw full profile data into a csv file.



Record Size	Specifies the number of desired profile range sets (i.e. the number of recorded frames). The sensor will automatically stop (i.e. the laser line will be turned off automatically) after the specified number of range sets is collected.

Press the *Record* button (red circle) in the toolbar to record the profile data into a comma-separated-values (csv) file. The csv file is saved to the same folder where the client is installed. In the csv file, each row corresponds to the full profile captured in a frame.

If "Receive Z data Only" is disabled, the format of each row is as follows:

Column Index	**Field**	**Description**
0	timestamp	Captured time (in microseconds).
1	trackingMode	Indicates whether the range data is obtained from a tracking window (0) or a search window (1).
2	SyncCounter	Counter for the number of image frames captured by the camera.
3+2n	z(n)	z range of the n-th point of the profile
3+(2n+1)	x(n)	x range of the n-th point of the profile

If "Receive Z data Only" is enabled, the format of each row is as follows:

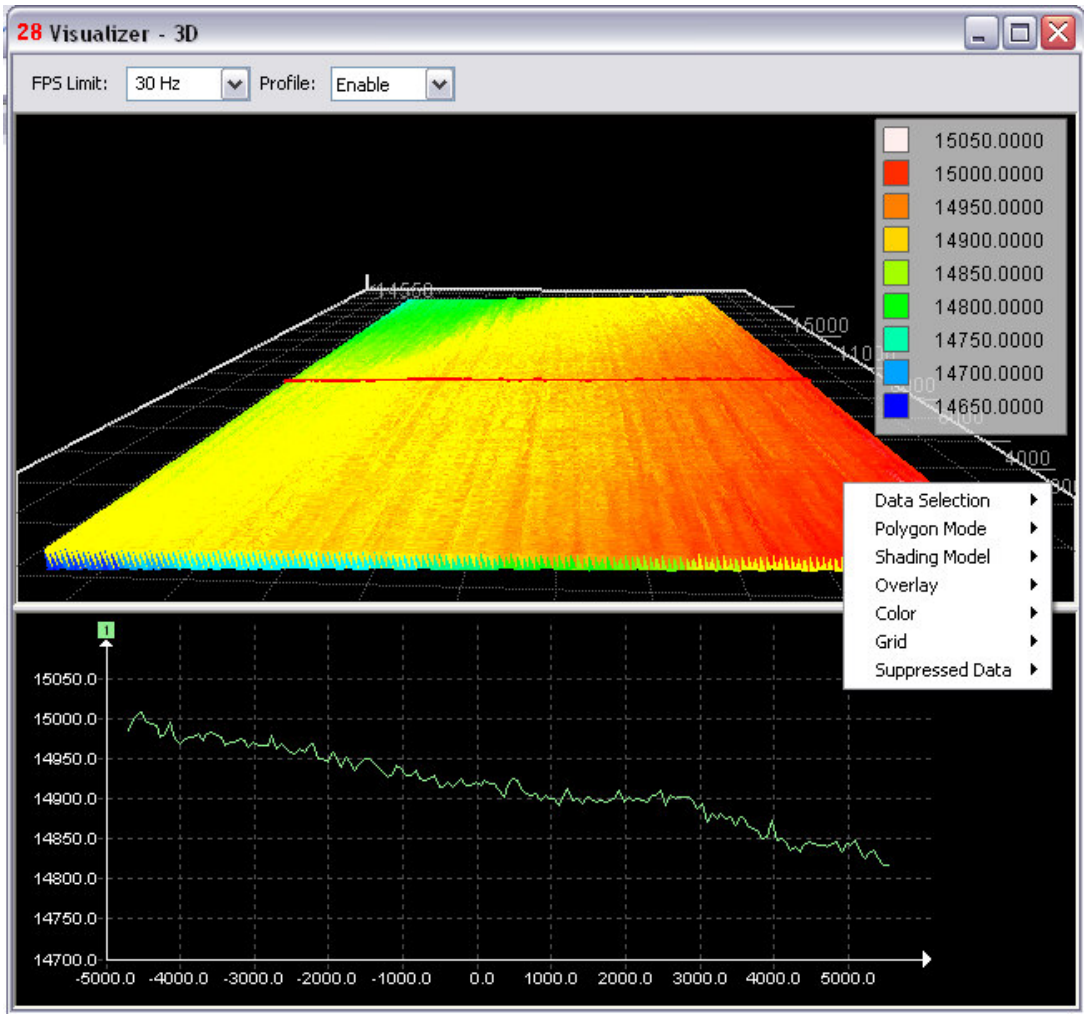
Column Index	**Field**	**Description**
0	timestamp	Captured time (in microseconds).
1	trackingMode	Indicates whether the range data is obtained from a tracking window (0) or a search window (1).
2	SyncCounter	Sync counter
3+n	z(n)	z range of the n-th point of the profile

Note that invalid profile points are represented by the 16 bit value, -32768 (or 0x8000).

