

# Antenna and Cable Guide

## Introduction

Telemetric devices use commercial cellular networks to communicate and report operational information to and from field equipment. The networks serve over 98% of the population base in North America. Each Telemetric device is equipped with a cellular radio and antenna that transmit at the maximum power allowed by the cellular network they are communicating through. The industrial rated cellular radios used in Telemetric devices have the capability to operate at power levels significantly above the level of typical consumer handsets. Because of this capability Telemetric devices can be deployed in locations where cell phones may not work.

In some cases it may be necessary to install a Telemetric device in a remote or other area with a weak cellular signal. To improve the signal in these areas Telemetric offers a number of optional antennas to increase the signal strength and extension cables allowing the antenna to be located at a higher elevation minimizing obstructions in the signal path. When antennas are mounted remotely using an extension cable Telemetric recommends the addition of a surge suppressor at the Telemetric device to protect it from lightning surges.

## What is Adequate Signal Strength?

Signal strength can vary greatly and Telemetric devices will still function properly. Generally speaking Telemetric devices will function with an acceptable number of retries on transmissions down to a about -100 dBm. Figure I illustrates inadequate to excellent signal strength in dBm and can be used as a guide to determine adequate signal strength.

When signal strength at a location is in the -94 dBm to -95 dBm range it is often advisable to use a higher gain antenna and elevate it using an extension cable. Figure I is a graphical representation of inadequate to very strong signal strength.

Table I and Table II on the next page list the antennas

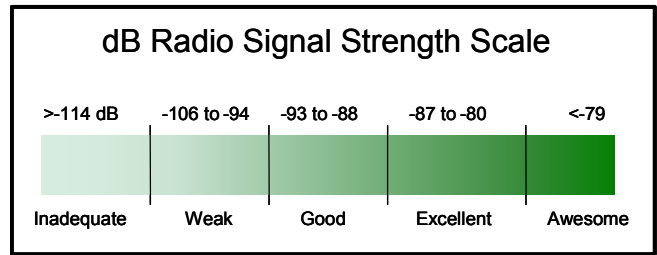


Figure I. Signal Strength in dBm

available for typical applications by the type of antenna along with their design frequency and gain.

Table III lists various extension cables available along with their attenuation at 800MHz and 1900MHz.

## Technical Information

Although the user does not need to be a radio frequency (RF) expert to operate the Telemetric system, it is helpful to understand the basic types of antennas, and signal strength factors such as dB, gain and attenuation (losses) before deploying devices in areas with low signal strength.

## Decibels (dB)

In many cases, such as when measuring gain or attenuation, the ratio of two powers, or relative power, is frequently the desired quantity rather than absolute power. Relative power is the ratio of one power level,  $P$ , to some other level or reference level,  $P_{ref}$ . The ratio is dimensionless because the units of both the numerator and denominator are watts. Relative power is usually expressed in decibels (dB).

The dB is defined by:

$$dB = 10 \log_{10}(P/P_{ref})$$

The use of dB has two advantages. First, the range of numbers commonly used is more compact; for example +63 dB to -153 dB is more concise than  $2 \times 10^6$  to  $0.5 \times 10^{-15}$ . The second advantage is apparent when it is necessary to find the gain of several cascaded devices. Multiplication of numeric gain is then replaced by the addition of the power gain in dB for each device.

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Telemetric Part No.	Description	Frequency (MHz)	Gain <sup>1</sup> (dB)
ANTDB900/1900S-8SK	Omni, Blade, dual band	800/1900	3/3dBi
TRA821/18503P	Omni, Phantom, dual band	800/1900	3/3dB MEG
ANTDB RM3 900/1900-3	Omni, RM body mount, dual band	800/1900	3/5dBi
<i>Call Telemetric</i>	Omni, Lo-Pro, dual band	800/1900	3/3dBi
MA-CL67-14RMNT	Directional, Panel, dual band	800/1900	8.5/10dBi

<sup>1</sup> Approximate values and subject to change by manufacturer

**Table I. Standard Dual Band Antennas Available from Telemetric**

Telemetric Part No.	Description	Frequency (MHz)	Gain <sup>1</sup> (dB)
EXE-821-SM	Omni, Flexible Whip, single band	800	2.5
TRA8213	Omni, Phantom, single band	800	3dB MEG
<i>Call Telemetric</i>	Omni, Lo-Pro, single band	800	3dBi
YAG3385D-06	Directional, Yagi, single band	800	8.5dBd
<i>Call Telemetric</i>	Directional Yagi, single band	800	11dBd
<i>Call Telemetric</i>	Directional Yagi, single band	800	14dBd

