RobotEye RE08

3D Laser Scanning System
User Manual

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Copyright Notice and Disclaimer

Revision Table

Date	Notes
28/05/2015	Draft
17/09/2015	Initial Release
25/02/2016	Updated operation mode and metadata information
16/11/2016	Updated Mechanical Drawings and Connection procedure

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FCC COMPLIANCE STATEMENT: 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 instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at own expense.

CE COMPLIANCE STATEMENT: This equipment has been tested and passed with the requirements relating to electromagnetic compatibility based on the standards EN 55022:2010 +AC:2011 (Class A) and EN61000-6-2:2005

1 Introduction

IMPORTANT
READ CAREFULLY BEFORE USE
KEEP FOR FUTURE REFERENCE

The RE08 User Manual is provided as a guide to the connection, configuration and safe use of the Ocular Robotics RE08 3D laser scanner. For development of custom software applications for use with the RE08 system see the EyeLib Application Programming Interface (API) Reference Manual and UDP Packet Specification Manual. For further information, contact Ocular Robotics.

Chapter 2 Basics, describes the initial setup and basic use of the RE08 including information on cleaning, maintenance and safety. Chapter 3 General Description presents a system description in terms of the system's Mechanical and Electrical properties and its communication and power interfaces. Chapter 4 Measurement Accuracy outlines the impact of the various system settings on system performance and the accuracy of measurements made. Chapter 5 Scan Patterns describes the scanning features available to the RE08 laser scanner. Chapter 6 LIDAR Rangefinder provides information on the measurement modes and return data provided by the laser.

CAUTION - USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN RISK OF INJURY. IT WILL ALSO VOID YOUR WARRANTY

2 Basics

IMPORTANT – Before connecting the power to this system or attempting to operate it in any way, read and follow all instructions regarding safe operation of this system contained in Section 2.5.

2.1 System Components

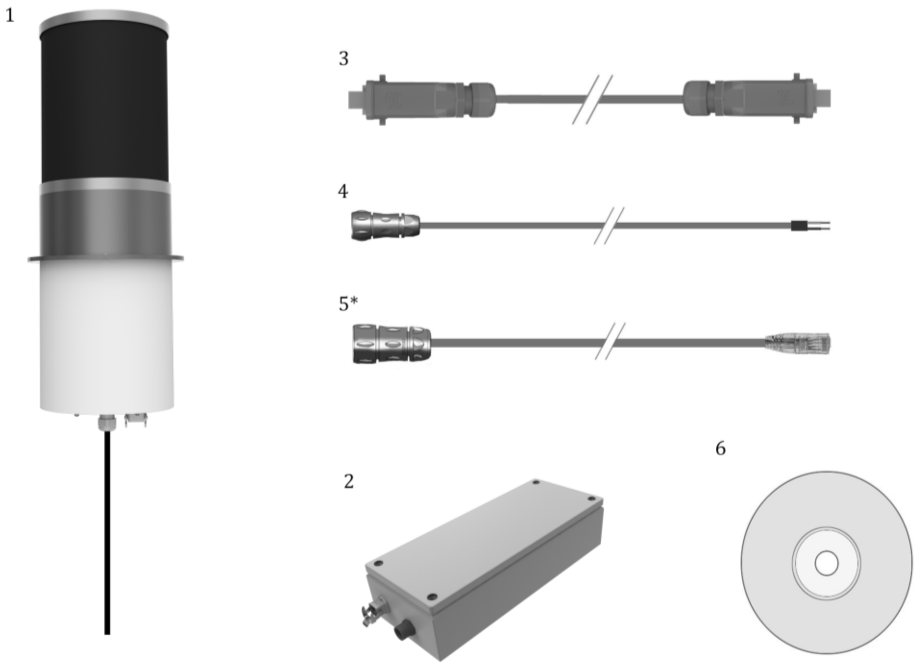


Figure 2-1 – RE08 Packing List

The RobotEye RE08 3D laser scanning system is supplied standard with the following components, each of which can be seen in Figure 2-1:

1. The RobotEye RE08 3D laser scanning head with Optical Fibers and 10m Interconnecting Cable (Other lengths available for Interconnecting Cable)
2. The RobotEye RE08 Control and Sensor Enclosure (CSE)
3. RE08 10m Composite Interconnecting Cable
4. RE08 5m power cable.
5. IP68 LAN cable (*optional).
6. Installation & documentation disk.

2.2 What You Need

In order to operate the RE08 laser scanning system, you will need:

1. Power supply – A 24 volt DC power supply with 25 amp surge current capability and a continuous current capacity of 10 amps is recommended

2. Ethernet cable – A standard Ethernet cable (Cat5e or Cat6) is needed for control and communication with the RE08 system.

3. A computer with a Windows or Linux operating system with an available Gigabit Ethernet port.

2.3 Handling and Transportation

Avoid handling the RobotEye using the dome. Doing so may result in damage to the dome, reducing optical performance.

When transporting, avoid external loads, stresses or impacts on the dome section.

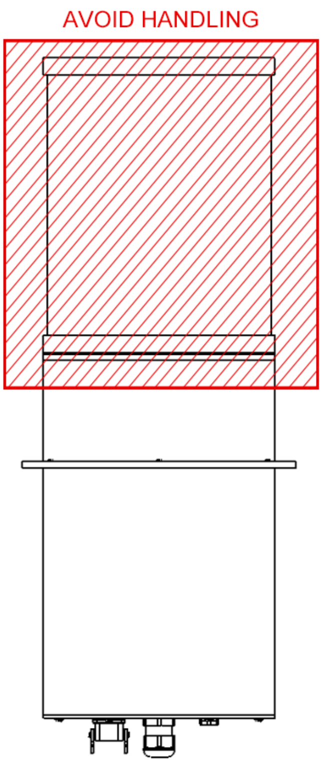


Figure 2-2 – RE08 Handling Zones

2.4 Initial Setup

NOTE – The robot eye dome must be handled with care during transport and installation. Excessive external loads or abrasion to the dome may result in damage or reduced performance.

Follow the steps below to set the RE08 system up for use on a computer with a Windows or Linux operating system. The system IP address shipped with your system should be noted on the supplied *Certificate*.

1. Connect one end of the Ethernet cable to the network port on the PC or switch. Connect the other end to the RE08 CSE Ethernet port. Refer to Figure 2-4

2. Connect the Interconnecting Composite Cable to the RE08 Scanning Head and secure with the latch. Repeat for the RE08 CSE.

3. Connect the Optical Fibres to the Laser Unit within the CSE by guiding them through the panel connector and connecting the Fibres according to Figure 2-3 below.

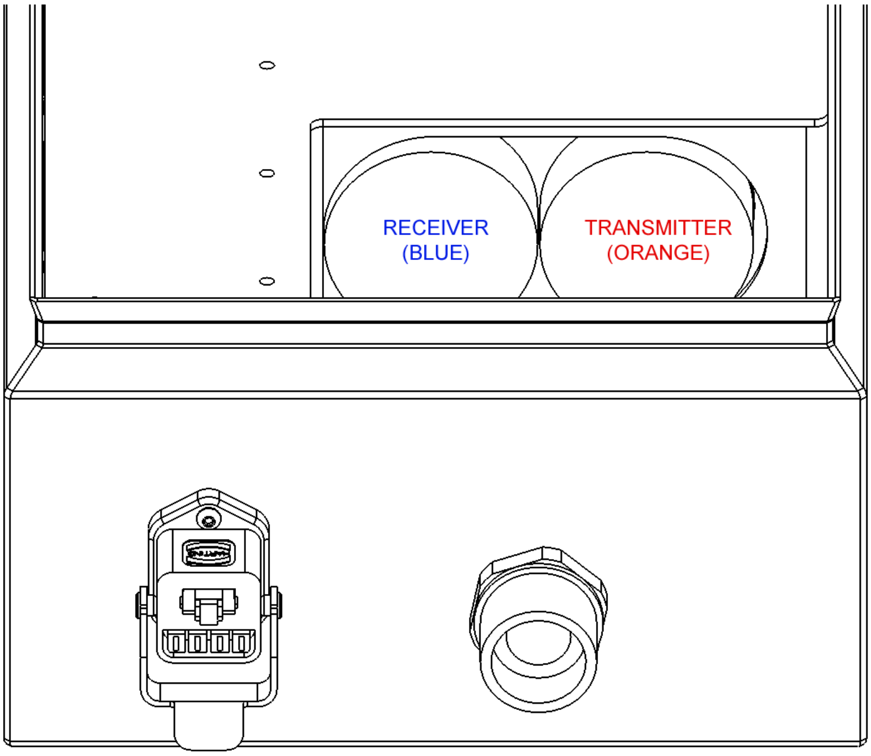


Figure 2-3 - RE08 CSE Fibre Connections

4. Make sure the 24 volt power supply is switched OFF. Connect the supplied power cable to the 24 volt power supply. On the unterminated end of the cable you will find three wires one black, one with a red sheath on it and a green and yellow cable. The black wire should be connected to the negative terminal on the power supply. The cable with the red sheath should be connected to the positive terminal on the power supply. The green and yellow cable should be connected to a ground reference.

