

Installation Guide

Ruggedized Access Point AP 21

Enabling cellular wireless connectivity for enterprise environments, within private spectrum options



celona

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Introduction

This document provides the necessary guidance to help the user enable services on the Celona Ruggedized Outdoor 5G NR Access Point (AP), AP 21. This guide provides an overview of the AP capabilities and the installation procedures that must be accompanied.

About the AP

The Celona AP 21 is a 3GPP Release 15 compliant integrated 5G NR with external antenna support, operating within the 3300–4200 MHz spectrum band. AP 21 supports 2x2 MIMO (multiple-input, multiple-output), up to 256-QAM modulation and can be pole or wall mounted.

Frequency Band Support (SKUs)

AP21-48	3.55–3.7 GHz
AP21-78H	3.6–3.8 GHz
AP21-77	3.8–4.2 GHz

Introduction

Installation Instructions

Ensure the packaging is not damaged or wet. If it is, or if any items inside are missing or damaged, contact Celona at support@celona.io for instructions. The table below contains the shipping list showing the quantity of each item that should be received.



Item	Qty	Description
AP 21 unit	1	Confirm tag on the unit to ensure received model is correct.
Power adaptor	1	48V DC (AC adapter and power surge protector included)
Power terminal	1	2 wires green terminal
Power plug	1	Standard power plug (US, EU or UK based on AP21 SKUs)
Optical module	2	SFP, LC optical module, LC needs dual strand fibre cable
GPS antenna assembled kit	1	Assembled kit: GPS antenna GPS fixing accessories Unassembled / Individual kit: M4 (x12) screw (x3) GPS jumper cable (x1)
Installation bracket assembled kit	1	Assembled kit: Installation bracket (x1) Omega (x4) M10 * 160 outer hex bolt (x4) M10 flat gasket (x4) M10 spring gasket (x4) M10 nut (x4) Unassembled / Individual kit: M10 flat gasket (x6) M10 spring gasket (x6) M10 nut (x6) M8 (x80) expansion bolt (x2)
OT Ground Terminal	2	For ground cabling
Cold Shrink Tubes	6	Installation accessory

Introduction

Installation Preparation

Personnel

Celona recommends that installation personnel review this entire installation guide prior to beginning the installation. Please note that installing the AP on a cell tower, building, or other structure may require at least two people or a qualified tower crew. Installation personnel must follow standard safety precautions concerning height, electricity, and other regulations.

Network Design Plan

Each cell site may be unique in terms of the type and number of components to install, the coverage area, the user requirements, and so forth. Identify the structure on which the AP equipment will be installed, the intended height where the antenna and AP will be attached, the degree of antenna down tilt, and other necessary specifications that may impact the success of the installation. AP 21 is operating in single carrier mode and uses ANT0 and ANT1.

Materials and Tools

The table that follows describes the materials required during the installation. The antenna elements chosen must support the channel of operation. The total output EIRP (Equivalent Isotropic Radiated Power) for AP21-48 is governed by Part 96 regulations of FCC and hence power is automatically calculated and regulated by Celona software.

Item	Description
Power cable	< AWG16, e.g., AWG14
RF antenna cable	50-ohm feeder
RF antenna	Omni or directional
Optical fiber	Single mode optical fiber
Ethernet cable	CAT6 rated for outdoor use
Ground cable	Shorter than 330 feet (100 meters)

Introduction

Interfaces

Interface Name	Description
PWR	Power supply: -48VDC (-60V to -42V)
GPS	Port for optional external Global Positioning System (GPS) antenna, N-female connector
ANT0	Port for external RF antenna 0, N-female connector
ANT1	Port for external RF antenna 1, N-female connector
OPT	Optical backhaul interface for connecting to external transmission network and used for data backhaul
ETH	RJ-45 interface, used for debugging or data backhaul

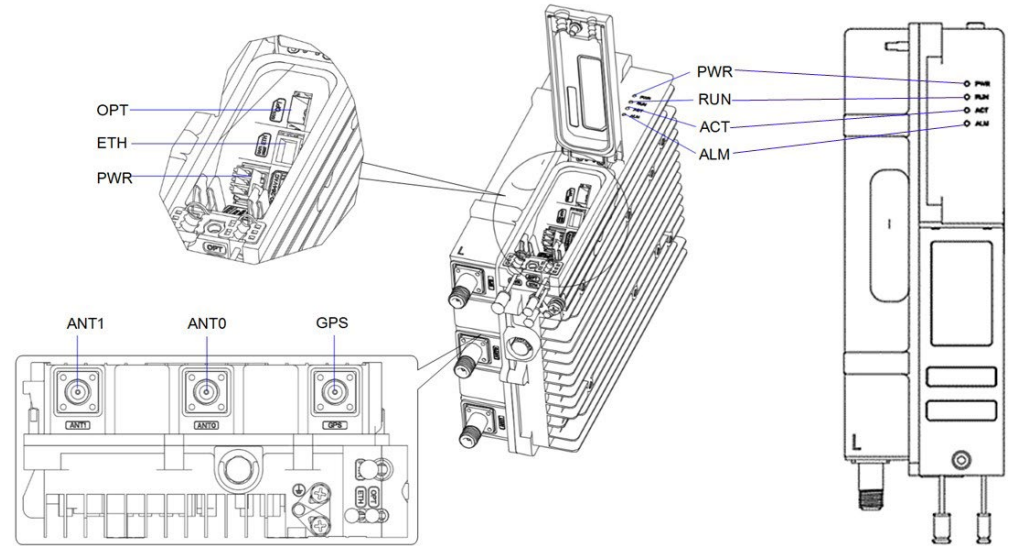


Figure shows the interfaces on AP 21.

