

User Manual

RT-600 Light



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LoJack is a registered trademark of LoJack Corporation.

Note:

The manufacturer reserves the right on making modifications of the product described herein at any time and without previous information.

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Reference Documents

Ref	Document-ID	Document Title	Rev	Editor
[1]	12-9-4-5-00002-2	Interface Specification for Antenna Units (RT-500-M RT-600 RT-800)	[Rev 1.00]	RHOTHETA

The reference document is issued from RHOTHETA separately on request.

1 Legend of Signal Words

Note

This symbol designates tips or additional notes that must be paid attention to and make work easier.

Caution

means that ignoring the instructions may lead to property damage or loss of data.

Warning

means that ignoring the instructions, there may be a danger to health or life.

2 Safety

2.1 General Safety Information

RHOTHETA Elektronik GmbH is constantly trying to keep the safety standard of the products up to date and to offer the customers the highest possible level of safety.

RHOTHETA products are designed and tested in accordance with the valid safety regulations. The compliance with these standards is continuously monitored by our quality assurance system.

This product is tested and left the factory in perfect technical and safety-relevant condition. To maintain this condition and to ensure safe operation, the user must pay attention to all instructions and warnings given. For any questions regarding these safety instructions, RHOTHETA Elektronik GmbH can be contacted at any time.

The observance of the safety instructions will help to prevent personal injury or damage caused by all kinds of dangers. This requires that the following safety instructions must be read carefully and understood before using the product, as well as observed when using the product. The additional safety instructions such as for protecting persons appear in relevant parts of the product documentation and must also be paid attention to.

The use of this product other than its designated purpose or in disregard of the instructions of the manufacturer is the responsibility of the user. The manufacturer takes no responsibility for the misuse of the product.

The manufacturer is not liable beyond the scope of legal rules!

This guide is part of the product RT-600 Light and is retained throughout the lifetime and to pass with the product.

For the reasons explained in 6.3 "Tracking in the 216 to 220 MHz band" RHOTHETA does not offer - and is not to be held responsible for - any guaranteed minimum range or distance to a transmitter in this band.

2.2 Basic Safety Instructions

Caution / Warning

Read and observe the following instructions, warnings and safety instructions of the manufacturer!

- At all work, the local or national safety and accident prevention regulations must be observed.
- When installing or operating with the product always follow the manufacturer's instructions.
- Do place the product on appropriate locations.
- Do not expose the product environmental conditions (heat, humidity, wind load etc.) that exceed the specified conditions in the manuals.
- Use only the manufacturer prescribed components and/or use only recommended material and do not change this. Any other use or unauthorized modifications to the product will void the authorization to operate it.
- Connect only approved accessories kits or additional equipment.
- Ensure that the connections with information technology equipment, e.g. industrial computers, comply with the IEC 60950-1/EN 60950-1 standard that applies in each case.
- The product may only be opened by authorized personnel. The connector must always be disconnected before opening.

3 General Information

The RHOTHETA direction finder system RT-600 Light is designed to receive and locate emergency signals and special application signals on the international distress and application specific frequencies in the VHF / UHF frequency range.

The system consists of an Antenna Unit (AU), which is designed light and robust for typical use on unmanned aircraft.

The RT-600 Light is a modern precision direction finder intended for professional SAR (search and rescue) and LE (Law Enforcement) purposes, and there are two versions of the RT-600 Light:

- The STANDARD or “A” version receives and locates signals on all international VHF-UHF emergency frequencies, including marine channel 16 and all COSPAS/SARSAT channels
- The LAW ENFORCEMENT or “LE” version receives and locates special signals tracked by law enforcement and special organizations, but it also receives and locates signals on international VHF emergency frequencies including marine channel 16 and all COSPAS/SARSAT channels.

The system is based on the proven and reliable RT-600 system for manned aircraft, which was designed for usage in harsh conditions, mounted on aircraft or vehicles.

The excellent performance of the RT-600 Light is possible due to our revolutionary patented wide band antenna and it's sophisticated bearing analyzing algorithms, which deliver quick and steady information.

The system is operated over the serial interface. The appropriate communication protocol is described in the reference document (please s. Ref. [1]).