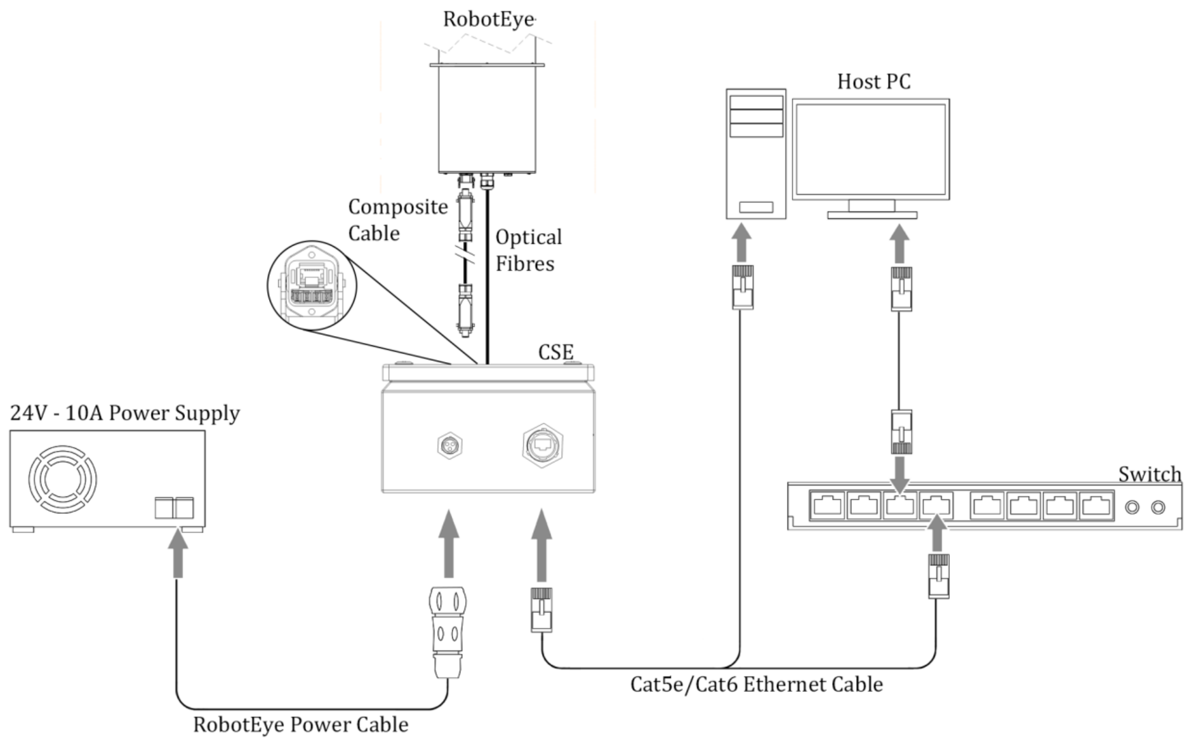


Figure 2-4 Wiring and connections for the RobotEye

NOTE - Make sure the power supply is not powered before connecting the cables.

5. Connect the power supply cable to the corresponding plug on the RE08 CSE. Ensure the correct orientation by aligning the polarization keys on the panel connector and the plug. If forced in the incorrect orientation, damage to the system is likely to result. Refer to Section 3.2 for further details.

2.5 Safety

The RobotEye RE08 3D Laser Scanning System is a Class 1M laser device which contains a laser which emits invisible radiation.

The device complies with Laser Class 1M based on IEC 60825-1:2007 and does not pose any significant risk to a naked human eye unless passed through magnifying optics.

Protection Class 3. The device operates with a separated extra low voltage (SELV) of 24 Volts DC.

The device may only be operated as intended and in faultless condition. Safety and warning signs must not be removed.

The Scanning Unit is in accordance with Ingress Protection 67 (IP67). The device is protected against dust and immersion in 1 meter of water for up to 30 minutes.

The CSE is in accordance with Ingress Protection 66 (IP66). The device is protected against dust and water jets.

All instructions regarding safe operation of this system should be strictly followed.

- The user is responsible for the safe operation and maintenance of this system at all times.
- The RE08 is NOT intended for use by inexperienced personnel.
- Installers of laser sensors are responsible for ensuring their safe use in accordance with all applicable regulations in the state, country or territory of use.
- **Ensure fiber optic cables are correctly installed before powering on the System. Laser radiation emitted directly from the CSE may cause damage to the naked eye.**
- **The laser beam emitted from this device should not be modified using any optical instruments or viewed directly with optical instruments.**
- **Opening the device potentially exposes personnel to laser radiation that may cause eye injuries.**
- Tampering with any enclosure will void warranty coverage.
- The device must be securely mounted during operation to prevent unstable motions.
- The manufacturer will not accept liability for any resulting damages caused by the non-observance of this manual or any unauthorized modification to the system.

2.5.1 Safety Features

Class 1M laser products are required to be fitted with specific safety features. These features are issued in the Laser Safety Standards ANSI Z136 and IEC 60825. The required features fitted to the RE08 System are listed below:

Laser Safety Warning Labels – The following laser safety warning labels are fitted to the RobotEye RE08 3D Laser Scanning System:

Laser Classification and Information Label on both the Scanning Unit and CSE

Figure 2-5 Laser Classification label

RobotEye Model Label on both the Scanning Unit and CSE

Figure 2-6 RobotEye Model Label

RobotEye Identification Label appears on both the Scanning Unit and CSE

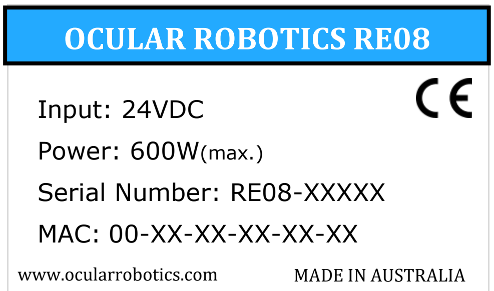


Figure 2-7 RobotEye Identification Label

2.6 Cleaning and Maintenance

CAUTION – Power must be disconnected from the RE08 system before any cleaning or maintenance is carried out.

User performable cleaning and maintenance of the RobotEye RE08 3D Laser Scanning System is limited to cleaning of the exterior housing and the dome. For ANY other maintenance or repair the unit should be returned to the factory. Opening of the system enclosure will void warranty. Use the following guidelines for cleaning of the system enclosure and dome.

- It is **VERY** important not to abrade or scratch the dome during cleaning or at any other time as it has the potential to significantly degrade system performance.
- Rinse the dome first to remove particles from the surface. Use a soft non-abrasive cloth or tissue to clean the dome, ensure there are no foreign abrasive particles on the dome before performing cleaning, as this may damage the dome. **DO NOT** use solvents. If a cloth alone is not sufficient, a mixture of water and soap may be used.
- The rest of the RE08 unit housing can be cleaned with a soft damp cloth.

2.6.1 Replacement Parts

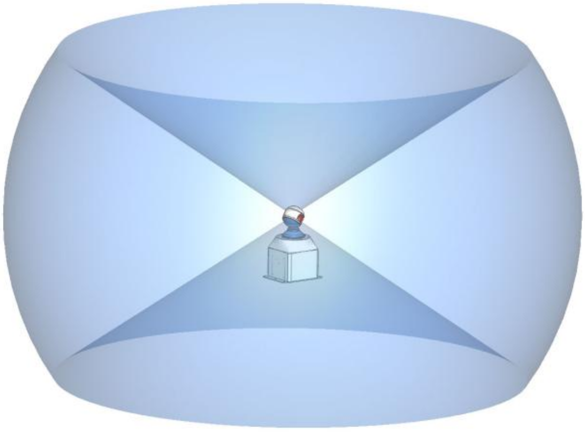
Replacement parts can be ordered directly through Ocular Robotics.