<sup>1</sup> Approximate values and subject to change by manufacturer

**Table II. Standard Single Band Antennas Available from Telemetric**

Part No.	Description	Length (Feet)	Attenuation (dB) <sup>1</sup>	
			800MHz	1900MHz
SMARF-1952	195, SMA(M)-SMA(F) Bulkhead	2	0.2	0.32
SMARF-1953	195, SMA(M)-SMA(F) Bulkhead	3	0.3	0.48
SMARF-19510	195, SMA(M)-SMA(F) Bulkhead	10	1.0	1.6
SMARF-19525	195, SMA(M)-SMA(F) Bulkhead	25	2.5	4.0
N195-25	195, SMA(M)-N(M)	25	2.5	4.0
N195-25-N-N	195, N(M)-N(M)	25	2.5	4.0
LMR400SM-NM-25	LMR400, SMA(M)-N(M)	25	0.92	1.46
LMR400SM-NM-50	LMR400, SMA(M)-N(M)	50	1.83	2.91
LMR400NM-NM-25	LMR400, N(M)-N(M)	25	0.92	1.46
LMR400NM-NM-50	LMR400, N(M)-N(M)	50	1.83	2.91

<sup>1</sup> Approximate values and subject to change by manufacturer

**Table III. Standard Antenna Cables Available from Telemetric**

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Part No.	Description
ISB50HNC2	PolyPhasor Surge Suppressor, Bulkhead, SMA(F) to N(F)
PTCONFONF09S	Nextek Surge Suppressor, Bulkhead, N(F) to N(F)
PTCSAMSAF09S	Nextek Surge Suppressor, In-line, SMA(F) to SMA(F)
RDMB	Flexible Antenna Mounting Bracket suitable for SMA Bulkhead
MA-CL67-14RMNT	Directional Panel Antenna, high-gain, N(F) connector, includes: <ul style="list-style-type: none"> <li>• Dual Band Panel Antenna, 800/1900MHz, 8.5dBi/10dBi</li> <li>• Mounting bracket for up to 4" round mast, elevation &amp; azimuth adjustments, incl. hardware</li> </ul>
PANELKIT	Directional Panel Antenna, high-gain, N(F) connector, includes: <ul style="list-style-type: none"> <li>• Dual Band Panel Antenna, 800/1900MHz, 8.5dBi/10dBi</li> <li>• 25" LMR400 low-loss cable, SMA(M) to N(M)</li> <li>• Mounting bracket for up to 4" round mast, elevation &amp; azimuth adjustments, incl. hardware</li> </ul>
PANELKITN	Directional Panel Antenna, high-gain, N(F) connector, includes: <ul style="list-style-type: none"> <li>• Dual Band Panel Antenna, 800/1900MHz, 8.5dBi/10dBi</li> <li>• 25" LMR400 low-loss cable, N(M) to N(M)</li> <li>• Mounting bracket for up to 4" round mast, elevation &amp; azimuth adjustments, incl. hardware</li> </ul>
PANELKITSP	Directional Panel Antenna, high-gain, N(F) connector, includes: <ul style="list-style-type: none"> <li>• Dual Band Panel Antenna, 800/1900MHz, 8.5dBi/10dBi</li> <li>• Surge Suppressor, bulkhead, N(F) to N(F)</li> <li>• 25" LMR400 low-loss cable, N(M) to N(M)</li> <li>• Mounting bracket for up to 4" round mast, elevation &amp; azimuth adjustments, incl. hardware</li> </ul>
YAGIKIT	Yagi kit includes: <ul style="list-style-type: none"> <li>• Yagi Antenna, 800MHz, 8.6 dB, N(F) Connector</li> <li>• 25' Cable, N195N-25, SMA(M) to N(M) Connectors</li> <li>• Angle mounting bracket with 1/4" stainless steel bolts and nuts</li> </ul>
YAGIKITN	Yagi kit includes: <ul style="list-style-type: none"> <li>• Yagi Antenna, 800MHz, 8.6 dB, N(F) Connector</li> <li>• Bulkhead Adapter, N(F) to N(F)</li> <li>• 25' Cable, N195N-25, N(M) to N(M) Connectors</li> <li>• Angle mounting bracket with 1/4" stainless steel bolts and nuts</li> </ul>
YAGIKITSP	Yagi kit includes: <ul style="list-style-type: none"> <li>• Yagi Antenna, 800MHz, 8.6 dB, N(F) Connector</li> <li>• Surge Suppressor, bulkhead, N(F) to N(F)</li> <li>• 25' Cable, N195-25-N-N, N(M) to N(M) Connectors</li> <li>• Angle mounting bracket with 1/4" stainless steel bolts and nuts</li> </ul>