LEDs

Identity	Color	Status	Description
PWR	Green	Steady on	Power is on
		OFF	No power supply
ACT	Green	Steady on	The cell is activated
		OFF	The cell is not activated
RUN	Green	Fast flash: 0.125s on, 0.125s off	Hardware alarm, e.g., VSWR alarm
		Slow flash: 1s on, 1s off	The software is initializing
		OFF	No power input, or faulty board
ALM	Red	Steady on	Hardware alarm, e.g., VSWR alarm
		OFF	No alarm



Introduction

Location and Environment

AP 21 can be installed on a pole or a wall. For the best signal coverage, place the AP 21 in an unobstructed location. In addition to network planning, when determining where to place the AP 21, you need to consider factors such as climate, hydrology, geology, the possibility of earthquakes, reliable electric power, and transportation access. Avoid locating the AP 21 in areas with extreme temperatures, harmful gases, unstable voltages, volatile vibrations, loud noises, flames, explosives, or electromagnetic interference (e.g., large radar stations, transformer substations). Avoid areas prone to impounded water, soaking, leakage, or condensation. The AP is certified for Class 1, Div. 2 HAZLOC installation.

Environmental Specifications

Item	Description
Operating Temperature	-22°F to 131°F / -30°C to 55°C
Storage Temperature	-40°F to 149°F / -40°C to 65°C
Relative Humidity (no condensation)	2% to 95% RH
Atmospheric Pressure	70 kPa to 106 kPa
Safety voltage	DC: -40 VDC to -57 VDC AC: 90 VAC to 264 VAC

Grounding and Lightning Protection

You should protect the AP 21, antenna, and GPS against lightning. Following are guidelines concerning grounding.

- The yellow-green ground wire must be at least 6 AWG (10 mm²) in diameter.
- Always place the grounding as near as possible to the equipment.
- Connect to a reliable outdoor grounding point (earth) using one ground screw.
- The connection of the grounding points and ground bar needs to be tight and reliable. Rustproofing the terminals, e.g., with antioxidant coating or grease, is required.

Installation

Some cell site structures may have existing frameworks for attaching the AP and antenna. For purposes of explaining the installation procedure, this section assumes the AP will be installed on a support pole or on a wall.

Process Overview

Figure below provides an overview of the installation process.

- Installation Process Overview
- Install GPS antenna on the AP
- Install AP to the pole (or wall)
- Mount the antenna equipment
- Connect the Ethernet and ground cables
- Power on device
- Check LEDs

Weatherproofing

To protect the connection points from weather and climate, clean each connection point before installing cold shrink tubes, per the following.

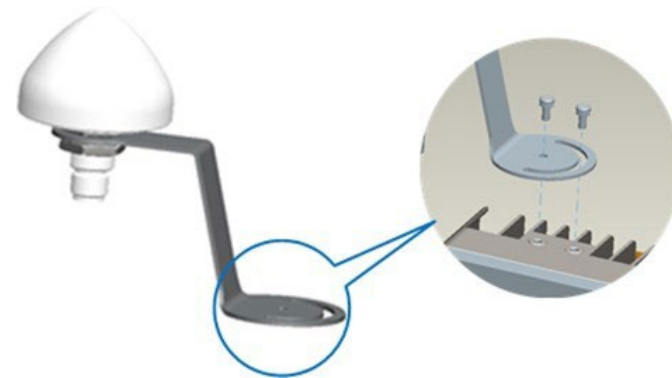
1. Insert the cable into the cold shrink tube.
2. Tighten the connector.
3. Push the cold shrink tube to the top joint and pull out the strip.
4. Ensure the cold shrink tube is tightly fitted with the connection.



Install GPS Antenna

Read the following requirements before installing the GPS antenna on the AP.

- GPS works best when line of sight exists with the sky. Ensure no major blockage from buildings in the vicinity. Ensure the space atop is at least 45 degrees unblocked by any buildings.
- If possible, avoid installing the GPS antenna in the vicinity of any other transmitting and receiving devices, to avoid interference. The GPS antenna should be installed within 45 degrees to the lightning rod.
- The GPS antenna system is assembled in manufacturing before packing. The only installation step is to fix the GPS mounting bracket on the AP 21 with the M4*14 screws, as shown in Figure below.

