

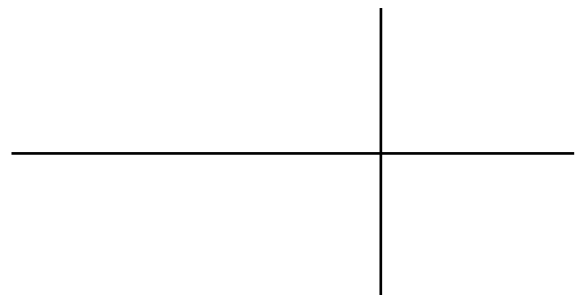
Airgain Inc.



Lighthouse™

Smart Network Controlled Repeater

User Manual



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Federal Communication Commission Interference Statement

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 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.

FCC Caution: To assure continued compliance, any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. (Example - use only shielded interface cables when connecting to computer or peripheral devices).

FCC Radiation Exposure Statement

To comply with FCC RF exposure compliance requirement, adhere to the following warnings:

Warning! Antennas used for this product must be fixed mounted on indoor permanent structures, providing a separation distance of at least 35 and above cm from all persons during normal operation. Warning! Each individual antenna used for this transmitter must be installed to provide a minimum separation distance of 35 cm or more from all persons and must not be co-located with any other antenna for meeting RF exposure requirements. Warning! The design of the antenna installation needs to be implemented in such a way to ensure RF radiation safety levels and non-environmental pollution during operation.

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.

WARNING: This is NOT a CONSUMER device, It is designed for installation by **FCC LICENSEES** and **QUALIFIED INSTALLERS**. You **MUST** have an **FCC LICENSE**, or express consent of an FCC Licensee to operate this device. Unauthorized use may result in significant forfeiture penalties, including penalties in excess of \$100,000 for each continuing violation.

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Preface

Audience

This document is written for Airgain authorized customer service personnel and authorized system integrators who install, configure, commission, and maintain the repeater system in a cellular network.

Scope

This manual provides guidance to support customer engineering practices, site standards, and relevant safety regulations when installing and configuring the Airgain Lighthouse™ repeater to enhance communication quality. It is intended to complement existing site engineering design documents. If any instructions conflict, don't hesitate to get in touch with the Airgain Customer Service Department for assistance.

How this manual is organized

Chapter 1	Safety precautions and general warranty information
Chapter 2	Repeater system introduction and its applications
Chapter 3	Overview of the installation process
Chapter 4	Examples and Calculations Providing Commissioning Suggestions
Chapter 5	Steps to take and check for repeater problems
Chapter 6	Appendix

Text Conventions

This manual uses symbols to call attention to important information to the reader.



Note: Presents nonessential but potentially helpful information that helps to understand a topic.



Important: Presents information to avoid an undesirable result.



Warning: Notifies the reader of a potentially hazardous situation that could damage the repeater.

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1 General

This user's manual provides information on installing, configuring, operating, and maintaining the repeater. Specifications are also detailed to help users better understand the repeater's performance.

Please read this user's manual carefully and follow all instructions to ensure the unit's long life span and trouble-free operation.

1.1 Safety Information

- **Personnel Safety**

The entire manual should be read and understood before installing or replacing any repeater equipment. Operators need to supply appropriate power to the repeater. Incorrect power settings can damage the repeater and may cause electrical-related injury to the user.



It is recommended that gloves be worn at ALL times when handling the product.

DO NOT operate equipment in an explosive environment.

DO NOT open the Lighthouse enclosure for any reason: cell site technical and operating personnel are not authorized to remove equipment covers. Only personnel authorized by Airgain may remove equipment covers to replace components or perform internal repairs.

- **Equipment Safety**

Before installing, replacing, or using this product, it is necessary to read and understand the manual and follow all safety precautions during operation. Failure to comply with the following general safety precautions and specific precautions described elsewhere in this manual violates the safety standards of this product's design, manufacture, and intended use.

The aluminum alloy heatsink on the enclosure is an excellent heat conductor. Therefore, during normal operation, the unit may feel warm or hot (depending on ambient conditions).



Do not touch the heatsink without heat-protective gloves and appropriate safety equipment.

- **Electrostatic Sensitivity**

ESD: Electrostatic Sensitive Devices

Electrostatic discharge may damage the active components used in this product. When unpacking or handling the repeater, follow preventive procedures, including using grounded wrist straps, grounded workbench surfaces, and grounded floor mats.

- **Proper Grounding**

To avoid a power supply spark, please ground the connection of the equipment racks, chassis, and appropriate tools. Ensure the equipment's power cable is inserted into the proper main sockets (three-pin).



The third pin must be used for a grounding connection for a three-pin socket.

Directly connect the supplied power cable to the main socket. In the case of a two-pin socket, the green grounding wire provided with the package needs to be connected to the electrical grounding facility at the power outlet.

To avoid equipment damage or human injury caused by lightning, static electricity, and other phenomena of leakage electricity, Airgain suggests that all products undergo the electric discharge of the electrical grounding in the setup process. Power supply components must meet international electro-technical commissioning safety standards.

1.2 Other Precautions

- Only authorized personnel should install, operate, and maintain the repeater.
- Ensure the power is switched off when installing or disassembling the repeater's cables to avoid short circuits or electrical shocks that may result in personal injury or damage to the equipment.
- The repeater supports mains power for AC 100~240V, 50/60Hz. This power range must be followed to avoid any damage to the equipment.
- ⚠WARNING: This product can expose you to chemicals which are known to the state of California to cause cancer, birth defects, or other reproductive harm For more information, go to www.P65Warnings.ca.gov.
- If using an external outdoor antenna for the repeater, an RF coaxial lightning surge protector (also known as a lightning arrestor or suppressor) is recommended to connect to each of the repeater's RF ports.
- Please ensure that the warning indicators on the enclosure are visible to detect alarming conditions quickly.
- ⚠WARNING: This product can expose you to chemicals which are known to the state of California to cause cancer, birth defects, or other reproductive harm For more information, go to www.P65Warnings.ca.gov.

2 Introduction to Lighthouse Smart Repeaters

2.1 Background

RF repeaters are electronic devices that amplify and retransmit radio frequency signals, extending the coverage and improving signal quality in wireless communication systems. They receive weak signals from a source, amplify them, and then transmit the boosted signals to areas with poor reception. RF repeaters are widely used in various applications, including cellular networks to enhance coverage in urban and rural areas, in-building solutions (IBS) to improve indoor signal strength, and public safety communication systems for reliable emergency response. They are also crucial in point-to-point and point-to-multi-point communication networks, ensuring stable connectivity in next-generation 5G deployments.

Airgain's Lighthouse Smart Network Controlled Repeater (NCR) is engineered to enhance 5G network coverage by amplifying signals within specific frequency bands (see datasheet of the chosen Lighthouse model for specific band information). This outdoor/indoor repeater offers a flexible design with unique smart features, including an optional built-in smart donor antenna with beam-switching capability to ease installation. It supports up to 200 MHz instantaneous bandwidth with different carrier aggregation and MIMO options, providing robust and reliable coverage for 5G networks.

2.2 Basic Repeater System Components

- ***RF Splitter/Combiner***

An RF splitter/combiner is a passive device used in radio frequency systems to either split an input signal into multiple outputs or combine multiple signals into a single output. It ensures minimal signal loss and impedance matching to maintain efficient transmission. RF splitters distribute signals to multiple antennas or devices in communication networks, such as in in-building systems (IBS) coverage. On the other hand, RF combiners merge signals from multiple sources, such as in multi-carrier transmission systems or antenna diversity setups. These components are crucial in cellular, broadcast, satellite, and test & measurement applications, optimizing signal distribution and network performance.

- ***RF Couplers***

An RF coupler is a passive device used in radio frequency systems to sample a portion of a signal without significantly disturbing its transmission. RF couplers are crucial in splitting and directing signals to different antennas while maintaining controlled power levels. They help distribute RF signals efficiently across large buildings, tunnels, and stadiums, ensuring seamless coverage and minimizing signal loss. Directional couplers are commonly used to enable precise signal

monitoring, power balancing, and interference control, optimizing network performance for cellular and public safety communications. Their ability to manage signal distribution makes them essential components in IBS deployments.

- ***RF Diplexer***

An RF diplexer is a passive device that allows two different frequency bands to share a common antenna or transmission line (RF coax cable) while preventing interference between them. It consists of two filters that separate or combine signals operating at distinct frequencies, ensuring efficient frequency isolation. Diplexers are widely used in wireless communication systems, i.e., combining 4G and 5G signals in IBS, and enabling multi-band transmission. Diplexers enhance system performance and network efficiency by optimizing spectrum utilization and reducing the need for additional antennas.

- ***Antenna***

Donor Unit (DU) Antenna

A donor unit antenna (or DU) in a repeater system is a crucial component that receives signals from the base station and transmits them to the repeater for amplification and redistribution. Typically installed in an optimal outdoor location with a clear line of sight to the cell tower, the donor antenna ensures strong signal reception, minimizing noise and interference. Directional donor antennas, such as Yagi, log-periodic array, panel array antenna, or parabolic dishes, are commonly used to focus signal reception from a specific base station, improving signal strength and overall system performance.

Service Unit (SU) Antenna

A service unit antenna (or SU) in a repeater system distributes the amplified signal to the target coverage area, such as inside buildings, tunnels, or remote locations. It receives the boosted signal from the repeater and transmits it to users, ensuring improved signal strength and network coverage. Service antennas come in various types, including omnidirectional antennas for broad coverage and panel or ceiling-mounted antennas for targeted indoor distribution. A directional antenna, like the DU, can be used for outdoor area coverage. Proper placement and isolation from the donor antenna are critical to preventing interference and feedback and optimizing the repeater's performance.

- ***Coaxial Cable***

Using 1/2" and 7/8" coaxial cables with a foam core (50Ω impedance) is highly recommended for repeater installations due to their low attenuation properties, which help maintain signal strength over longer cable runs. The foam dielectric reduces signal loss compared to solid-core alternatives, making these cables ideal for large-scale deployments such as in-building solutions.

Their durability and superior shielding also minimize interference, ensuring stable and efficient signal transmission in high-performance RF applications.

- ***Jumper Cables***

RF jumper cables are short, flexible cables connecting RF components like antennas, repeaters, and main coaxial cables. They provide low-loss, high-frequency performance and are essential for minimizing strain on connectors in tight installation spaces.

2.3 Advantages of Repeater

- ***Coverage Optimization***

During the gNodeB coverage optimization process, full coverage cannot always be achieved due to the effects of shadows and blind spots. Suppose optimization is performed simply by adjusting the antenna direction or height of the gNB. In that case, the process is cumbersome and requires a long trial-and-error process until the desired coverage is achieved. Individual optimizations can be performed using repeaters without affecting system correlation parameters.

- ***Same Service Quality with Low Investment***

When coverage needs to be extended or optimized, installing a gNB or small cell may not always be the best and most cost-effective solution. In most cases, a repeater will be the best choice, providing the same quality of service at a lower cost.

- ***Fast & Easy Installation***

Compared to gNodeB or small cells, wireless repeaters save space and require no additional wiring. They are also simple to install and easy to operate, making them attractive to many operators for rural or temporary coverage during network optimization.