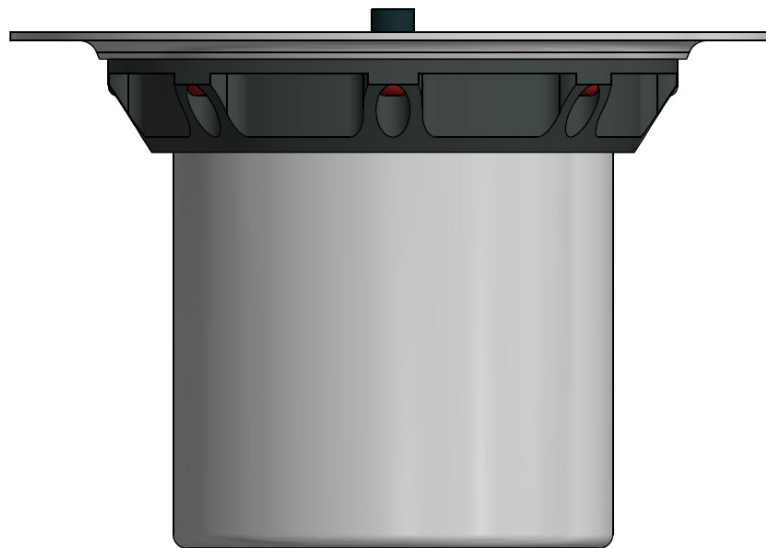


Fig 1) RT-600 Light Front View

4 Installation

4.1 Antenna unit

A convenient position of the monopole bearing antenna is crucial for good bearing results. The antenna needs an effective ground connection to the body of the aircraft or to the roof of the vehicle. If there is no metallic mounting surface available, a metallic sheet or similar (e.g. net) with connection to ground has to be applied first between aircraft-body and antenna.

For optimal function of the direction finder it is recommended to use a metallic ground plane with a minimum diameter of 470 mm.

In the hatched area, the antenna touches the body of the aircraft / vehicle. In order to obtain a good ground connection, the surface of the body should be bared. (Measuring unit [mm])

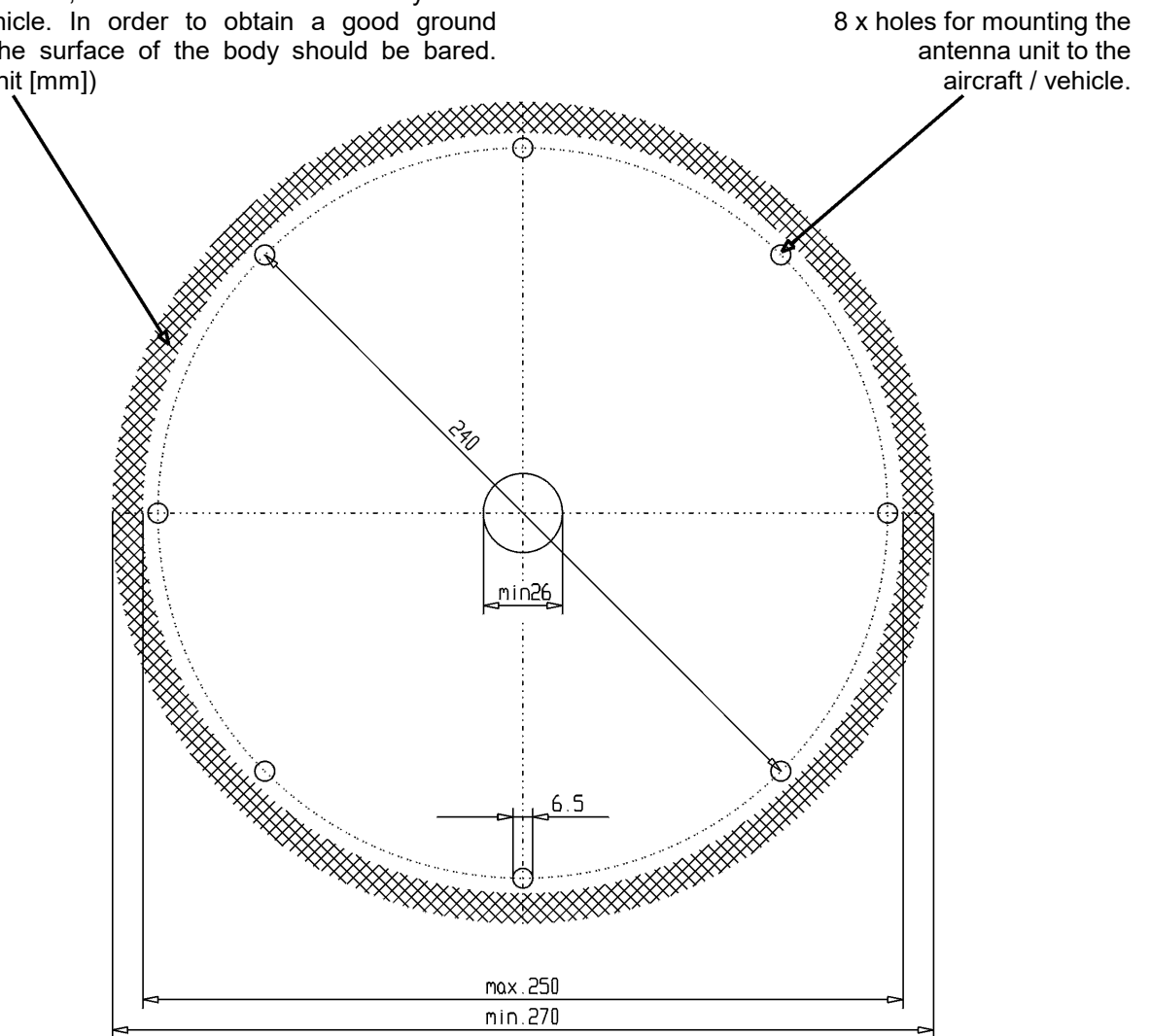


Fig 2) Antenna Mounting Drawing, all dimensions are in [mm]

For the electrical and data connection, the antenna should be connected to the aircraft by a suitable cable (corresponding to the used Control Unit). The mating connector is included in the scope of delivery. For the pinout description please see chapter 7.2 Interface.

