GLX-RSS-3-150CS

FMCW Radar Surveillance Sensor User Manual

Revision History

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Starting Point

Thank you for purchasing Geolux GLX-RSS-3-150CS radar sensor! We have put together the experience of our engineers, the domain knowledge of our customers, the enthusiasm of our team, and the manufacturing excellence to deliver this product to you.

You may freely rely on our field-proven technology for intrusion detection and collecting statistics on detected targets. The use of advanced RF technology and signal processing algorithms ensures that Geolux Radar Speed Sensor can be used in any intrusion detection, perimeter monitoring or similar surveillance application.

Although we are certain that you are more than capable of connecting the Radar Surveillance Sensor to your system using a serial cable, we have created this User Manual to assist you in setting up and using Geolux Radar Surveillance Sensor device.

Should there be any questions left unanswered, please feel free to contact us directly:

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1. Introduction

Geolux Radar Surveillance Sensor devices are used to detect distant objects and measure the speed, distance and angle of detected objects (targets). This functionality is achieved by transmitting modulated electromagnetic wave in 24 GHz frequency range (K-band), and measuring the frequency shift of the reflected electromagnetic wave. The frequency shift is caused by the Doppler effect of the moving target and difference in frequency due the travel time of the electromagnetic wave from radar to target and back to the radar receiver. As the distance to the radar is increasing the frequency shift is increased also due the modulation of the electromagnetic wave and travel time. Also as the relative speed between the radar sensor and the target increases, the detected frequency shift also increases, thus enabling the radar sensor to precisely determine the target speed. Combining electromagnetic wave modulation and advanced signal processing of the received signals, the precise measurement of the distance and speed for each detected target is possible. Combining two receivers and processing of the received signals allows the radar to measure the angle to the target.

GLX-RSS-3-150CS Surveillance Radar Sensor uses a high power transmitter and very low noise input amplifier to yield effective target detection range of up to 800 meters (2600 ft) for vehicles and up to 150m for moving humans.

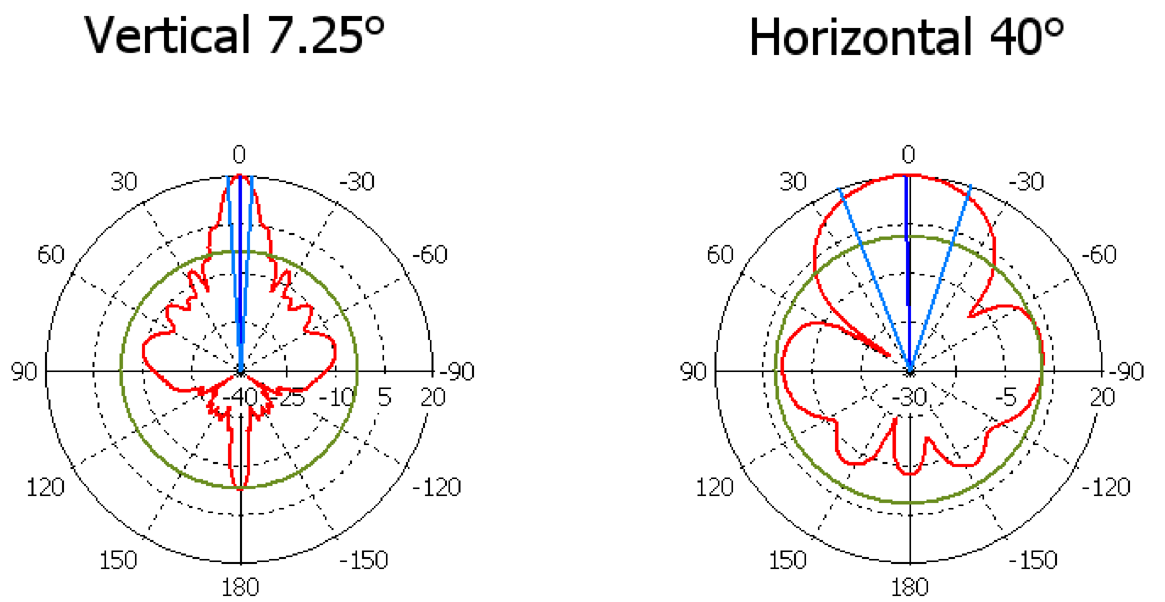
The radar sensor is able to detect all objects (targets) stationary or moving in the angle of up to 40°. Speed measurement of the targets speed is limited to the ±1km/h. Detected targets are tracked by the radar sensor, and the current speed, distance, angle, detection level and direction are reported over the serial (RS-232 or RS-485) interface or over Ethernet IEEE 802.3 10/100Base-T interface. The radar sensor is able to track multiple stationary, approaching and receding targets at the same time, which makes this radar sensor an excellent choice for all surveillance monitoring applications.

2. Electrical Characteristics

The electrical characteristics of the Geolux Radar Sensor are given in the Table 1.

Table 1. Electrical characteristics

Parameter	MIN	TYP	MAX	Unit
Communication interface:				
RS-232 interface speed	1200		115200	bps
RS-485 interface speed	1200		115200	bps
Ethernet	10		100	Mbit
Radar Sensor				
Frequency		24.125		GHz
Radiated power (EIRP) GLX-RSS-3-150CS	25	27	29	dBm
Sensitivity	-108	-110	-112	dBm
Beam-width (3dB) – Azimuth		7		°
Beam-width (3dB) – Elevation			40	°
Power supply voltage	9,0	12,0	27,0	V
Power dissipation		5400		mW
Operational temperature range	-20		+70	˚C

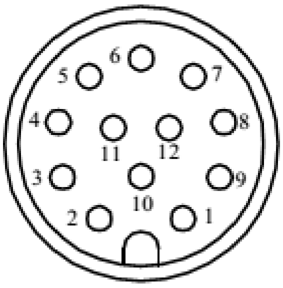


Picture 1. Antenna directional pattern

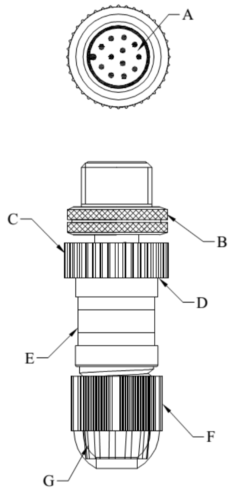
3. Connector Pin-Out

The Radar Surveillance Sensor uses two connectors to interface external systems: circular M12 IP66 connector with 12 positions and circular 8 position IP66 Ethernet connector.