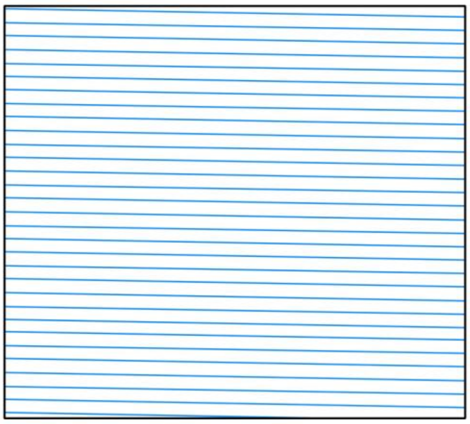
1) *RobotEye power cable.*
2) *IP68/IP69K Data cable.*
    a) An optional 5m or 10m IP68 Cable can be purchased from Ocular Robotics
3) *5mmx20mm 16A Slow Blow Fuse.*
    a) The fuse is located in the Fuseholder located next to the power connector.

3 General Description

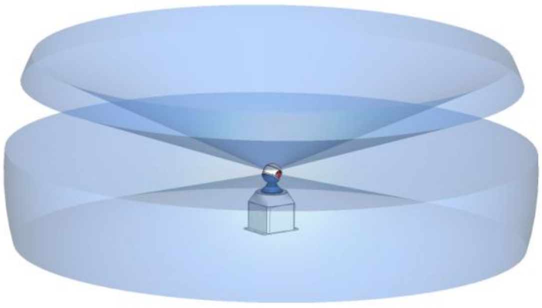
The RobotEye RE08 3D Laser Scanning System is a high performance long range laser scanning system, designed for rapid 3D cloud point imaging. The RE08 System with sample rates of 25 kHz, 5 kHz and 500 Hz and high scan speeds is ideally suited to generating dense point clouds of the environment both indoors and outdoors, at ranges up to 270 meters for most natural surfaces. The RE08's embedded RobotEye technology brings to laser scanning previously unavailable control over scanning behavior. Three scanning schemes are currently standard with the RobotEye RE08 System. Each scan pattern is fully parameterized, so that the behavior of the system is entirely user defined.

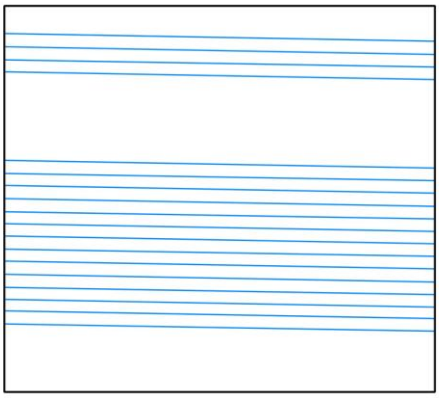
Full Field Scanning — When Full Field Scanning is used, the RobotEye scan parameters are the azimuth and elevation rates. Varying these parameters results in a wide variety of possible scan patterns, ranging from fast, coarse scans, to slower, more dense sampling patterns.



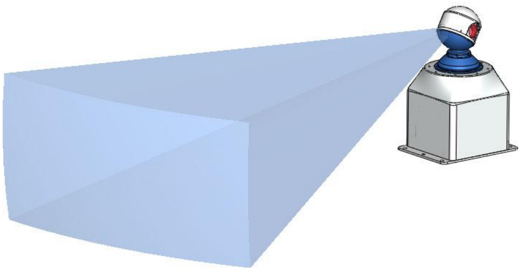


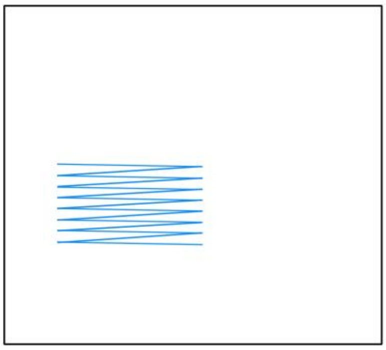
Bounded Elevation Scanning — In bounded elevation scanning mode, the operator is able to define a scan that covers a full 360° in azimuth but is restricted to a region of the elevation range of the RE08. Again the azimuth rate is configurable as is the line density of the scan. This mode enables the operator to concentrate the focus of the RE08 Scanner to a desired region and at the same time have complete control over the density of the samples taken in that region.





Region Scanning — The region scanning mode allows the operator to define a region within the RE08's azimuth and elevation range in which to concentrate the range scanning. The region scan mode gives the most control over the attention of the scanner with settings for azimuth rate and number of lines as in the bounded elevation scan as well as the extent of the scan region relative to its top left hand corner where it will scan repeatedly until a different scan is commanded.





The RE08 3D Laser Scanning System is also able to reconfigure or swap between any of these scanning modes immediately, making dynamic control of the scanner behavior easy. Further details about the scanning behaviors are covered in Chapter 5.

3.1 Electrical

The RE08 System requires a 24 Volt DC power supply that has a continuous current capacity of 10 Amps. The output voltage of the 24 VDC power supply used with the RE08 System should not vary by more than ±15% from the nominal 24V under any circumstances otherwise damage to the RE08 System may result.

3.2 Power

Power is delivered to the RE08 with the supplied 5 meter power cable. The unterminated end of the power cable has three wires, one black, one with a red sheath on it and a green/yellow wire. The black wire should be connected to the negative terminal on the power supply. The cable with the red sheath should be connected to the positive terminal on the power supply and the green/yellow wire to a ground reference.

During connection of the power supply cable to the corresponding plug on the RE08 CSE, ensure the correct orientation by aligning the polarization keys on the panel connector and the plug. If forced in the incorrect orientation, damage to the system is likely to result.

A 3.15A and a 16A rated fast acting fuses are housed in the fuseholder within the CSE to prevent potential damage to internal electrical components from power surges.

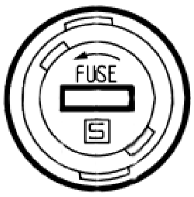


Figure 3-1 – Fuseholder on the RE08 Enclosure

3.3 Mechanical

The bounding dimensions and positions of mounting holes for the RE08 are shown in Figure 3-2 and Figure 3-3. Units are in mm [inches].

