APPLICATION NOTE

Communications Device

Antenna Selection

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1. Introduction

Campbell Scientific data loggers and communications products support a wide variety of wireless technologies, each requiring an antenna matched to the correct frequency band, gain, and installation scenario. Using the wrong antenna, even one that physically fits the connector, can significantly reduce communications range and reliability.

This guide covers antennas for the following technologies:

- 900 MHz ISM spread-spectrum
- 868 MHz SRD (Europe)
- 2.4 GHz ISM/Wi-Fi
- Cellular multiband (698–960 MHz and 1710–2700 MHz LTE)
- GOES satellite
- VHF telemetry

This reference guide is intended as a quick resource for users who already understand antenna types and simply need to identify which antennas Campbell Scientific offers for specific products. It also provides concise background information for newer users, including explanations of common antenna types, frequency bands, connectors, and recommended applications.

If you need to quickly identify a compatible antenna, start here: Quick reference tables (p. 1). If you are new to antennas or want additional background information, continue to Antenna types (p. 4) and the sections that follow for details on antenna types, frequency bands, connectors, and installation considerations.

2. Quick reference tables

The following two tables are independent references. To select an antenna, find your radio or device in Table 2-1 (p. 2) to identify its operating frequency band, then find antennas covering that same band in Table 2-2 (p. 3). Any antenna rated for the correct frequency band and connector type is a valid option; there is no required one-to-one pairing between a specific radio model and a specific antenna model. Antenna choice within a band is driven by installation scenario (direct-connect vs. cabled), gain required, mounting method, and whether MIMO is needed.

In Table 2-2 (p. 3), gain is shown in both dBd and dBi, using the published value as the primary value and the converted value as an approximation. See Antenna gain units: dBi vs. dBd (p. 4) for more information on these units.

> **NOTE:**
> The tables below provide operating band references for radio/device families and intended-band references for antenna models. They are provided for convenience and may not be exhaustive. Always verify current specifications, approvals, and ordering details on the relevant Campbell Scientific product page prior to purchase and deployment.

2.1 Radio and device models: operating frequency bands

Table 2-1: Wireless communications options by frequency band

Band/technology	Radio/device models (examples)
900 MHz ISM	RF401A, RF407, RF411A, RF412, RF452
868 MHz SRD (EU)	RF422
2.4 GHz ISM (spread-spectrum / Wi-Fi)	RF416, RF432, NL240, Wi-Fi options (product-dependent)
Cellular multiband (698–960 MHz & 1710–2700 MHz, LTE)	CELL220, CELL205, other cellular modems (band support depends on modem/certification)
GOES satellite	TX321, TX320, TX312, TX325, SAT HDR
VHF telemetry	ALERT/ALERT2, RF323 (and other VHF systems as applicable)

2.2 Supported antennas by band and gain

Antennas are tuned to perform optimally within specific frequency ranges. Match the antenna's frequency coverage to your radio or device's operating band (Table 2-1 [p. 2]). Do not assume an antenna is suitable based on connector fit alone; always verify the frequency rating.

> **NOTE:**
> The part numbers in the table below are provided for reference only. Part numbers and availability may vary by geographic region.

