Lacuna space

LS300 Sensor and Relay

Wireless satellite terminal with integrated multi-band circularly polarized antenna system

DESCRIPTION

The LS300 Sensor and Relay has been designed for direct communication with the Lacuna satellite network. The terminal is battery powered and is based around a dual-core ARM M4/M0+ processor. The terminal contains a number of sensors, a GNSS receiver and has an integrated Right Hand Circularly Polarized (RHCP) satellite antenna, providing a 110° wide beam. The terminal should be used outdoors and is contained in a protective enclosure.

The terminal communicates with the satellite network in both SRD/ISM-Band as well as in the S-Band. It can be ordered in two different SRD/ISM frequency band configurations: 862-870 MHz or 902-928 MHz. The S-Band antenna is tuned to 1980-2200 MHz (1980-2010 MHz uplink, 2170-2200 MHz downlink) for both configurations.

APPLICATIONS

The primary applications of the terminal are direct communication of (internal) sensor data to the satellite network and relay of data received from third party LoRaWAN® compatible sensors or devices.

As such the device is ideally suited for getting acquainted with the services offered by the Lacuna satellite network. The device may also be used as a reference design for third parties wishing to develop their custom designs.

LS300 SENSOR AND RELAY

FEATURES

- 862-870 MHz or 902-928 MHz RHCP antenna
- MSS S-band RHCP antenna
- GNSS RHCP antenna
- 84 x 84 x 20 (mm) without casing
- 94 x 94 x 45 (mm) with casing

APPLICATIONS

- Satellite communication
- Low power wireless relay
- LPWAN device

TECHNICAL SUPPORT

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support@lacuna.space

Part numbers

LS300-XXX-A
Where:
-XXX refers to frequency option: 868 for 862-870 MHz, 915 for 902-928 MHz
Warning: The use of certified protected batteries is mandatory

Part Number	Freq (MHz)	Battery holder
LS300-868-A	868	3 x AA alkaline battery holder
LS300-915-A	915	3 x AA alkaline battery holder

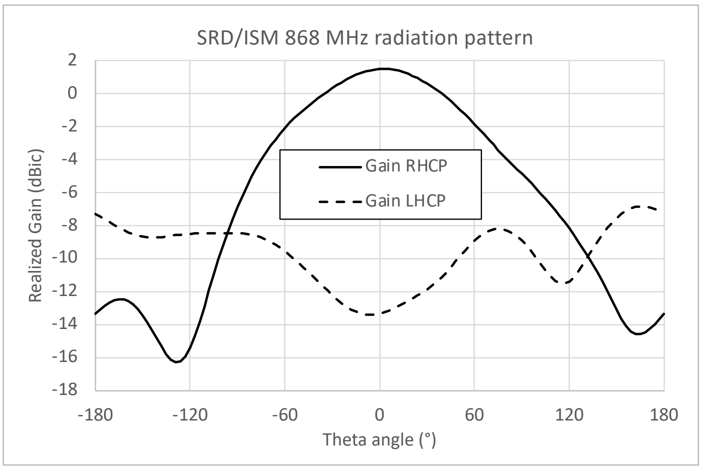
General Data

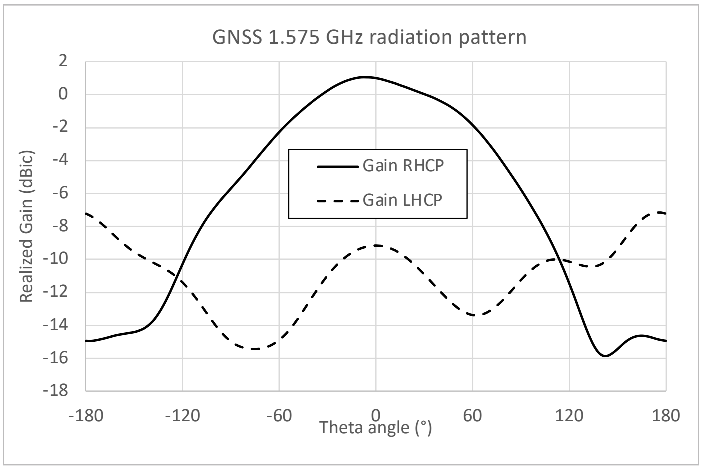
Parameter	Value	Comments
Operating temperature	-20°C to 55°C	
Characteristic Impedance	50 ohm	
Weight	215 gram	Including casing, excluding batteries
Dimensions (Board)	84*84*20 (mm)	Battery holder not considered
Dimensions (Casing)	94*94*45 (mm)	Includes casing and battery holder
Battery	3 AA alkaline	
Mounting holes	M3	