Details of the 12 position M12 connector and cable are shown on Picture 2. The Table 2 gives detailed description for each pin.



Connector rear (solder pins) view

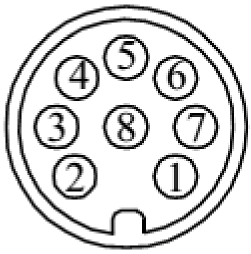


Picture 2. Radar Speed Sensor connectors

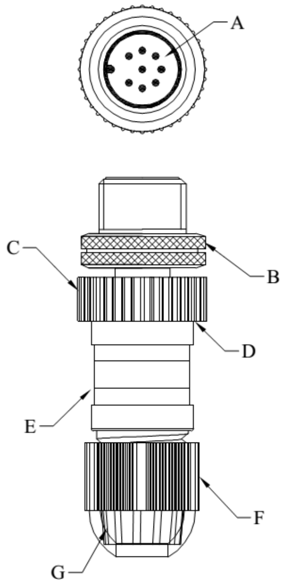
Table 2. Connector and cable pin-out

Pin No.	Wire Color	Pin Name	Pin Description
1	-	GND	This pin should be connected to the ground (negative) pole of the power supply.
2	-	+Vin	The power supply for the Radar Speed Sensor is provided on this pin. The Radar Speed Sensor power supply voltage must be in the range 9 VDC to 27 VDC, and the power supply must be able to provide at last 1,2W.
3	-	RS232 – TxD	RS-232 data transmit signal.
4	-	RS232 – RxD	RS-232 data receive signal.
5	-	GND	Signal ground.
6	-	+Vin	This pin is internally connected to pin 2
7	-	RS485 – D+	RS-485 data transmitter/receiver high signal.
8	-	RS485 – D-	RS-485 data transmitter/receiver low signal.
9	-	Alarm V+	Alarm – power supply max. +5V / 100mA.
10	-	Alarm1 SW	Alarm 1 - open collector switch signal max. 30V/200mA
11	-	GND	Signal ground.
12	-	Alarm2 SW	Alarm 2 - open collector switch signal max. 30V/200mA

Details of the 8 position M12 Ethernet connector are shown on Picture 3. The Table 3 gives detailed description for each pin.



Connector rear (solder pins) view



Picture 2. Radar Speed Sensor connectors

Table 3. Connector and cable pin-out

Pin No.	Wire Color	Pin Name	Pin Description
1	-	RD+	Signal receive +
2	-	RD-	Signal receive -
3	-	TD+	Signal transmit +
4	-	NC	Not connected
5	-	NC	Not connected
6	-	TD-	Signal transmit -
7	-	NC	Not connected
8	-	NC	Not connected

4. Data Interface

Geolux Radar Surveillance Sensors offer multiple data interfaces, in order to make the system integration of the radar sensor device easy. In addition to RS-232 and RS-485 serial interfaces, Geolux Radar surveillance Sensors also have an Ethernet interface, and additional Alarm signal pins.

Serial RS-232 interface

Serial RS-232 interface is used to send detected targets report as well as target detection statistics reports. Additionally, Radar Surveillance Sensor configuration is also performed through RS-232 interface.

Default communication parameters are:

Bitrates:	**115200 bps**
Data bits:	**8**
Stop bits:	**1**
Parity:	**None**

Two communication protocols are available, and more are possible upon the request. Simple ASCII-S protocol will report only the strongest target's speed and the more complex NMEA protocol will report multiple targets, counting and statistics. Detailed description of the communication protocols is given in the Chapter 5 of the User Manual.

Serial RS-485 interface

Serial RS-485 interface is used to send detected targets report as well as target detection statistics reports using the same data protocol that is used on RS-232 interface. This interface is also capable for radar sensor configuration. The RS-485 interface uses differential signals for communication so it is more convenient for the applications where distance from radar sensor to the controller that is collecting data from radar sensor is greater than 5m.

Default communication parameters are:

Bitrates:	**115200 bps**
Data bits:	**8**
Stop bits:	**1**
Parity:	**None**

Communication is done half-duplex over one twisted-pair communication line. The radar sensor is using communication line as master device – will send data to the communication line as targets are detected.

Same communication protocols that are available on the RS-232 interface are available on the RS-485 serial interface.

Ethernet interface

Ethernet interface is used to connect radar to any Ethernet enabled system. All detection reports, live monitoring of target detection and setup of radar parameters are sent using UDP-based protocol through the Ethernet interface. The UDP protocol is described in the section 5 of this document. The Ethernet interface is also used to access the embedded Web-based user interface that displays basic radar information and can be used to perform radar device configuration. The Web-based user interface uses HTTP REST API that can also be used by 3rd party programs.

Alarm signals

Alarm signals are used to indicate events to the collecting controller. That signals can be configured to indicate various events and states:

Table 3. Alarm signals events

No.	Event	Description
0	Inactive	Alarm signal is inactive
1	Target	Detected at least one valid target.
2	Approaching Target	Detected at least one valid approaching target.
3	Receding Target	Detected at least one valid receding target.
4	Speed – over limit	Detected at least one valid target with speed over the configured speed limit.
5	Speed – under limit	Speed of all detected targets is under the configured speed limit.
6	Approaching Speed – over limit	Detected at least one valid approaching target with speed over the configured speed limit.
7	Approaching Speed – under limit	Speed of all approaching detected targets is under the configured speed limit.
8	Receding Speed – over limit	Detected at least one valid receding target with speed over the configured speed limit.
9	Receding Speed – under limit	Speed of all receding detected targets is under the configured speed limit.
10	Target detected in the AOI	Detected minimum one target in AOI (area of interest)

5. Data Protocols

Geolux GLX-RSS-3-150CS radar sensors support three different communication protocols that send the detected target data from the radar sensor device. Two of the protocols are used over serial interface, and the user may select which data protocol will be used based on the system requirements. The ASCII-S protocol is very simple, as it only outputs the detected speed for a single, strongest, target only. The more complex NMEA-like protocol outputs the detected speed, location and reflected signal power for all detected targets. The third protocol is used over Ethernet interface.

