GLX-RSS-4

FMCW Radar Surveillance Sensor

User Manual

Starting Point

Thank you for purchasing Geolux GLX-RSS-4 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 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, 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. Specification

Table 1. Specification

Parameter	MIN	TYP	MAX	Unit
Detection range:				
Walking human (1m^2 RCS)		150		m
Driving vehicle		250		m
Range accuracy for positioning	±1	±2	±5	m
Angle accuracy for positioning		±1		°
Target speed accuracy		±1		km/h
Target minimal speed		0.5		km/h
Simultaneous targets tracking			32	
Target track updates per second[1]		5		
Detection reliability:				
Walking human in specified range (1m^2 RCS)	99,0	99,4		%
Driving vehicle in specified range	99,0	99,8		%
False alarm ratio[2]		0,5	1	Alarm/day
Radar Sensor				
Frequency – K-band version	24.000		24.250	GHz
Radiated power (EIRP)	17	19	20	dBm
Sensitivity	-110	-112	-116	dBm
Beam-width (3dB) – horizontal		90		°
Beam-width (3dB) – vertical		22		°
Connection interface:				
Ethernet 1000Base-T	10		1000	Mbit
RS485	9600	57600	112500	kbps
RS232	9600	115200	115200	kbps
Power supply voltage	9,0		48,0	V
Power consumption		12	15	W
Mechanical dimensions		19x12x5		cm
Weight			2.5	kg
Operational temperature range	-20		+60	°C
Protection	IP66			

1.1 FCC compliance

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

[1] Range-Doppler spectrum extraction from the signal processing could reduce refresh rate of the signal processing in the radar.

[2] False alarm ratio is measured on flat grass field in sunny weather conditions and with light wind.

FCC Part 15.21 - Information to the user/installer

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC 15.105(b) - Information to the user/installer

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. 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. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

1.2 ISED Notices

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

This device may not cause interference.

This device must accept any interference, including interference that may cause undesired operation of the device.

Ce dispositif contient des émetteurs exemptés de licence qui sont conformes aux RSS(s) d'Innovation, Science et Développement économique Canada exemptés de licence. L'opération est soumise aux deux conditions suivantes :

Cet appareil peut ne pas causer d'interférences.

Cet appareil doit accepter toute interférence, y compris toute interférence qui peut causer le fonctionnement indésirable de l'appareil.

RADIATION EXPOSURE STATEMENT

The device meets the exemption from the routine evaluation limits in section 2.5 of RSS 102. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and users.

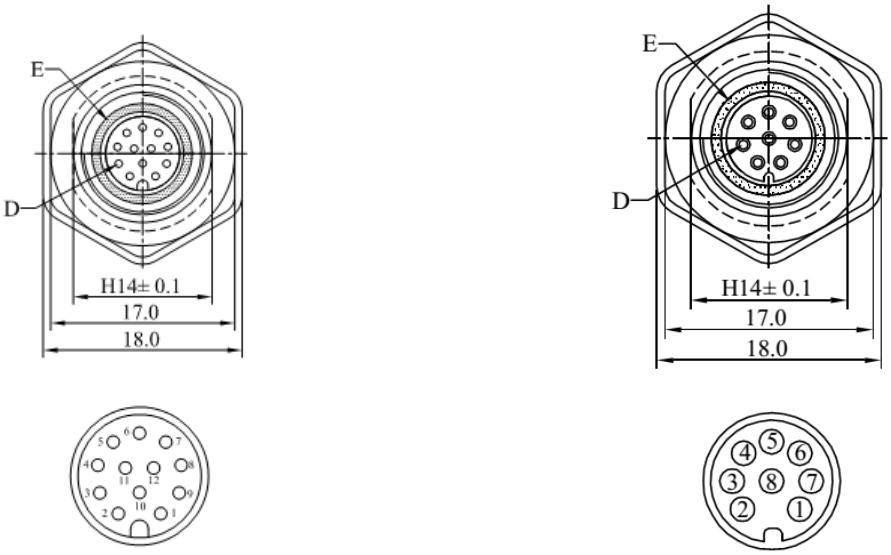
L'appareil satisfait à l'exemption des limites d'évaluation de routine de la section 2.5 de RSS 102. Cet équipement doit être installé et utilisé à une distance minimale de 20 centimètres entre le radiateur et l'utilisateurs.

2. Connector Pin-Out

The Radar Surveillance Sensor RSS-4 uses single or dual connector to interface external systems: circular M12 IP68 connector with 8 positions for Ethernet connection with PoE supply option and additional M12 IP68 12 positions connector with additional interfaces and connectivity options.