2.4 Appearance

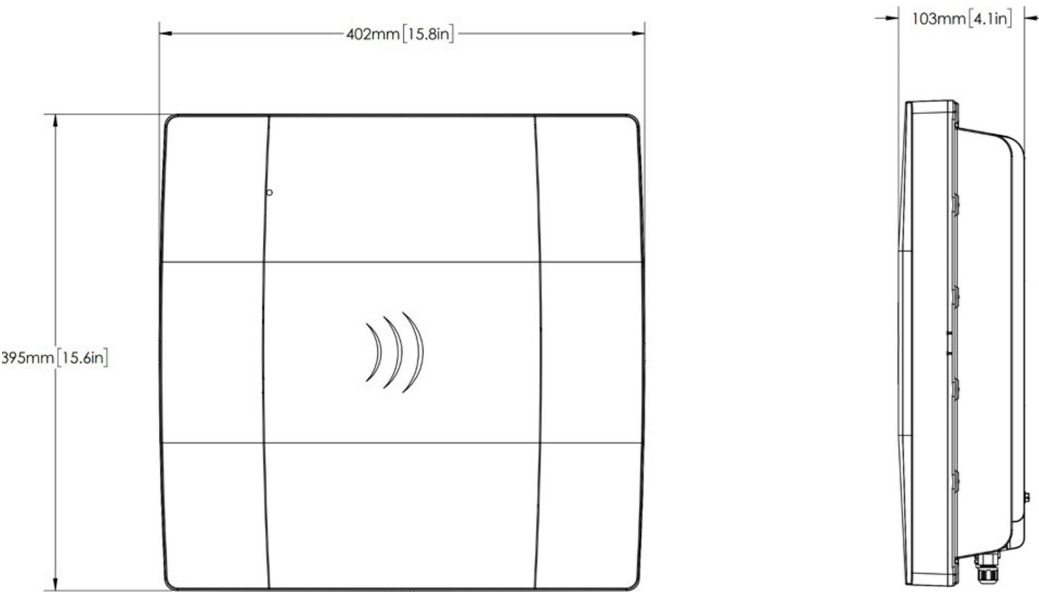


Figure 1: Lighthouse n77 repeater appearance and dimensions

Part#: CY-LH0-22-XB1

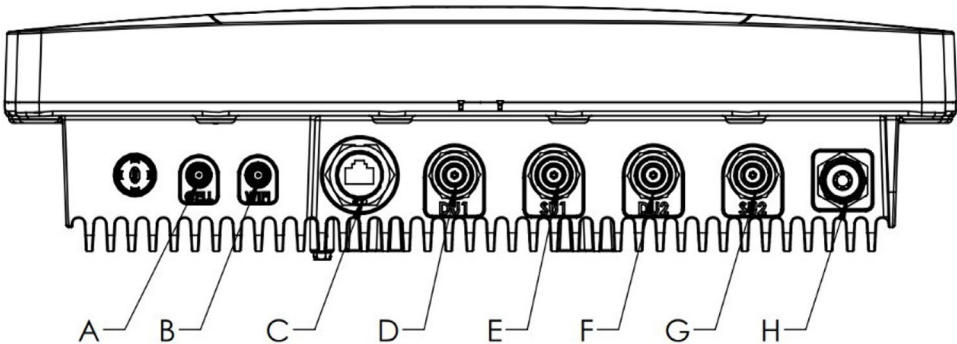


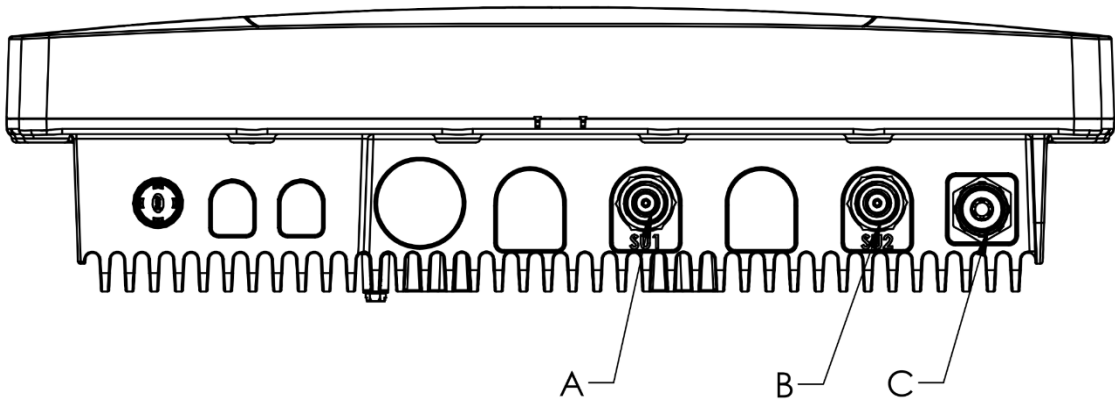
Figure 2: Lighthouse n77 repeater port definition

A	SMA (Female)	N/C
B	SMA (Female)	N/C
C	RJ45	Ethernet for local access
D	N-Type (Female)	Donor antenna, port 1
E	N-Type (Female)	Service antenna, port 1
F	N-Type (Female)	Donor antenna, port 2
G	N-Type (Female)	Service antenna, port 2

H	Power	Power cord connection (included in the package)
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* The port may or may not be connected per design request.

Part#: CY-LH0-22-SB1



A	N-Type (Female)	Service antenna, port 1
B	N-Type (Female)	Service antenna, port 2
C	Power	Power cord connection (included in the package)

* The port may or may not be connected per design request. 

2.5 Technical Specifications Overview

Part Number	CY-LH0-22-SB1	CY-LH0-22-XB1
System	5G NR TDD	
Operational Frequency	3300~4000 MHz (n77)	
Max. Instantaneous Bandwidth	200 MHz (two CA each up to 100MHz)	
Channelization	10MHz up to 200MHz with 10MHz steps	
Carrier Aggregation	2CA (2T2R MIMO 10~100MHz) or 4CA (1T1R SISO 10~50MHz)	
MIMO Option	Up to 2T2R	

Max. Output Power UL/DL	27/27 dBm $\pm$ 2dB	
Max. Gain UL/DL	40~85 dB $\pm$ 2 dB, 1 dB/step, Manual or Auto Gain Control Support	
Gain Flatness	$\leq$ 3 dBpp within 100 MHz	
Group Delay	$\leq$ 3.2 μ s	
UL/DL EVM	$\leq$ 3.5% (at Max. Output Power)	
UL Noise Figure	$\leq$ 5 dB (at Max. Gain)	
VSWR	$\leq$ 1.8	
Max. Input Power Without Damage	$\geq$ 0 dBm (UL&DL)	
Out-of-band Gain Rejection	Compliant to 3GPP TS 38.106	
Adjacent Channel Leakage Ratio		
Frequency Stability		
Spurious Emission		
Unwanted Emission (Emission Mask)		
TDD Synchronization	Automatic Frame Start Time Acquisition Rx Sensitivity: -88 dBm for 100 MHz and 30 kHz SCS User-set TDD Slot Format for RF SW Control	
DU Antenna	Integrated smart beam switching antenna, gain $\geq$ 13dBi, beam direction: 0°, $\pm$ 15°, $\pm$ 30°	External antenna. 2 x N-Type Female RF Connectors.
SU Antenna	2 x N-Type Female RF Connectors	
Impedance	50 Ω	
Power	AC 100~240V, 50/60Hz	
Power Consumption	< 110W	
Power Cable	X length and Y gauge (get from Behrouz)	
Power Plug	Type G	
Dimensions	402 x 395 x 103 mm (LxHxD)	
Weight	10kg (22LBS)	200g
Operating Temperature	0°C ~ +60°C	
IP Rating	IP 66	

Automatic Shutdown Function	RSSI Overpower Shutdown (Max. 0 dBm Programmable) RSSI Underpower Shutdown (Min. -86 dBm $\pm$ 2 dB, OMT Programmable)
Local Control	Wi-Fi 802.11 b/g/n with commissioning tool
Remote Control	Remote Control Unit with Cellular IoT Modem, 802.11b/g/n, and Gigabit Ethernet OMC: Web Server Connection: SNMP

3 Installation

3.1 Preparation

- a. Ensure the power to be accessed is within the repeater's working range: VAC 220~240; VAC 100~120 or -48VDC based on the label. A separate circuit breaker is recommended.
- b. Ensure there is sufficient isolation between the donor and service antennas (as described in section 3.4.2).
- c. Ensure that the mounting location is strong enough to support the repeater's weight. If installed outdoors, ensure the mounting location can also support wind-load on the repeater.
- d. It is recommended that some jumper cables be on hand.
- e. The repeater is IP66 and IP67 rated and suitable for outdoor installation, but extreme temperatures and humidity can still affect its performance. As a precaution, installing it in an indoor, well-ventilated communication room is recommended to prevent it from weathering and overheating. If outdoor installation is necessary, place it in a shaded area and ensure proper heat dissipation.
- f. The repeater operates between -30°C and 55°C but avoid turning it on (cold start) if the temperature is below -10°C .

Required tools list

The following table lists the tools required for a successful installation:

Item	Quantity	Item	Quantity
FR1 Signal analyzer	1	RF arrestor (optional)	1
Laptop	1	Test Mobile Phone	1
Multi-meter	1	Electrical Drill	1
Socket wrench set	1	Wrench set or Spanner	1
Screwdriver	1	Waterproof glue	1
50Ω load (> 3 Watt)	2	Safety belt	1

3.2 Donor Antenna

The placement and type of antenna can critically impact the 5G signal strength and quality in the coverage area, specifically affecting SS-RSRP (Reference Signal Received Power) and SS-SINR (Signal-to-Interference-plus-Noise Ratio). Choosing the right antenna is essential to ensuring the repeater system performs effectively and provides reliable coverage.

3.2.1 Donor Antenna Selection

We strongly recommend using an Airgain-approved antenna with the Lighthouse repeater. If the customer chooses otherwise, we recommend the following antenna characteristics to be met when selecting a donor antenna:

1. *Operating frequency*: The donor antenna must be compatible with the operating frequency range of the repeater.
2. *Directionality*: A directional antenna is recommended as it helps capture a strong and clean signal from the gNB base station. Choose an antenna with low side-lobe levels (>20dB) and a low front-to-back ratio (>30dB) to minimize interference and ensure reliable performance. This helps maintain proper signal isolation and improves overall system efficiency.
3. *IP66 rated (minimum)*: The donor antenna must be waterproof to prevent rainwater from affecting its performance, characteristics, and/or reliability, which could impact the repeater's performance.
4. *Environment and reliability*: a donor antenna designed for outdoor installation must be built to withstand various environmental conditions while maintaining reliable performance. It should be constructed with weather-resistant materials to endure rain, wind, and UV radiation exposure. The antenna must also operate efficiently across a wide temperature range and resist corrosion in humid or coastal environments.
5. *Mounting system*: A robust mounting system is essential to ensure stability against strong winds and vibration.

3.2.2 Donor Antenna Installation

In most cases, the donor antenna should be installed on a pole or against a wall on the exterior of the building to receive the incoming signal optimally.

To find the optimal direction for receiving the strongest 5G signal, use a 5G signal analyzer combined with a high-gain directional antenna mounted with a bracket with two degrees of freedom for precise adjustment in elevation and azimuth. Begin by setting the analyzer to measure key parameters such as SS-RSRP and SS-SINR. Slowly adjust the antenna's azimuth angle (horizontal rotation) while monitoring the signal strength, then fine-tune the elevation angle (vertical tilt) to optimize the reception signal. This iterative process helps align the antenna with the strongest donor cell while minimizing interference. Once the peak signal quality is identified, the antenna is securely locked to maintain stable performance.