Press the *Play* button (black triangle) in the toolbar to visualize the profile data[1] in 3D. The view angle of the 3D visualization can be adjusted by holding the shift key, then left-

[1] The profile data is re-sampled for visualization demonstration.

click (rotate) or right-click (zoom) on the visualization area. Additional view options, such as displaying the profile or adding color, are available by right clicking on the visualization. Please note that depending on your computer specifications, the Client is unable to produce a 3D visualization from a large amount of scans. Therefore, to scan a large amount of range data, it is recommended to use the *Record* feature instead.



6.2 File Formats

6.2.1 Sensor Settings

All sensor settings are stored in a file named “settings.xml” on each RoLine 11X0 sensor. To configure the sensor’s operation, the sensor settings can be accessed or modified using the FireSync Host Protocol Read File and Write File commands. The following example illustrates the format of the “settings.xml” file:

```
<?xml version="1.0" ?>
<SensorGroup>
  <OutputBatchingCount>100</OutputBatchingCount>
  <TrackingEnabled>1</TrackingEnabled>
  <FreeMode>
```

```
    <BigEndian>1</BigEndian>
    <ChannelCount>1</ChannelCount>
    <Subsampling>1</Subsampling>
    <Region>
      <Begin>10</Begin>
      <End>169</End>
    </Region>
  </FreeMode>
  <BridgeMode>
    <BridgeWindowSize>196</BridgeWindowSize>
    <BridgeWindowSkip>10</BridgeWindowSkip>
    <BridgeWindowInvalid>196</BridgeWindowInvalid>
    <BridgeNormalize>1</BridgeNormalize>
    <SelcomSerial>
      <Enabled>0</Enabled>
      <BitArrangement>0</BitArrangement>
      <AutoStartEnabled>0</AutoStartEnabled>
      <BaudRate>0</BaudRate>
    </SelcomSerial>
  </BridgeMode>
  <VideoMode>
    <VideoTracking>0</VideoTracking>
    <VideoStyle>0</VideoStyle>
  </VideoMode>
  <Capture>
    <Enabled>0</Enabled>
    <Source>0</Source>
    <Divisor>6</Divisor>
  </Capture>
  <Members>
    <Sensor>
      <Name>RoLine 1140</Name>
      <SerialNumber>2711</SerialNumber>
      <Enabled>1</Enabled>
    </Sensor>
  </Members>
</SensorGroup>
```

The example above specifies the settings for the standalone RoLine 11x0 sensor. Sensor-level (SensorGroup) settings include the following entries:

Setting	**Description**
Name	The sensor name as a formatted string (“RoLine 1130”, “RoLine 1140” or “RoLine 1145”)
SerialNumber	The serial number of the sensor, which can be seen on the sensor housing.
Enabled	Enables (1) or disables (0) the sensor. Disable sensors will not emit laser light and will not report results

Setting	Description
OutputBatchingCount	The number of profiles batched together in a single message. Used in Free Mode and Bridge Mode. This value should be set to a high value (ie.100) due to the high frame rate of the sensor.
TrackingEnabled	Enable the fast laser tracking algorithm by setting this parameter to 1. To run the sensor at a slower speed without the laser tracking algorithm, set this to 0. **To use the system normally, please ensure that TrackingEnabled is enabled by setting it to 1.**
FreeMode	
ChannelCount	Indicates whether to include the x-values in the Free mode profile data. If channel=1, only the z-values are delivered. If channel=2, both z- and x-values are delivered.
BigEndian	The profile data in Free mode can be little-endian (0) or big-endian (1).
Subsample	The Free mode profile data can be sub-sampled by a factor of 1, 2, 4 and 8.
Region[2]	Users may specify the size of the imager window from which the profile data is computed.
Begin	Must be set between 0 and RegionEnd.
End	Must be set between RegionBegin and 199.
VideoMode	
VideoTracking	Images can be captured using the tracking window (0) or search window (1).
VideoStyle	The system can overlay additional centroid information on video images. This setting enables (1) or disables (0) the display of the centroid.
BridgeMode	
BridgeWindowSize	The number of profile points sorting from the most elevated point of the profile used in the bridging calculation. This should be set to an integer between 0 and 196.
BridgeWindowSkip	The number of profile points sorting from the most elevated point of the profile to be excluded in the bridging algorithm. This should be set to an integer between 0 and 196.