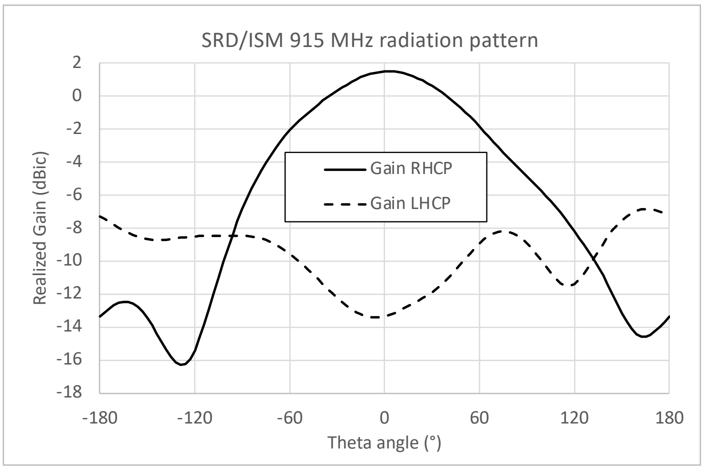
RF Characteristics

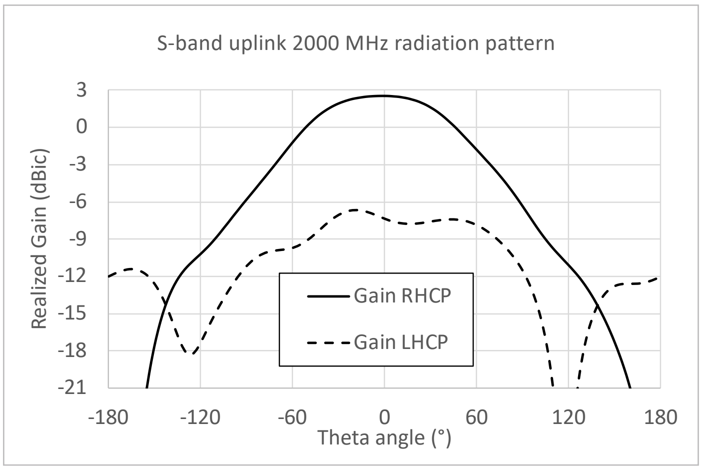
Parameter	868/915 band*		GNSS	S-Band	
Frequency Range (MHz)	862-870	902-928	1500-1700	1950-2250	
Typical Frequency (MHz)	870	915	1575	2000 (up)	2180 (down)
Peak Total Gain (dBi)**	1.69	1.75	1.31	2.68	2.78
Peak RHCP Gain (dBic)**	1.49	1.62	0.99	2.51	1.53
Average Gain (dBi)**	-2.3	-2.2	-2.74	-1.77	-2.85
Total Efficiency (max)	49%	50%	37%	46%	45%
Axial Ratio (dB)	< 6	< 6	< 6	< 6	< 6
Reflection coefficient (dB)	< -10	< -10	< -6	< -6	< -6
Peak EIRP (dBm)***	23.69	23.75	N/A	26.51	N/A

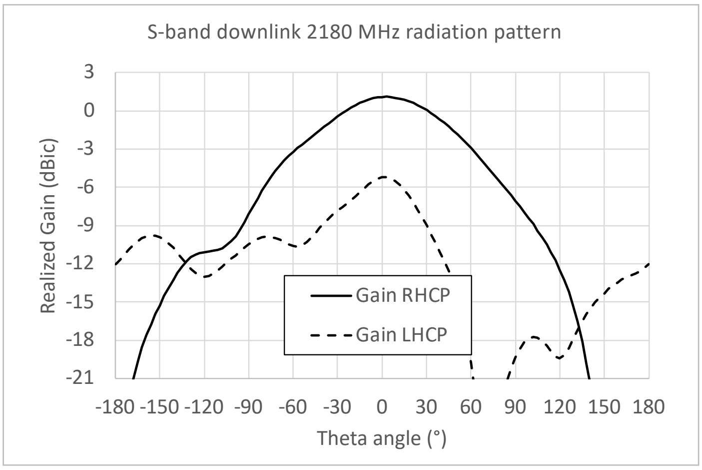
* Model variant 868: LS300-868-A, Model variant 915: LS300-915-A
** Values for "Typical Frequency"
*** Hardware maximum. Transmissions will be limited in software according to regional regulations.