Support for additional protocols is available upon customer request.

Geolux GLS-RSS-3-150CS sensors also support a servicing protocol on serial interface that allows the users to modify radar sensor device operating parameters.

ASCII-S protocol (serial interface)

The ASCII-S protocol has been designed with simple applications in mind. It is minimal and straightforward. ASCII-S protocol provides only the direction and speed information for the single strongest detected target. Radar device settings determine whether the radar detects only approaching targets, only receding targets, or both kind of targets. The radar sensor device periodically outputs the target data. The data output frequency depends on the current radar device setting, and can be either 20Hz, 10Hz, 2Hz or 1Hz. If there are no valid detected targets, no data will be sent from the radar device.

ASCII-S protocol periodically sends exactly 4 bytes of data plus additional <0x0D> ('\r') carriage-return character.

The first byte of data denotes the detected vehicle direction, and can be either a minus sign ('-'), a plus sign ('+') or a question mark sign ('?'). The minus sign denotes receding targets, the plus sign denotes approaching targets, and the question mark sign denotes non-directional targets.

The next three bytes of data indicate the speed of the detected vehicle. The speed is reported either in metric units (km/h) or in imperial units (mph), depending on the radar device settings. The speed reading is ASCII encoded.

The following line contains an example of the radar sensor output for an approaching target moving at 25 mph:

+025<0x0D>

The target with same speed but receding will have output:

-025<0x0D>

NMEA protocol (serial interface)

NMEA protocol is based on the standard protocol family widely used by the navigation equipment. NMEA protocol is sentence oriented, and is capable of sending multiple sentences with different information. The sentence content is designated by the starting keyword which is different for each sentence type. NMEA sentences are terminated with the checksum which makes this protocol extremely reliable.

While in NMEA mode, the radar sensor device outputs any of the following data sentences:

Detected targets speed report

$RDTGT,D1,S1,L1,D2,S2,L2,...,Dn,Sn,Ln*CSUM<CR><LF>

$RDTGT: The keyword sent on the beginning of each detection report. This sentence is sent whenever there is detected at least one valid target.

D1: The direction of the first (strongest) target (1 approaching, -1 receding).
S1: The speed of the first detected target (speed[1] is reported as speed*10).
L1: The detected level of the signal reflection from the first target.
D2: The direction of the second detected target (1 approaching, -1 receding).
S2: The speed of the second detected target (speed is reported as Speed*10).
L2: The detected level of the signal reflection from the second target.
...
Dn: The direction of the last detected target (1 approaching, -1 receding).
Sn: The speed of the last detected target (speed is reported as Speed*10).
Ln: The detected level of the signal reflection from the last target.
CSUM: The check sum of the characters in the report from $ to * excluding these characters.

Immediately after sending $RDTGT sentence, the radar transmits corresponding $RDTLC sentence which reports location information for each of the targets already reported by previous $RDTGT sentence.

Detected targets location report

$RDTLC,D1,PHI1,A1,D2,PHI2,A2,...,Dn,PHIn,An*CSUM<CR><LF>

$RDTLC: The keyword sent on the beginning of each detection report. This sentence is sent always after matching RDTGT sentence.

D1: The distance from the radar to the first (strongest) target (distance[2] is reported as distance*10).
PHI1: The angle to the first detected target (degree*10, 0 is straight ahead, negative values are to the left, positive values are to the right).
A1: The index of the Area-of-Interest that contains this target.
D2: The distance of the second detected target.
PHI2: The angle to the second detected target.

[1] In the radar sensor setting it is possible to select km/h or mph for the speed reporting
[2] In the radar sensor setting it is possible to select m or ft unit for distance reporting

A2: The index of the Area-of-Interest that contains this target.

...

Dn: The distance of the last detected target.

PHIn: The angle to the last detected target.

An: The index of the Area-of-Interest that contains this target.

CSUM: The check sum of the characters in the report from $ to * excluding these characters.

Targets count report

$RDCNT,D,S,L,aprCNT,rcdCNT,AOI*CSUM<CR><LF>

$RDCNT: The keyword sent on the beginning of each counting report. The counting report is sent whenever new valid target is detected.

D: The direction for the new counted target (1 approaching, -1 receding).

S: The speed for the new counted target (speed is reported as Speed*10).

L: The detection level for the new counter target.

aprCNT: The cumulative counter for the approaching targets.

rcdCNT: The cumulative counter for the receding targets.

AOI: The index of the Area-of-Interest where this target was detected.

CSUM: The check sum of the characters in the report from $ to * excluding these characters.

Every second the radar transmits a system status report sentence, as described below (available only on GPS-enabled models):

System status report

$RDSTS,LAT,LONG,ALT,UTC,SATS,HDOP,VDOP,CHD,TLT,TEMP,VOLT
*CSUM<CR><LF>

$RDSTS: The keyword sent on the beginning of each system status report. This sentence is sent every second.

LAT: Radar GPS/GLONASS coordinates: Latitude value in degrees (e.g. 16.321554).

LONG: Radar GPS/GLONASS coordinates: Longitude value in degrees (e.g. -54.3888321).

ALT: Radar GPS/GLONASS coordinates: Altitude in meters.

UTC: UTC timestamp in seconds.

SATS: The number of visible GPS/GLONASS satellites.

HDOP: GPS/GLONASS Horizontal Dilution of Precision value.

VDOP: GPS/GLONASS Vertical Dilution of Precision value.

CHD: Compass heading angle, in tenths of degrees, clockwise.

TLT: Radar tilt angle, in tenths of degrees, 0 is parallel with the horizon, negative points downwards, positive upwards.