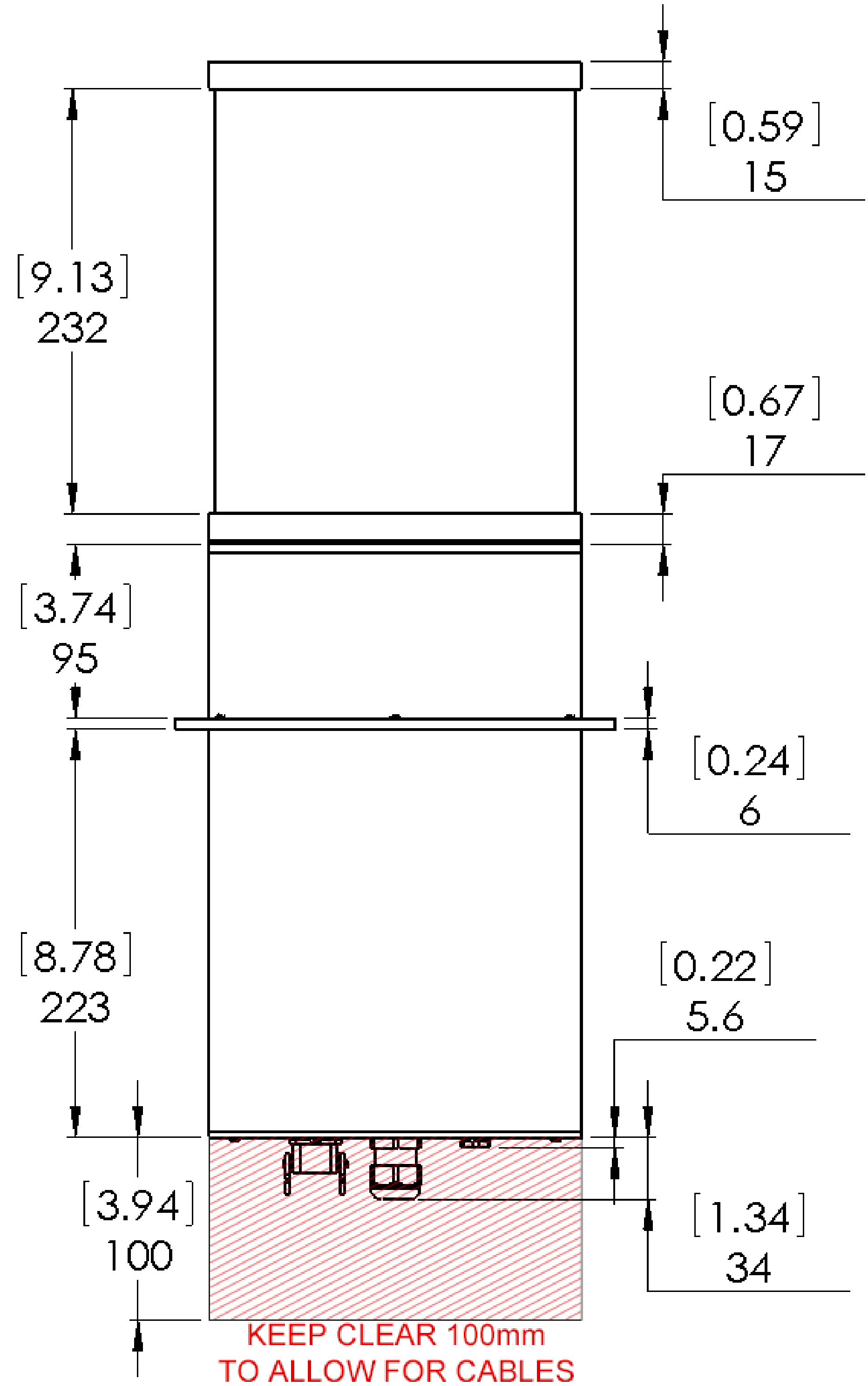


Figure 3-2 – RE08 Scan Head Mechanical Dimensions

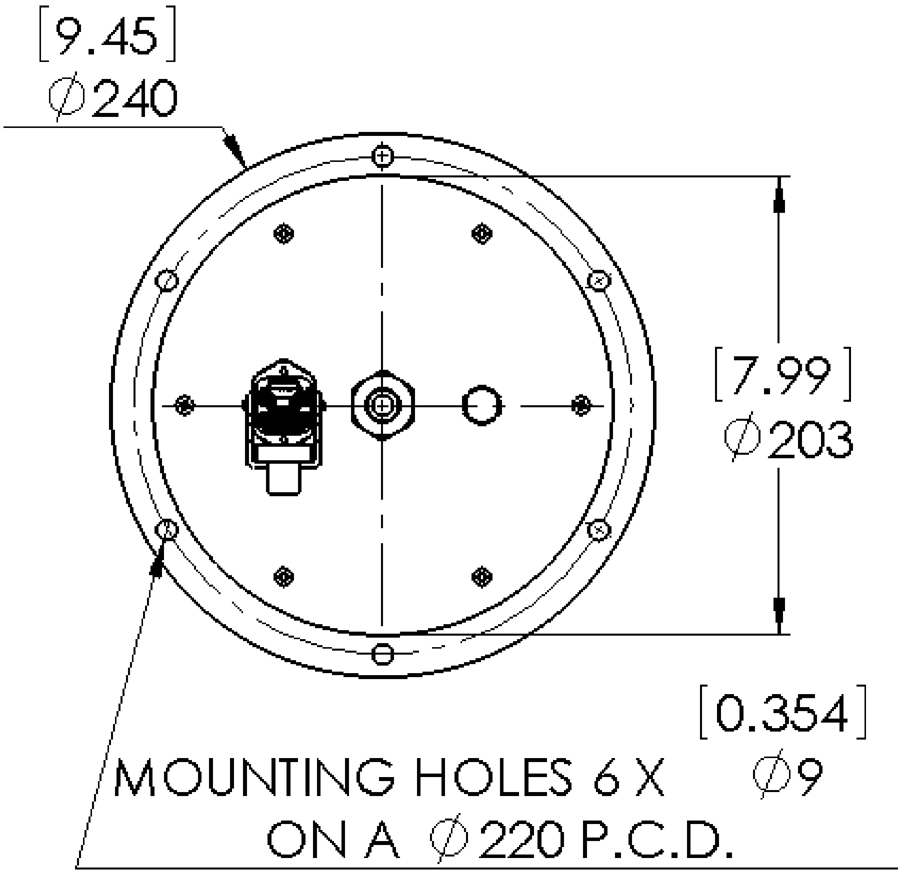


Figure 3-3 - RE08 Scan Head Mechanical Dimensions

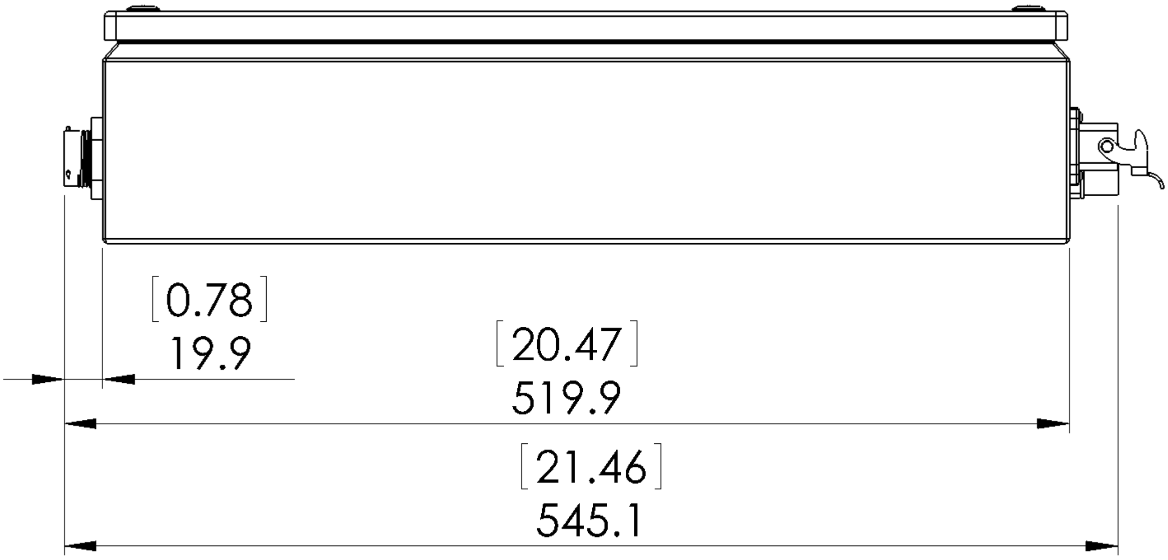


Figure 3-4 - RE08 Control Enclosure Mechanical Dimensions

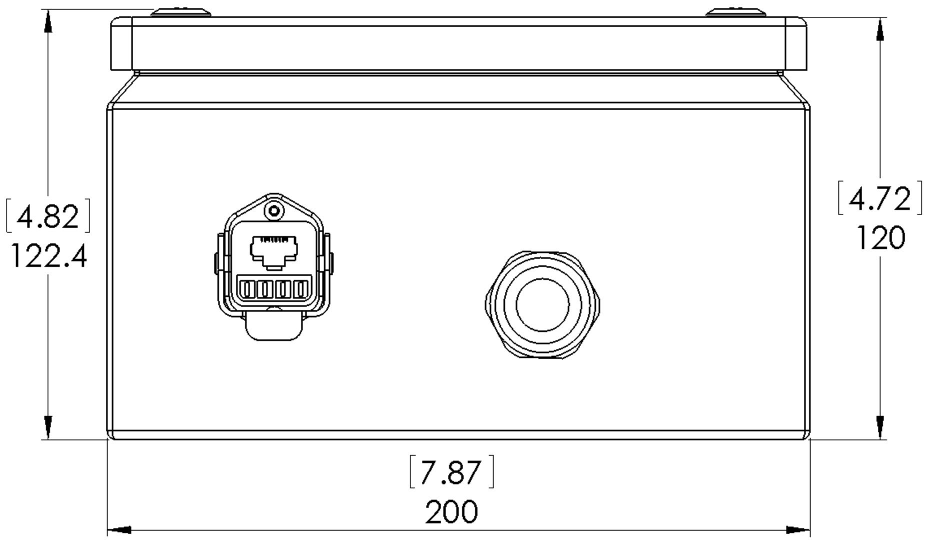


Figure 3-5 - RE08 Control Enclosure Mechanical Dimensions

3.4 Ethernet

The RE08 System interfaces with a computer via a standard Ethernet cable. Gigabit connectivity is recommended.

In most situations use of a Cat5e Ethernet cable will be sufficient for operation of the RE08 system; however it is recommended that a Cat6 cable be used over long distances to avoid packet loss due to the large volume of data.