Picture 1. Radar view on the back side of the device

Details of the 8 and 12 position M12 connectors are shown on Picture 2. The Tables 2 and 3 gives detailed description for each pin.



Picture 2. Radar connectors on the back side

Table 2. Connector and cable pin-out

Pin No.	Wire Color	Pin Name	Pin Description
1	White	GND	This pin should be connected to the ground (negative) pole of the power supply.
2	Brown	+Vin	The power supply for the Radar is provided on this pin. The Radar power supply voltage must be in the range 9 VDC to 48 VDC, and the power supply must be able to provide at last 15W.
3	Green	RS232 – TxD	RS-232 data transmit signal.
4	Yellow	RS232 – RxD	RS-232 data receive signal.
5	Grey	GND	Signal ground.
6	Pink	CAN – H	CAN2.0B high signal.
7	Blue	CAN – L	CAN2.0B low signal.
8	Violet	RS485 – D+	RS-485 data transmitter/receiver high signal.
9	Orange	RS485 – D-	RS-485 data transmitter/receiver low signal.
10	Red	Output 1	Alarm 1 - open collector switch signal max. 60mA
11	Black	Input 1	General purpose input 1 – low active
12	Purple	Input 2	General purpose input 2 – low active

To simplify installation and improve reliability cable with over-molded 12pin M12 connector with IP68 protection is supplied with the radar. Cable has over molded ferrite core (Wurth Elektronik 742 700 777) for EMI reduction and system protection.

Table 3. Connector and cable pin-out

Pin No.	Wire Color	Pin Name	Pin Description
1	White	BI_DA+ / PoE V1+	Bi-directional pair A +
2	Brown	BI_DA- / PoE V1+	Bi-directional pair A -
3	Green	BI_DB+ / PoE V1-	Bi-directional pair B +
4	Yellow	BI_DC+ / PoE V2+	Bi-directional pair C +
5	Gray	BI_DC- / PoE V2+	Bi-directional pair C -
6	Pink	BI_DB- / PoE V1-	Bi-directional pair B -
7	Blue	BI_DD+ / PoE V2-	Bi-directional pair D +
8	Red	BI_DD- / PoE V2-	Bi-directional pair D -

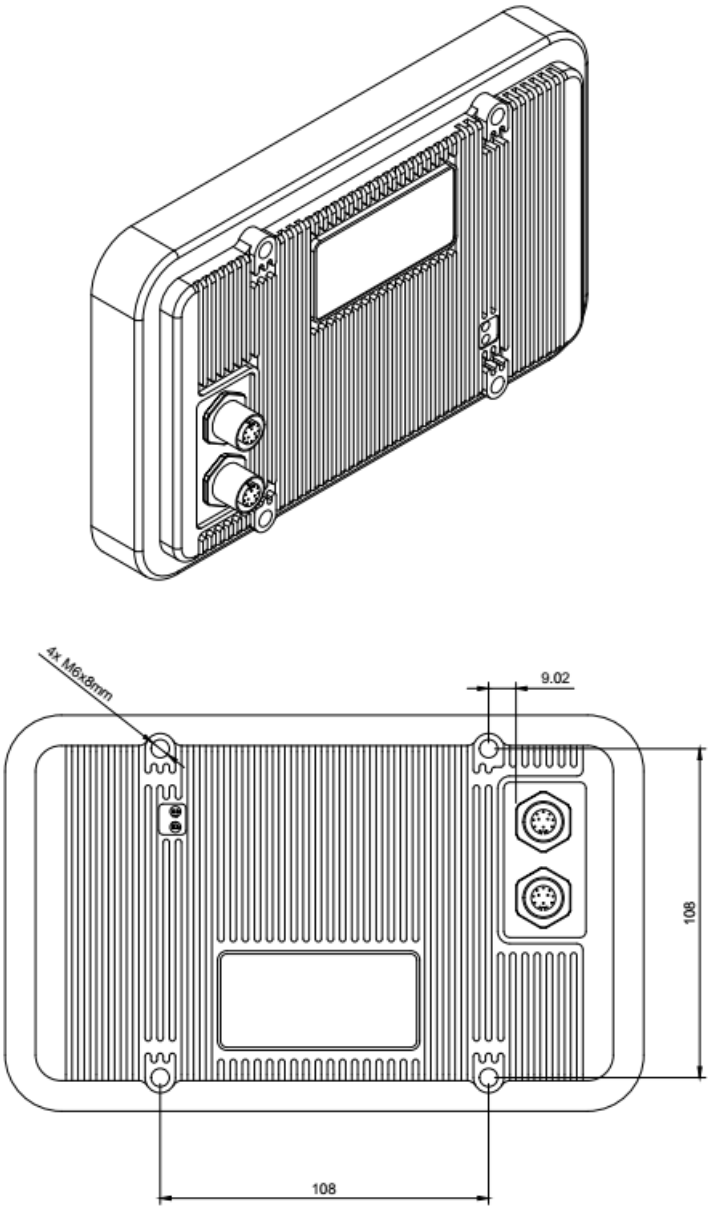
To simplify installation and improve reliability cable with over-molded 8pin M12 connector with IP68 protection is supplied with the radar connected to the RJ45 standard Ethernet connector on the other side of cable.