When installing the donor antenna, the following conditions should be considered:

1. For the best 5G NR performance, the SS-RSRP and RSRQ received at the repeater's DU

port should be greater than -85dBm and -10dB, respectively. Also, the SS-SINR at the repeater's DU is recommended to be greater than 20dB.

2. A lightning arrester must be used when installing the donor antenna at a high position. Both the lightning arrester and the antenna must be grounded.
3. For optimal signal reception, the antenna should be installed in an open, unobstructed area free from nearby structures, vegetation, foliage, and any other surfaces that could cause signal reflections, degradation, or interference. This will ensure a clear and direct path to the signal source.
4. The donor antenna should be mounted at a minimum height of 8 meters above the street level to avoid obstructions, ensure a clear line of sight, and prevent interference from moving traffic or other obstacles in the signal path.

3.3 Service Antenna

3.3.1 Service Antenna Selection

We strongly recommend using an Airgain-approved SU antenna with the Lighthouse repeater for each installation. We highly recommend using an Airgain-approved installation service to guarantee the best coverage throughout the target area. The following requirements must be met for SU antennas:

1. *Operating frequency*: The service antenna must be compatible with the operating frequency range of the repeater.
2. *Half-power beam width*: Based on the coverage area, choose an antenna with an appropriate half-power beam width.
3. *For outdoor coverage*, the antenna must be waterproof to prevent rainwater from affecting its performance, characteristics, and reliability, which could ultimately impact the repeater's performance. Additionally, the front-to-back ratio must be greater than 30 dB to ensure sufficient isolation for the site.
4. Recommended service antennas:
 - For Indoor Application: Indoor omnidirectional antenna(s) and/or, indoor panel antenna(s)
 - For Outdoor Application: Outdoor panel antenna(s)

3.3.2 Service Antenna Installation

Finding an appropriate location for the service antenna to achieve optimal coverage is essential.

The following conditions should be considered for indoor coverage:

1. Avoid installing the antenna near metal objects or obstacles that may affect its coverage or performance.
2. Do not install the coverage antenna near the donor antenna to avoid isolation and/or echo issues.

For outdoor coverage, the following considerations should be made:

1. The service antenna should be mounted at a **minimum height of 8 meters** above the street level to avoid obstructions, ensure a clear line of sight, and prevent interference from moving traffic or other obstacles in the signal path. Here are the minimum antenna height guidelines for using an outdoor 5G C-Band directional antenna (EIRP 40–45 dBm):

Terrain Type	Suggested Min. Height	Notes
Flat open land	10–15 meters	High risk of ground reflection. A taller height clears more of the Fresnel zone.
Rooftop (urban)	8–12 meters	Rooftop reflections still matter; stay well above reflective surfaces.
Suburban with trees	12–18 meters	Foliage introduces scattering; higher elevation helps with penetration.
Rural hilly terrain	15–20+ meters	Use terrain modeling (e.g., ITU-R P.526) to avoid diffraction shadows.

2. Avoid installing the antenna near trees or other obstacles that may impact its coverage performance.
3. To RF echo, the coverage antenna should not be installed too close to the donor antenna (please refer to the section 3.4.2). The angle between the directions of the donor antenna and the service antenna must be greater than 90 degrees. Ideally, the donor and service antennas should be installed in opposite directions.
4. A lightning arrester must be used when installing the coverage antenna outdoors. Both the lightning arrester and the antenna must be grounded.
5. If a jumper cable or a cascade of cables is used, the connection should be enclosed in a waterproof seal box to prevent moisture ingress. Additionally, ensure that the coaxial cable forms a U-shaped drip loop before connecting to the repeater or any intermediate point. This configuration allows water to drip off the cable naturally, preventing accumulation and

minimizing the risk of water entering through the connectors.

3.4 Lighthouse Repeater Installation

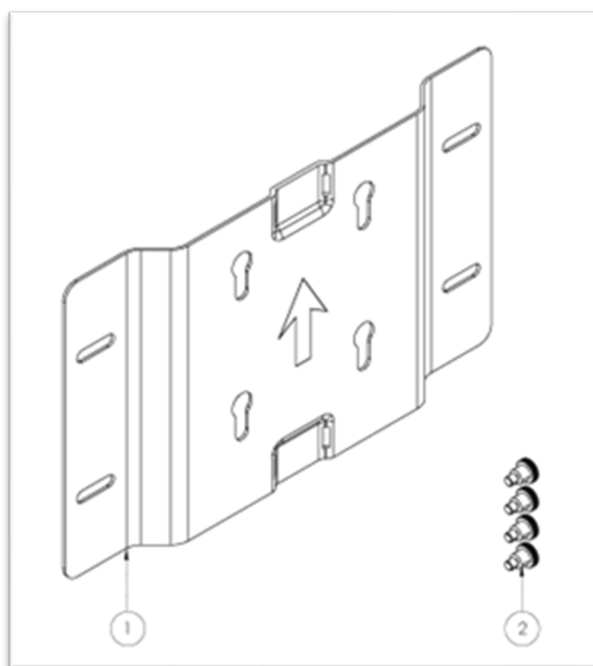
Using the relevant mounting bracket kit, the Lighthouse repeater can be securely installed on a mast or a wall. These kits ensure a stable and secure installation for various environmental conditions. Proper installation is essential for optimal performance and durability. Depending on configuration, the Lighthouse repeater ships with either the wall-mounted bracket or adjustable bracket. Both are available as optional accessories.

Wall-Mount Bracket Kit



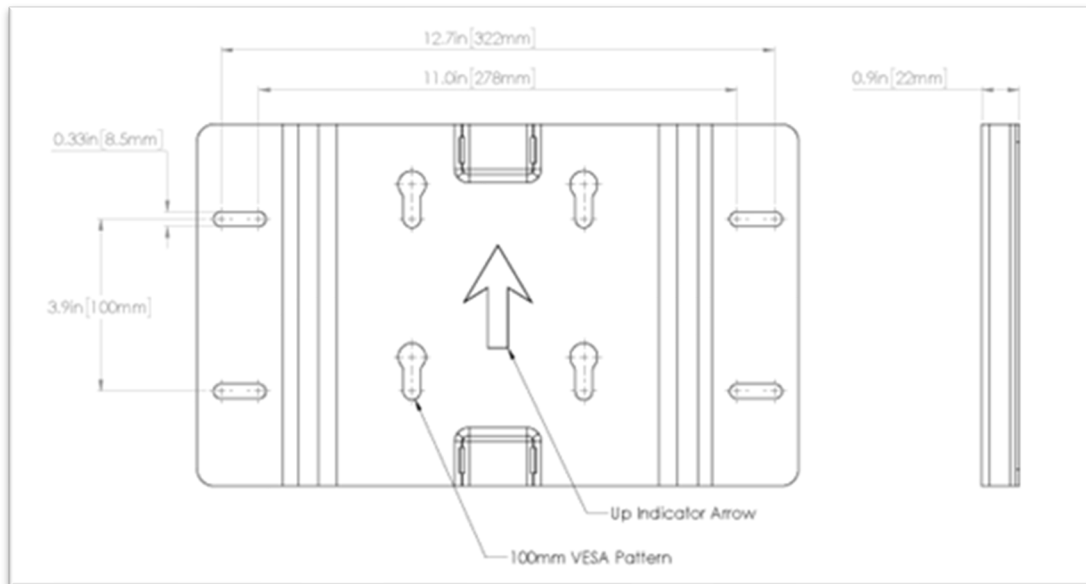
For indoor use only: when mounting the Lighthouse DU to a wall or other flat vertical surface.

Wall-mount bracket kit contents



Number	Description	Quantity
1	Wall-Mount Bracket	1
2	M6 Bracket Thumb Screws	4

Wall-mount bracket dimensions



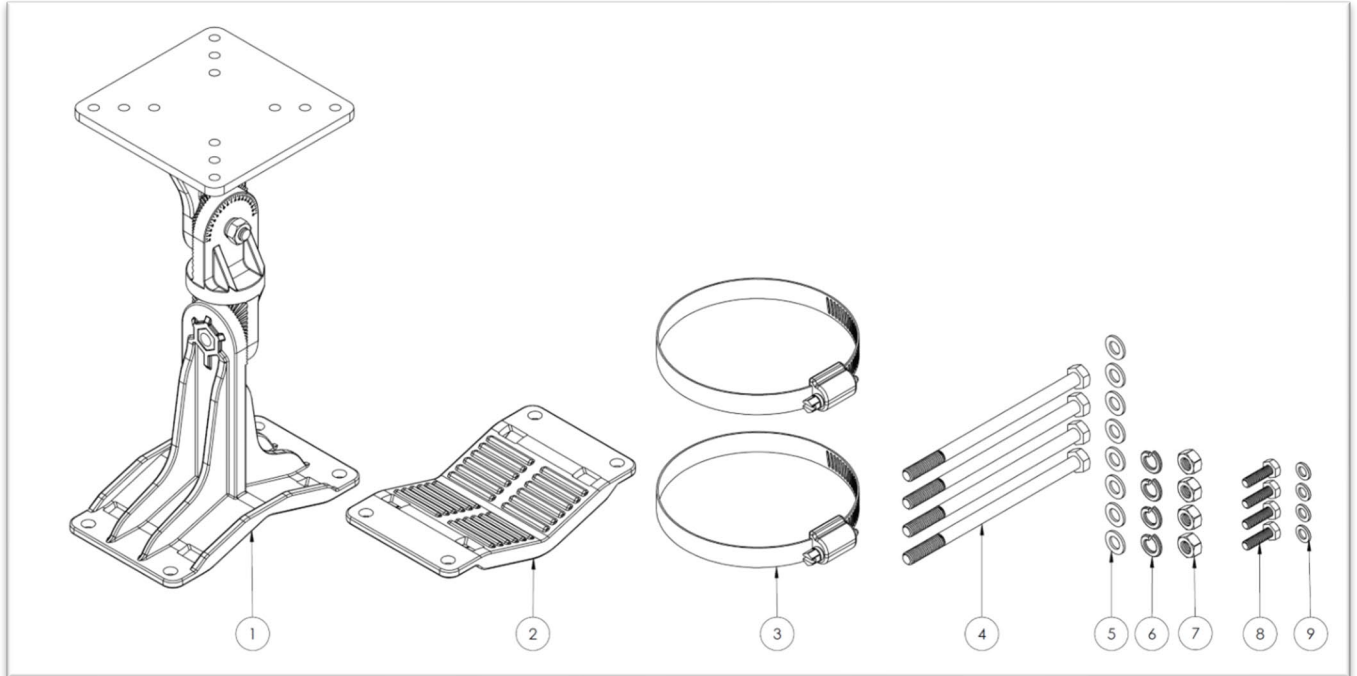
Wall-mount bracket kit installation instructions

- Ensure there are no obstructions or utilities behind the mounting surface
- Align the rear bracket on the wall in the desired position
- Secure rear bracket to the wall with appropriate M8 or 5/16" diameter screws
- Install 4x thumb screws to the holes on the rear of the Lighthouse DU. Tighten to finger tight.
- Align thumb screws with keyhole slots on the bracket and install to the bracket.