TEMP: Internal temperature in degrees Celsius.
VOLT: Power supply voltage, in V*10.
***CSUM*:** The check sum of the characters in the report from $ to * excluding these characters.

UDP-based protocol (Ethernet interface)

The radar uses a UDP-based protocol on port 2700 for communication over Ethernet interface. The radar periodically sends packets containing list of all detected targets. **The packets are sent to the IP address configured through the web-based radar configurator interface.**

Each UDP packet (datagram) consists of a packet header and data payload. The packet header has the same format for all packets. Data payload format depends on the packet type. All data types are stored in little-endian format.

The packet consists of the following fields:

PacketType: (unsigned byte) Set to *0x01* for radar targets report. In the future, additional packets may be defined, with different *PacketType* field.
TargetCount: (unsigned byte) The number of currently detected targets.
***PacketID*:** (unsigned int32) Unique packet identifier. The first packet sent will have Packet ID set to 0, then the next packet sent will have Packet ID set to 1 etc. Each radar device will start counting packets at 0, incrementing the value +1 for each subsequent packet. The Packet ID is used to determine if an UDP packet duplication has occurred, or if UDP packets are received out of order.
***Reserved*:** (unsigned byte[32]) 32 bytes are reserved for future use.
***Targets*:** (RadarTarget[TargetCount]) An array of the detected targets. The array has *TargetCount* elements. Each element is a structure, described in the next subsection.

Radar Target Structure

Speed *(float32) The target speed in km/h. Negative speed denotes receding target, while positive speed denotes an approaching target.*
Angle *(float32) The angle to the target, negative values point to the left, while positive values point to the right.*
Distance *(float32) The distance in meters.*
SignalStrength *(float32) The relative strength of the reflected signal from the target, can be used to determine which target the camera should point to.*
TargetID *(unsigned int32) The unique target identifier. The first detected target will have TargetID set to 0, the next target will have TargetID set to 1 etc. The TargetID field is used to identify the same target's movement through time, and to enable drawing movement track for each target.*

HTTP REST API

The radar has an embedded web server that is used to provide user-friendly interface to configure the radar. The embedded web server also provides a simple REST API that can be use to retrieve the list of active radar targets.

The web server listens on port 80 of the radar. The API for accessing the list of active targets is /scan_radars. For example, if the radar's IP address is 192.168.1.120, then the API can be accessed by issuing HTTP GET request to the following URL:

http://192.168.1.120/scan_radars

The response will be a JSON document, with the following fields:

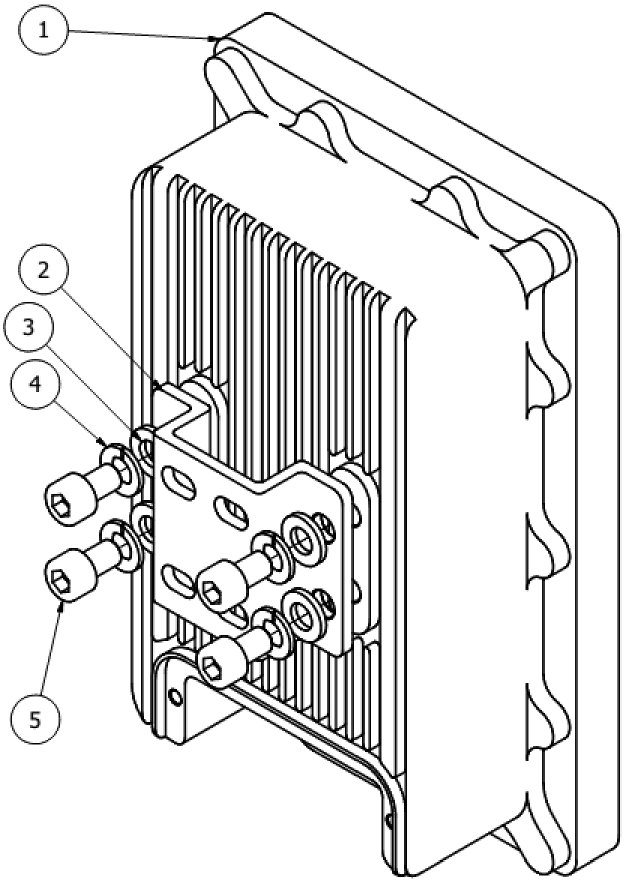
timestamp	*relative timestamp in seconds – the radar does not have real-time clock, so the reported timestamp is not an actual time, but a timer that increases every second*
targets	*an array of targets currently detected by the radar; each array element is an object containing the following fields:*

id	*an integer identifying target ID; the same target always keeps its ID so that it can be tracked over time*
distance	*distance from the radar in meters*
angle	*angle from the center of the radar beam; negative values are to the left*
speed	*the target speed relative towards the radar, in km/h; positive values denote approaching targets*
strength	*the relative reflected signal strength*

6. RSS-3-150CS Radar Sensor Installation

The Surveillance Radar Sensor installation should be done by skilled personnel to avoid any damage to the device. Radar Sensor can be pole mounted or mounted to the fixed object. It is also possible to mount Surveillance Radar Sensor to the tripod for mobile applications.

Fixing of the Surveillance Radar Sensor is done by four M6 screws on the back side of the device. Maximal length of the screws penetrating to the mounting holed on the back side of the device has to be less than 5mm. All four screws have to be used for safe operation of the device. Drawing of recommended mounting for RSS-3-150CS sensor is shown on the picture 3.



PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	RSS-3-150CS	Geolux Radar Sensor
2	1	Mounting Flange	
3	4	DIN 125 - A 6.4	Washer
4	4	DIN 128 - A6	Spring Washer
5	4	ISO 4762 - M6 x 10	Hexagon Socket Head Cap Screw

Picture 3. Radar mounting guidelines

It is also recommended to use threadlocker glue for better lock of screws. Radar assembly was tested for vibrations and screw locking with Loctite 243 medium strength threadlocker glue.

Additional 2 mounting holes are available on the bottom side of the radar device for applications where additional fixing is required. It is not recommended to use bottom two mounting holes for mounting of the radar if radar is not fixed with 4 mounting holes on the back side. For reference detail mechanical construction of the Surveillance Radar Sensor is shown in Appendix A.