[2] The number of points being outputted is defined: N = (RegionEnd – RegionBegin + 1)/Subsample, where N ≤ 150 to ensure proper sensor operation

	BridgeWindowInvalid		The maximum tolerance regarding the number of invalid profile points in a profile. This should be set to an integer between 0 (lowest tolerance) and 196 (maximum tolerance).
	BridgeNormalize		Enables (1) or disables (0) the compensation for lateral tilt of the scanned surface.
	SelcomSerial		
		Enabled	Uses Selcom Serial (1) or FireSync/Ethernet (0) to deliver bridging value. **This option is applicable only for the RoLine 1140 and 1145.**
		BitArrangement	Uses one of four available bit arrangements for selcom serial. See the Selcom Serial section in Product Overview for detailed descriptions. **This option is applicable only for the RoLine 1140 and 1145.**
		AutoStartEnabled	Enables (1) or disables (0) Auto Start. If Auto Start is enabled, the sensor will automatically start running in Bridge Mode and sends out bridging values in Selcom Serial. **This option is applicable only for the RoLine 1140 and 1145.**
		BaudRate	Uses 96kHz (0) or 512kHz (1) as the Selcom clock speed to deliver the bridging value. The baud rate is default to 96kHz (0) if this is not explicitly specified. **This option is applicable only for the RoLine 1140 and 1145.**

The Capture settings determine the behavior of the system when capturing data for diagnostic analysis by LMI Technologies. The proper configurations for the Capture settings will be provided when diagnostic analysis is required. **To use the system normally, please ensure that capture is disabled by setting Capture/Enabled to 0.**

6.2.2 Modes and Messages

The sensor can operate in different modes, each of which has a specialized purpose. The Client should use the FireSync Host Protocol *Set Operation Mode* command to set the current mode before sending the *Start* command.

As the sensor runs, data will be transmitted in a platform-independent binary format. The general rules for this format are described in the *FireSync Host Protocol* Reference Manual, in the section entitled FireSync Result Format. However, it is not necessary to consider the FireSync result format; the sensor Result messages are described below as an independent data format. Note, some fields that pertain to the FireSync Result details are marked reserved in this document, where those fields are not strictly required to understand the sensor's messages.

Message specifications in this document use a shorthand notation for data types. All values are little-endian (least significant byte transmitted first).

Data Type	Size (bytes)	Description
8s	1	Signed 8-bit integer
8u	1	Unsigned 8-bit integer
16s	2	Signed 16-bit integer
16u	2	Unsigned 16-bit integer
32s	4	Signed 32-bit integer
32u	4	Unsigned 32-bit integer
64s	8	Signed 64-bit integer
64u	8	Unsigned 64-bit integer

RoLine 11x0 can operate in one of the following three modes: *Video* mode, *Free* mode and *Bridge* mode. Each of these modes employs its own message format.

6.2.2.1 Video Mode

In *Video* mode, images captured by the sensor's camera are transmitted. When *operation* is selected, the streaming video demonstrates how the tracking algorithm functions by intelligently repositioning the tracking window based on the position of the laser projection. When *diagnostic* is selected, the streaming video shows the relative position of the laser in the sensor's field of view in the y-axis.

The string name of this sensor mode is "*Video*". Use this string with the *FireSync Host Protocol Set Operation Mode* command to set the sensor to run in this mode.

The format of the video message is described as follows.

Video Message

Field	Type	Description
messageSize	64s	Total size of message (bytes)
messageId	64s	Type of message (3)
reserved[2]	64s	Reserved for internal use
deviceId	64s	Sensor serial number
timestamp	64s	Capture time (in microseconds)
syncIndex	64s	Counter of the number of 3kHz clock periods.
trackingMode	64s	Indicates whether the range data is obtained from a tracking window (0) or a search window (1).
reserved [10]	64s	Reserved for internal use
height	64s	Image height
width	64s	Image width

reserved[2]	64s	Reserved for internal use
pixels[height][width][4]	8u	Image pixels (blue, green, red, reserved)

6.2.2.2 Free Mode

In *Free* mode, the sensor performs range lookup to produce profile range data (Full Profile) for each period. The full profile is an array of points representing the z- and x-coordinates of the laser line projection onto the scanned surface. The profile data is transmitted without any additional processing (such as interpolation) from the sensor.

The string name of this sensor mode is "*Free*". Use this string with the *FireSync Host Protocol Set Operation Mode* command to set the sensor to run in this mode.

The Free mode message format is defined below. Note that invalid profile points are represented by the 16 bit value, -32768 (or 0x8000).