4.2 Influence of antenna location and environment on the bearing accuracy

The bearing accuracy of the direction finder antenna unit is severely influenced (comparable to an airspeed sensor) by the environment. For comparison, a perfect high quality speed sensor will not indicate the true airspeed, if this sensor is interfered by strong turbulences.

The direction finder antenna unit acts as a sensor for electromagnetic waves. In the near field of this antenna unit, any conductive (e.g. metallic) obstacle will influence the incoming wave field and create reflections which decrease the bearing accuracy. These are general physical limitations concerning all types of direction finder systems.

Note

To achieve the best bearing results, it should be considered that the antenna unit is installed as far away as possible from any other vertically polarized conductive structure. If possible, there should be no reflectors within an area of 2-3 feet (0,5 – 1 m) around the antenna unit.



Fig 3) Worst case example of the installation

In this example, the antenna unit is located too close to the cable cutter of the helicopter. This cutter will produce strong reflections, especially as the length is equal to $\lambda/4$ within the VHF airband and the direction finder system will not work properly.

5 Configuration

5.1 Mounting

The RT-600 Light can be mounted in a “top”-position (e.g. roof of the vehicles) or a “bottom”-position (e.g. bottom of the aircraft).

The mounting position is crucial for the correctness of the bearing results.

The mounting position has to be adjusted over the mounting parameter of the serial interface data protocol (for data protocol please s. Ref. [1]).

Based on this, the bearing is calculated considering the angle of incidence of the wave and the mounting position of the antenna. This setting is crucial for correctness of the bearing results.

To guarantee a correct configuration and performance of the system, the user should verify – and change if necessary – the mounting parameter via the serial interface data protocol by setting the appropriate byte (for detailed information please s. Ref. [1]).

5.2 Offset of Bearing

The RT-600 Light has to be mounted on the aircraft in the way that, the 0° - marker ("North"-marker) is on the longitudinal axis of the aircraft and points in the flight direction. If the antenna cannot be mounted (for different reasons) in such way, the deviation correction has to be done via the setting of the appropriate byte in the interface data protocol (please s. Ref. [1]). The offset is adjustable from 0° to 359° (e.g. -15° = 345°).

6 Operation

6.1 Operational Modes

The operation of the RT-600 Light is ensured by the settings of the serial interface protocol. For detailed information please s. Ref. [1].

There are several modes to operate the direction finder system RT-600 Light:

1. Bearing Standard Direction Finder Mode

This is the standard mode of operation. To ensure the main function of the RT-600 Light (the bearing) the frequency and the squelch settings have to be done. To operate the direction finder in this mode the appropriate data byte of the interface data protocol has to be set (detailed information about squelch s. chapter 6.1).

2. Cospas/Sarsat Decoding Mode

This mode is intended especially for the use together with beacons transmitting a data signal according to COSPAS-SARSAT specifications in the 406-MHz-Band.

The COSPAS-SARSAT pulses are decoded (message content, GPS position) in this mode. While this operation the bearing is interrupted.

To operate the direction finder in this mode the appropriate data byte of the interface data protocol has to be set (for detailed information please s. Ref. [1]).

3. Cospas/Sarsat Scanning Mode (Auto scanning of CospasSarsat: 406.022...406.076 MHz)

If the exact frequency of the COSPAS-SARSAT beacon is unknown, it is strongly recommended to use the COSPAS-SARSAT scanning functionality in order to detect the correct frequency. In this mode the whole COSPAS-SARSAT sub-band is scanned within less than 400 ms in order to detect the presence of a signal on any of the frequencies. If a signal is detected, the scanning stops and the signal at the founded frequency can be used for the bearing.

While this mode is activated the bearing is interrupted (for detailed information please s. Ref. [1]).

4. LoJack Decoding & Bearing Mode with [Filter=VLU]

This mode is only available with the RT-600 Light version "LE".

The mode is created for the Law Enforcement and other special ops users, who frequently engage in tracking SVRS (Stolen Vehicle Recovery System) signals such as LoJack (LoJack Corp, FCC 90.20 Part 2 SVRS).

In the "VLU" filter mode the direction finder system scans the LoJack frequency (173.075 MHz) for a signal with the valid VLU (Vehicle Location Unit) code. That means, the signals only coming from the vehicles will be analyzed (not the base station signals).

Since several signals with the valid VLU can be received simultaneously, the correct one (which has the searched ID) can be targeted explicitly in the mode "Decoding & Bearing Mode with "Filter = ID" (for detailed information please s. Ref. [1]).

For additional information you can request the "User Manual RT-600" at RHOTHETA Elektronik.

5. LoJack Decoding & Bearing Mode with [Filter=ID]

This mode is only available with the RT-600 Light version "LE".

After receiving the wanted signal with the correct VLU code from the stolen vehicle, due to the "Decoding & Bearing Mode with [Filter=ID]", this vehicle can be targeted explicitly (without receiving the distracting VLU signals from other vehicles) (for detailed information please s. Ref. [1]).