In all mounting variants the Surveillance Radar Sensor should be solid fixed to the holder and holder should be implemented solid to reduce vibrations and movements of the device. In case radar is moving or strong vibrations are present on the device false detections of void targets is possible.

Detection range of the radar is also very dependable on the radar installation. In general radar is able to detect targets that are visible to the radar and not in the "radar shadow" with maximal detection distance proportional to the radar cross section of the target. For the average single human walking towards the radar detection range of 150m can be achieved when Surveillance Radar Sensor is mounted to the rigid pole 4m above the ground. Minimal distance from the radar where detection is possible in general depends to the coverage area but absolute minimal distance for target to be detected is 10m from the radar.

For the best radar operation near field zone around the radar should be clear of obstacles and objects. It is recommended to have clear zone of minimum 2m around the radar in all directions and if this is not possible, at least zone in front of radar ±45° in vertical and horizontal axis and radius of 2m has to be clear. If there are obstacles, specially reflective obstacles in this zone in front of radar this could cause very big return of the radio frequency signal to the radar and it could cause saturation of the input low noise amplifier circuits on the receiver.

7. Coverage area design guidelines

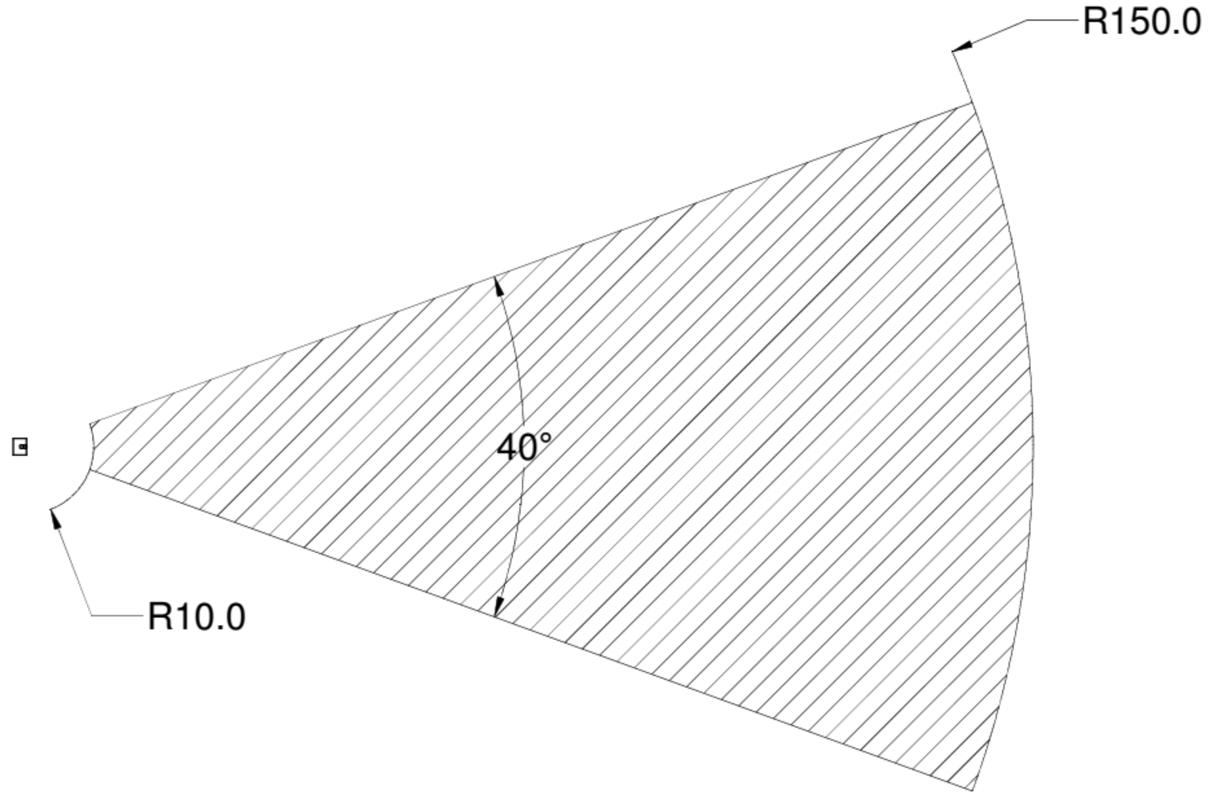
For the best radar positioning and optimal coverage area design there are few basic factors to take in to account when designing coverage area:

1. Radar sensor coverage area for the RSS-3-150CS sensor
2. Minimal target return signal to be detected
3. Shape and obstacles in the radar coverage area

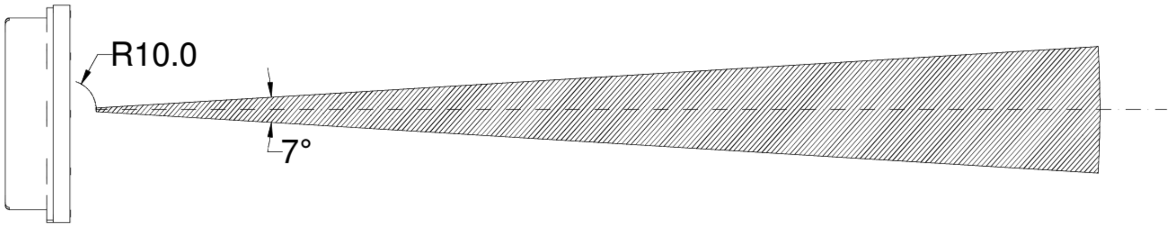
RSS-3-150CS Coverage Area

The radar sensor is able to detect all objects (targets) stationary or moving in the angle of 40° in horizontal axis and it can detect all objects in the angle of 7° in vertical axis. The detection range is symmetrical to the left and right side in horizontal plane and also it is symmetrical in the same way in vertical axis plane. Minimal distance from radar for target to be detected is 10m. Maximal distance for the target with radar cross-section of 0,75m^2 and detection probability of 99% is 150m on flat paved terrain.