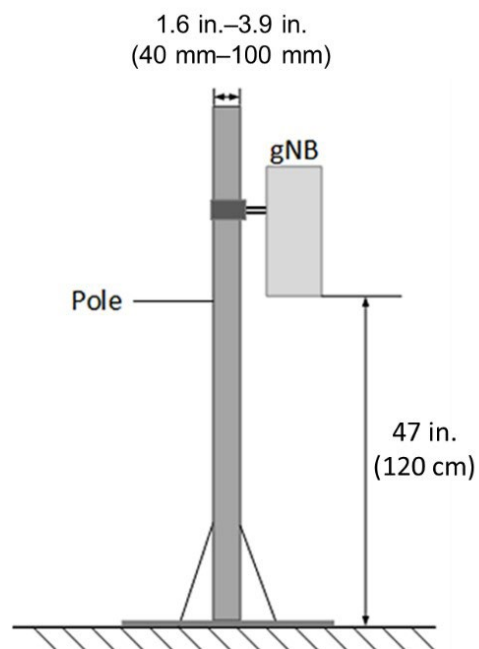


Installation

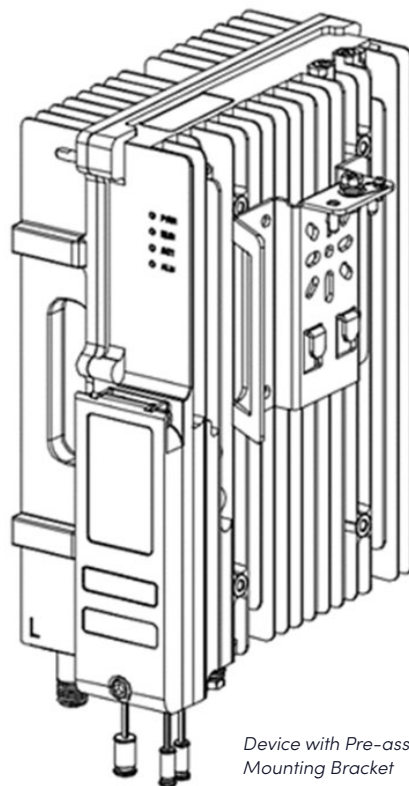
Install AP on Pole or Wall

Install on Pole

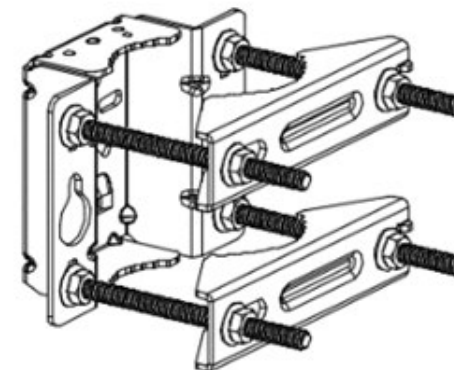
Ensure the pole's diameter is in the range of 1.6 in.–3.9 in (40 mm–100 mm). The position of the AP 21 on the pole should be at least 47 inches (120 cm) in height.



Diameter and Height Requirements



Device with Pre-assembled Mounting Bracket



Pole or Wall Mounting Bracket

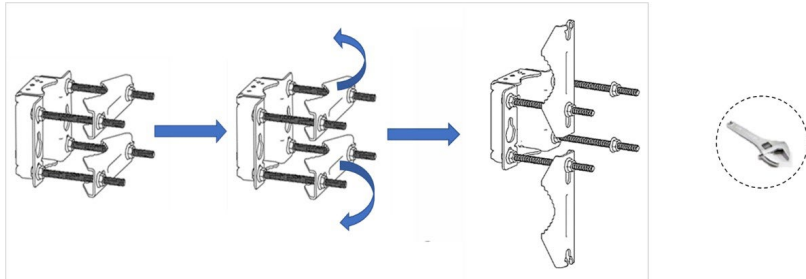
The AP 21 mounting bracket is assembled before packing and includes two components: the pre-assembled bracket on the back of the device and the pole or wall mounting bracket.

Installation

Follow the steps below to install the AP 21 on a pole.

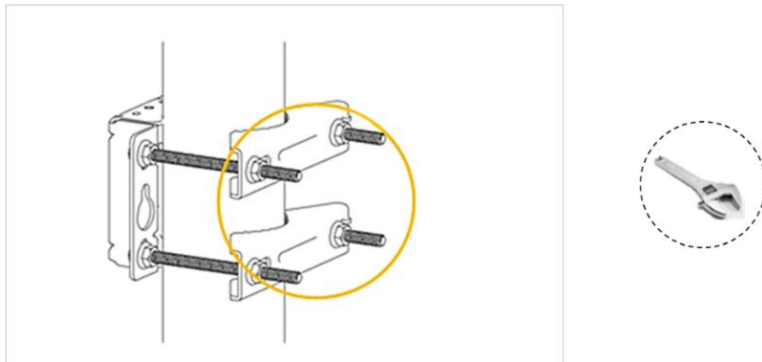
1. Unscrew the nuts of the pole mounting bracket, slide the two clamps to the left, and turn them up or down.