6. Fast Band Scanning Mode

In this mode the direction finder system scans the actual frequency band (defined by "Frequency Start" and "Frequency Stop" bytes in the transmitting interface data protocol) in order to detect a signal. The duration of one scanning cycle is approx. 3 seconds.

While the scan is running, the bearing is interrupted (for detailed information please s. Ref. [1]).

7. Bearing Test Mode (PS-RAM right rotation / only for RHOTHETA internal use)

The test modes are designed only for RHOTHETA internal use.

8. Bearing Test Mode (PS-RAM left rotation) / only for RHOTHETA internal use)

The test modes are designed only for RHOTHETA internal use.

9. Calibration for Bearing Mode (only for RHOTHETA internal use)

This mode is designed only for RHOTHETA internal use.

10. Fast Channel Scanning Mode (fast scanning of up to 8 frequencies)

The Fast Channel Scan enables the scanning of eight freely selectable frequencies across all supported bands in a very fast manner. The scan process lasts less than two seconds. All channels are scanned continuously. In Fast Channel Scan mode the Autosquelch is enabled automatically (for detailed information please see Ref. [1]).

11. AU Info & Auto Error Send Mode

The RT-600 Light always waits for an incoming data stream message from the Control Unit (Master). If there is no data available (timeout after 500 ms, or data inconsistent) then the Antenna Unit switches to auto send mode and sends automatically without request from Control Unit the auto send data protocol. In the moment of receiving valid data of the Control Unit this mode is disabled and the Antenna Unit operates in the standard mode (for detailed information please see Ref. [1]).

6.2 Squelch

The main challenge of operating a direction finder is trying to use only the signal transmitted by the target in order to calculate its bearing accurately, because noise and RF disturbances will cause misleading bearing indications.

In order to prevent the direction finder to calculate bearing results which are due to noise and disturbances, several techniques are available.

If a signal can be distinguished from noise or other signals by its message content (e.g. LoJack ID), only transmissions containing the required message content are used for bearing.

In other cases the squelch can be used to suppress unwanted weak signals and noise. A squelch level, called threshold has to be set by the user via the serial interface data protocol by setting the appropriate byte (for detailed information please see Ref. [1]). All signals with strength below this threshold value will be ignored, while signals with strength above this level will cause a bearing indication.

So for a signal to be usable for bearing calculation it has to be sufficiently stronger than noise or disturbing signals that the receiver can clearly distinguish between wanted and unwanted signals. As a result of the squelch technique the receiver sensitivity is reduced to the level set by the squelch threshold, decreasing the maximum distance or range to the transmitter.

However it might be desirable to obtain bearing information even for weak signals which are very close to the noise level. In this case it will be necessary to reduce the squelch level below the noise level. As soon as the modulation of a signal can be heard on the speaker, it can be expected that bearing calculation is possible.

If the noise is randomly distributed – as with “white noise” – and no other signal is received, the bearing indication will also be random. If the noise is not random but rather a specific disturbance, the bearing indication will point to the source of the noise.

If there is a very weak signal “buried” in the noise, this signal will produce a correct bearing indication thanks to sophisticated bearing technologies used in the RT-600 Light system. Fluctuations due to noise will be small even at low signal levels however the reaction time of the bearing indication can increase.

To verify if a bearing indication is due to white noise or to an internal disturbance source, or if it is due to a valid signal, the aircraft should make a slow turn. If the bearing indication is due to an external signal, e.g. a SAR beacon, the bearing indication should compensate the changed relative flight angle. Example: With a bearing indication of 30° the signal is hardly audible as it is buried in the noise. The airplane makes a turn left by 60°. If the bearing indication is not changing to approximately 30°+60° = 90° after a few seconds, the bearing is likely to be due to noise or internal disturbances from the aircraft.

Note

The weaker a signal is, the longer it will take to change the bearing. Durations around 5 seconds are not unfamiliar in such cases. Therefore, it is not useful to use this procedure for signals with short transmission times and low transmit duty cycles, such as COSPAS-SARSAT transmission. The procedure is best suited for ELT transmission with a continuous signal and still well-suited for ELTs with intermittent transmission (down to 33%).

In cases where the RT-600 Light checks signal validity autonomously and without useful possibilities of user interaction, user interaction is not possible and the squelch purely follows internal rules appropriate to the type of signal received. The appropriate setting "Autosquelch" can be done over the serial interface data protocol by setting the appropriate byte, which is described in the reference document (please s. Ref. [1]).

6.3 Frequency Band

Frequency bands availability depends on the system version (A, LE) and its wide band options (F1 to F4). These optional wide bands are available if ordered in addition to the default bands. Here is a listing of DEFAULT and OPTIONAL bands available with each version of the system.