Drawing of the horizontal and vertical radar coverage area is shown on the picture 4 and picture 5.



Picture 4. Radar coverage area - horizontal plane



Picture 5. Radar coverage area - vertical plane

Minimal detectable target

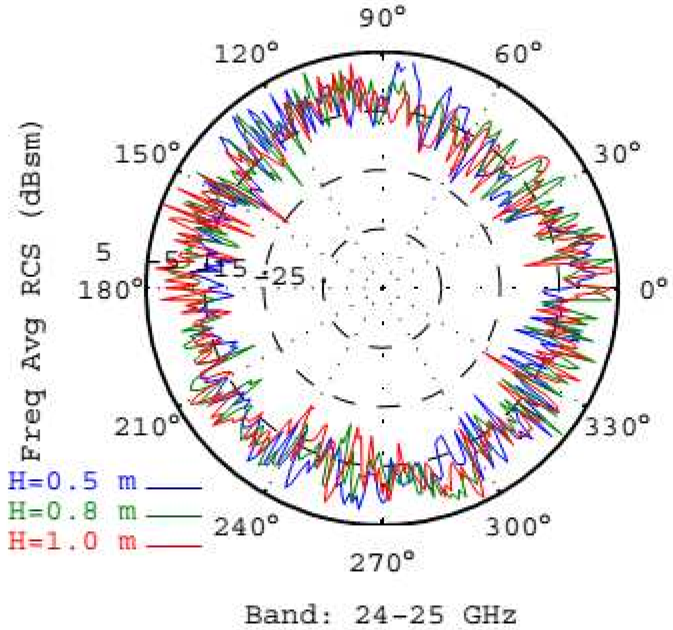
RSS-3-150CS radar sensor detects moving and stationary targets in the radar field of view by transmitting modulated electromagnetic wave in 24 GHz frequency range (K-band), and measuring the frequency shift of the reflected electromagnetic wave. Reflection of the electromagnetic wave from the target is making it detectable and better the reflection is better are the chances to detect target and target will be detectable in the greater distance from the radar sensor. Radar cross-section (RCS) is a measure of how detectable an object is with a radar. A number of different factors determine how much electromagnetic energy returns to the source such as:

- material of which the target is made
- absolute size of the target
- relative size of the target (in relation to the wavelength of the illuminating radar)
- the incident angle (angle at which the radar beam hits a particular portion of target which depends upon shape of target and its orientation to the radar source)
- reflected angle (angle at which the reflected beam leaves the part of the target hit, it depends upon incident angle)
- the polarization of transmitted and the received radiation in respect to the orientation of the target

In respect to above factors that are defining target radar cross-section and target detect ability by the radars, some typical values of the measurement radar cross-section for typical targets are:

- Insect: 0,00001 m^2 (-50dBsm)
- Small bird: 0,008 m^2 (-20,97dBsm)
- Large bird: 0,01 m^2 (-20dBsm)
- Crawling human: 0,25 m^2 (-6 dBsm)
- Walking human: 0,75 m^2 (-1,25dBsm)
- Average car: 4 to 8 m^2 (6 to 9 dBsm)
- Average truck: 6 to 10 m^2 (7,78 to 10dBsm)

Average RCS measurement is averaged in reflected angle and time. RCS for most targets is not constant for all incident and reflected angles and it is not constant in time as the consequence of the target moving. Typical measurement of radar cross-section for the standing human in all angles is shown on the picture 6.



Picture 6. RCS measurement for single walking human

To overcome problems with changes of the RCS and signal variations on the receiver of the radar, RSS-3-150CS is sampling complete field of view few times in the second to get better reliability of the detection. Variations of the RCS as factor of the incident angle can't be avoided but in 24GHz band differences of the RCS as the factor of angle are relatively low and are changed very fast over the angle so this problem is also avoided with multiple scanning per second and averaging of the results.

Shape of the monitored area

The shape of the monitored area that has to be covered by the radars will mostly affect radar arrangement and quantity required to cover the area. In some cases it will be possible to cover the area with single radar, in some cases more radars will be required to cover the area. When designing radar placement and coverage area there are few simple rules to be followed in order to get best results:

- Avoid mounting of the radar sensor on height below 2m
- Detection possibility for the target is better when more radars are sensing the same area and radar detection range overlapping will increase detection possibility.
- If possible avoid all obstacles in the radar coverage area

- If strongly reflective (usually metal, reinforced concrete or similar) obstacle is present in the radar field of view it will create radar shadow and detection of the targets behind the obstacle won't be possible. To check radar shadow area simple ray tracing method can be used.

- Vegetation and other not strongly reflective objects in the radar detection area will reduce the return signal from target to the radar and will reduce the detection range of the radar or/and probability for the target to be detected. Typical light vegetation (bushes, small trees etc.) can reduce detection range for 0,75m^2 RCS target by average 10 to 50m and in extreme cases even more. Heavy vegetation like forest can reduce detection range for 0,75m^2 RCS target by average 10m to 75m, or more in extreme cases.

- It is not recommended to mount radar if more than one radar is used to cover same area in the way that radars are on the same horizontal and vertical axis line.

- In general it is better to place radar as high as possible above the ground. Special case is only when radar is mounted in the closed space or under the cover of some kind. In this case radar should be mounted 1m from the roof if possible.

- If radar height is above 0,65m and radar sensor is mounted with horizontally angle of 0° the minimal detection distance will be greater than 10m which is absolutely minimal detectable distance. For higher radar sensor mounting this distance will be larger, for example if radar sensor mounted to 4m height minimal detection distance will be around 65m. To decrease minimal detection distance tilt down of the sensor can be used. It is recommended to keep tilt down in range from 0° to 6°.