GPS antenna connection is implemented with SMA connector on the back of the device. Active GPS antenna with +5V power supply is recommended for the best performance. GPS receiver is used for synchronization purpose and antenna location is not particularly important if good visibility of the sky is assured.

3. RSS-4 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 hole on the back side of the device must be less than 8mm. All four screws must be used for safe operation of the device. Drawing of mounting hole spacing and dimension for RSS-4 sensor is shown on the picture 3.



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.

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 are possible.

Detection range of the radar is also very dependable on the radar installation. In general radar can 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 3m above the ground. Minimal guaranteed distance from the radar where detection is possible is 3m.

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 ±65° in vertical and horizontal axis and radius of 2m must be clear. If there are obstacles, especially reflective obstacles in this zone in front of radar this could cause very strong return of the radio frequency signal to the radar and it could cause saturation of the input low noise amplifier circuits on the receiver decreasing detection abilities of the radar significantly.

4. Coverage area design guidelines

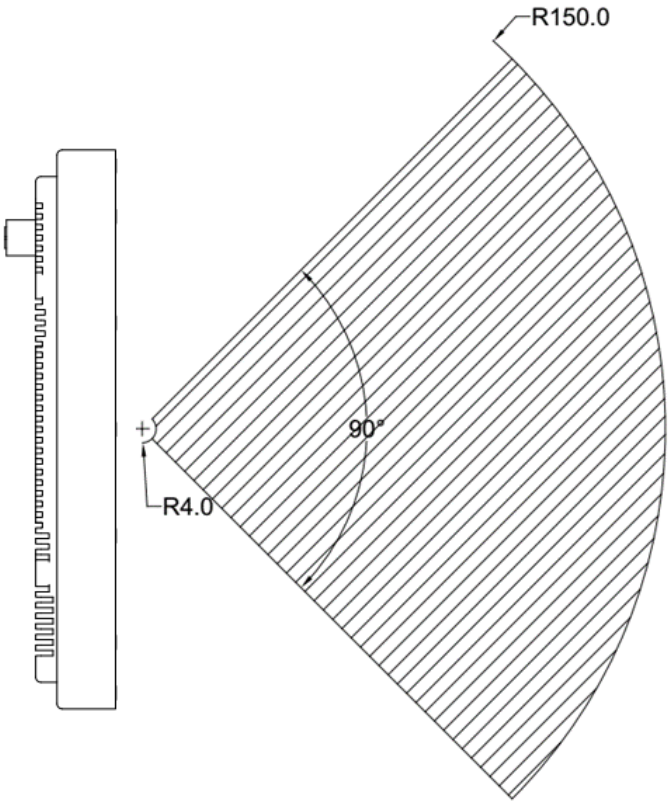
For the best radar positioning and optimal coverage area design there are few basic factors to take in to account when designing coverage area:

1. Radar sensor coverage area for the RSS-4 sensor
2. Minimal target return signal to be detected
3. Shape and obstacles in the radar coverage area