RT-600 Light (STANDARD) Listing of bands:

Default bands available	
Band designation	Frequency limits
VHF Emergency Band:	118.000 ... 124.000 MHz
VHF Marine Band:	154.000 ... 163.000 MHz
UHF Emergency Band:	240.000 ... 246.000 MHz
COSPAS SARSAT:	400.000 ... 406.092 MHz
UHF FM Band:	406.100 ... 410.000 MHz

OPTIONAL extended bands available		
Option	Designation	Frequency limits
F1	VHF Air Band:	118.000 ... 136.992 MHz
F2	Extended VHF Marine:	137.000 ... 224.995 MHz
F3	UHF Air Band:	225.000 ... 399.975 MHz
F4	Additional UHF FM:	406.100 ... 470.000 MHz

RT-600 Light (Law Enforcement) Listing of bands:

Default bands available	
Band designation	Frequency limits
VHF Emergency Band:	118.000 ... 124.000 MHz
VHF Marine Band:	154.000 ... 163.000 MHz
LoJack:	164.000 ... 174.000 MHz
ETS:	216.000 ... 220.000 MHz
COSPAS SARSAT:	400.000 ... 406.092 MHz

OPTIONAL extended bands available		
Option	Designation	Frequency limits
F1	VHF Air Band:	118.000 ... 136.992 MHz
F2	Extended VHF Marine:	137.000 ... 163.000 MHz

6.4 Tracking in the 216 to 220 MHz band (only available with version LE)

The Version RT-600 Light LE features scanning and bearing functionality in the 216.000 MHz to 220.000 MHz band.

The 216.000 MHz – 220.000 MHz band contains frequencies and signals used by special services, and tracked by law enforcement, special ops, and similar organizations. These are some of the frequencies and services in this band:

- CFR 90.259 tx: 216.000 MHz to 220.000 MHz
- Low Power Radio Service (LPRS) tx: 216.000 MHz to 217.000 MHz
- Medical beacons, Project Lifesaver tx, wrist/ankle tx: 213.000 MHz to 216.000 MHz
- ETS tx, stolen cash/asset recovery tx, “bait”/“tag” tx: 216.000 MHz to 220.000 MHz

tx = transmitter(s)

Note

However any user of the RHOTHETA RT-600 Light must be aware that tracking signals on the frequencies listed above may be challenging and even frustrating, due mostly to negative factors in some of the transmitters:

- Very low RF power output,
- Inefficient antennas,
- Battery-powered devices with a “low battery” condition,
- Devices worn or located in conditions of poor RF propagation,
- Devices with channel spacing different than the one specified for the RT-600 Light.

These factors can make it very difficult for the direction finder to receive the signal and/or to display an accurate bearing.

Disclaimer:

For the reasons explained above, and even though the RT-600 Light features top performance in its class, RHOTHETA does not offer - and is not to be held responsible for - any guaranteed minimum range or distance to a transmitter in this band.

7 Technical Data

7.1 Electric features

Method of bearing:	Doppler-principle (3 kHz rotational frequency, right / left rotation)		
Bearing accuracy ¹ :	± 5° RMS		
Internal resolution:	1°		
Bearing Sensitivity:	VHF Air / Emergency Band:	≤ 6 μV/m	(4 μV/m typical)
	VHF Marine Band:	≤ 5 μV/m	(2.5 μV/m typical)
	UHF Emergency and ETS:	≤ 6 μV/m	(4 μV/m typical)
	COSPAS-SARSAT:	≤ 15 μV/m	(8 μV/m typical)
	LoJack Decoding (50 % Message Error Rate) and bearing:	≤ 5 μV/m	(2 μV/m typical)
Frequency stability:	± 2.0 ppm ($\Delta f/f = \pm 2 \cdot 10^{-6}$)		
Reception frequencies, SAR version (Standard):	VHF Emergency Band:	118.000 to 124.000 MHz	(8.33 kHz steps, AM)
	VHF Marine Band:	154.000 to 163.000 MHz	(5 kHz steps, FM)
	UHF Emergency Band:	240.000 to 246.000 MHz	(25 kHz steps, AM)
	UHF FM Band:	406.100 to 410.000 MHz	(5 kHz steps, FM)
	COSPAS-SARSAT:	400.000 to 406.092 MHz	(8.33 kHz steps, PSK) Including 406.022 to 406.076 MHz (Channel A .. S)
Frequency Options:	F1: VHF Air Band:	118.000 to 136.992 MHz	
	F2: extended VHF Marine Band:	137.000 to 224.995 MHz	
	F3: extended UHF Air Band:	225.000 to 399.975 MHz	
	F4: additional UHF FM Band:	406.100 to 470.000 MHz	
Reception frequencies, LAW Enforcement version:	VHF Emergency Band:	118.000 to 124.000 MHz	(8.33 kHz steps, AM)
	VHF Marine Band:	154.000 to 163.000 MHz	(5 kHz steps, FM)
	LoJack:	164.000 to 174.000 MHz	(12.5 kHz steps, AFSK)
	ETS:	216.000 to 220.000 MHz	(10/12.5 kHz, AM)
	COSPAS-SARSAT:	400.000 to 406.092 MHz	(8.33 kHz steps, PSK) Including 406.022 to 406.076 MHz (Channel A .. S)
Frequency Options:	F1: VHF Air Band:	118.000 to 136.992 MHz	
	F2: extended VHF Marine Band:	137.000 to 163.000 MHz	
COSPAS-SARSAT fast scan mode:	Full automatic detection of any active COSPAS-SARSAT channel A to S within 400 ms		
COSPAS-SARSAT decoding:	Reception and decoding of COSPAS-SARSAT data signal (data formats, according to specification COSPAS-SARSAT C/S T.001)		
LoJack decoding:	Choosing a LoJack transmitter by selecting the LoJack identification code		

¹With undisturbed wave field and sufficient field strength. Measuring by changing the angle of incidence, with the antenna rotating on a revolving table in order to eliminate environmental influences on the results. No modulation.