Turn Clamps



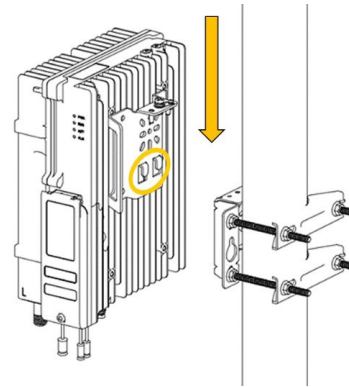
2. Place the pole mounting bracket against the pole and return the clamps to the horizontal position. Slide the clamp to the right and retighten the nuts.

Place Bracket on Pole



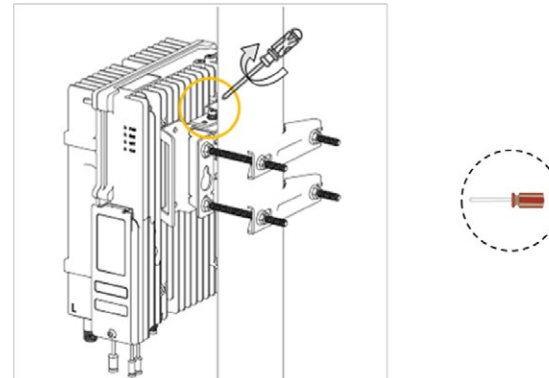
3. Hold the AP 21 vertically and align the two pins on the AP 21 bracket with the pin holes on the pole mounting bracket. Push the AP 21 down until the hooks are firmly attached to the corresponding slots on the pole mounting bracket.

Attach AP 21 to Bracket



4. Tighten the bolt and screw on the top of the AP 21 with a Phillips-head screwdriver.

Tighten Bolt and Screw



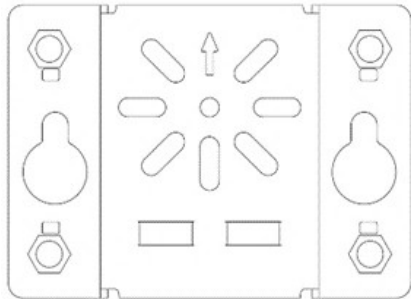
5. Once the installation is complete, proceed to "Connect Cables" section.

Installation

Install on Wall

Ensure the wall can bear at least four times the weight of the AP 21.

The wall mounting bracket is shown below.

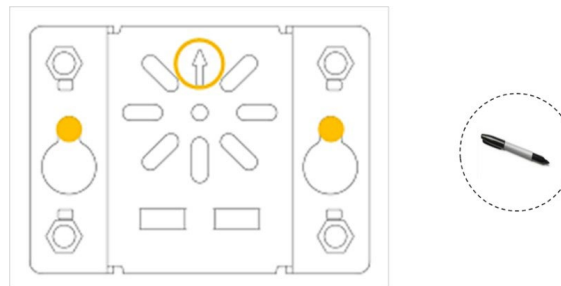


Wall Mounting Bracket

Follow the steps below to install the AP 21 on a wall.

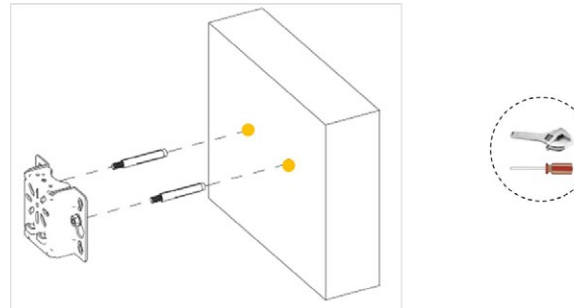
1. Place the wall mounting bracket on the wall with arrow point up and mark the drilling location using a pencil or marker.

Mark Drilling Location



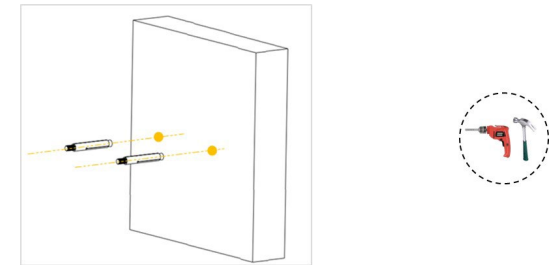
2. Drill two 0.4 in. (10 mm) diameter by 2.8 in. (70 mm) deep holes in the wall at the marked locations and insert expansion bolts.

Install Expansion Bolts



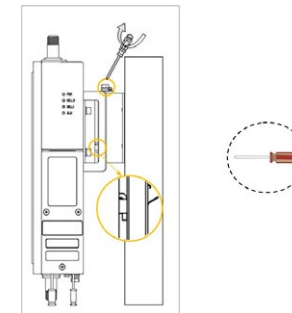
3. Hang the wall mounting bracket on the expansion bolts and fasten it with flat washers, spring washers, and nuts.