NOTE – The RE08 will accept any IP, other than IP address in the range 223.223.223.0 to 223.223.223.255. This subnet is reserved for factory use and the RobotEye will respond to any SPIC command in that subnet with error code 0x05 – ERROR_INVALID_ARGUMENT

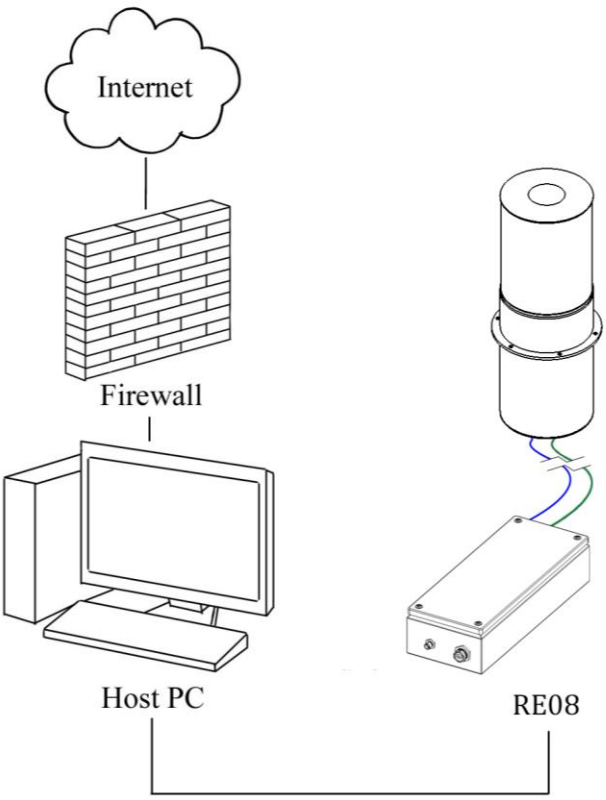


Figure 3-6 – Network Schematic for Single Host PC to Single RE08

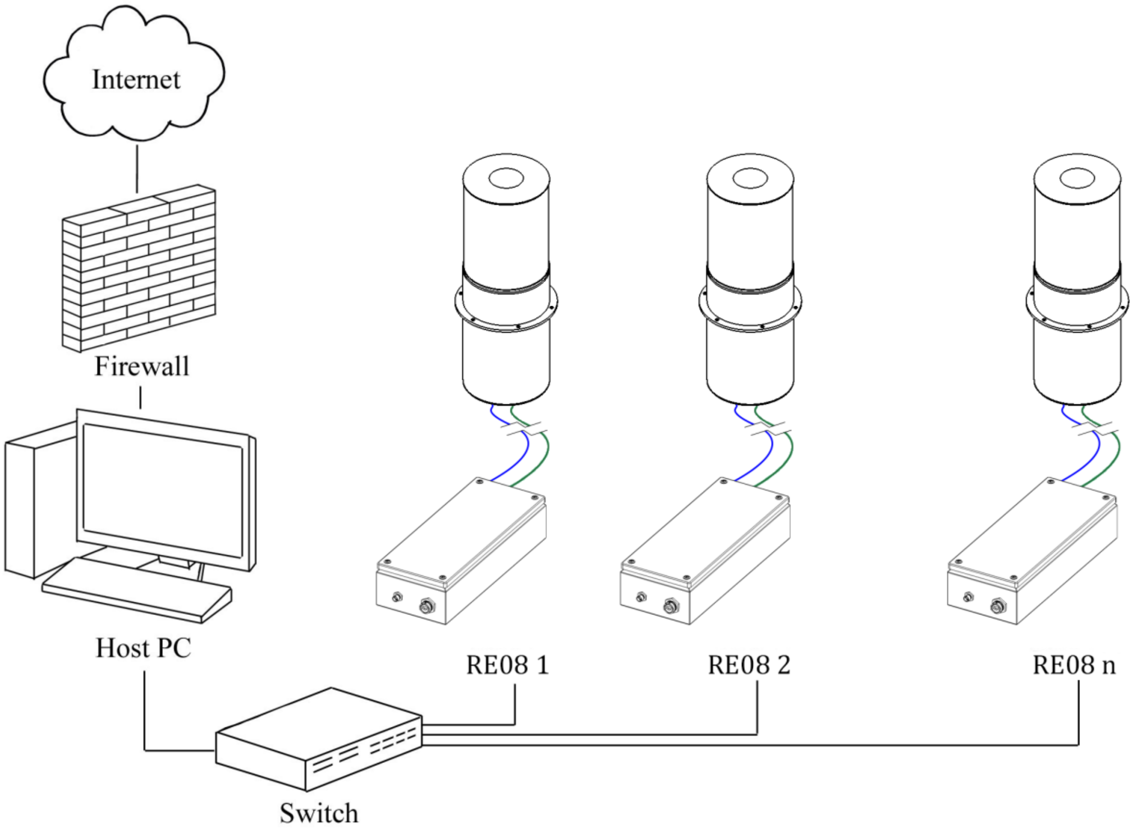


Figure 3-7 – Network Schematic for Single Host PC to Multiple RE08s

4 Measurement Accuracy

4.1 Angular

The RE08 laser scanner natively records 3D data in spherical coordinates of *range, azimuth* and *elevation* and also provides *intensity, reflectance* and *pulse width* for each data point. The accuracy of the two angular components of *azimuth* and *elevation* along with the *range* measurement determine the accuracy with which each data point can be placed in 3D space.

The angular resolution of both the *azimuth* and *elevation* components is 0.0025°. The reporting accuracy is <0.01° for both *azimuth* and *elevation*. The accuracy of the reported *azimuth* and *elevation* aperture angles is independent of any path following errors of the aperture. This means that regardless of what type of scan mode or *azimuth* and *elevation* rates are set the angular accuracy of the positions of the points reported by the RE08 are unchanged.

4.2 Range

The laser range finding module accurately measures range to a wide variety of surfaces and materials. The rangefinder achieves measurement accuracy nominally of ±14mm , ±10mm and ±8mm in High Speed, High Range and Extended Range Mode respectively, however measurement accuracy for any particular scenario will be determined by factors such as the nature of the surface being measured and ambient light levels.

NOTE – The RE08 laser scanner has a minimum range of 1 m from the aperture regardless of measurement mode. Objects within 1 m might be resolved based on the surface properties but performance is not guaranteed.

5 Scan Patterns

The RE08 currently supports three configurable scan patterns; the *Full Field Scan*, *Bounded Elevation Scan*, and *Region Scan*. These scan patterns are able to be altered, or switched between on-the-fly (usually within a couple of milliseconds of the command being sent) which is an unprecedented capability for a 3D laser scanner. Each scan pattern is fully parameterized, meaning that the parameters (or variables) that define the way the aperture moves can be altered by the user to create the arbitrary scanning behavior demanded by a given application. Users are encouraged to explore the range of options available to them, so that an 'optimal' configuration can be found for the problem at hand.

The settings for each of these scan patterns will be examined in the following sections.

5.1 Sampling Rate

Three laser sampling rates are supported on the RE08.

The **High Speed Mode** operates at a 25 kHz sampling frequency. The distance values are returned with corresponding intensity, reflectance and pulse width values. In this mode, there is no pre-detection averaging.

The **High Range Mode** operates at 5 kHz sampling frequency. The distance values are returned with corresponding intensity, reflectance and pulse width values. In this mode, pre-detection averaging occurs across 5 samples.

The **Extended Range Mode** operates at a 500 Hz sampling frequency. The distance values are returned with corresponding intensity, reflectance and pulse width values. In this mode, pre-detection averaging occurs across 50 samples.

Table 1 – Distance Measurement Dispersion

Mode	Freq [Hz]	Avg	Output Freq [Hz]	Dispersion [mm]
High Speed	25000	1	25000	14
High Range	25000	5	5000	10
Extended Range	25000	50	500	8