Free Profile Message

Field	Type	Description
messageSize	64s	Total size of message (bytes)
messageId	64s	Type of message (1)
reserved[2]	64s	Reserved for internal use
deviceId	64s	Sensor serial number
endianness	64s	Endianness for the profile data*. Little-endian = 0, big-endian = 1
reserved[4]	64s	Reserved for internal use
count	64s	Count of profile arrays grouped in message
width	64s	Count of range points per profile array
channel		If channel=2, then the profile arrays contain both z- and x-values. If channel=1, then the profile arrays contain only the z-values
reserve[1]	64s	Reserved for internal use
attributes[count][3]	64s	Profile attributes (defined below)
points[count][width][channel]	16s	Profile arrays consisting of (z,x) or only (z), depending on 'channel' (in 0.01mm). Can be little-endian or big-endian

Free Profile Attribute (Full Profile)

Field	Type	Description
timestamp	64s	Capture time (in microseconds)

syncIndex	64s	Counter of the number of 3kHz clock periods
trackingMode	64s	Indicates whether the range data is obtained from a tracking window (0) or a search window (1).

6.2.2.3 Bridge Mode

The purpose of the *Bridge* mode is to reduce the high resolution, high-density full profile data to an averaged z-value, characteristic to the road-tire contact point in that profile. This value is referred to as the bridged value.

The string name of this sensor mode is "*Bridge*". Use this string with the *FireSync Host Protocol Set Operation Mode* command to set the sensor to run in this mode.

The Bridge mode message format is defined below. Note that invalid profile points are represented by the 16 bit value, -32768 (or 0x8000).

Bridge Message

Field	Type	Description
messageSize	64s	Total size of message (bytes)
messageId	64s	Type of message (2)
reserved[2]	64s	Reserved for internal use
deviceId	64s	Sensor serial number
count	64s	Count of bride values grouped in message
reserved[7]	64s	Reserved for internal use
attributes[count][3]	64s	Attributes (defined below)
bridgeValue[count]	16s	Bridged value arrays (in 0.01mm)

Bridge Message Attribute

Field	Type	Description
timestamp	64s	Capture time (in microseconds)
syncIndex	64s	Counter of the number of 3kHz clock periods.
trackingMode	64s	Indicates whether the range data is obtained from a tracking window (0) or a search window (1).

Please note that when delivered via Ethernet instead of Selcom Serial, the bridged values are reported in units of 0.01mm, and are relative to the sensor's clearance distance.

6.2.3 Sample Code

The FireSync Host protocol is a standard protocol based on TCP/IP that allows a client application to communicate to the RoLine 11x0. Example source code illustrates how to use FireSync Host protocol to configure the sensor and receive sensor messages. The example project is installed along with the FireSync Client.

7 Warranty

7.1 Warranty policies

The sensor is warranted for a predetermined number of years from the date of purchase from LMI Technologies Inc. This warranty period is defined by your business agreement in place with LMI Technologies. For exact warranty periods by product, please contact your Business Development Manager. Products that are found to be non-conforming during their warranty period are to be returned to LMI Technologies Inc. The sensor must be properly handled, installed and maintained, as described in Section 2: Proper Handling and Precautions. LMI will void the warranty of the sensor if the sensor has been improperly installed or mishandled.

The shipper is responsible for covering all duties and freight for returning the sensor to LMI. It is at LMI's discretion to repair or replace sensors that are returned for warranty work. LMI Technologies Inc. warranty covers parts, labor and the return shipping charges. If the warranty stickers on the sensors are removed or appear to be tampered with, LMI will void the warranty of the sensor.

7.2 Return policy

Before returning the product for repair (warranty or non-warranty) a Return Material Authorization (RMA) number must be obtained from LMI. Please call LMI to obtain this RMA number. Carefully package the sensor in its original shipping materials (or equivalent) and ship the sensor prepaid to your designated LMI location. Please insure that the RMA number is clearly written on the outside of the package. With the sensors, include the address you wish this shipment returned to, the name, email and telephone number of a technical contact should we need to discuss this repair, and details of the nature of the malfunction. For non-warranty repairs, a purchase order for the repair charges must accompany the returning sensor. LMI Technologies Inc. is not responsible for damages to a sensor that is the result of improper packaging or damage during transit by the courier.

8 Getting Help

If you wish further help on the component or product, contact your distributor or LMI directly. Visit our website at www.lmi3D.com for the agent nearest you.

For more information on Safety and Laser classifications, contact:

Center for Devices and Radiological Health, FDA
Attn: Electronic Product Reports
Electronic Product Document Control (HFZ-309)
Office of Communication, Education, and Radiation Programs
9200 Corporate Blvd.
Rockville MD 20850