Table 2-2: Supported antennas by band and gain			
Part #	Intended band	Type	Gain
15731	900 MHz	1/4λ helical whip, direct-connect	0 dBd (≈ 2.15 dBi)
15730	900 MHz	1/4λ whip, right-angle (indoor/enclosure)	0 dBd (≈ 2.15 dBi)
14204	900 MHz	1/2λ whip, articulating	0 dBd (≈ 2.15 dBi)
15970	900 MHz	Dipole, adhesive	1 dBd (≈ 3.15 dBi)
14221	900 MHz	Omni, outdoor fiberglass	3 dBd (≈ 5.15 dBi)
14201	900 MHz	Yagi, directional	9 dBd (≈ 11.15 dBi)
14205	900 MHz	Yagi, directional	6 dBd (≈ 8.15 dBi)
28767	868 MHz	1/4λ whip, helical	-3.65 dBd (≈ -1.5 dBi)
16005	2.4 GHz	1/2λ whip, articulating	0 dBd (≈ 2.15 dBi)
17480	2.4 GHz (and other supported bands per spec)	Tri-band dipole, adhesive	1 dBd (≈ 3.15 dBi)
16755	2.4 GHz	Yagi, directional	13 dBd (≈ 15.15 dBi)
32256	698–960 MHz & 1710–2700 MHz (LTE multiband)	Whip, direct (SMA)	0 dBd (≈ 2.15 dBi)
32262	698–960 MHz & 1710–2700 MHz (LTE multiband)	Omni, outdoor	2 dBd (≈ 4.15 dBi)
32261	698–960 MHz & 1710–2700 MHz (LTE multiband)	Omni, bulkhead/enclosure mount (no mast hardware)	2 dBd (≈ 4.15 dBi)
38485	698–960 MHz & 1710–2700 MHz (LTE multiband, MIMO)	MIMO directional panel, 2-port (requires aiming)	9 dBi (≈ 6.85 dBd)
20679	806–960 MHz & 1850–1990 MHz (legacy dual-band)	Omni, 800/1.9 GHz (legacy dual-band; does not cover LTE 700 MHz)	0 dBd (≈ 2.15 dBi) / 3 dBd (≈ 5.15 dBi)
25316	GOES	Cross-Yagi RHCP	11 dBi (≈ 8.85 dBd)
35539	VHF	Tunable whip + radials	Field-tuned (gain varies)

3. Antenna types

3.1 Antenna gain units: dBi vs. dBd

Antenna gain measures how well an antenna focuses energy in a specific direction. It is always compared to a reference antenna, not measured on its own. Two reference units are commonly used:

- **dBi** compares the antenna to an **isotropic radiator**, a theoretical antenna that sends energy equally in every direction.
- **dBd** compares the antenna to a **half-wave dipole**, a simple and widely used antenna type.

A half-wave dipole focuses energy better than an isotropic radiator by 2.15 dBd. This is why the two units differ by that amount:

- dBi = dBd + 2.15
- dBd = dBi – 2.15

Table 3-1: Interpreting gain values and units

Gain	Meaning
0 dBi	Same as an ideal isotropic radiator
0 dBd	Same as a dipole antenna
3 dBd	3 dBd better than a dipole
-3 dBd	3 dB worse than a dipole

A gain value of 0 dBd does not indicate a poor antenna. An antenna at 0 dBd is already concentrating energy more than an isotropic radiator would. Many common whip antennas fall near this value.

Similarly, a negative dBd value does not mean the antenna is broken or low quality. It means the antenna focuses energy less than a half-wave dipole does. Small antennas often have lower gain because they are designed to be compact rather than highly directional.

3.2 Whip/omnidirectional antennas

Omnidirectional antennas radiate energy in all horizontal directions. They require no pointing or alignment and are commonly used for base stations communicating with multiple field stations, mobile deployments, and applications where the best RF path is not constant. Small direct-connect whip antennas attach directly to a connector with no cable required for short-range use. Larger outdoor omnidirectional antennas typically mount on a mast and require a coaxial cable run.

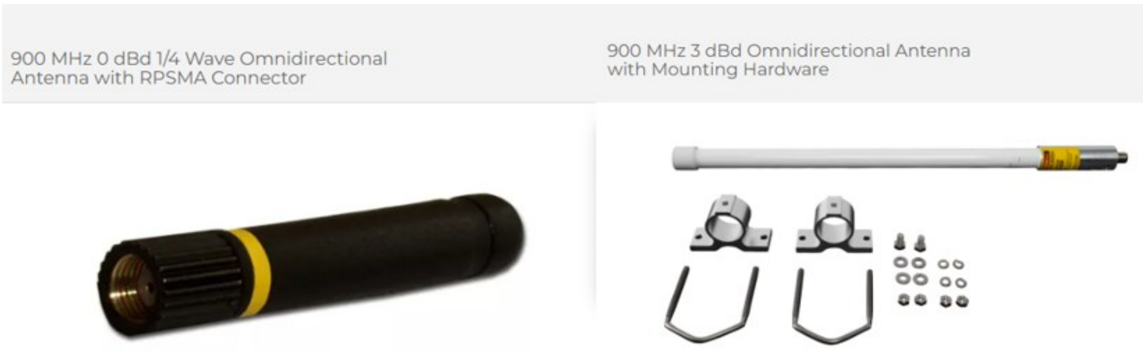

Figure 3-1. Examples of omnidirectional antennas

3.3 Yagi (directional) antennas

Yagi antennas concentrate RF energy into a narrow forward beam for higher gain, but they require aiming toward the other station. They are commonly selected for longer point-to-point links with clear line of sight. Because higher gain increases EIRP, regulatory limits may require reduced transmitter power in some systems.