5.2 The Full Field Scan

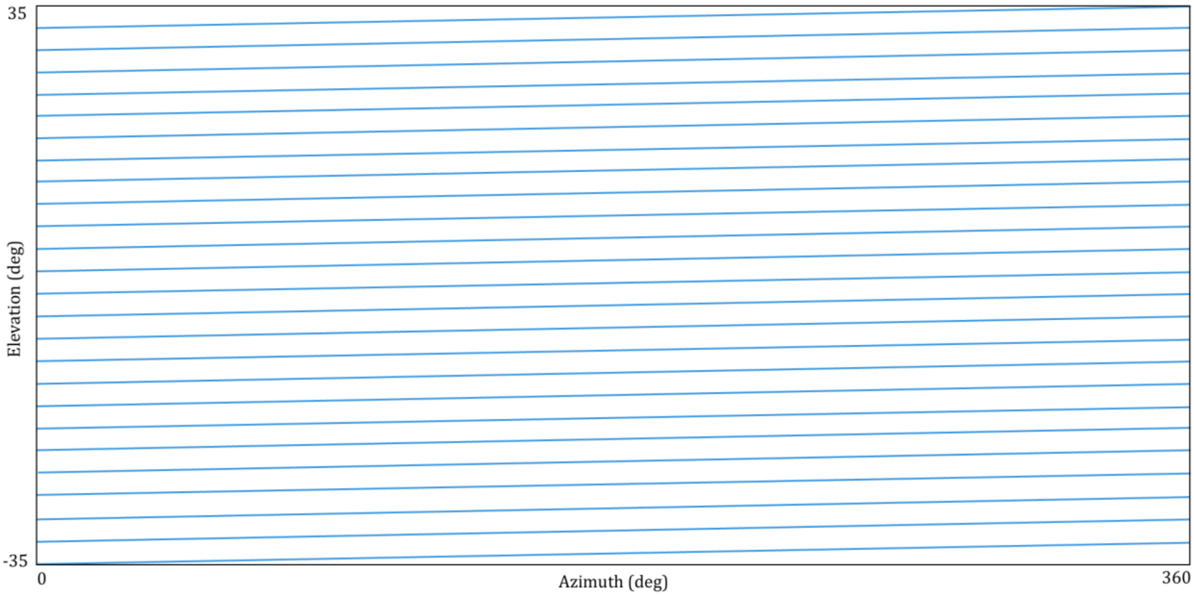


Figure 5-1 – The Full Field Scan Pattern

Parameter	Limit
Azimuth Rate	Maximum 4320 degrees/second (= 12 revolutions/second)
Number of Scan Lines	Based on Azimuth rate, down to an absolute minimum of 3 lines per scan. $$nLines_{MIN} = \frac{azRate}{360} \geq 3$$ e.g.: Minimum 3 lines/scan at 3 rev/second Minimum 8.5 lines/scan at 8.5 revs/second Minimum 15 lines/scan at 15 revs/second **NOTE:** All units in this equation are in degrees or degrees/second. **NOTE:** The number of lines per scan is a fixed point argument. Fractional scan lines will result in interlaced scans **NOTE:** There is a special error code for attempted scans with an insufficiently dense scan pattern: 0x08 = ERROR_SCAN_TOO_SPARSE

This mode is completely parameterized by two variables: the *Azimuth Rate* and *Number of Scan Lines*, which are given in units of Hertz (Hz) and lines across the full elevation range. An *Azimuth Rate* of 1Hz is therefore equivalent to one rotation per second in azimuth, or 360 degrees per second. A *Line Number* of 10 is defined as one sweep (360 degrees of azimuth) per 1/10th total elevation range (i.e. one line every 7 degrees of elevation over -35 to +35 degrees).

For a given *Azimuth Rate* and *Number of Scan Lines*, the RE08 laser aperture elevation rate is constant over the total elevation range.
Because of the configurable nature of the scan pattern, it is possible to obtain a 'coarse' scan, followed by a 'dense' scan if desired, simply by changing the *Azimuth Rate* and *Number of Lines* parameters on-the-fly at the desired moment.

5.3 The Bounded Elevation Scan

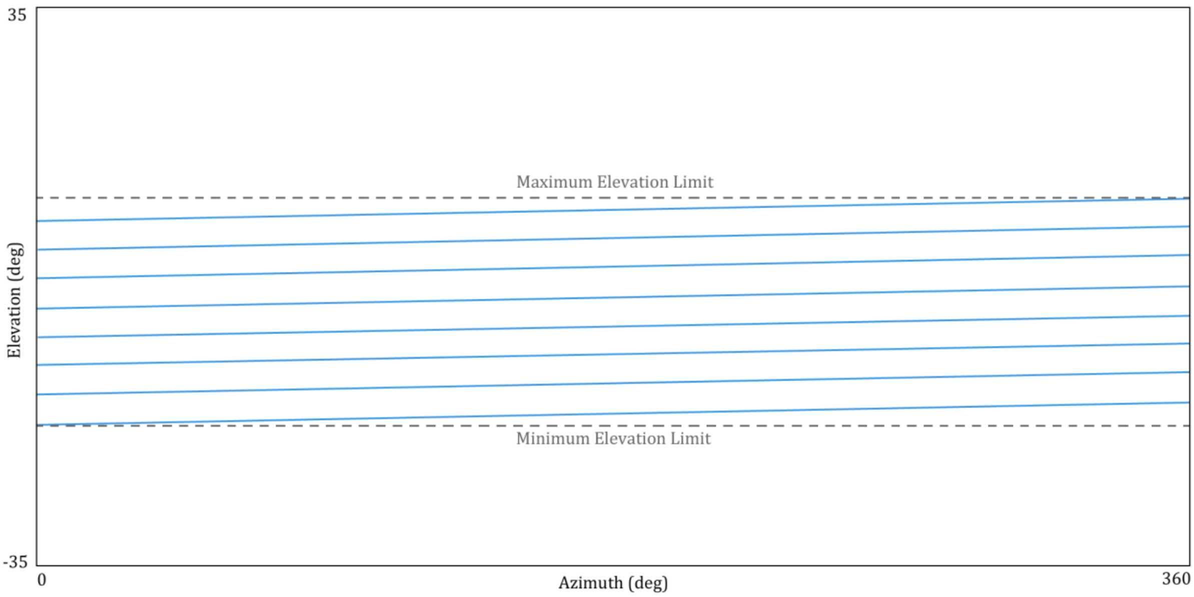


Figure 5-2 – The Bounded Elevation Scan Pattern

Parameter	Limit
Azimuth Rate	Maximum 4320 degrees/second (= 12 revolutions/second)
Elevation Scan Width	Minimum 2 Degrees $$ElRange = ElMax - ElMin \geq 2°$$
Number of Scan Lines	Based on Azimuth rate and elevation width, down to an absolute minimum of 3 lines per scan. $$nLines_{MIN} = \frac{AzRate \times ElRange}{25200} \geq 3$$ e.g.: Minimum 4 lines/scan for a 35° high scan at 8 revs/second Minimum 7.5 lines/scan for a 35° high scan at 15 revs/second Minimum 3.75 lines/scan for a 17.5° high scan at 15 revs/second **NOTE:** All units in this equation are in degrees or degrees/second. **NOTE:** The number of lines per scan is a fixed point argument. Fractional scan lines will result in interlaced scans. **NOTE:** There is a special error code for attempted scans with an insufficiently dense scan pattern: 0x08 = ERROR_SCAN_TOO_SPARSE

The *Bounded Elevation Scan* pattern is similar to the *Full Field Scan* with one important difference. The lower and upper extents in elevation in the aperture space can be configured, thus limiting the RE08 sensor's vertical field of view.

In this mode, the vertical extents of the scan in aperture space are defined by the parameters *Minimum Elevation* and *Maximum Elevation*. The *Number of Lines* defines the number of horizontal scan lines within the elevation limits. See Figure 5-2 for an example of how these parameters affect the trajectory of the RE08 sensor.

5.4 The Region Scan

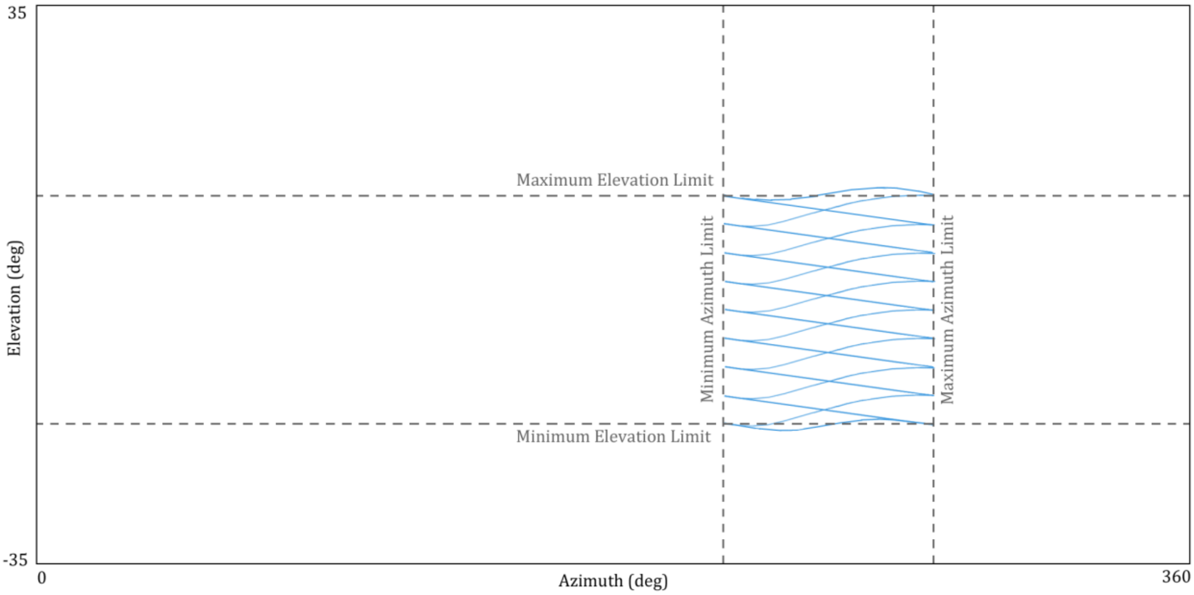


Figure 5-3 – The Region Scan Pattern for Number of Lines = 9

Parameter	Limit
Azimuth Rate	Maximum 4320 degrees/second (= 12 revolutions/second) **NOTE:** Azimuth rate in region scan is an upper limit only, for some scans a lower limit may be applied due to the acceleration limits of the eye. The internal velocity limit can be calculated as: $AzRate_{MAX} = \sqrt{0.375 \times Accel \times AzWidth_{degrees}}$ If the specified AzRate is lower than this limit, then the specified rate will be used. The acceleration limit [$°/s^2$] is set by the user. **NOTE:** Maximum acceleration is limited to 40,000$°/s^2$. This velocity limit is also used for the transition segment from the current eye location to the region scan starting location.
Elevation Scan Width	Minimum 2 Degrees $ElRange = ElMax - ElMin \geq 2°$
Azimuth Scan Width	Minimum 5 Degrees Maximum 180 Degrees **NOTE:** The region scan will take the shortest path between the specified Azimuth limits. Azimuth limits are specified in the range 0-360, so a scan from 340° to 20° will be a 40° wide scan.