Direction Finder RHOTHETA RT-600 Light

Special scanning modes:	Complete maritime ship band scanning within 5 s
Bearable modulation:	AM / FM voice (A3E, F3E), ELT modulation (A3X), PSK, AFSK, FSK, ASK These types of modulation do not affect bearing quality.
Polarization:	Vertical
Polarization error :	$\leq 5^\circ$ at 60° field vector rotation
Cone of silence:	30° (additional bearing error $\leq 5^\circ$)
Response time ² :	≤ 50 ms
Operating voltage:	+10 V to 30 V DC
Power consumption:	At 12 V DC: Power consumption = 200mA / 2.4 Watt At 24 V DC: Power consumption = 100mA / 2.4 Watt
Audio Signal / Analog Test (Service) Line:	Max. output current = 50 mA Output Voltage Range max. [0 V DC ... +5V DC] to GND
Serial data interface:	Serial interface RS-485 (9600 baud, 8 data bits, 1 stop bit, no parity, LSB sent first)

² Measured with field strength ≥ 20 dB above sensitivity level. Signals below this level can increase the response time.

7.2 Interface

External connection (Amphenol Connector, 6-pol. Amphenol plug, female, PTG06SE10-6S(SQ))

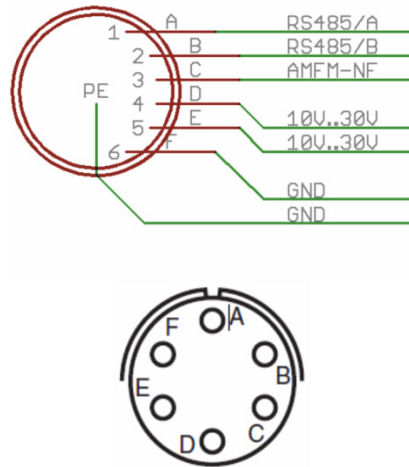


Fig 4) Connector Amphenol (PT07GS1)

RS-485 (9600 baud, 8 data bits, 1 stop bit, no parity, LSB sent first):

Pin A	RS 485 A / +	Serial data connection Antenna Unit to DCU or any other Control Unit. Max Voltage Range [0 V DC ... +5V DC]
Pin B	RS 485 B / -	- II -

Audio/LF:

Pin C	AMFM-NF	Audio signal / Analog Test (Service) line Max. output current = 50 mA Output Voltage Range max. [0 V DC ... +5V DC] to GND
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Power Supply:

Pin D	+10...+ 30 V DC	Power Supply for Antenna Unit
Pin E	+10...+ 30 V DC	-II-
Pin F	GND	-II-

7.3 Mechanical features

Temperature range:

- permissible operating temperature ³: -40 °C ... +60 °C
- permissible storage temperature: -55 °C ... +80 °C

Protective system:

IP 67

Weight:

ca. 1300 g

Dimensions:

Ø270 mm x 182,4 mm

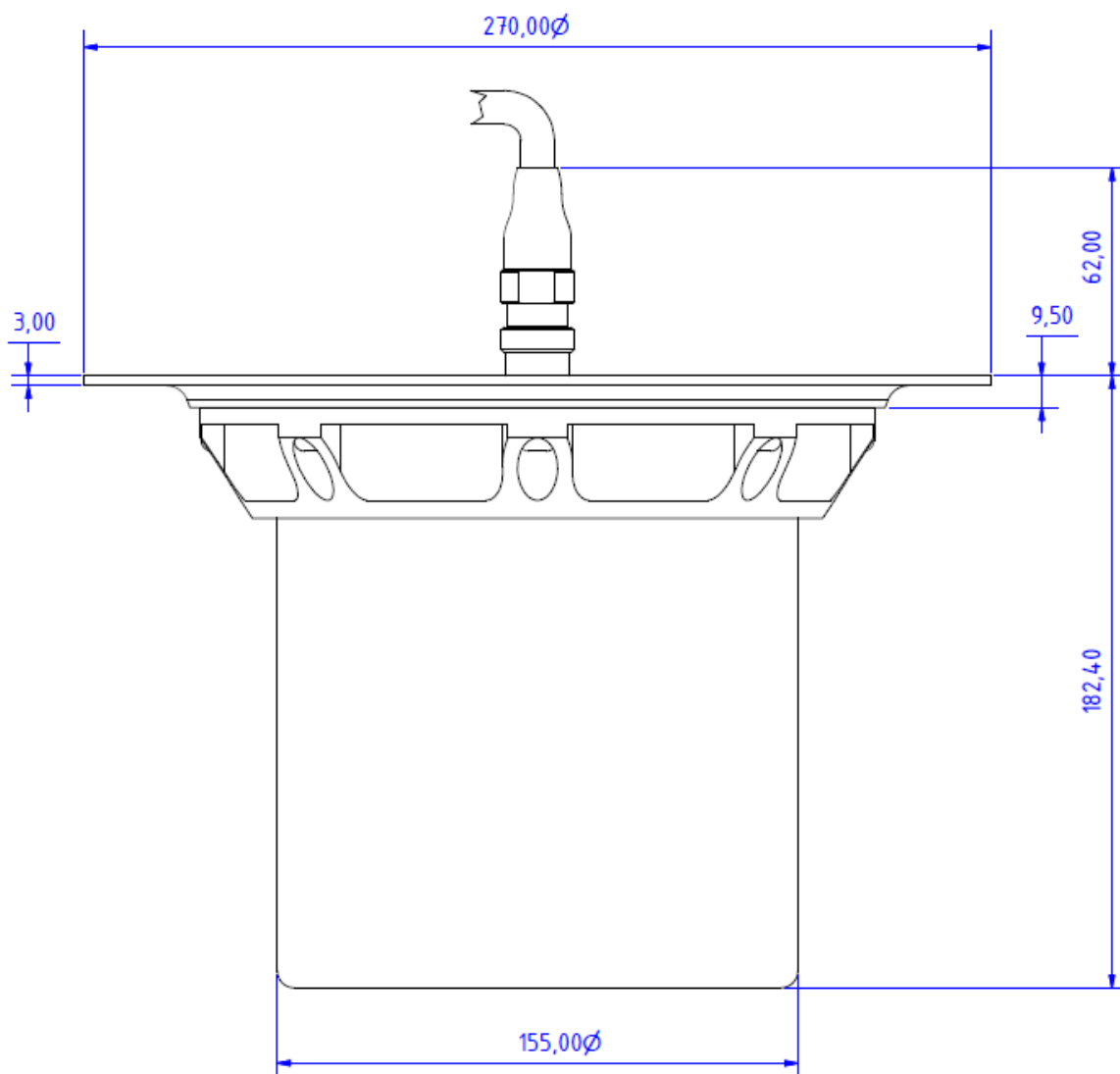


Fig 5) Mechanical Drawing (all dimensions in [mm])

³ For temperatures lower than -10° C a warm-up period of 15 min should be allowed

8 Legal Information

8.1 Legal Limitations of Use within the EU

Due to its conformance to "Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC", declared in the EU declaration of conformity, the equipment may be used within the European Union without limitations regarding the use of frequencies in those countries.

Please also consider national limitations or requirements for special operational permissions in your country.

8.2 EU Declaration of Conformity

Hereby, RHOTHETA Elektronik GmbH declares that the product RT-600 Light is in compliance with the essential requirements to be put on the market, and with other relevant provisions:

- Directive 2014/53/EU relating to radio equipment
- Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment

A copy of the EU declaration of conformity is available at <http://www.rhotheta.com/>

8.3 Disposal within the European Union

Product Recycling



Product labeling in accordance with EN 50419

At the end of the life of the product, this product may not be disposed of with normal household waste. Even disposal via the municipal collection points for electrical and electronic equipment is not allowed.

The correct disposal of this product will help to conserve resources and prevent potential negative effects on the environment and human health which may occur due to improper handling of the product.

- Therefore, carry out the inoperative device, an electronics recycling.
or
- The RHOTHETA Elektronik GmbH takes back all its products, subject to redemption, in accordance with the requirements of the WEEE Directive (2012/19/EU) of the European Union to deliver it to a professional disposal.

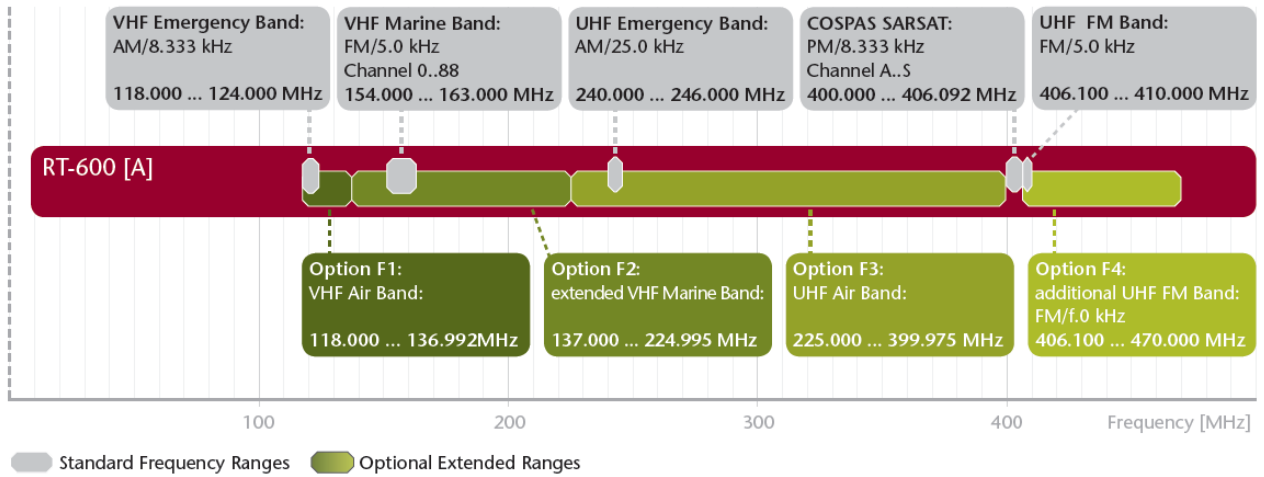
8.4 Disposal outside the European Union

For proper disposal of used electronic equipment in accordance with the respective national regulations in countries outside the European Union please check it with your dealer or the local authorities.