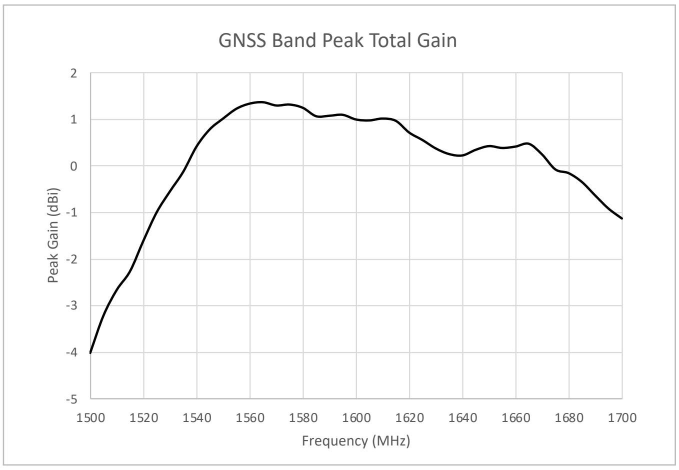


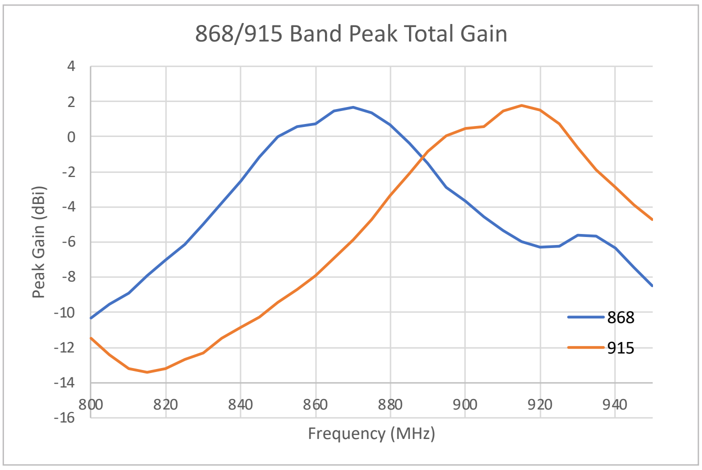


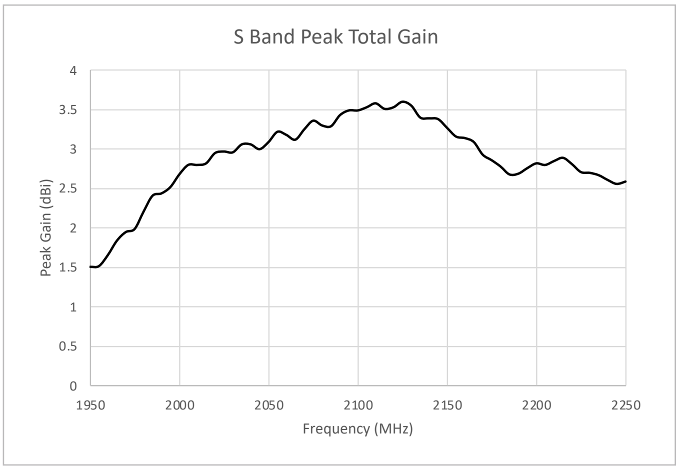












* Depending on model variant (LS300-868-A or LS300-915-A)

Main components

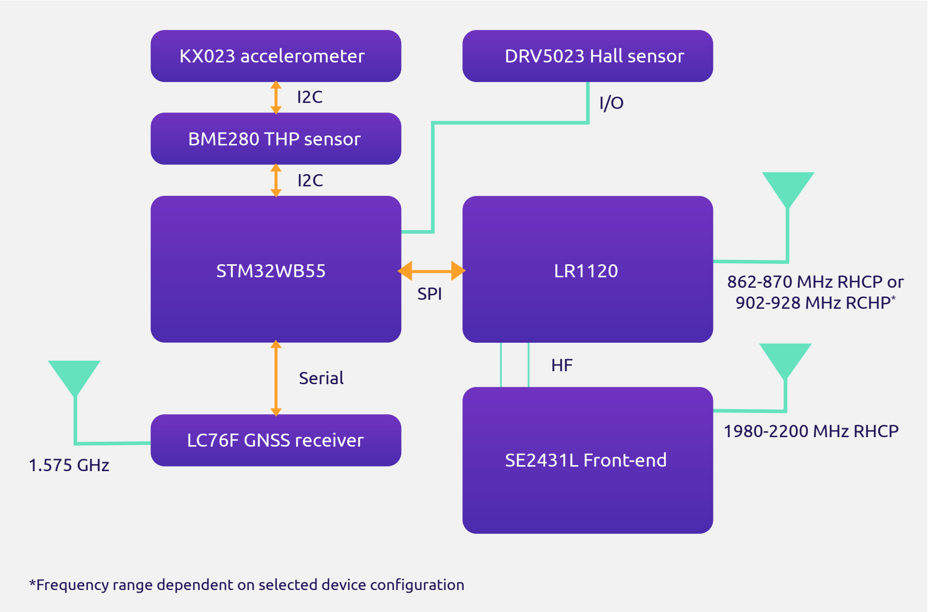
Traditional satellite terminal solutions often are comprised of several macro components, e.g. power supply, modem, amplifiers, splitters, antennas, that are interconnected with coaxial cables. With the LS300 Sensor and Relay terminal all these components are integrated onto a single printed circuit board resulting in a much smaller and power efficient device. All components listed in the table below are surface-mounted, integrated chips that cannot be removed or replaced without damage to the electronics board. The components cannot be used as stand-alone modules.