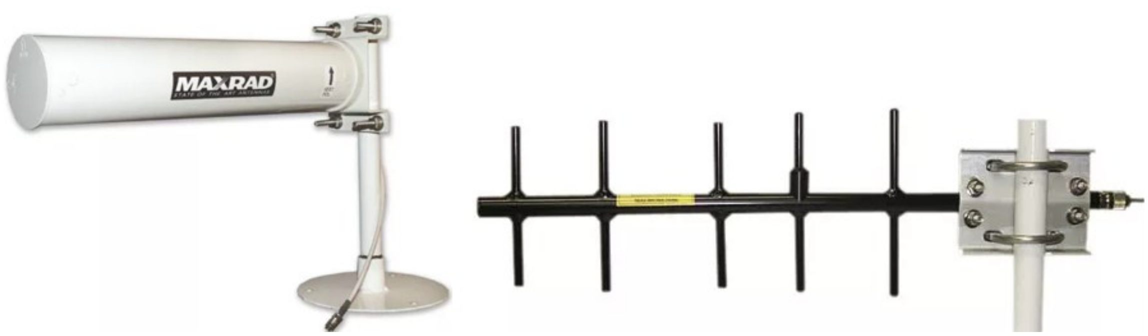

Figure 3-2. Examples of Yagi directional antennas

3.4 MIMO/diversity antennas

Many LTE modems support MIMO (multiple-input, multiple-output), which uses two antenna elements/ports to improve throughput and reliability. MIMO antennas provide two independent ports and should be connected to a MIMO-capable modem to obtain the intended benefit.

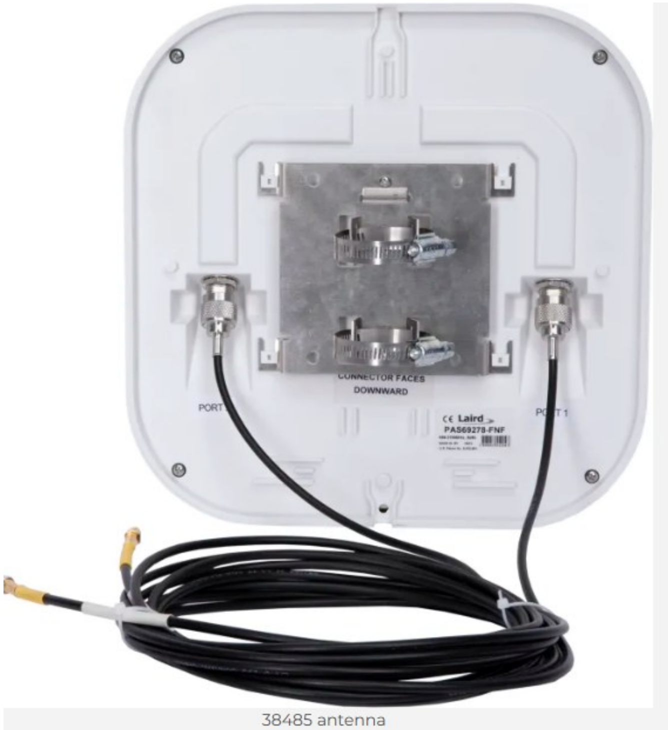

Figure 3-3. Example of a MIMO cellular antenna

4. Band overview

4.1 900 MHz ISM spread-spectrum

The 900 MHz ISM band is used by Campbell Scientific spread-spectrum radio networks (RF401A, RF407, RF411A, RF412, RF452, and others). Use antennas specifically rated for 900 MHz operation. Direct-connect whip antennas are suitable for short-range applications, while mast-mounted omnidirectional or Yagi antennas can be used to extend communication range. Verify connector compatibility (RPSMA versus Type N) and use surge protection on outdoor cable runs.