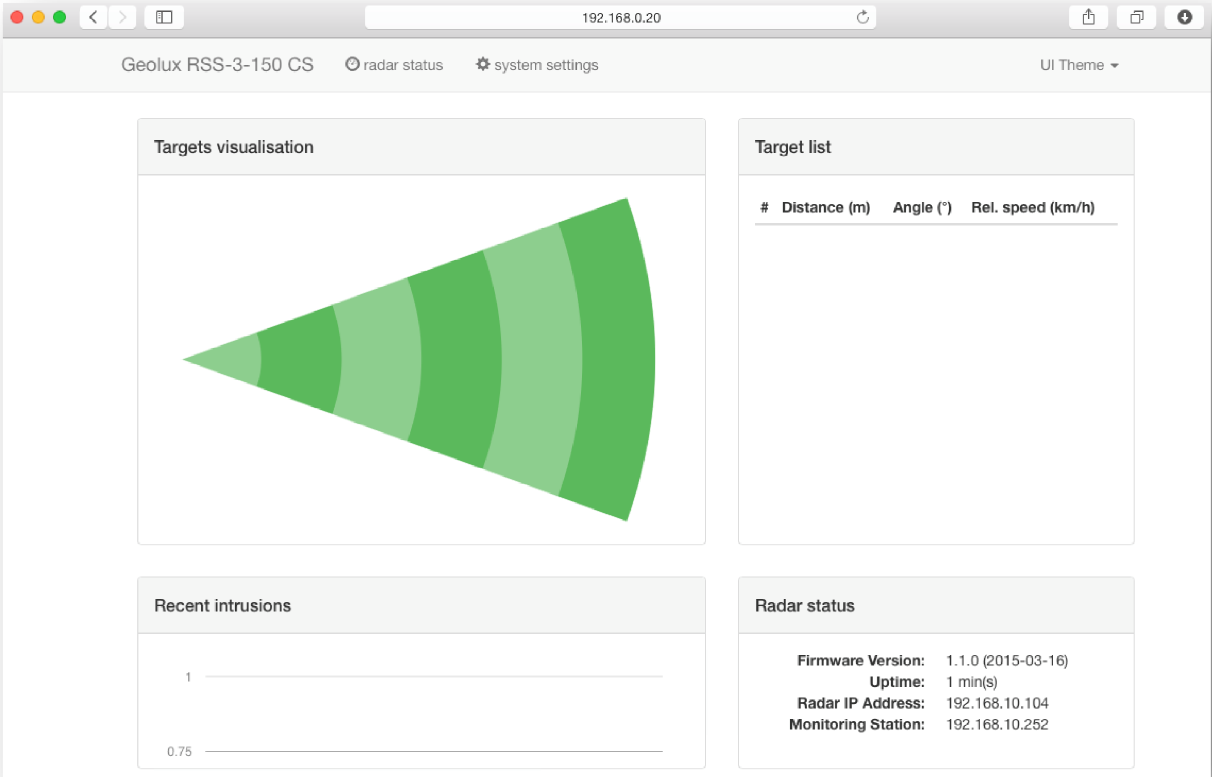
- When using wireless links to connect radar sensors to control center or some other radio frequency equipment is used on the location it is recommended to move antennas of this equipment minimum 2m from the RSS-3-150CS radar sensor.

- When mounting RSS-3-150CS radar sensors to the pole it is mandatory to ground the pole and to implement lighting protection of the pole. RSS-3-150CS radar sensor are very robust designed and have protected all power supply and communication lines, but lighting protection is not implemented for direct lighting strike to the device or mounting pole.

8. Radar Configurator Utility

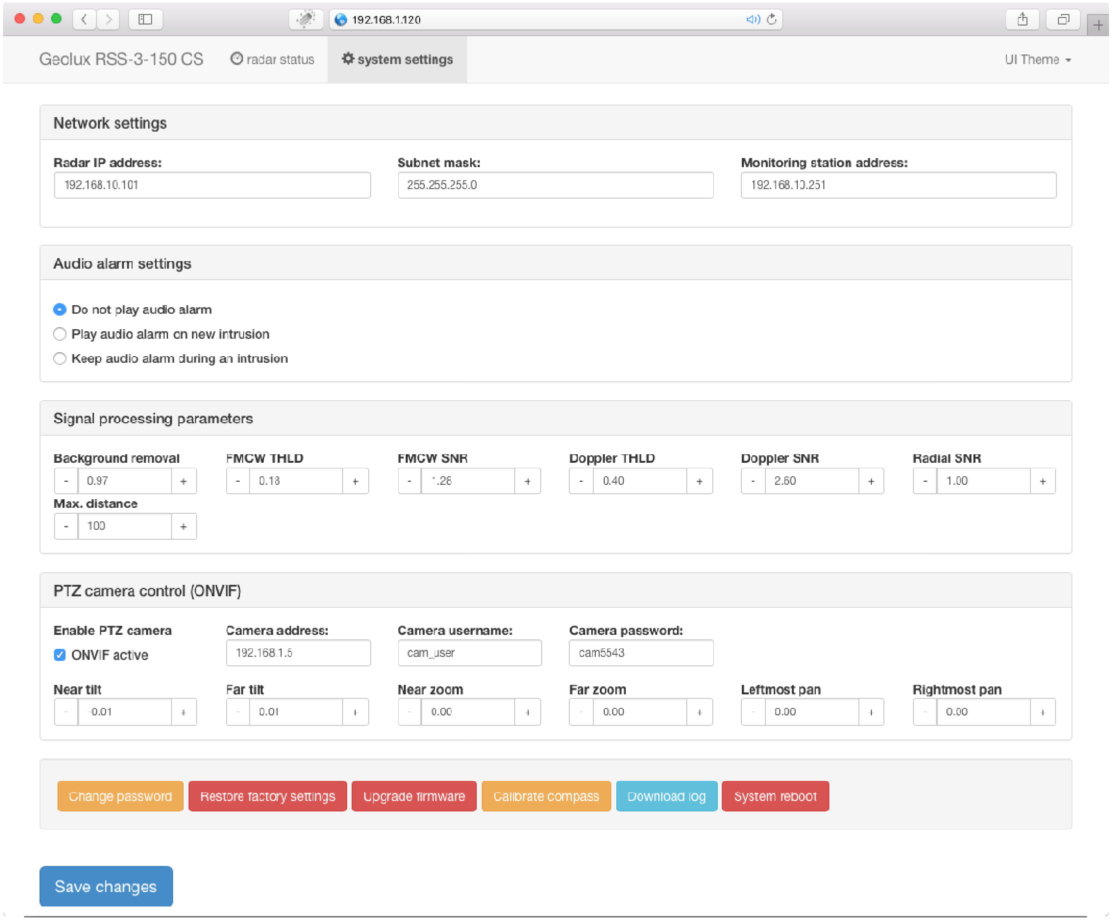
Geolux provides integrated in the sensor web-based utility for configuring the radar operation. To connect to the radar configurator utility, connect the radar and the computer to the same Ethernet network, or connect the radar directly to the computer using an Ethernet cable. The default radar address (factory-programmed) is 192.168.1.120. The computer's IP address must reside on the same subnet (it must also start with 192.168.1); otherwise the initial connection will not be possible.