Adjustable Mounting Bracket Kit

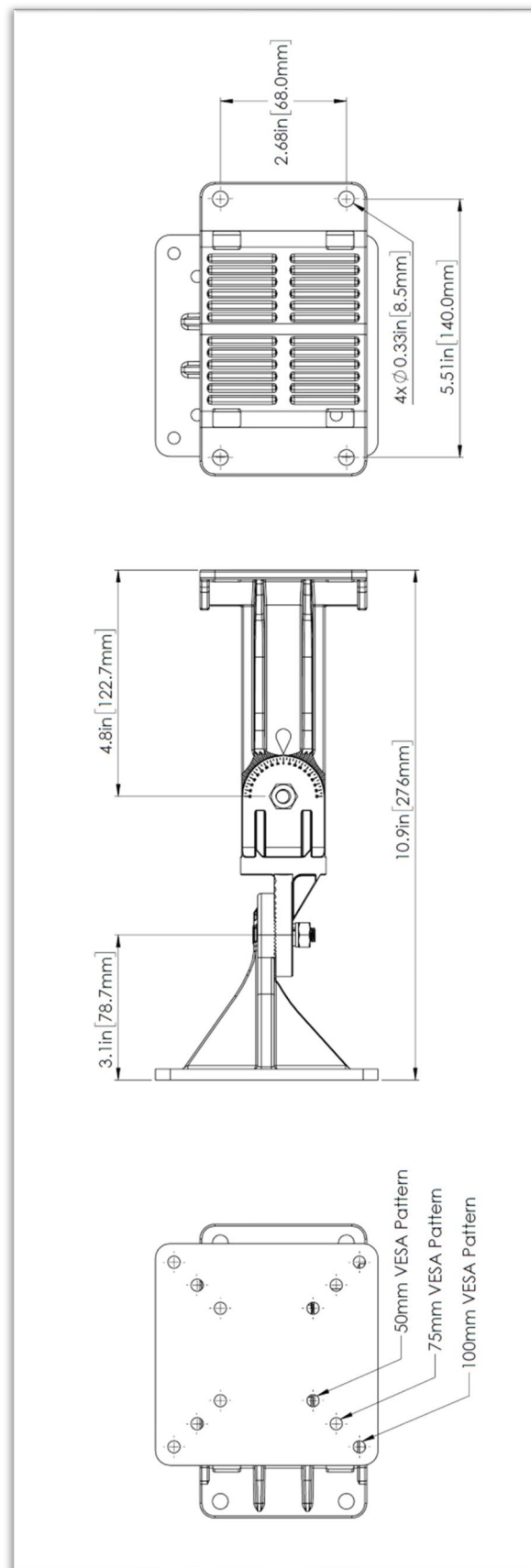
For indoor or outdoor use when mounting the Lighthouse DU to a flat surface or mast.

Adjustable mounting bracket kit contents



Number	Description	Quantity
1	Bracket Assembly	1
2	Mast-Mount Bracket Flange	1
3	Tension Clamp	2
4	M8 x 140mm Long Hex Head Bolt	4
5	M8 Flat Washer	8
6	M8 Spring Lock Washer	4
7	M8 Nut	4
8	M6 x 20mm Long Hex Head Bolt	4
9	M6 Flat Washer	4

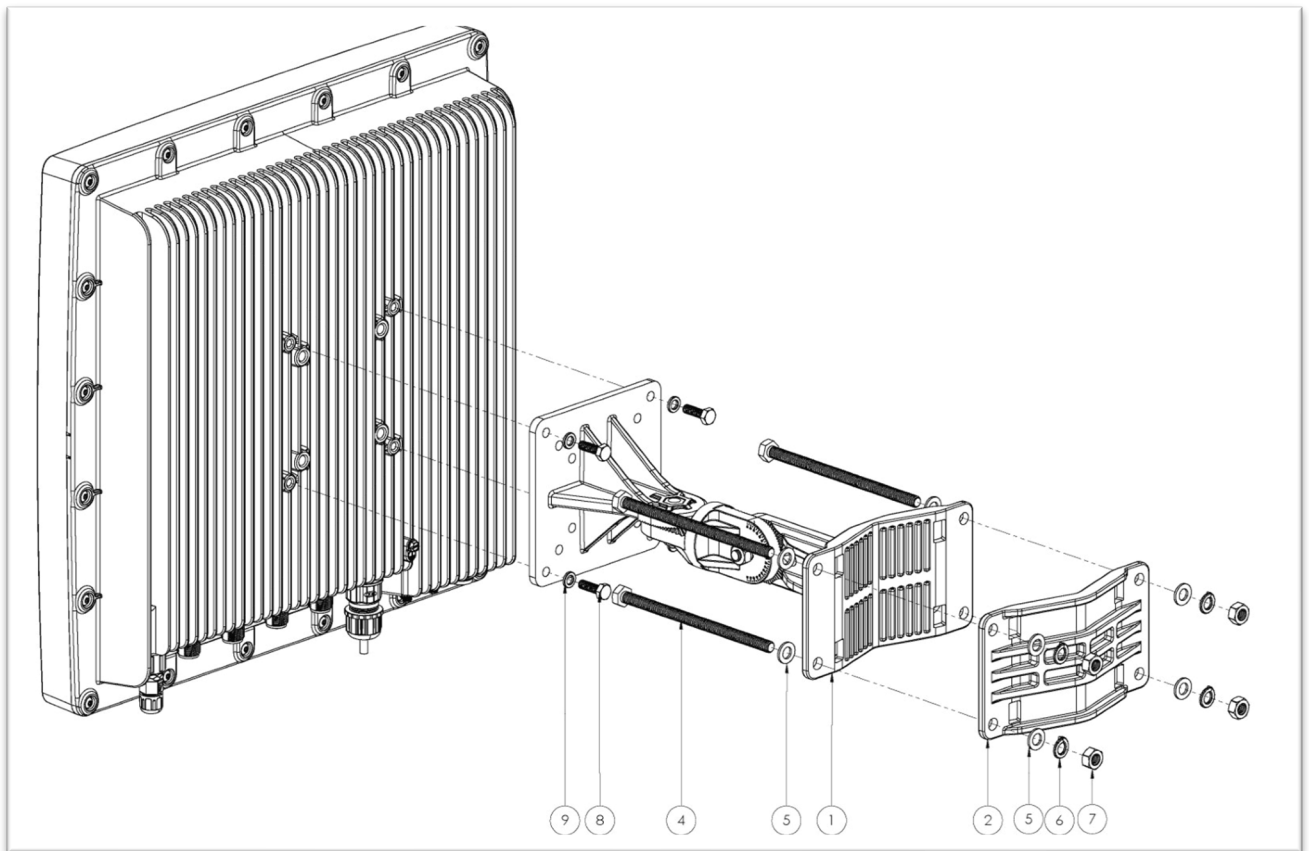
Adjustable mounting bracket dimensions



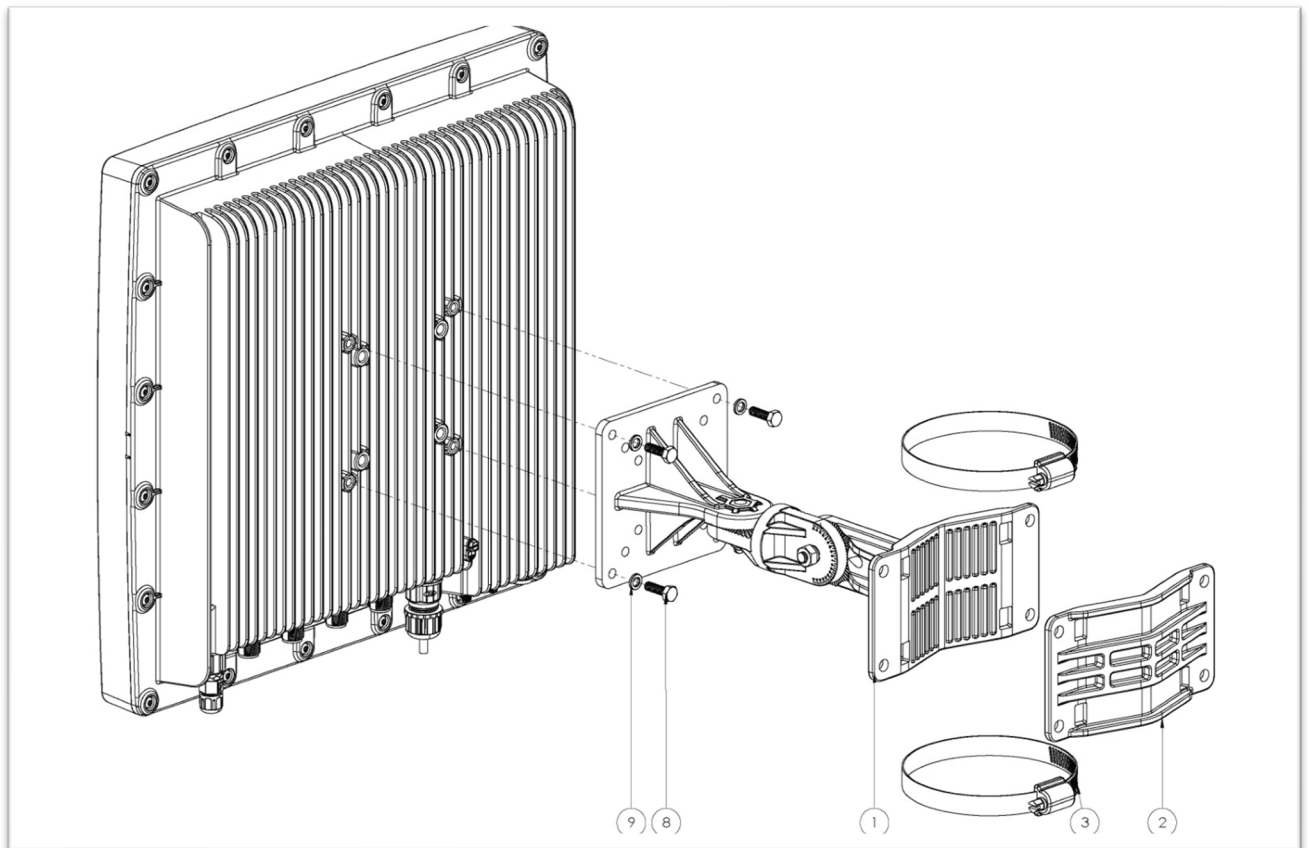
Adjustable mounting bracket kit installation instructions

- Mounting to a wall
 - Ensure there are no obstructions or utilities behind the mounting surface
 - Align the rear bracket on the wall in the desired position
 - Secure rear bracket to the wall with appropriate M8 or 5/16" diameter screws

- Mounting to a mast with M8 screws
 - Mast should not exceed 5 in (12.7 cm) in diameter
 - Fit the rear of the bracket assembly and mast-mount bracket flange around the mast and secure at desired height with the M8 bolts, washers, and nuts
 - Torque each M8 bolt to 10 Nm (88 in-lbs). Avoid overtightening, as this may damage or distort the mast tube section