Number of Scan Lines	Based on *Actual* azimuth rate, azimuth width and elevation width, down to an absolute minimum of 3 lines per scan. **Maximum 500 lines per scan.** $$nLines_{MIN} = ROUND\_UP\left(\frac{ElRange \times AzRate \times 10^6}{420\left(\frac{AzRange \times 10^6}{6} + AzRate^2\right)}\right) \geq 3$$ **NOTE:** All units in this equation are in degrees or degrees/second. Be aware that the *actual* azimuth rate is used in this equation, so if the internal velocity limit as above is being applied, this is the velocity used to calculate the minimum line count. **NOTE:** There is a special error code for attempted scans with an insufficiently dense scan pattern: 0x08 = ERROR_SCAN_TOO_SPARSE

The *Region Scan* pattern is a parameterized scan pattern intended to allow a user to focus in on a subject in the environment and obtain dense 3D data from just that area. The scan pattern is similar to a standard 'raster' pattern used in many applications, such as television and computer graphics. The specific pattern used for the RE08 sensor can be seen in Figure 5-3, which shows the typical trajectory for specified bounds in the aperture space.

When viewed in aperture space, the raster pattern is scanned over a rectangular region which is defined by the *Minimum Azimuth, Maximum Azimuth, Minimum Elevation,* and *Maximum Elevation* parameters. The *Azimuth Rate* and *Number of Lines* define the speed of the scan, and the line resolution within the bounded region.

Note the *Region Scan* is limited to a 180° azimuth window. Hence it will always select the shortest arc segment out of the *Minimum Azimuth* and *Maximum Azimuth* parameters.

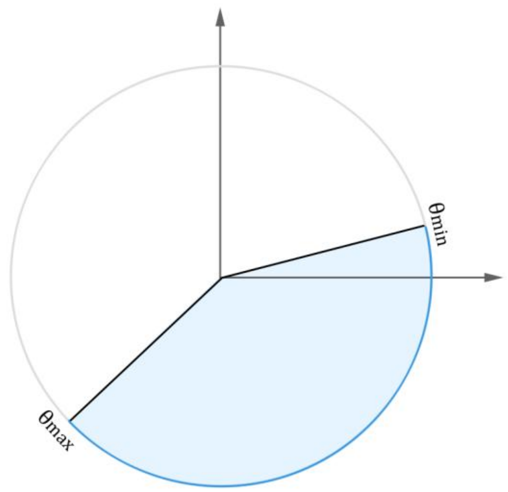
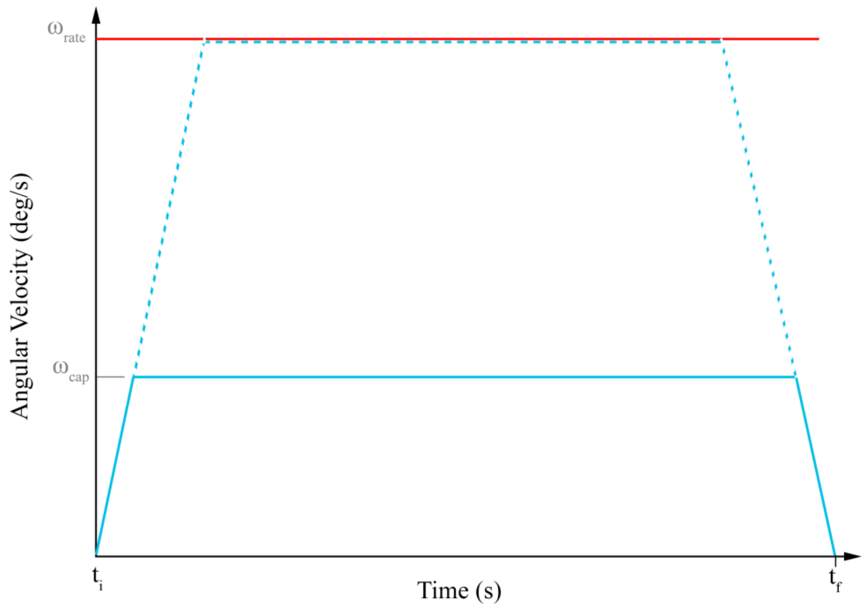


Figure 5-4 – Selected Azimuth Scan Arc for given Min/Max Azimuth Parameters

5.4.1 Region Scan Velocity Profile

The general velocity profile of the scanning head is illustrated below for *Bounded Elevation* and *Region Scan* modes.



As the *Region Scan* mode requires the scanning head to accelerate and decelerate at the specified Azimuth boundaries, using the *Bounded Elevation* mode may be faster in certain situations. Conversely, slow high resolution region scans may be more efficient when utilizing the *Region Scan* mode.

NOTE: A ***single frame*** consists of a scan that spans across an *Azimuth Width* and *Elevation Height* determined by the *min/max* limits of *Azimuth* and *Elevation* respectively, i.e. A single sweep starting at the bottom of the region to the top that contains *n* scan lines.

5.4.2 Bounded Elevation Duration

Scanning a region of the aperture space using ***Bounded Elevation*** for a single frame requires,

$$t_{BE} := \frac{n}{\omega_{rate}} \tag{1}$$

where ,

t_{BE} is the total time taken for the region scan in [sec]
n is the **Number of Scan Lines**
ω_{rate} is the *user specified* **Azimuth Rate** in [Hz]

As *Bounded Elevation* requires the scanning head to do full azimuth revolutions, the total scan time is the same irrespective of Azimuth Width/Boundary limits.

5.4.3 Region Scan Duration

Scanning a region of the equivalent aperture space using ***Region Scan*** for a single frame requires,

$$t_{RS} := \left(\frac{540\omega_{RS}}{a} + \frac{\Delta\theta_{AZ}}{360\omega_{RS}}\right) n \tag{2}$$

$$\begin{array}{ll} \omega_{\mathrm{RS}} = \omega_{cap} & \text{if } \omega_{cap} < \omega_{rate} \\ \omega_{\mathrm{RS}} = \omega_{rate} & \text{if } \omega_{cap} \geq \omega_{rate} \end{array} \qquad \text{where } \omega_{\mathrm{cap}} := \frac{\sqrt{0.375a\times\Delta\theta_{AZ}}}{360}$$

where,

t_{RS} is the total time taken for the region scan in [sec]
a is the *user specified* **Acceleration Limit** [deg/sec^2]
$\Delta\theta_{AZ}$ is the **Azimuth Width** in [deg]
n is the **Number of Scan Lines**
ω_{rate} is the *user specified* **Azimuth Rate** in [Hz]
ω_{RS} is the *applied* **Azimuth Rate** in [Hz]

Therefore if $\boldsymbol{t_{RS}} > \boldsymbol{t_{BE}}$ then it is faster to use the Bounded Elevation scan mode to scan a region of interest.

For example, using the following parameters [n = 50 lines, $\Delta\theta_{AZ}$ = 20°, ω_{rate}= 15 Hz] we obtain the following scan durations for a single frame, seen in Figure 5-5. Using this graph it can be seen that it is faster to use the Bounded Elevation scan mode if using an acceleration limit of up to roughly 30 000°/s², however between 30 000°/s² and up to the maximum limit of 40 000°/s², it is faster to use the Region scan mode.