After the Ethernet connection is established, and the radar is powered up, open a web browser (Safari or Chrome are preferred browsers), and type-in radar IP address (http://192.168.1.120). The radar web-page will be displayed:



The page consists of four panels. The upper-left panel displays the radar beam, and if any targets are detected, these targets will be displayed overlaid over the beam image. The upper-right panel contains a list of all currently detected targets, with position and speed information for each target. The lower-left panel contains a history graph that displays the number of detected targets in the last 30 minutes, and the lower-right panel displays basic radar status information.

To configure radar operation, click "system settings" button on the page. You will be prompted to enter the password for changing settings. The default, factory-preset password is ***radarpwd***. It is highly recommended that you change this password.



The first panel allows you to change the radar IP address, and the Monitoring station address. The monitoring station IP address is used by UDP protocol, as UDP packets with radar targets are sent to this IP address. For more information about the UDP protocol, see page 15.

The second panel configures Sound alarm for the web user interface. You can define whether and audio alarm will be heard from your computer, when you are looking at the main page of the web-based radar user interface, and a target is detected.

The third panel contains radar tuning parameters. These parameters define the sensitivity levels for the radar – more sensitivity allows detection of smaller targets, but will also increase the rate of false alarms. These parameters should be tuned depending on the monitored area layout. When these parameters are changed and saved, the radar will need approximately one minute to update internal state and retune according to the new parameters. The following parameters can be configured:

Background removal : this factor determines the amount of background noise removal. The optimum values are between 0.5 and 0.9.

FMCW THLD: The noise threshold level for ranging of the targets moving to/from radar. If this level is higher, more false alarms will be removed, but the detection of valid targets will also decrease. Optimum values are between 0.1 and 0.2 but this is highly dependent on the application and terrain.

FMCW SNR: The minimal signal to noise ratio for the detection of targets moving to/from radar during ranging period. Higher value removes false alarms but decreases detection sensitivity. Optimum values are between 1.15 and 1.4.

Doppler THLD: The noise threshold level for measuring speed of the targets moving to/from radar. Optimum values are between 0.2 and 0.5. In the more noisy environment this level can be increased to get better readings and lower false alarms number.

Doppler SNR: The minimal signal to noise ratio for detection of targets moving to/from radar during speed measurement period. Optimum values are between 2.1 and 2.5.

Radial SNR: The minimal signal to noise ratio for detection of targets moving perpendicular to the radar beam. Optimum values are between 1.3 and 2.2.

Max. distance: The upper limit for target detection. Allows decreasing of the detection area.

The fourth panel contrains parameters for PTZ camera operation. The radar (if the PTZ module is available in the radar), can control any PTZ camera through Ethernet-based ONVIF protocol. The parameters to configure ONVIF protocol are available in this panel:

Enable PTZ camera: When checked, the radar will control the PTZ camera so that it follows the movement of objects detected by the radar.

Camera address: The IP address of the PTZ camera.

Camera username: The username used to access the camera through ONVIF protocol.

Camera password: The password used to access the camera through ONVIF protocol.

Near/far tilt: The pair of PTZ tilt values (the values are given in the range from -1.00 to +1.00) to control the camera tilt (vertical angle) movement. The *near tilt* value controls the camera angle when no objects are detected. The *far tilt* value is the tilt value to which the camera will be tilted when an object is at the Maximum distance from the radar (see Max. distance parameter). If the detected object is between the radar and the maximum distance, the camera tilt will be adjusted to a value between *near tilt* and *far tilt*, using linear interpolation. For example, if near tilt value is set to -1.00, far tilt value is set to 0.00, and maximum distance is 100 meters, the camera tilt will be set to -0.50 when the radar detects an object 50 meters from the radar, and it will be set to -0.25 when the radar detects an object 75 meters from the radar.

Near/far zoom: Similar to near/far tilt, these two parameters control the amount of camera zoom applied when an object is detected by the radar.

Leftmost pan/rightmost pan: These two values are also in the range from -1.00 to +1.00. They control the pan (horizontal angle) for the camera; the leftmost pan value is the pan value that the camera will use when the radar detects the object 20 degrees to the left, and the rightmost pan value will be set to the camera, when the radar detects an object 20 degrees to the right. For objects within the radar beam, the pan value will be interpolate between these two values. For example, is leftmost pan value is set to -0.5, and the rightmost pan value is set to +0.1, when the radar detects the object exactly at the center of the radar beam, the camera's pan angle value will be set to -0.2.

The last two panels allow the user to perform any of the following actions:

- Change password – change the password needed to access system settings page
- Restore factory settings – revert all settings back to factory defaults; take care when using this feature, as radar IP address will also be reverted to the default value of 192.168.1.120
- Upgrade firmware – used to update the radar firmware to the latest version
- Calibrate compass – pressing this button start compass calibration process; the internal digital compass must be calibrated on site prior to radar installation
- Download log – downloads system log to assist in radar operation troubleshooting
- System reboot – initiates safe radar reboot
- Save changes – saves the changes radar settings; after the settings are saved the radar typically needs 15-45 seconds to reinitiate with the updated setting values

Depending on the radar sensor application, it is possible that additional settings are exposed on the web-based configuration util.

9. Appendix A – Mechanical Assembly