Description	MPN	Manufacturer
Ultra-low-power dual core Arm Cortex-M4 MCU 64 MHz, Cortex-M0+ 32 MHz with 512 Kbytes of Flash memory, Bluetooth LE 5.2, 802.15.4, Zigbee, Thread, USB, LCD, AES-256	STM32WB55RE	STMicroelectronics
LR1120 Low Power Wi-Fi/ GNSS Scanner + LoRa® Transceiver	LR1120	Semtech
S-band Front-end Module	SE2431L-R	Skyworks
Quectel LC76F Compact GNSS Module, concurrent reception of GPS, GLONASS, BeiDou and QZSS	LC76F	Quectel
Tri-axis digital accelerometer sensor ± 2g / 4g / 8g	KX023-1025-FR	Kionix
Digital humidity, pressure and temperature sensor -40...+85C, 0...100% RH, 300...1100 hPa	BME280	Bosch Sensortec
Digital-switch hall effect sensor 6.9 / 3.2 mT	DRV5023AJQLPGM	Texas Instruments
Fully Integrated Li-Ion, Li-Polymer Charge Management Controller	MCP73831T-2ATI/OT	Microchip Technology

Block diagram

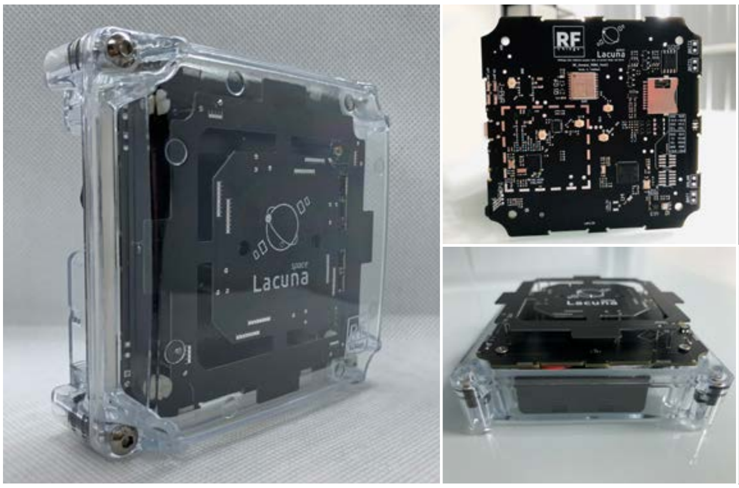
The block diagram below shows how the main components are interconnected on the printed circuit board. All antennas are integral part of the LS300 Sensor and Relay device and cannot be removed or replaced. The elements of the RF chain are included in the circuitry as follows:

- 862-870 MHz/ 902-928 MHz RCHP: All elements integrated in LR1120 chip
- 1980-2200 MHz RHCP: All elements integrated in LR1120 chip except PA/LNA, which are integrated in SE2431L front end
- 1.575 GHz GNSS: All elements integrated in LC76F chip

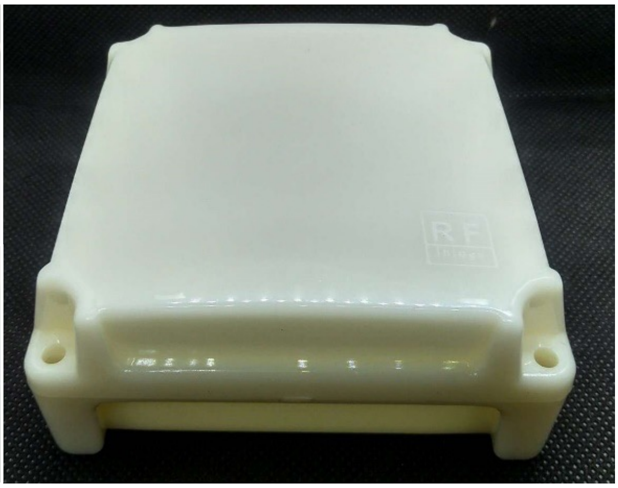


*Frequency range dependent on selected device configuration

Terminal dimensions



Casing



The casing includes a vent on the bottom. The vent can be replaced by a cable gland to connect external sensors. The top cover is fixed to the bottom part using M3 screws. The casing is made from white ABS material.

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For contact and product information, visit https://lacuna.space

About Lacuna Space

Low-cost, simple and reliable global connections to sensors and mobile equipment. It just works everywhere, and all the time, so you can focus on using your data.

LS300 Sensor and Relay

User Manual

Version 1.2 21.02.2023

Contents

1 LS300 Sensor and Relay

1.1 Introduction

The LS300 Sensor and Relay is intended to give users hands-on experience with the Lacuna satellite network. The device supports several different operational modes allowing it to be used as a stand-alone satellite terminal or as a satellite relay. In relay mode the device forwards data received from standard LoRaWAN® sensors to the Lacuna satellite network.

The device can also be used as a reference design for device manufacturers to create or adapt their own hardware and software for operation with the Lacuna satellite network.