Hang Bracket



4. Hold the AP 21 vertically and align the two pins on the AP 21 bracket with the pin holes on the pole mounting bracket. Push the AP 21 down until the hooks are firmly attached to the corresponding slots on the pole mounting bracket. Then, tighten the screw to complete the installation.

Completed Installation



5. Once the installation is complete, proceed to the "Connect Cables" section.

Installation

Connect Cables

General requirements:

- Bending radius of antenna feeder cable: $7/8" > 250\text{mm}$, $4/5" > 380\text{mm}$
- Bending radius of jumper cable: $1/4" > 35\text{mm}$, $1/2"$ (super soft) $> 50\text{mm}$, $1/2"$ (ordinary) > 127
- Bending radius of power cable and grounding cable: $>$ triple the diameter of the cable
- The minimum bending radius of the optical fiber is 20 times the diameter of the optical fiber.

Bind the cables according to the type of cable; intertwining and crossing are performance-impacting and hence forbidden. An identification label should be attached after the cable is laid for cataloging and referencing.

Optical fiber cable requirement:

- Avoid circling and twisting.
- Avoid binding on a turn.
- Avoid pulling and weighing down the optical fiber.

Grounding cable requirement:

- The grounding cable must connect to the grounding point.
- The grounding cable must be separated from the signal cables with sufficient distance to avoid signal interference.

Connect GPS Antenna Cable

- Insert the GPS jumper into a cold shrink tube.
- Connect one end of the GPS jumper to the GPS antenna.
- Push the cold shrink tube to the top joint and pull out the strip.
- Connect the other end of the GPS jumper to the GPS interface on the AP, which also needs weatherproof protection.

Connect RF Cable

- Open the dust caps of the ANT0, ANT1 interfaces.
- Insert the RF cables into cold shrink tubes.
- Connect one end of the RF cables to the ANT0, ANT1 interfaces on the AP and tighten them with a wrench.
- Push the cold shrink tube to the top joint and pull out the strip.
- Connect the other end of the RF cables to the external antennas, which also need weatherproof protection.

Installation

Connect Power Connector

Since the length of cable needed for power varies from site to site, the two ends of the power adaptor are bare terminal ends. The installer would need to make the power cable according to the actual measurements of the installation site and assemble the power plug and power terminal on the two ends of the power adaptor. Strip 0.47in/12mm of the insulating layer with a wire stripper which is then used for connecting to the connector. The power cord length is ideally kept below 330 ft/100m.

The connection steps for the power cable are as follows.

- Assemble the power plug. The power plug will be installed on the end of the input direction. Refer to the labels on the power plug for connecting the live wire and ground wire to the corresponding terminals separately and tighten the screws. Assemble the power terminal. The power terminal will be installed on the end of the output direction. Refer to the figure below to connect the live wire and neutral wire.
- Connect the power cable to the PWR interface in the wiring cavity.
- The power cable lays along the lint slot and stretches out the wiring cavity from the PWR port.
- The input of the power adaptor connects to the outlet. If the outlet is outdoors, place the power adaptor Outdoors. If the outlet is indoors, place the power adaptor in a waterproof box.
- After the cable connection is complete in the wiring cavity, tighten the screws on the cover to close the wiring cavity using an M4 cross screwdriver.



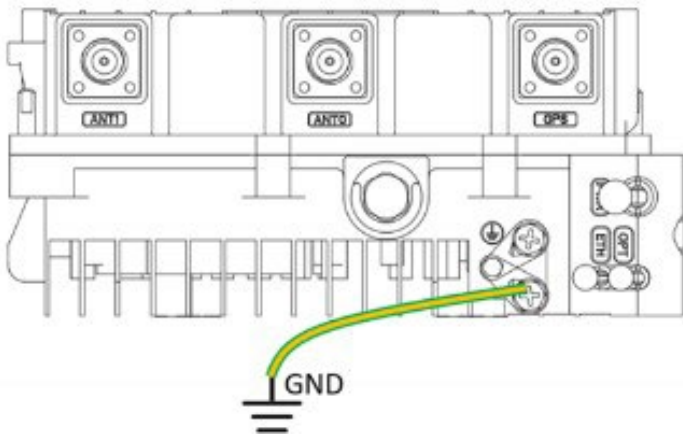
Brown wire: This is typically the "live" or "hot" wire and should be connected to the "L" or "Line" terminal on the power supply and the "black" wire on the access point. The "black" wire on the access point is used for the "live" or "hot" connection.

Blue wire: This is typically the "neutral" wire and should be connected to the "N" or "Neutral" terminal on the power supply and the "white" wire on the access point. The "white" wire on the access point is used for the "neutral" connection. Also, strip the wire to fit to the connector accessory provided in the unit.

Installation

Connect Ground Cable

Prepare the grounding cable according to the actual measurements and requirements of the specific installation site. The AP 21 has two grounding screws located on the bottom of the unit as shown below.