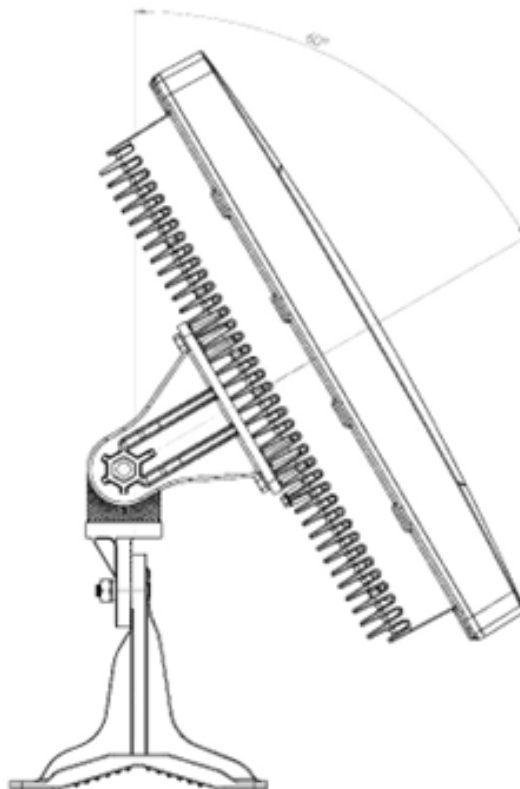
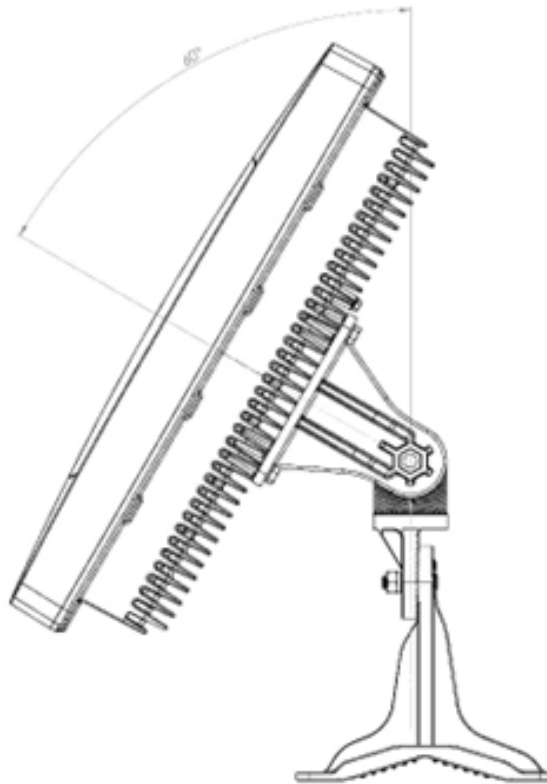


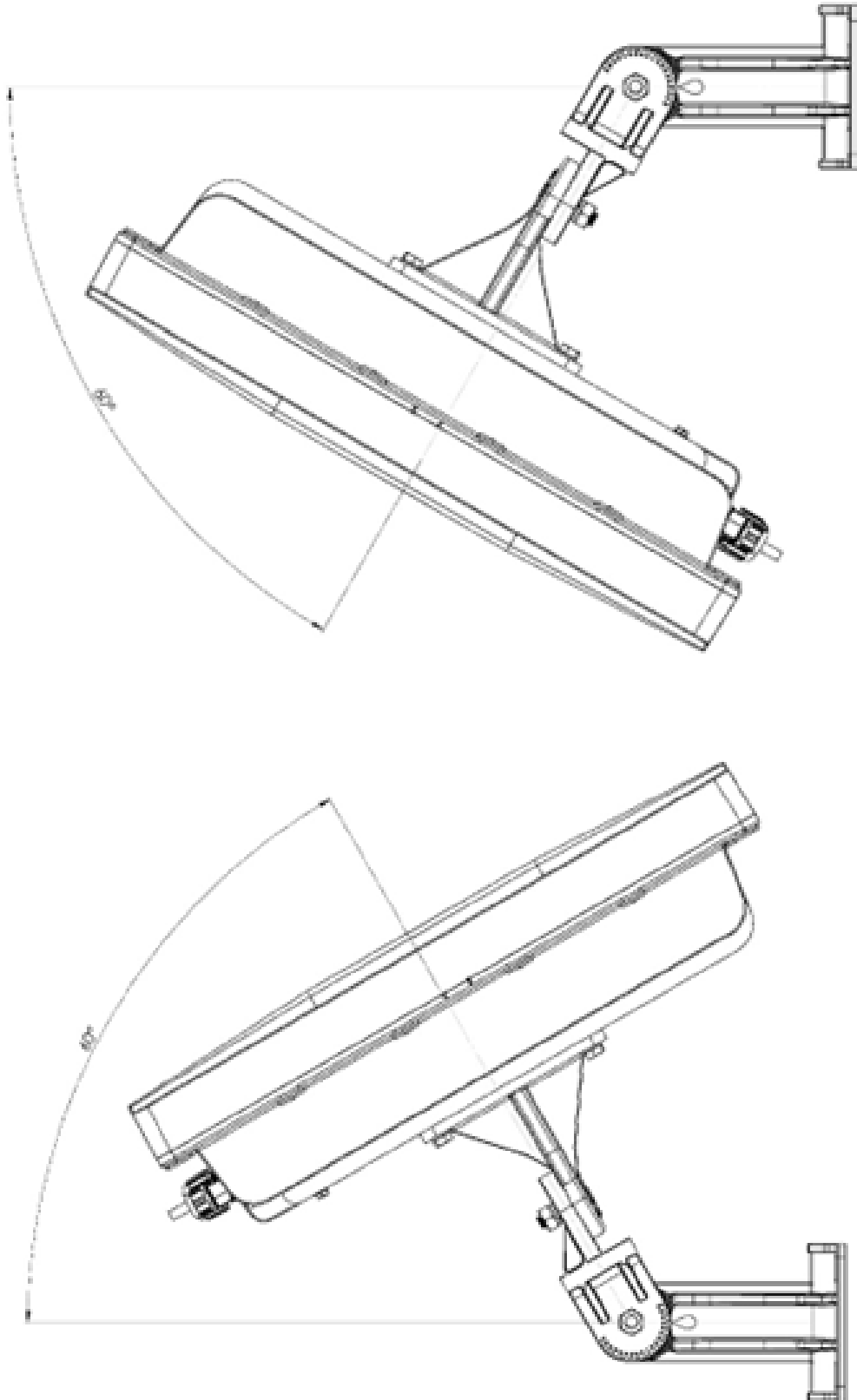
- Mounting to a mast with tension clamps
 - Mast should not exceed 5 in (12.7 cm) in diameter
 - Fit the rear of the bracket assembly and mast-mount bracket flange around the mast and secure at the desired height with the tension clamps through the slots on both parts.
 - The two clamps must be tightened evenly and avoid overtightening, as this may damage or distort the mast tube section



- Fitting the Lighthouse DU
 - Ensure the bracket assembly is securely fixed
 - Align the 100x100mm VESA pattern on the rear of the Lumos antenna with the front of the bracket assembly such that the connectors point towards the ground. If necessary, the front bracket can be separated from the rear bracket at the inner joints to ease installation
 - Secure the Lighthouse DU to the front bracket with the included M6 bolts. Torque each M6 bolt to 8 Nm (70 in-lbs)
 - Adjust the horizontal and vertical angles as desired by loosening and tightening the inner bracket assembly joints
 - Both joints can be adjusted 5° for each tooth, not to exceed a total of 60° in either direction

- Torque each M8 inner joint bolt to 20 Nm (15 ft-lbs)





3.4.1 Connecting Feeder and Power Cables

Once the repeater has been installed, follow the procedures below to connect the cables:

- Connect the **donor antenna cable** to the **DU port** and the **service antenna cable** to the **SU port**. Before making the connections, create a **half-loop (U-shape) in both cables** near the ports. This loop helps prevent water from flowing into the **DU and SU ports**, ensuring better protection against moisture and potential damage.
- Connect the grounding cable to the bolt marked "■": To ensure proper grounding of the Lighthouse device during installation, use the designated screw boss located on the unit. The package includes a green grounding screw and grounding wires specifically for this purpose. Begin by securing the green screw into the designated screw boss, then connect the provided grounding wire to a suitable earth ground. Ensure all connections are tight and secure to maintain electrical safety and protect the device from potential surges. Proper grounding is a crucial step in the installation process and should not be overlooked.



Please note the following when connecting the repeater to coaxial cables.

- The connector type of the repeater DU and SU ports is N-Type female. Make sure the cable's connectors are compatible.
- When the donor antenna and service antenna are installed at a high location outdoors, lightning arresters need to be connected to the DU and SU connection ports of the repeater. Grounding is critical to the operation of a lightning arrester.
- After the repeater has been mounted and all RF connections and antennas have been installed, connect the power cord to the **PWR** port on Lighthouse and then plug the power cord into the power socket. Use the power cord provided in the package.

3.4.2 Oscillation (Echo) Mitigation

Oscillation occurs when insufficient isolation causes the signal from the transmitting antenna (i.e., SU antenna in DL state) to be picked up by the receiving antenna (i.e., DU antenna in DL state), creating a feedback loop. This can lead to unstable performance, signal distortion, and potential damage to the repeater's amplifiers. An Isolation Checking System (ICS) is integrated into the repeater's hardware and software to prevent this. This system can detect and remove unwanted feedback from the desired signal. The echo canceller detects unwanted feedback signals within the received signal and removes them if they are below a certain level. If the feedback signal exceeds the threshold, the ICS will automatically reduce the repeater's active gain to bring the feedback below the limit. If the issue persists, the ICS will disable the link and trigger an alert.

Isolation refers to the received power value from the repeater's output port to its input port. Insufficient

isolation between the donor and service antenna for wireless repeaters can lead to self-oscillation.

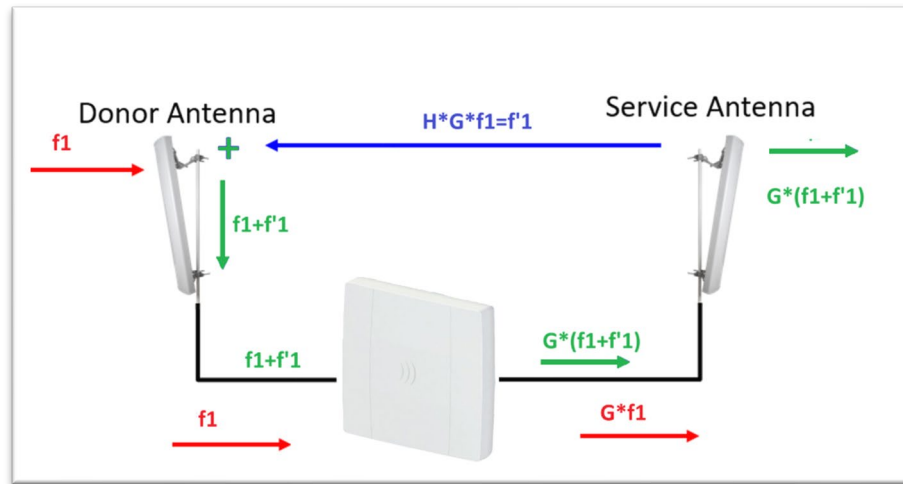


Figure 3: Isolation and echo between DU and SU antenna

As shown in the Figure 3, the donor antenna receives an RF signal f_1 from the gNodeB. After being amplified by the repeater with a gain of G , this received signal is radiated through the service antenna. A portion of f_1 (denoted as $f'_1 = H \cdot G \cdot f_1$) could be re-radiated back to the donor antenna due to the installation environment (i.e., antenna back radiation), which the donor antenna picks up again and goes through another amplification process ($G \cdot (f_1 + f'_1)$). Severe self-oscillation can lead to a degradation in signal quality and may even damage the amplifier in the repeater. To prevent self-oscillation, it is recommended to have an isolation at least 10 dB higher than the gain of the repeater.