Lacuna encourages vendors and end users to build their own sensor hardware and software. It is however recommended to first get started with the LS300 Sensor and Relay and the standard operational modes provided. This will help accelerate through initial proof-of-concept trials, familiarizing the user with the specifics of the Lacuna space network and give a good start for further exploration.

1.2 Description

The LS300 Sensor and Relay is shown below and is built around a STM32WB55 MCU and a Semtech LoRa Edge™ LR1120 transceiver. For S-Band communications, a dedicated frontend (Skyworks SE2431L-R) is included. The device is battery powered and can run autonomously for prolonged periods. Battery lifetime is dependent on the configuration and transmission intervals.

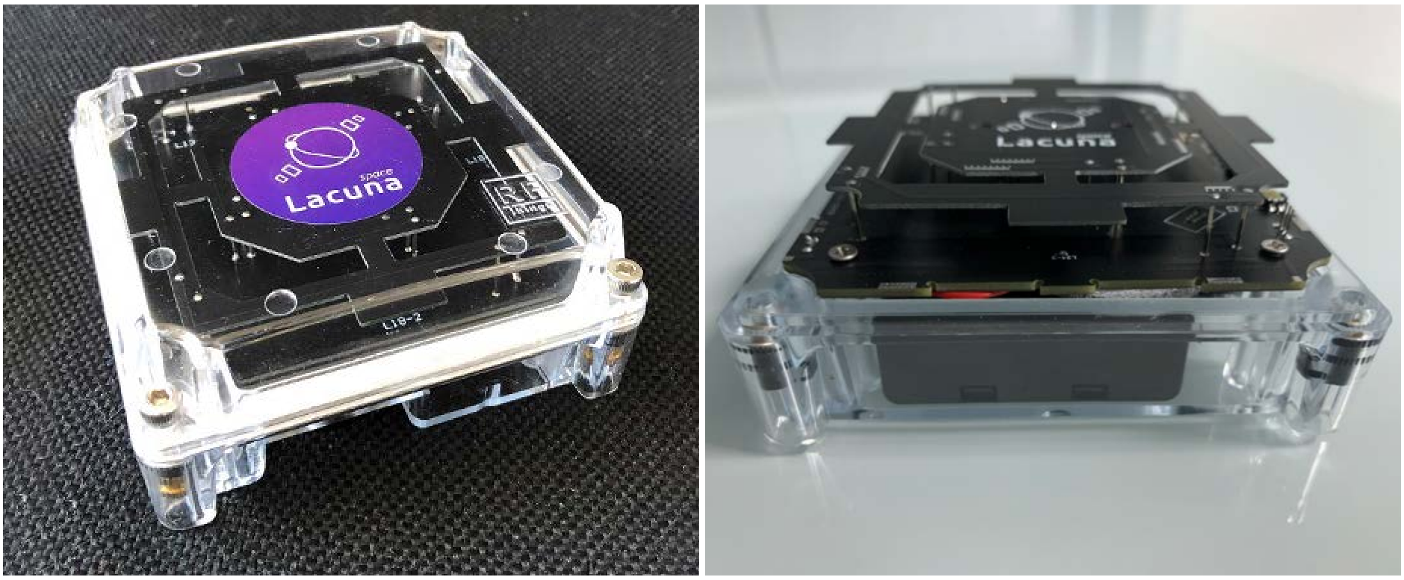

Figure 1: LS300 Sensor and Relay (transparent case for better insight; shipped case is white)

The device contains the following sensors and peripherals:

- GNSS module (Quectel LC76F)
- Tri-axis accelerometer (Kionix KX023-1025-FR)
- Combined pressure, temperature and humidity sensor (Bosch Sensortec BME280)
- Hall-effect sensor (Texas Instruments DRV5023AJ)