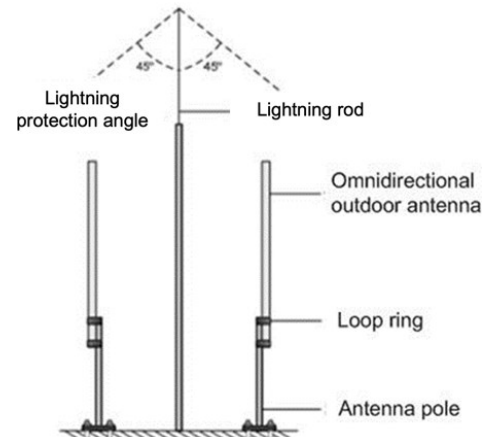
Unscrew one grounding screw, connect one end of the ground cable to the grounding screw, and fasten it again. The other end of the ground cable needs to connect to a good grounding point.

Install Antenna Feeder System

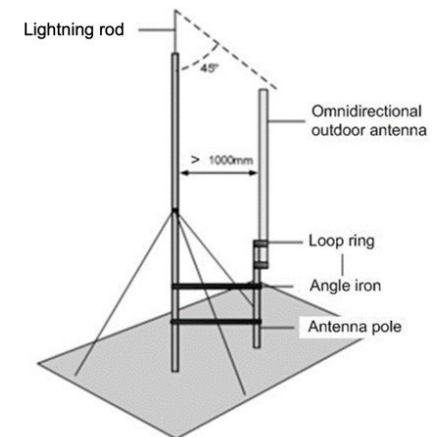
There are two kinds of outdoor antennas, omni-directional and directional.

- Adhere to the following guidelines when installing an omni-directional antenna. The diameter of the pole should be 1.4in/35mm to 2in/50mm. A typical case is to use the 50mm-diameter round-steel-made pole (with details depending on the specific antenna type). Make sure that the top of pole and the clamp beneath the antenna are at the same level after installing the omni-directional antenna on the pole. Make sure the antenna is high enough to meet the coverage requirements, and that the antenna top falls within the 45 degrees safety angle towards an independent lightning rod. Refer to Figure: Omni antenna installation.
- In case it is impossible to install an independent lightning rod due to environmental limitations, the installation method shown in Figure: Alternative omni antenna installation can be used. Be aware that the pole supporting the lightning rod should be kept at least 1m away from the omnidirectional outdoor antennas.

Omni antenna installation



Alternative omni antenna installation



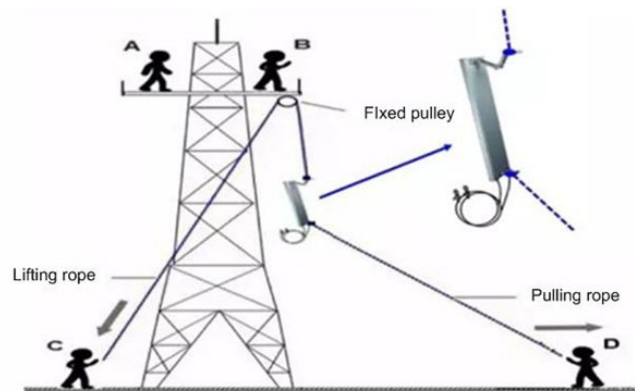
Installation

Install Directional Antennas

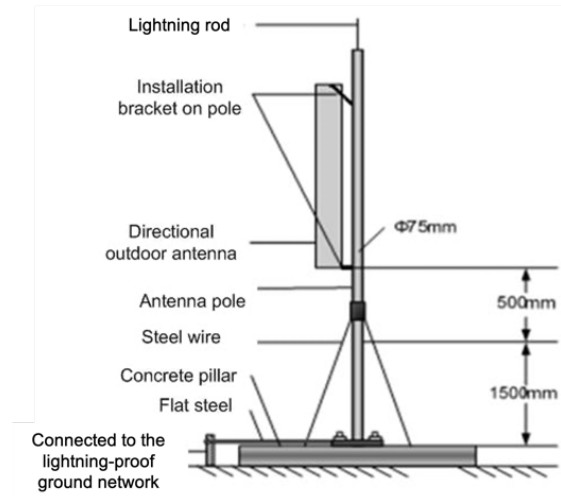
Assemble the directional antenna as demonstrated below.



To install the antenna on a tower or other structure, use a pulley to transport the antenna assembly to the platform, as shown below. Follow standard safety rules when working at these heights.



Fix the pole vertically to the ground, or to concrete pillars on a rooftop, using expansion screws. Fasten the pole with steel wires. Then, mount the directional outdoor antenna onto the pole using the installation rack as shown below.



When the AP has been installed in a proper position, connect all the cables and wires. Seal and weatherproof all the connections after the testing have been successfully completed.

Installation

Power on to Check LEDs

Power on the AP and check that the LED indicators are lighting as expected. Refer to the LED descriptions detailed in earlier sections of this document.