3.4.2.1 Isolation Value Acquisition

Using External Donor and Service antennas:

To measure the isolation between the donor and service antennas, a two-port Vector Network Analyzer (VNA) is used to assess the S21 parameter, representing the coupling between the two antennas. Follow these steps for an accurate measurement:

1. Calibration: Perform a full two-port calibration on the VNA to ensure accurate readings.
2. Connection Setup: Connect Port 1 of the VNA to the Donor antenna and Port 2 to the Service antenna using low-loss RF cables.
3. Frequency Sweep Configuration: Set the VNA to sweep across the repeater system's operating frequency range (e.g., 3.5 GHz for C-band 5G).
4. Measurement: Observe the "S21" parameter, indicating the signal leakage between the antennas. The measured S21 value in dB represents the isolation level (higher negative values

(e.g., -80 dB) indicate better isolation).

5. Analysis and Adjustment: To prevent oscillation, ensure the measured isolation is at least 10dB greater than the repeater's maximum gain. If isolation is insufficient, increase the physical separation, adjust the antenna angles, or use shielding techniques to improve it. The figure below provides an illustration of the isolation measurement setup using a two-port Vector Network Analyzer (VNA)

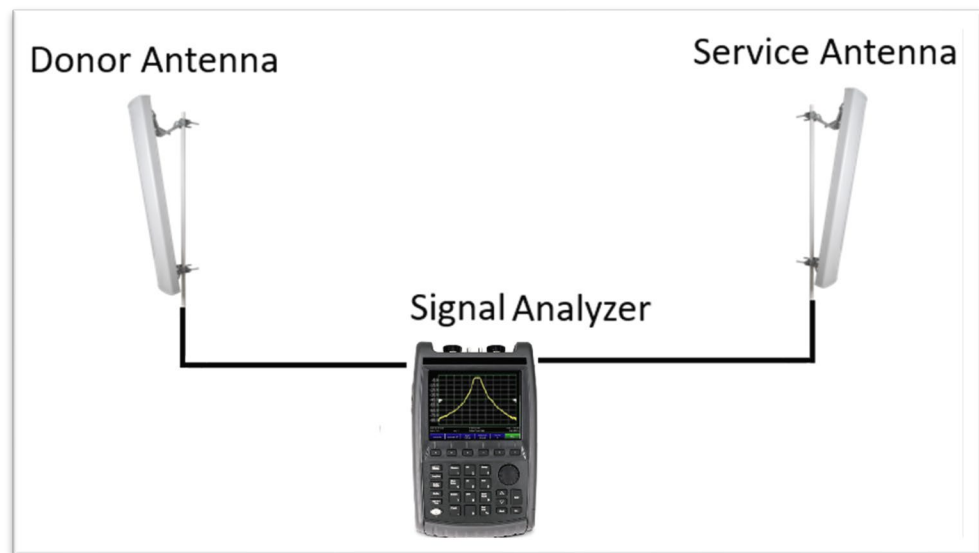


Figure 4: DU and SU antenna isolation measurement setup

Lighthouse with Integrated Smart Donor Antenna and External Service antenna(s):

When measuring isolation using a Lighthouse repeater with an integrated smart donor antenna, follow these steps to ensure accurate results:

- Change the repeater operation mode from “TDD” to “Downlink-only” mode to ensure that the DU only receives the signal while the SU antenna only transmits signals.

- Set the repeater output power (DL) to max (27 dBm)



If necessary, add an attenuator to avoid any harm to the VNA

- Set the repeater gain to 65 dB
- Connect VNA Port 1 to the RF port of the SU antenna
- Connect VNA Port 2 to the repeater port marked as “SU port”
- Configure the VNA to sweep across the repeater's operating frequency.
- Measure the S21 value (dB), representing the coupling between the service antenna and the

repeater's designated SU port (*isolation plus the repeater gain*).

- Calculate “isolation” using the following formula:

Isolation (dB)=Measured S21 (dB)–Repeater Gain (65 dB)+ fix attenuator (if used)

Optimization and Considerations

- Isolation must be at least 10dB greater than the repeater's maximum gain. To improve isolation, the separation between the antennas needs to be increased.
- If the measured signal is below the VNA dynamic range threshold, you can increase the repeater gain, OP, and fixed attenuators. If getting a signal is impossible, you have sufficient isolation!
- The Smart donor antenna can peak the beam toward the best signal direction. During isolation measurement, make sure to test all angles.

By following these methods, you can accurately measure the isolation, ensuring optimal repeater performance and minimizing self-oscillation risks.



4 Commissioning

In this section, we will cover the commissioning process for the Lighthouse repeater, ensuring proper configuration and optimization for seamless operation. The process involves accessing the repeater's local web GUI, which provides a graphical interface for on-site setup and monitoring. Key parameters will be reviewed, including operational settings such as Absolute Radio Frequency Channel Number (ARFCN) selection, TDD pattern configuration, and frequency coverage for CA1 and CA2. Additionally, we will configure the output power and gain for both uplink (UL) and downlink (DL), as well as monitor the received power levels at the Service Unit (SU) and Donor Unit (DU) ports. Furthermore, we will discuss echo presence and power levels, ensuring that the repeater operates efficiently while maintaining stability and minimizing interference.

4.1 Accessing the Local Configuration

There are three ways to connect to the Lighthouse repeater's configuration locally: via Wi-Fi or Ethernet and through the IoT cellular modem.



Note: cellular access **will not be covered** in this manual.

To connect using Wi-Fi, use the SSID and password provided to you. Once connected to the repeater's Wi-Fi, enter **https://192.168.1.1:8000/** in your web browser (Chrome, FireFox, or equivalent). The same method applies when connecting through the LAN port, where a direct wired connection allows access to the repeater's interface using the same IP address and port number. The figure below shows the front page of the Web GUI with login interface.  The username and password will be provided separately.



Login

Username

Password

Login



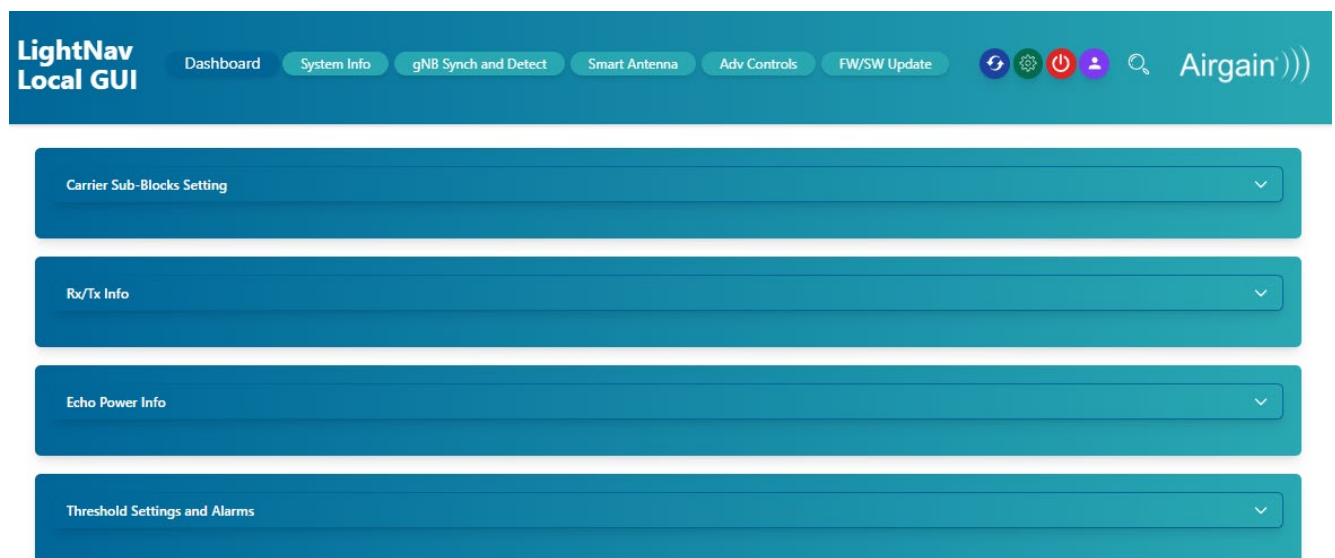
Login

Username

Password

Login

After login, a web page includes several tabs for configuring and monitoring the Lighthouse repeater will be shown.



Here is a description for each tab:

- **Dashboard:**
 - Set repeater parameters such as Carrier Sub-block (CSB) on/off, center frequency, bandwidth, max output power, and gain.
 - Monitor UL and DL received and transmitted signal power level
 - echo power levels, and consequently the isolation between the CSB.
 - Modify alarm settings and thresholds
- **System Info:**
 - Displays relevant information for each subsystem.
- **gNB Synch and Detect:**

- Modify synchronization parameters.
- Check if the repeater is connected to the gNB.
- View received signal quality.
- **Smart Antenna (if available):**
 - Manually steer the beam or automatically search to find the optimal signal direction.
- **Debug:**
 - Provides tools for troubleshooting and debugging.
- **FW/SW Update:**
 - Allows users to receive and apply the latest firmware updates for the repeater and RCU module.