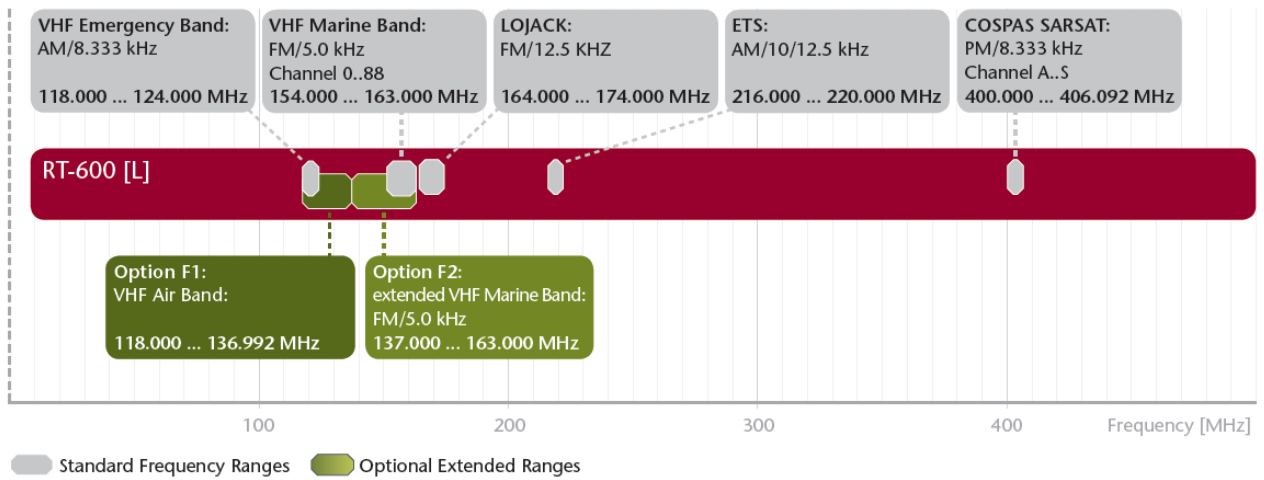
9 Appendix

9.1 Frequency Ranges

SAR version (Standard)



LAW Enforcement version



9.2 Frequencies of channels on maritime band

(only for standard [A] version)

Frequency-range of the RT-600 Light in the maritime band: 156.000 MHz ... 162.025 MHz

Channel No.	frequency (ship - station)	Frequency (coast - station)
1	156,050 MHz	160,650 MHz
2	156,100 MHz	160,700 MHz
3	156,150 MHz	160,750 MHz
4	156,200 MHz	160,800 MHz
5	156,250 MHz	160,850 MHz
6	156,300 MHz	160,900 MHz
7	156,350 MHz	160,950 MHz
8		156,400 MHz
9		156,450 MHz
10		156,500 MHz
11		156,550 MHz
12		156,600 MHz
13		156,650 MHz
14		156,700 MHz
15		156,750 MHz
16		156,800 MHz
17		156,850 MHz
18	156,900 MHz	161,500 MHz
19	156,950 MHz	161,550 MHz
20	157,000 MHz	161,600 MHz
21	157,050 MHz	161,650 MHz
22	157,100 MHz	161,700 MHz
23	157,150 MHz	161,750 MHz
24	157,200 MHz	161,800 MHz
25	157,250 MHz	161,850 MHz
26	157,300 MHz	161,900 MHz
27	157,350 MHz	161,950 MHz
28	157,400 MHz	162,000 MHz
60	156,025 MHz	160,625 MHz
61	156,075 MHz	160,675 MHz
62	156,125 MHz	160,725 MHz
63	156,175 MHz	160,775 MHz
64	156,225 MHz	160,825 MHz
65	156,275 MHz	160,875 MHz
66	156,325 MHz	160,925 MHz
67		156,375 MHz
68		156,425 MHz
69		156,475 MHz
70		156,525 MHz
71		156,575 MHz
72		156,625 MHz
73		156,675 MHz
74		156,725 MHz
75		156,775 MHz
76		156,825 MHz
77		156,875 MHz
78	156,925 MHz	161,525 MHz
79	156,975 MHz	161,575 MHz
80	157,025 MHz	161,625 MHz
81	157,075 MHz	161,675 MHz
82	157,125 MHz	161,725 MHz
83	157,175 MHz	161,775 MHz
84	157,225 MHz	161,825 MHz
85	157,275 MHz	161,875 MHz
86	157,325 MHz	161,925 MHz
87	157,375 MHz	161,975 MHz
88	157,425 MHz	162,025 MHz

10 Notes