Checking AP Status

The Celona AP 21 is designed to be plug-and-play, and therefore arrive pre-configured. The status is inferred by the LEDs and subsequently by connecting a mobile device to the Celona AP. A properly connected AP will show the Celona logo as the operator on the mobile's screen.

Certified Professional Installation

The Celona AP 21 is a Class-B, FCC Part 96 certified device. Class-B devices are required to be professionally installed by a Certified Professional Installer (CPI). A CPI is an FCC approved person that has the legal authority to validate and confirm the installation with a digital signature.

The following information must be entered for each AP 21 by the CPI and the information must be signed off by a CPI with current standing.

- GPS coordinates: Latitude, Longitude, Height, Height Type ("above sea level" or "above ground level")
- Antenna details: Antenna Azimuth, AntennaDowntilt, AntennaGain, EirpCapability (Conductive power), AntennaBeamwidth, AntennaModel

The CPI information detailed above is packaged alongside the AP's FCC ID, the operator's ID (user ID) and signed with CPI's private key.

The CPI ensures the above values are verified for each AP and signs off the CPI data with the CPI Identification, CPI Name and Certified Installation time.

The CPI information is securely uploaded per AP to the Celona Orchestrator over an HTTPs interface. Celona Edge uses the information for each AP when it registers the APs with the Spectrum Manager.

Regulatory Compliance

FCC Compliance

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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.

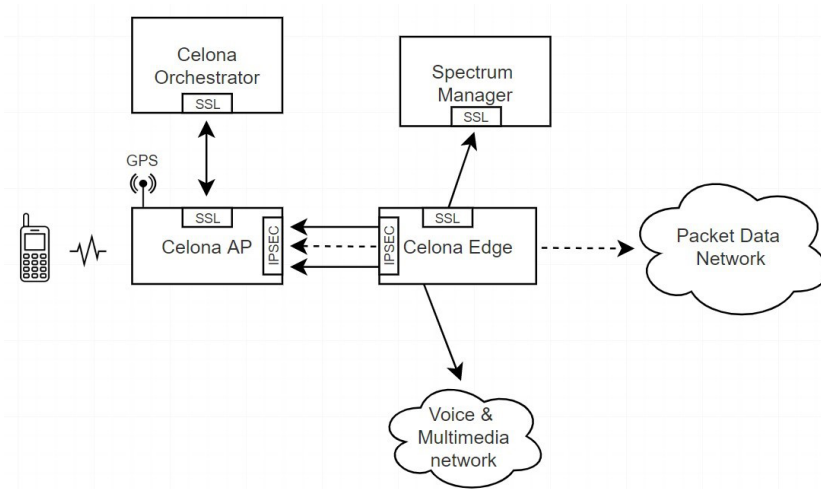
Warning: This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 12 inches (30 cm) between the radiator & your body.

CE Compliance

Celona AP 21 conforms with those essential requirements of the Radio Equipment Directive 2014/53/EU such as Health, Safety, EMC, and Radio Spectrum.

System architecture

The high-level architecture that enables the Celona AP 21 is shown below.



The system consists of the essential functions for a private 5G NR network.

The Celona Orchestrator performs AP authentication, validates the AP's serial number, determines the network the AP needs to connect to and finally directs the Celona AP 21 to the serving Celona Edge.

Each Celona AP 21 obtains service via its serving Celona Edge. The Celona Edge registers the Celona AP 21, arbitrates spectrum with an FCC approved Spectrum manager and algorithmically determines the most optimal radio parameters for the AP.

The Celona Edge is aware of the Celona AP 21's location and its existing surrounding radio environment automatically. Once the AP is admitted by the Celona Edge, the AP can commence radio transmissions and service the mobile stations.

Celona AP 21 capabilities

The following sections give the reader the capabilities of the Celona AP 21. The AP is a 5G NR small cell.

The AP hosts functions to provide the following services:

- Resource management: Admission control, Flow control
- Encryption of user data and control streams
- Registering mobile stations with Celona Edge for Voice and Data services
- Data only or Voice only or Data + Voice service
- Paging the mobile stations that are in power save mode
- Fairness in allocation of resources across multiple mobile stations in both uplink and downlink directions
- Measurement configurations and handling of mobility of mobile stations

Discovery

The Celona AP 21 supports zero-touch provisioning. The AP is preconfigured with details necessary to discover the Celona Orchestrator and the Celona Edge automatically. After the DP (Domain Proxy) discovers the Celona Orchestrator and the Celona Edge, the AP gets provisioned with operational parameters and is authorized to transmit.

The Celona Edge alone controls the radio frequency transmission of the Celona AP 21. Once the AP is operational, it can provide services to mobile stations. The mobile stations can connect with the Packet data network as well with Voice and multimedia networks via the Celona Edge.

The user data and control signals are encrypted. The Celona AP 21's performance is periodically monitored by the Celona Edge and operational parameters are continually optimized.

System architecture

Operations and Maintenance

The Celona AP 21 is operationally maintained by the Celona Orchestrator and Celona Edge using NETCONF.