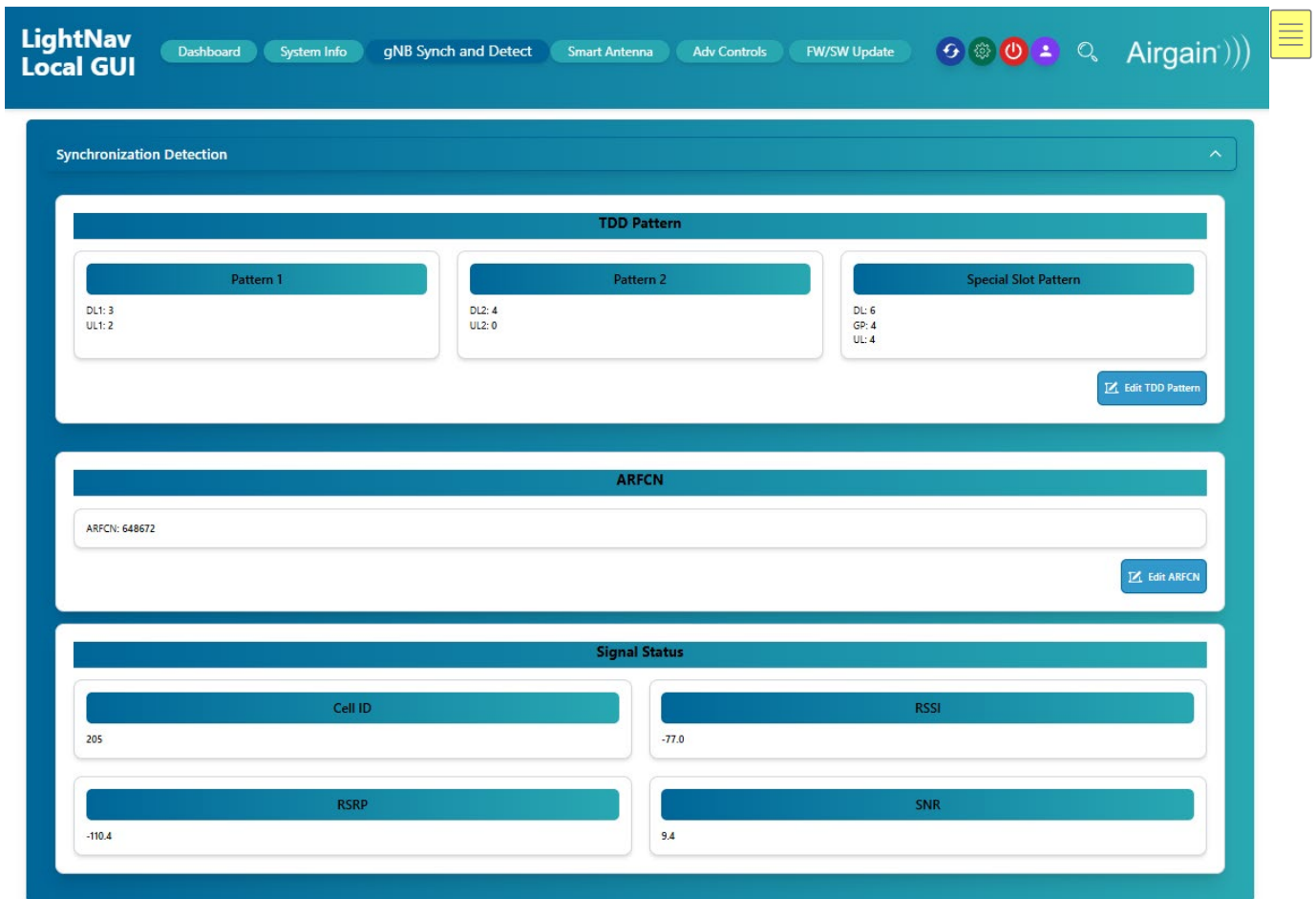
4.2 Base Station Synchronization

The first step in commissioning the repeater is ensuring it is properly synchronized with a 5G base station (gNB). The correct TDD pattern and SSB ARFCN must be configured to achieve this. These parameters can either be provided by the network operator or identified through over-the-air measurements using tools such as a 5G analyzer or a cell phone with the appropriate software. Once the TDD pattern and SSB ARFCN are obtained, they should be entered into the corresponding fields in the local configuration interface.

To do so, move to the “gNB Synch and Detect” tab, then click on the edit TDD Pattern and ARFCN. Insert the correct pattern and ARFCN, then click Apply. After refreshing the page, the repeater should display the detected SSB signal information, including the Cell ID of the serving tower, RSSI, RSRP, and SINR, confirming a successful connection to the gNB.



Note: Ensure that the ARFCN frequency set in the “gNB Sync” tab falls within the operational band of Carrier Sub-block 1 (CSB1) as mentioned in section 4.3.



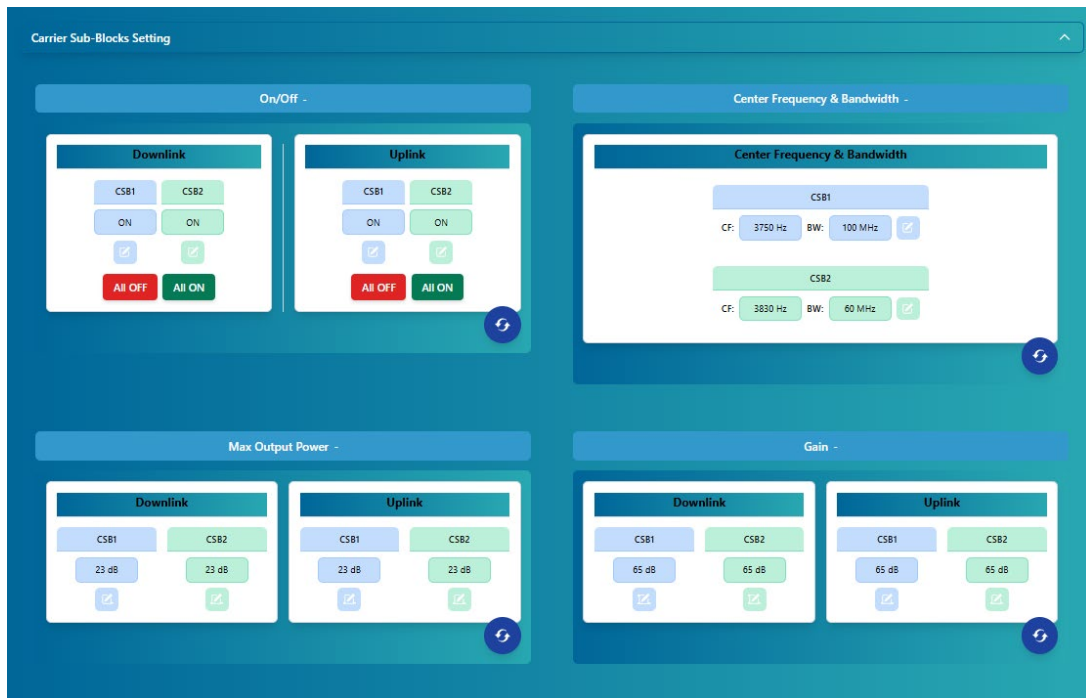
4.3 Repeater Configuration

The Lighthouse repeater operates within the 3300–4000 MHz frequency range and supports up to two carriers, each configurable with a bandwidth between 10 and 100 MHz. The user must set the center frequency and bandwidth for each carrier. If only one carrier is used, it should be configured as Carrier 1, and Carrier Sub-block 2 (CSB2) should be turned off. Users can also configure the maximum output power and gain for uplink (UL) and downlink (DL) signals. The maximum output power for a combined 2CA operation is 27 dBm. If both carrier sub-blocks are enabled, the maximum output power should be set to 24 dBm per carrier to ensure proper operation.

These parameters can be configured under the “**Dashboard**” tab in the “**Carrier Sub-block Setting**” section.



Note: Ensure that the ARFCN frequency set in the “gNB Sync” tab falls within the operational band of Carrier Sub-block 1 (CSB1).



4.4 Repeater Output Performance Check

To verify the Lighthouse repeater's performance, users can check the output and input power levels for both the downlink (DL) and uplink (UL) signal chains. This information is available under the Dashboard tab and shown separately for each Carrier Sub-block (CSB1 and CSB2), allowing for precise monitoring of the repeater's operation.

For each sub-block, the interface displays:

- **DL Input Power (Downlink Rx):** This shows the received signal power from the gNB through the donor antenna port.
- **DL Output Power (Downlink Tx):** Indicates how much power is being transmitted toward the service antenna for each carrier at the SU port.
- **UL Input Power (Uplink Rx):** This reflects the strength of the signal received from the user side (UEs) through the service antenna port.
- **UL Output Power (Uplink Tx):** Represents the signal power transmitted back toward the gNB from the donor antenna port.

In addition, the system provides:

- **Echo Power:** Displays the measured level of any unwanted feedback signals in both UL and DL paths for each CSB.
- **Isolation Value:** Indicates the measured separation (in dB) between the donor and

service antennas, separately for CSB1 and CSB2.

- **Real Gain Measurement:** Calculated as the difference between the input power and output power of the UL or DL transmit chain. While users can configure a preferred gain setting, this value is considered the maximum gain, as the ICS may automatically reduce actual gain to compensate for echo or feedback.
- **MIMO Performance:** UL and DL chains include MIMO-specific signal metrics, helping users evaluate diversity and signal integrity across spatial streams.

Monitoring these values ensures the repeater operates within optimal power and isolation limits. If any metrics are out of the expected range, users should review gain settings and antenna placement and check for system alarms.



4.5 Smart Antenna Setting and Control

The Lighthouse repeater supports an optional integrated smart donor antenna (DU side) capable of scanning across a range of -30° to $+30^{\circ}$ in azimuth. This smart antenna is designed to automatically detect and align itself toward the direction of the strongest incoming signal from the gNB.

Upon powering on the repeater, the smart antenna performs an initial scan and evaluates the received signal quality based on key parameters such as RSSI, RSRP, and SINR. Once the optimal direction is determined, the antenna locks into that angle to ensure maximum signal reception and system performance.

If the smart antenna module is present and installed in the repeater, the user can access the Smart Antenna tab in the local configuration interface. From this section, users can:

- View the current beam angle set by the system.
- Manually adjust the antenna angle if needed.
- Re-run the automatic scan process to re-optimize the antenna direction in case of environmental changes or site modifications.

This feature provides flexibility and ensures the repeater consistently operates with the best possible donor signal, reducing the need for manual antenna alignment during installation and maintenance.

4.6 Adv Control

The Adv Control tab in the local configuration interface is intended for use by trained installers or authorized personnel during installation, testing, or maintenance. This section provides advanced control and diagnostic tools to help troubleshoot the repeater in the field.

Within the Adv Control tab, users can perform tasks such as:

- Turning on or off the interference cancellation function based on the echo power in the field
- Verifying the functionality of individual transmit and receive paths with RF Switch function.

These tools allow for precise control and observation of the repeater's behavior under various configurations, aiding in fast and efficient troubleshooting. Access to this tab may be restricted

and requires training to avoid unintended system behavior or performance degradation.

5 Maintenance

5.1 Over-the-Air Firmware Updates

The Lighthouse repeater supports firmware over-the-air (FOTA) updates, allowing users to keep the device and its components updated with the latest features, improvements, and security patches. This function is accessible through the **FW/SW Update** tab in the local configuration interface.

If firmware updates are available, the system will notify the user and provide the option to update either the Repeater Firmware or the RCU (Remote Control Unit) Firmware. Users can initiate the update process with a simple click through the interface.

It is important to note that the update process may take several minutes to complete, during which the repeater may become unfunctional, causing brief interruptions in service. To minimize impact, it is recommended to perform updates during a scheduled maintenance window or a period of low traffic.

Keeping the firmware up to date ensures optimal performance, compatibility with evolving network standards, and access to the latest diagnostic and control features.

5.2 Alarms and Solutions

Local GUI is used to determine the alarm type when an alarm is triggered.

The following table lists the alarms and possible solutions to correct the fault.

Alarm	Cause	Solution
DL Overpower Shutdown Alarm	1. The repeater DU port input is too high, the AGC is active, and more than 25dB of attenuation has been applied 2. Insufficient isolation conditions may also occur	1. Add an RF attenuator to the DU port to reduce the input power. 2. If an echo is present, increase the distance between the donor and service antennas. Then, adjust the gain to meet the isolation

DL Underpower Shutdown Alarm	1. The repeater DL input power is too low 2. The repeater's receiving amplifier(s) is damaged. Most of the time, this is caused by self-oscillation	1. Adjust the donor antenna to receive stronger signals. It is recommended that the repeater DU port input RSSI is within the range of -40dBm ~ -60dBm 2. Use the Local GUI to read the output power measured by the repeater. The repeater is damaged if the measured output power is low and cannot satisfy the formula $\text{Output} = \text{Input} + \text{Gain}$. Return the repeater to the place of purchase for repair
UL Overpower Shutdown Alarm	1. The repeater SU port input is too high, the AGC is active, and more than 25dB of attenuation has been applied 2. Insufficient isolation conditions may also occur	1. Add an RF attenuator to the SU port to reduce the input power 2. If an echo is present, increase the distance between the donor and service antennas. Then, adjust the gain to meet the isolation
UL Underpower Shutdown Alarm	1. The repeater UL input power is too low, or there are no UEs 2. The repeater's receiving amplifier(s) is damaged. Most of the time, this is caused by self-oscillation	1. Checking whether no UE is operating in the field. If that is the case, the Alarm is normally triggered. 2. Use the Local GUI to read the output power measured by the repeater. The repeater is damaged if the measured output power is low and cannot satisfy the formula $\text{Output} = \text{Input} + \text{Gain}$. Return the repeater to the place of purchase for repair
Over-Temp Alarm	The repeater temperature is higher than the set threshold	The repeater must be installed vertically. In addition, move the repeater to a more ventilated location in a shaded area.
PLL Unlock	The PLL circuit cannot lock to the programmed frequencies	Restart the repeater. If the alarm persists, the repeater is damaged. Please return the repeater to the place of purchase for repair

Isolation Alarm	The measured isolation is insufficient for any RF path	1. Make sure the ICS is active (under Adv Control tab) 2. Increase the separation between the SU and the DU antennas
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5.3 Troubleshooting

The following table lists some situations, possible causes, and solutions for abnormal repeater status.