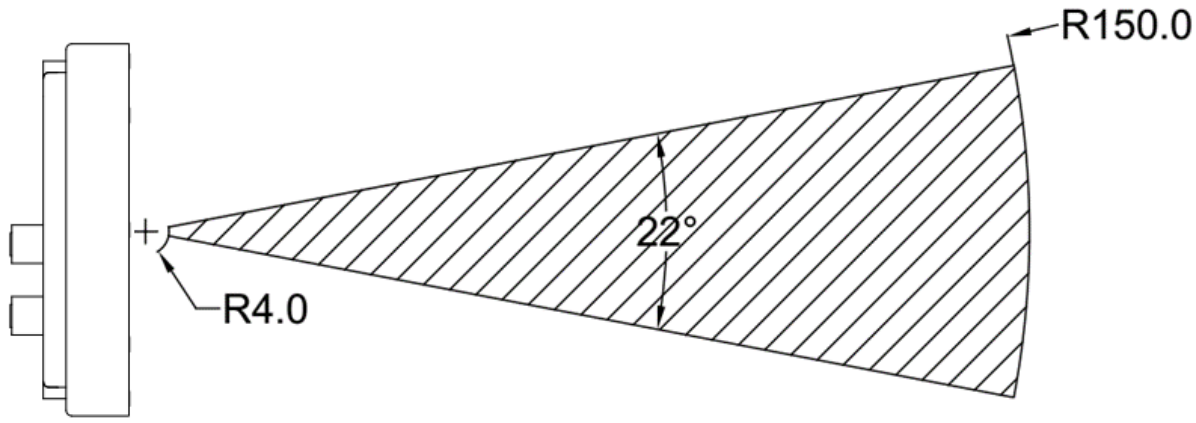
RSS-4 Coverage Area

The radar sensor can detect all objects (targets) stationary or moving in the angle of 90° (±45°) in horizontal axis and it can detect all objects in the angle of 22° (±11°) in vertical axis. The detection range is symmetrical to the left and right side in horizontal plane and it is symmetrical in the same way in vertical axis plane. Minimal distance from radar for target to be detected is 4m. Maximal distance for the target with radar cross-section of 0,75m^2 and detection probability of 99% is 150m on flat short grass 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-4 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 stronger 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. Several different factors determine how much electromagnetic energy returns to the source such as:

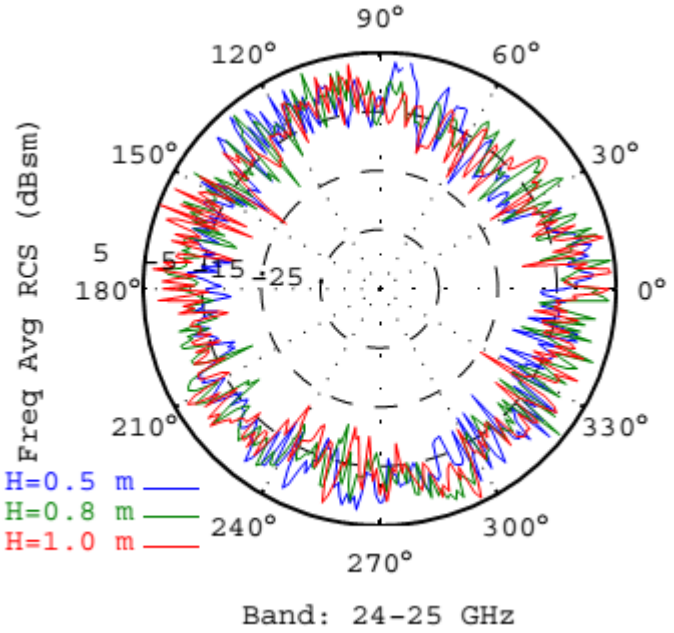
- material of which the target is made
- absolute size of the target
- relative size of the target (in relation to the wavelength of the illuminating radar)
- the incident angle (angle at which the radar beam hits a portion of target which depends upon shape of target and its orientation to the radar 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-4 is sampling complete field of view many 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 must 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 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 will not 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. Radar beam penetration ratio to the vegetation depends also on the water content in the vegetation so it is expected that wet vegetation will reduce penetration more than dry vegetation. This ratio is dependent on many factors but in most cases average value of 25% degradation of performance for wet vegetation can be used.
- 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 4m which is minimal detectable distance. For higher radar sensor mounting this distance will

be larger, and it can be simple calculated from basic geometry. 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 9°.

- 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-4 radar sensor.

- When mounting RSS-4 radar sensors to the pole it is mandatory to ground the pole and to implement lighting protection of the pole. RSS-4 radar sensor are very robust designed and have protected all power supply and communication lines internally, but lighting protection is not implemented for direct lighting strike to the device or mounting pole.

5. Initial radar setup

The unit configuration is done through the web-based user interface. To access the user interface, connect the radar to the Ethernet network, and then access the radar interface through a web browser of a PC computer that is connected to the same Ethernet network.

Default factory settings for connection to the radar are:

Default IP address:	192.168.0.208
Default password:	radarpwd
Configuration interface:	http://192.168.0.208/
Boot time:	≈1 min

6. Mechanical design