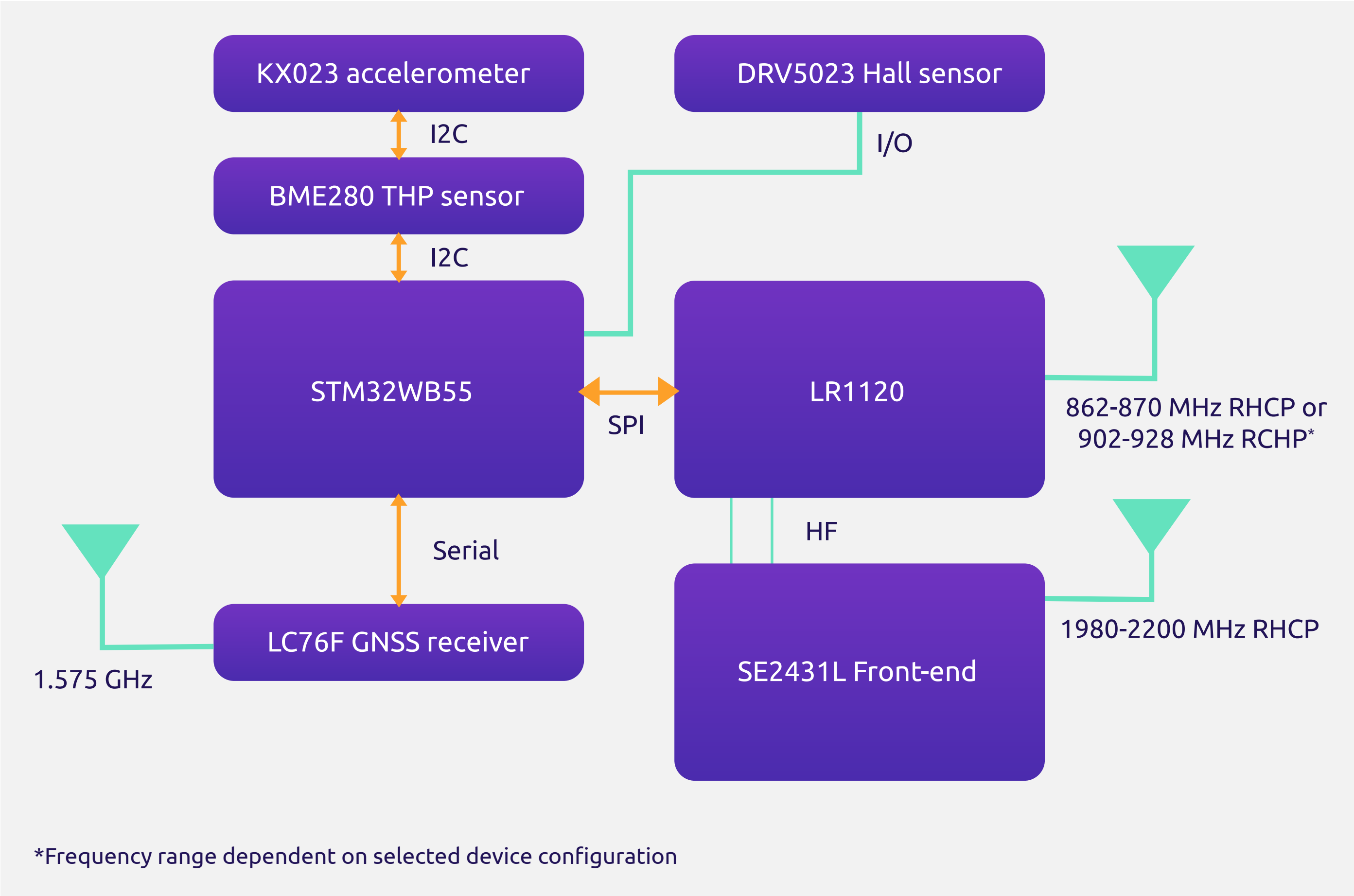

Figure 2: LS300 block diagram

1.3 LS300 operational modes

The main operational modes of the LS300 Sensor and Relay are:

1. Sensor
2. Relay
3. Program

In both sensor and relay modes the device runs the pre-installed Lacuna software. The pre-installed software enables the user to configure the device through a USB cable and serial console software.

In sensor mode the device runs standalone. It automatically makes contact with the Lacuna satellite network and transmits the values of its internal sensors. The user can configure parameters including region, LoRaWAN® security keys, transmission interval and which sensor data is to be transmitted. The user can also query the device for information such as the next available satellite pass and the date and time of the last transmission.

In relay mode the device operates as a receiver for compatible 3rd party LoRaWAN® sensors, stores the data and transmits the data to the Lacuna satellite network at the first opportunity. The user can configure parameters including receive interval, device IDs of the 3rd party sensors, and the priority rules for forwarding from multiple sensors. The relay mode is very convenient for operating the device in remote regions where no terrestrial network coverage is available or to assist with deep indoor or below ground penetration.

The program mode is intended for developers wishing to extend the device functionality. Lacuna Space provides a standard software library abstracting all specifics of the Lacuna satellite network operation including calculation of the next available satellite pass and configuration of the radio front-end for satellite transmission. The standard software library ensures that the device always operates within the limits for the region that is configured by the user.

Regardless of the operational mode, upon first use the device must be configured by the user for operation in a specific region. If the device is not configured for a specific region radio transmissions are disabled. The information on regional specifications, e.g. available frequency band, maximum transmit power, duty cycle and dwell time (where applicable) is included in the Lacuna supplied software.

NOTE: certification is only valid for sensor and relay modes with Lacuna supplied software. In program mode it is the responsibility of the developer to use the Lacuna supplied software library to ensure operation within local regulatory limits. Using program mode may require re-certification of the device.

1.4 LS300 setup and installation

Before the first use, batteries must be inserted into the device. This can be done by opening the casing with the supplied Allen key. Three standard AA Alkaline batteries should be used. Please check the correct polarity when inserting the batteries.