Situation	Possible Cause	Solution
PWR LED does not light up after power is turned on	1. The power cord is not connected correctly 2. The input AC voltage exceeds the rated voltage range 3. An external circuit breaker has been tripped and there is no power to the repeater.	1. Check the power cord and outlet to make sure there are no interruptions 2. The AC voltage range must be between AC100/240V 3. Check all circuit breakers providing power to the repeater.
Signals have not been amplified after the repeater was installed	1. Wrong connection between the antenna and repeater ports 2. Donor signal is too weak 3. SSB ARFCN setting error	1. Make sure the DU port is connected to the donor antenna and the SU port is connected to the service antenna 2. Adjust the direction or position of the donor antenna to obtain a stronger donor signal 3. Use the Local GUI to read the synchronization detection  Synchronization Detection Module (SDM) settings and check whether the detected cell ID is correct
Coverage quality (throughput) deteriorates after running for some time.	1. The quality of the donor signal deteriorates (For example, new buildings cause signal strength to fluctuate) 2. After the feeder cable system is used for a certain period, especially under harsh conditions (such as the seaside areas with chemicals) or	1. Check the signal strength of the donor antenna. Reposition the donor antenna to resolve the problem 2. Check the standing wave ratio of the feed cable system, find the fault point, and replace the damaged cable or connector 3. If this change occurs, reconsider the

	mice or insects damage the cable, the quality of the cable connector will be reduced due to oxidation 3. Change the interior structure or decoration. Changes in indoor structure or decoration will directly affect the propagation losses predicted in the previous design	location of the antenna and the layout of the cables
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5.4 Repeater Replacement

If the Lighthouse repeater needs to be replaced, the following steps should be followed carefully to ensure safety and preserve system integrity. These steps must be performed by a trained and approved installer:

1. **Turn off the power** to the repeater using the designated switch or breaker.
2. **Disconnect the power cord** from the repeater to fully isolate it from the power source.
3. **Disconnect the RF feeder cables** from the donor and service ports.
4. **Disconnect the grounding wire** attached to the repeater chassis.
5. **Loosen the mounting bracket screws** using appropriate tools.
6. **Carefully lift and remove the repeater from the bracket** to avoid damage.

Note: If a replacement device is not being installed immediately, all disconnected cables, including RF and power connectors, must be properly sealed and weatherproofed to prevent moisture ingress or damage from environmental exposure.

Following these steps will help maintain system safety and prepare the site for future equipment installation without introducing risks to personnel or hardware.

6 Appendix

6.1 Abbreviations

AGC	Automatic Gain Control
BS	Base Transceiver Station
DL	Downlink
DU	Donor Unit
Min	Minimum
PA	Power Amplifier
RF	Radio Frequency
RSSI	Receive Signal Strength Indication
SDM	Synchronization Detection Module
SIM	Subscriber Identity Module
SU	Service Unit
UL	Uplink
VSWR	Voltage Standing Wave Ratio
RCU	Remote Control Unit
ICS	Interference Cancellation Schem

6.2 W-dBm Conversion Table

W	dBm	W	dBm	W	dBm	W	dBm	W	dBm
0.01	10.00	0.11	20.41	0.21	23.22	0.31	24.91	0.41	26.13
0.02	13.01	0.12	20.79	0.22	23.42	0.32	25.05	0.42	26.23
0.03	14.77	0.13	21.14	0.23	23.62	0.33	25.19	0.43	26.33
0.04	16.02	0.14	21.46	0.24	23.80	0.34	25.31	0.44	26.43
0.05	16.99	0.15	21.76	0.25	23.98	0.35	25.44	0.45	26.53
0.06	17.78	0.16	22.04	0.26	24.15	0.36	25.56	0.46	26.63
0.07	18.45	0.17	22.30	0.27	24.31	0.37	25.68	0.47	26.72
0.08	19.03	0.18	22.55	0.28	24.47	0.38	25.80	0.48	26.81
0.09	19.54	0.19	22.79	0.29	24.62	0.39	25.91	0.49	26.90
0.10	20.00	0.20	23.01	0.30	24.77	0.40	26.02	0.50	26.99
W	dBm	W	dBm	W	dBm	W	dBm	W	dBm
0.51	27.08	0.61	27.85	0.71	28.51	0.81	29.08	0.91	29.59
0.52	27.16	0.62	27.92	0.72	28.57	0.82	29.14	0.92	29.64
0.53	27.24	0.63	27.99	0.73	28.63	0.83	29.19	0.93	29.68
0.54	27.32	0.64	28.06	0.74	28.69	0.84	29.24	0.94	29.73
0.55	27.40	0.65	28.13	0.75	28.75	0.85	29.29	0.95	29.78
0.56	27.48	0.66	28.20	0.76	28.81	0.86	29.34	0.96	29.82
0.57	27.56	0.67	28.26	0.77	28.86	0.87	29.40	0.97	29.87
0.58	27.63	0.68	28.33	0.78	28.92	0.88	29.44	0.98	29.91
0.59	27.71	0.69	28.39	0.79	28.98	0.89	29.49	0.99	29.96
0.60	27.78	0.70	28.45	0.80	29.03	0.90	29.54	1.00	30.00
W	dBm	W	dBm	W	dBm	W	dBm	W	dBm
1	30.00	11	40.41	21	43.22	31	44.91	41	46.13
2	33.01	12	40.79	22	43.42	32	45.05	42	46.23
3	34.77	13	41.14	23	43.62	33	45.19	43	46.33
4	36.02	14	41.46	24	43.80	34	45.31	44	46.43
5	36.99	15	41.76	25	43.98	35	45.44	45	46.53
6	37.78	16	42.04	26	44.15	36	45.56	46	46.63
7	38.45	17	42.30	27	44.31	37	45.68	47	46.72
8	39.03	18	42.55	28	44.47	38	45.80	48	46.81
9	39.54	19	42.79	29	44.62	39	45.91	49	46.90
10	40.00	20	43.01	30	44.77	40	46.02	50	46.99
W	dBm	W	dBm	W	dBm	W	dBm	W	dBm
51	47.08	61	47.85	71	48.51	81	49.08	91	49.59
52	47.16	62	47.92	72	48.57	82	49.14	92	49.64
53	47.24	63	47.99	73	48.63	83	49.19	93	49.68
54	47.32	64	48.06	74	48.69	84	49.24	94	49.73
55	47.40	65	48.13	75	48.75	85	49.29	95	49.78
56	47.48	66	48.20	76	48.81	86	49.34	96	49.82
57	47.56	67	48.26	77	48.86	87	49.40	97	49.87
58	47.63	68	48.33	78	48.92	88	49.44	98	49.91
59	47.71	69	48.39	79	48.98	89	49.49	99	49.96
60	47.78	70	48.45	80	49.03	90	49.54	100	50.00

$mW \Rightarrow 10 * \text{LOG}(mW) \text{dBm}$

6.3 Warranty Provisions and Disclaimer

6.4 6.4.1 Warranty Range

This document defines the after-sales service Airgain Technology Corporation (hereinafter referred to as Airgain) would provide for its own products. Airgain will be responsible for repairing or replacing the same type of product within the warranty period under the circumstances that the product has identical defects in material, manufacturing, or software process.

6.4.1.1 Warranty Period

From product shipping day, the deadline will follow the warranty period terms of the purchasing contract Airgain signed with accounts.

The rechargeable battery set belongs to expendables; Airgain will provide a six-month warranty period from the shipping month.

6.4.1.2 Hardware/Firmware

During the warranty period for Airgain's products, if any defects cause customers to be active and sent back to Airgain, Airgain will provide a free repair service.

6.4.1.3 Software

During the warranty period, if any bug exists in Airgain's software, Airgain will update the new software for free.

6.5 6.4.2 Range of Non-Warranty

6.4.2.1 Hardware/Firmware

These warranty provisions do not cover any defects or damages that could not be attributed to Airgain. The non-attribution subjects include but are not limited to the following conditions:

- I. Force majeure of natural disasters (such as floods, fire, earthquakes, lightning, typhoon...etc.)
- II. Physical abuse (such as beating, hitting, throwing, improper keeping, inappropriate shipment, losing, soaking...etc.)
- III. Damages by inappropriate setup (such as operating without following the instruction from the user's manual, the violation of grounding requirements, the violation of water-proof requirements...etc.)
- IV. Damage or defect caused by dismantling, changing specification/parts/design of a product or using non-standard components (such as power supply...etc.) without official authorization from Airgain

- V. Change or damaged product serial number label (including external/internal P/N label and QC PASS anti-tear label of modules) without authorization
- VI. Damages by the AC power of product setup environment, electrostatic or huge change/impact/unstable of magnetic field

6.4.2.2 Software

These warranty provisions do not cover any defects or damages that could not be attributed to Airgain. The non-attribution subjects include but are not limited to the following conditions:

- I. Artificial Modification (Analysis of the Software by reverse engineering, decoding or Disassembling)
- II. Trial version or free software
- III. Violation of the setup rules of the user's manual

6.6 6.4.3 Service in Non-Warranty

Airgain will continue to provide after-service services during a non-warranty period.

6.4.3.1 Hardware/Firmware

- I. Customers need to pay any shipping or transporting fees.
- II. Airgain will charge reasonable fees for repaired products, parts, and manpower working.
- III. For the repaired parts and components of the product during the non-warranty period, Airgain will provide another six-month warranty period.

6.4.3.2 Software

Airgain will provide a charge service to update new versions of software in the non-warranty period.

6.7 6.4.4 Disclaimer

- I. Airgain's product design is only applied to the telecommunication field. For anyone's death or injury, for any subject's damage, or for Airgain's products being applied, including but not limited to military or military-related equipment, traffic control equipment, disaster prevention system, and medical or medical-related equipment, Airgain has the exempt from any responsibility from the condition stated above. This non-commitment clause does not restrict or eliminate the responsibility caused by Airgain's fault or misrepresentation.
- II. In the range of any suitable laws, for any inability to use Airgain hardware or software to access data, loss of or corruption to data, loss of business, loss of profits, loss of revenue and anticipated savings, business interruption or the like for any direct/indirect, incidental,

consequential loss or damage whatsoever, in each case, arising out of the use of or inability to use the hardware/software even if Airgain has been advised of the possibility of such loss or damage.