Celona AP 21's radio parameter provisioning, performance monitoring and fault monitoring occur over the NETCONF interface. The AP supports the following technical reports from the Broadband Forum

Fault management

TR-157 Amendment 5

Celona AP 21's performance is monitored between every 5 minutes and 15 minutes, determined by the Celona Edge. Any AP faults are automatically propagated by the AP to the Celona Edge and Celona Orchestrator.

Security

The Celona AP 21's interfaces are secured by IPSEC or SSL. The certificates required to establish HTTPs connections with the Celona Orchestrator and IPSEC with the Celona Edge are provisioned at the factory.

If the certificates on the Celona AP 21 need to be updated or replaced, the process is automatically triggered and managed by the Celona Edge. The certificates conform to the industry compliant X.509 standard.

The IPSEC gateway is provisioned within the Celona AP 21 through the Celona Orchestrator. IKEv2 is used to establish the IPSEC tunnel between the Celona AP 21 and Celona Edge.

Phase and time synchronization

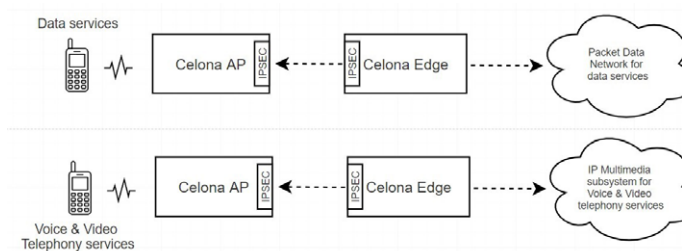
Celona AP 21 is a "Time division duplex (TDD)" 5G NR small cell. TDD small cells have strict requirements for maintaining time and phase synchronization so that they do not interfere with neighboring APs.

The Celona AP 21s have a built-in, high-fidelity GPS chip that can establish location as well as maintain clock synchronization. The AP's carrier frequency accuracy, time and phase drifts are disciplined by the onboard GPS clock.

Data and voice connectivity

As seen in the figure below, mobile stations can obtain data and/or voice connectivity via the Celona Edge after the Celona AP 21 has its radio enabled. Celona AP 21 automatically determines the capability of mobile stations before determining whether requested services can be accommodated.

Celona AP 21 and Celona Edge perform admission control for the mobile station and Celona Edge enforces authentication of the mobile station before accepting service requests. Further, Celona Edge and Celona AP 21 encrypt all control signals and user data between the mobile station and the Celona Edge.



Celona AP 21 employs sophisticated adaptive modulation & code rate control for adapting mobile stations' link according to the dynamic channel conditions seen on the air interface between the mobile stations and Celona AP 21. Celona AP 21 also employs effective power control to keep transmit powers from the mobile stations as low as practicable.

System architecture

Power save mode

Celona AP 21 monitors traffic volume and enables power save options when a mobile station has encountered a long lull in data volume, such as when a voice or video call is terminated.

While in power save mode,

- the mobile station can minimize its receiver and transmitter functions to essential functions, increasing the battery standby time.
- the Celona Edge will awaken the mobile station during user data transmission.

Radio access technology

Celona AP 21 implements an extensive set of 3GPP worldwide standards to provide advanced, 5th-generation packet radio service to mobile stations.

Type	5G Ruggedized Access Point (3GPP Rel. 15 TDD)
RF Specifications	2x2 MIMO UL/DL, up to 256 QAM Modulation
Channel Bandwidth	10/20/40/60/80/100 MHz

Supported frequency band

The following is a list of supported operational frequencies by specific AP 21 model:

AP21-48	3.55-3.7 GHz
AP21-78H	3.6-3.8 GHz
AP21-77	3.8-4.2 GHz

Seamless session mobility

If there are multiple Celona AP 21s in the system all connecting to the same Celona Edge, the Celona AP 21s can provide seamless service to the mobile stations. The mobile stations may establish data and/or multimedia sessions within the coverage area of one Celona AP 21 and seamlessly migrate to a coverage area provided by a different Celona AP 21. The source and target Celona AP 21s handle the transfer of contextual information corresponding to existing flows setup for the mobile station automatically.

Coverage area

The coverage area of each Celona AP 21 depends on several factors some of which are indicated below.

- Transmit power authorized by the Spectrum Manager and is set on the Celona AP 21 by Celona Edge.
- Number and proximity of other APs (Celona AP 21s or other APs) operating on the same frequency in the geographic area, or on a different frequency but in the same band.
- Building type and material types used at, near and around the installation site, along with the expected minimum data rate at the edge of coverage.

Supported System bandwidth

The Celona AP 21 supports only one cellular sector. The following combinations of system bandwidth are possible depending on authorization provided by the Spectrum Manager.

Channel bandwidth supported by one AP

20/40/60/80/100 MHz

Support and Warranty

Celona support is available on the web at <https://celona.io/support> where information about warranty on Celona's outdoor APs can also be found.



celona
celona.io

hello@celona.io

900 E Hamilton Ave Suite 200,
Campbell, CA 95008, United States

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