After the batteries are placed the device should be configured by using the supplied a USB cable. Details on how to configure the device through a serial console can be found here: https://lacuna.space/LS300

After the device is configured the casing can be closed again. Make sure the gaskets fit snugly when screwing the case shut, to prevent any moisture from entering the case. The device should now be placed outside, preferably at an elevated surface at least 15 cm above the ground (or roof). The device should have a clear line of sight to the sky and no obstructions should be nearby (in a cone of 45 degrees around the device). The device should now automatically start making contact with the Lacuna Satellite network. The interval of transmissions is dependant on the exact configuration of the device and network coverage in the region of use.

Please note that the Hall-effect sensor might give inaccurate readings when it is used near strong magnetic fields/ mains lines.

2 Lacuna system overview

2.1 Introduction

This chapter describes the key concepts of the operation of the Lacuna satellite network. This will help improve understanding of the key opportunities and applications of the technology. As mentioned before, the provided software (libraries) and tools will abstract most of the specifics of using satellite communications.

2.2 Satellite network

The Lacuna satellite network makes use of both Low Earth Orbit (LEO) satellites as well as Medium Earth Orbit (MEO) satellites. The LEO satellites operate at an altitude of 500-550 km above the surface of the Earth in an orbit that runs (nearly) over the North and South poles (polar orbit). Some satellites might orbit at lower inclinations, offering shorter revisit times for lower latitudes. The LEO satellites operate in the SRD/ISM band (862-870 MHz or 902-928 MHz depending on the region). Each LEO satellite orbits the Earth in about 100 minutes which equates to about 15 orbits per day. As the Earth rotates beneath the orbits of the satellites, the antenna beam eventually scans the whole of the globe's surface. A given location would be in contact with each satellite 1-2 times per day with a contact window of 2-4 minutes for each pass.

MEO satellites operate at approximately 10,000 km altitude, resulting in a slower orbit rate of 3-4 orbits per day, inclined by 45 degrees so that a given location would be in contact with the satellites 2 times a day with an extended contact window of up to 2 hours for each pass. Each satellite has 163 spot beams covering around 17% of the Earth at any time. The MEO satellites operate in the MSS S-Band frequency range (1980-2010 MHz uplink, 2170-2200 MHz downlink).

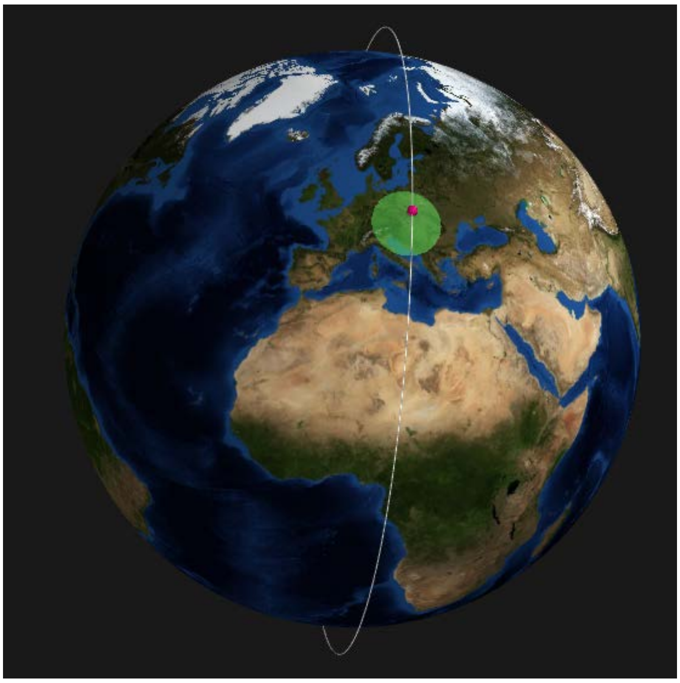
Figure 3: Example of a polar orbit

Although the revisit times and the frequencies used by the LEO and the MEO satellites differ, the same modulation and low-power chipset are used for communication. The end user does not have to be aware which satellite is used in which region, the LS300 Sensor and Relay abstracts all communications with the network. The embedded application sends a message which is automatically forwarded to the satellite network at the earliest opportunity, regardless of the type of satellite.

2.3 Principle of operation

A simplified diagram of the principle of operation is shown in figure 4.