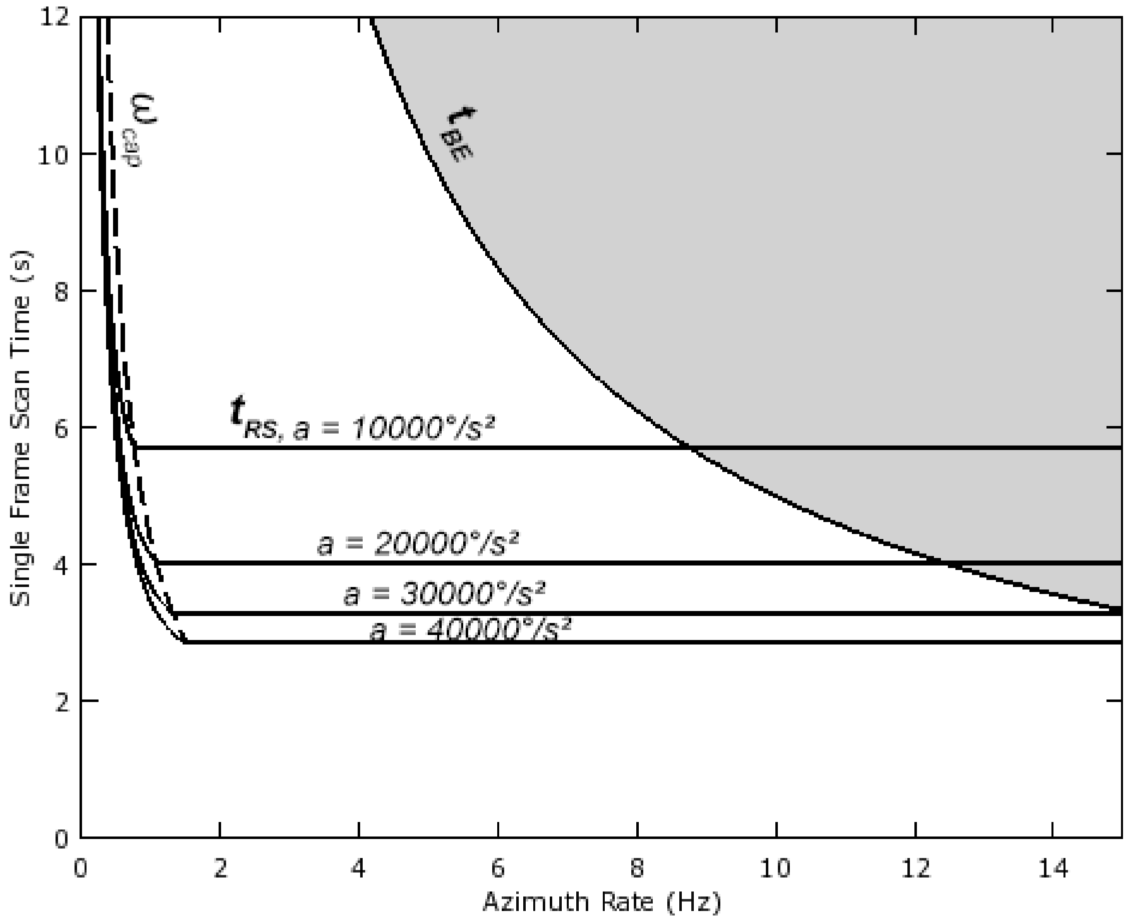


Figure 5-5 – Bounded Elevation versus Region Scan Times

6 LIDAR Rangefinder

The design of the RE08 3D scanning LIDAR allows for a high degree of independence between the scan patterns being executed and the behavior of the rangefinder. The rangefinder provides extremely rich information about the area being scanned, and also has a variety of modes of operation depending upon the desired performance.

This section of the user manual will discuss the various modes and options available for configuring the RE08's rangefinder system, and the metadata returned by the RE08 in addition to 3D range-bearing-elevation (RBE) observations.

6.1 Modes of Operation

The RE08 LIDAR system supports three modes of operation. These modes differ in both the sample rate available, the maximum range capability and the number of individual measurements averaged for each reported range measurement.

Fundamentally, the rangefinder transmits 25,000 pulses per second in all operation modes. The reduction in effective sample rate in LR and ER modes comes as a result of pre-detection averaging of multiple pulses before target detection is performed. This results in increased performance to long-range or low-reflectivity targets, but also an increase in the time taken to acquire each range measurement.

6.1.1 High-Speed Mode (HS)

The High-Speed mode allows for the highest possible sample rate, with the 25,000 transmit pulses per second being treated independently.

6.1.2 Long Range Mode (LR)

Long Range mode extends the range of the RE08 by performing 5-sample pre-detection averaging. This gives an improvement in the maximum range capability of approximately 50% and a reduction in the range dispersion of observations as 5 separate pulses are being averaged in order to detect targets.

6.1.3 Extended Range Mode (ER)

Extended range mode performs 50-sample pre-detection averaging, resulting in a substantial increase in maximum range and decrease in range measurement dispersion. It also provides the slowest sample rate of the three modes, 500Hz. This measurement mode is not recommended for high speed scanning and is better suited to monitoring small regions at significant range using the RE08's Region Scan capabilities or even just multiple discrete points.

6.2 Returned Data

The RE08 provides a rich set of meta-data in addition to the raw RBE observations of the received laser returns. This information can enable systems to make intelligent decisions around the utility of any individual measurement, along with some understanding of the properties of the target.

6.2.1 Return Amplitude

The logarithmic scaled amplitude of the received target echo. This is the amplitude of the returned pulse relative to the detection threshold of the RE08. It is returned in dB, to a resolution of 0.01 dB. The amplitude parameter gives an indication of how close to the limit of detection of the RE08 the returned laser pulse was, where a return with an amplitude of 0 dB would fall exactly on the detection threshold.

6.2.2 Return Reflectance

Reflectance is a variant of the amplitude measurement. It is provided as a ratio between the amplitude of the return pulse received and the expected amplitude of the return from a white target, intersecting the entire beam, at the same range. As with amplitude, reflectance is reported in dB, to a resolution of 0.01 dB. In this case, a value of 0 dB indicates that the target return was the same intensity as that of a white card at that range. Negative reflectances indicate more diffusely reflecting targets, while positive reflectances typically indicate retro reflective targets.

6.2.3 Return Shape Deviation

This parameter indicates how closely the intensity profile of the received pulse matches that of the transmitted pulse. Deviation of 0 indicates no distortion of the pulse. Deviations below 10-15 should be treated as good measurement results with high accuracy. Large deviations will typically indicate dirt, dust, rain, edges or other spatially diffuse reflecting targets.

6.3 Return Filtering

The RE08 also offers a number of options for post-detection filtering of received pulses. This can offload some filtering burden from the host machine in cases where the data rate of the RE08 can be unmanageable or where only specific targets are being scanned for. In all modes the detection algorithm produces between 0 and 5 targets for each observation, post-detection filtering enables the user to automatically restrict the points returned based on a number of available limits.

1. All Targets - For each observation, up to 5 returns will be provided as RBE points. Each point will be returned with all associated metadata.
2. First Target Only - Only the target nearest to the scan head of those detected will be returned, any additional observations will be disregarded.
3. Last Target Only - Only the target farthest from the scan head of those detected will be returned, any additional observations will be disregarded.
4. Highest Amplitude Only - Only the target with the highest amplitude of those detected will be returned, any additional observations will be disregarded.
5. Highest Reflectance Only - Only the target with the highest reflectance of those detected will be returned, any additional observations will be disregarded.

With up to 5 returned points per transmit, when running in HS mode, All Target filtering can result in up to 125,000 3D point observations per second.

7 Specifications

Mechanical	
Maximum Azimuth Rate	12 Hz
Maximum Elevation Rate	3 Hz
Azimuth Axis Resolution	0.0025°
Elevation Axis Resolution	0.0025°
Azimuth Range	360° Continuous
Elevation Range	70° (±35°)
Weight (Scan Head/CSE)	9.1/9.1 kg

Electrical	
Communication (minimum 100 Megabit)	Ethernet
Supply Voltage	24 VDC
Power Consumption — Typical (average)	<4.5 A (100 W)
— Maximum (peak)	25.0 A (600 W)

Rangefinder	
Laser Class	1M
Laser Wavelength	Near Infrared
Laser Divergence	2.4 milliradians
Max. Ranges per Laser Pulse	5
High Speed Mode	
Sample Rate	25 kHz
Range (ρ=10% / ρ=80% / reflector)	35 m/100 m/500 m
Range Accuracy	± 14 mm
High Range Mode	
Sample Rate	5 kHz
Range (ρ=10% / ρ=80% / reflector)	50 m/150 m/750 m
Range Accuracy	± 10 mm
Extended Range Mode	
Sample Rate	500 Hz
Range (ρ=10% / ρ=80% / reflector)	100 m/270 m/1300 m
Range Accuracy	± 8 mm
ρ = reflectance	

Environmental	
Operating Temperature Range (Scan Head)	-10°C - +65°C
Operating Temperature Range (CSE)	-10°C - +50°C
IP Class Rating (Scan Head/CSE)	67/66
! *Note: IP Rating valid only when both supplied power & optionally supplied Ethernet cable connectors are fitted.*	