4.2 868 MHz SRD (Europe)

The 868 MHz SRD band supports license-free operation of short-range devices across Europe (RF422). Although 868 MHz and 900 MHz antennas may look physically identical, they are not interchangeable. Always verify the antenna’s rated operating frequency, not just connector compatibility.

4.3 2.4 GHz ISM spread-spectrum and Wi-Fi

The 2.4 GHz ISM band is used by Campbell Scientific spread-spectrum radios (RF416, RF432) and Wi-Fi-enabled products (NL240, NL241). Select antennas rated for 2.4 GHz operation. Use omnidirectional antennas for multi-directional coverage, and use a Yagi antenna for long-distance point-to-point links.

4.4 GOES satellite and VHF telemetry

GOES and VHF systems use specialized frequencies and antenna types. The 25316 cross-Yagi RHCP antenna is designed for GOES transmitters (TX312, TX320, TX321, TX325, SAT HDR) and must be aligned toward the satellite. The 35539 VHF Antenna Kit covers typical VHF radio applications. Follow the product manual for alignment, mounting, and tuning procedures specific to your system.

5. Connector types

Using the wrong connector is one of the most common field mistakes. Three connector types appear across Campbell Scientific antenna products:

SMA vs RP-SMA (reverse-polarity SMA)

- SMA and RP-SMA use the same thread/interface size, but the center pin/socket gender is reversed.
- They can appear to “fit” mechanically in some cases, but they are not interchangeable electrically or mechanically in a reliable way.
- When adapting, verify both the interface type (SMA vs RP-SMA) and the center contact (pin vs socket).

Type N

- Common on outdoor/mast antennas and surge protectors due to robustness and weatherproofing options.
- Often used where longer coax runs and lower-loss cabling are required.

General best practices

- Avoid stacking multiple adapters (each adds loss, mismatch risk, and mechanical stress).
- Verify connector torque and weatherproofing (tape/boot) for outdoor installations.
- Confirm connector type/gender on both the antenna and the radio/modem before deployment.

6. Cables, surge protection, and accessories

When an antenna cannot connect directly to the radio or modem, a coaxial cable is required. Choosing the correct cable type, connector type, and lightning/surge protection is critical, particularly for outdoor and mast-mounted installations.

Table 6-1: RF Coaxial Cables and Accessories

Part	Description	Typical use case
COAXRPSMA-L	LMR195 cable, RPSMA to Type N (specify length)	Shorter runs where RPSMA/Type-N interfaces are required
COAXNTN-L	RG8 cable, Type N to Type N (specify length)	Longer runs / lower loss needs; Type-N systems
COAXSMA-L	LMR195, SMA to Type N (specify length)	SMA-to-Type-N cabling where applicable
31314	Surge Protector Kit, Type N to RPSMA, 700–2700 MHz	Outdoor installs with lightning/ESD risk; longer cable runs
28477	SMA pin to RPSMA socket adapter	Connector adaptation (verify acceptable loss/mechanics)
18686	Type N pin to RPSMA socket adapter	Connector adaptation (verify acceptable loss/mechanics)
CM230	Adjustable inclination mounting kit	Aiming/positioning directional antennas
COAXNTN	GOES coaxial cable, Type N both ends	GOES antenna cabling (Type-N systems)

7. Further learning

The following Campbell Scientific resources provide additional guidance on antenna selection, radio setup, and cellular communications:

- Getting the Best RF Signal: Antenna Gain, dB, Line of Sight, and Testing: www.campbellsci.com/videos/radios
- Troubleshooting Large Radio Networks: s.campbellsci.com/documents/us/technical-papers/rf-troubleshooting-paper.pdf
- Spread-Spectrum Radios Overview: www.campbellsci.com/spread-spectrum-radios
- IP Networking and Data Loggers (Part 1 & Part 2): www.campbellsci.com/videos/ip-networking-1 and www.campbellsci.com/videos/ip-networking-2
- Diagnosing CELL2XX Cellular Modem Connection Issues: www.campbellsci.com/blog/easily-diagnose-cell2xx-connection-issues

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