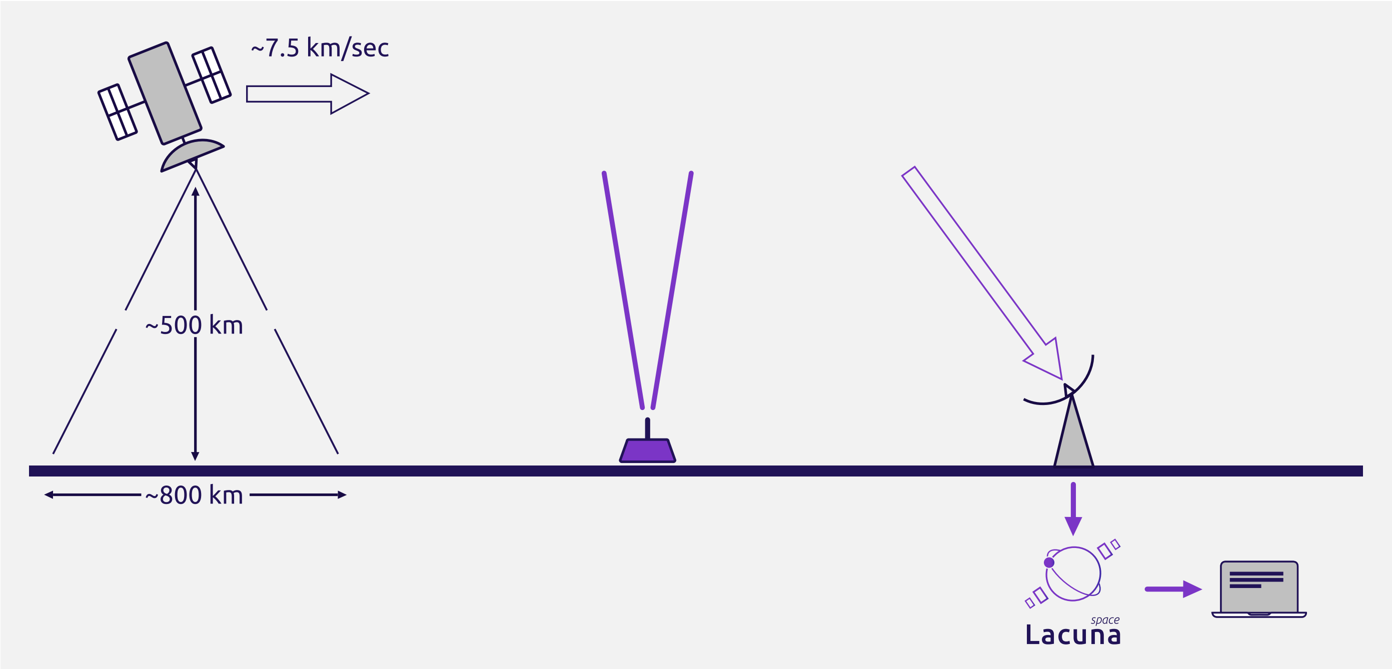

Figure 4: Principle of operation (LEO satellite case)

In the figure the LEO satellite travels from left to right with a speed of about 7.5 km per second. At a certain time, the sensor device (purple box) will be inside the footprint of the satellite, creating a contact window. As soon as this is the case the device can start its transmission. When the satellite receives the data sent from the device, it temporarily stores the data and the satellite continues in its orbit. MEO satellites operate at higher altitude with a slower orbit rate and wider beam footprint, but the working principle is the same.

When the satellite subsequently passes a ground station, the satellite then downloads the stored data to the ground station, which in turn forwards it to the Lacuna router hub, and then to the customer's account in a LoRa Network Server (LNS). All data transmitted by the device nodes is encrypted end-to-end, this means that neither Lacuna Space nor any party in the chain is able to decode the contents of what is transmitted. Only the end user can decode the data.

The latency between the transmission of data from the sensor device and reception at the customer's server account is determined by the relative position of the sensor device in relation to the ground station(s) as well as the type of satellite in view (LEO or MEO). The further the satellite must travel before it passes a ground station, the higher the latency will be. In specific regions a MEO satellite may be in view of both the sensor device and a ground station, providing a real-time (zero latency) connection.

The device nodes are only allowed to transmit with very limited power in the frequency bands used. The LS300 Sensor and Relay is fitted with a polarized antenna with upwards directional gain. This design gives the device optimum performance even at very low elevation angles (down to 20 degrees). It is up to the user to further optimize the conditions by optimal placement of the device. For example, a device can best be placed at least 15 cm from the ground in a position free from nearby obstructions (e.g. tree canopy), with a clear line of sight to the sky.

3 Compliance

3.1 FCC compliance

FCC ID: 2A8AP-LS300

This device complies with FCC 47 CFR Part 15 regulations for radio devices.

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.

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

The device 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.

The device must not be co-located or operating in conjunction with any other antenna or transmitter.

This statement is based on the FCC regulations in effect on Feb 8th 2023. The manufacturer assumes no responsibility for any errors or omissions in this statement. The user shall not make any changes or modifications to the device unless authorized by the manufacturer. Unauthorized changes or modifications could void the user's authority to operate the device.

3.2 ISED compliance

IC No: 28900-LS300
HVIN: LS300-915-A

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) this device may not cause interference, and

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

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20 cm from all persons.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radioexempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Afin de se conformer aux exigences d'exposition RF, cet appareil doit être installé pour fournir au moins 20 cm de séparation du corps humain en tout temps.

3.3 Anatel compliance

This equipment is not entitled to protection against harmful interference and may not cause interference with authorized systems. For more information, consult the ANATEL website: www.anatel.gov.br.

Este equipamento não tem direito à proteção contra interferência prejudicial e não pode causar interferência em sistemas devidamente autorizados. Para maiores informações, consulte o site da ANATEL: www.anatel.gov.br.

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