Table IV. Accessories and Kits

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## dBm

Popular usage has added another convenient unit, dBm. The formula for dBm is similar to the dB formula except that the denominator,  $P_{ref}$ , is always one milliwatt:

$$\text{dBm} = 10 \log_{10}(P/1 \text{ mW})$$

In this expression, P is expressed in milliwatts and is the only variable, so dBm is used as a measure of absolute power. 1mW power level is referred to as 0 dBm. Likewise, a power level of 1/1000mW can be referred to as -30dBm. As a rule of thumb, an increase in 3dB will approximately double signal strength.

An oscillator, for example, may be said to have a power output of 13 dBm. By solving for P using the dBm equation, the power output can also be expressed as 20 mW. So dBm means “dB above one milliwatt” (no sign is assumed positive) but a negative dBm is to be interpreted as “dB below one milliwatt.” The advantages of the term dBm parallel those for dB; it uses compact numbers and allows the use of addition instead of multiplication when cascading gains or losses in a transmission system.

## dB<sub>i</sub>

Decibels isotropic, a relative gain measurement with respect to an isotropic radiator in free space (a uniform emitter in free space is a theoretical situation). Normally used to describe gain for antennas operating at 1GHz or above; however, it is frequently used for antennas in the 800/900MHz bands.

## dB<sub>d</sub>

Decibels over dipole, a relative gain measurement with respect to a half wave dipole using a standard dipole antenna as a reference. dB<sub>d</sub> can be converted to dB<sub>i</sub> by adding 2.14 dB, e.g. (0 dB<sub>d</sub> = 2.14 dB<sub>i</sub>).

## dB MEG

Decibels Mean Effective Gain is used by one manufacturer. To establish the Mean Effective Gain for their antenna, received power is first measured and averaged using a ¼ wave whip (0 dB<sub>i</sub>) in a real mobile or reflective environment.

The whip is then replaced with their antenna, and again measured in the same environment.

The MEG gain is then the ratio of the two received powers. On average their antenna receives twice the power of the ¼ wave whip in a mobile or reflective environment. Alternatively said, their antenna has 3dB<sub>i</sub> Mean Effective Gain.

## dB Gain and Loss

Radio transmission strength is reduced by a variety of factors including noise, distance, obstructions and the weather. A way to overcome these factors is by increasing the gain and elevating the antenna using an extension cable. As antennas have dB gain, antenna cables and surge protectors have a dB loss. The value of the loss varies by several factors including: length of the cable, frequency, connector type and quality, and the design of the coaxial cable.

Typically the attenuation of connectors and surge suppressors is very low so it is not a major consideration. By contrast antenna extension cables can introduce substantial attenuation and this needs to be considered when installing a remote antenna. Attenuation also increases with frequency so dual band digital devices typically require better quality antenna cables to keep attenuation at a reasonable level. To help customers select the appropriate cable Table II includes approximate attenuation values at 800MHz and 1900MHz. Antenna cables with lower attenuation are available by special order. Contact Telemetric for information.

When considering using an extension cable, evaluate if signal strength will still improve after taking into consideration the loss added by the cable itself. For example, a standard 800MHz, half wave omni antenna with a 2.5 dB gain is attached to a 10-foot extension cable with a 1.0 dB loss, netting a 1.5 dB gain. Elevating the antenna and eliminating obstructions typically more than compensates for the loss from adding the extension cable.

When significant signal improvements are required, a directional antenna will provide between 9 and 14 dB of signal gain depending on the frequency and type. Directional units will also reduce the noise the cellular

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receiver hears from behind and to the sides of the direction the unit is pointed. The combination of additional gain and noise rejection allows customers to install Telemetric devices in areas with very weak signals.

## Antenna Types

Antennas are used to increase signal strength and they are specified based on their gain or the dB they increase the signal strength. Rating range from 0 dB (unity gain) to 10 dB or more. There are two main types of antennas used for cellular radio transmissions shown in Figure II: Omni-directional and directional. Both of these antenna types are designed for the specific RF frequency of the cellular radio being used.

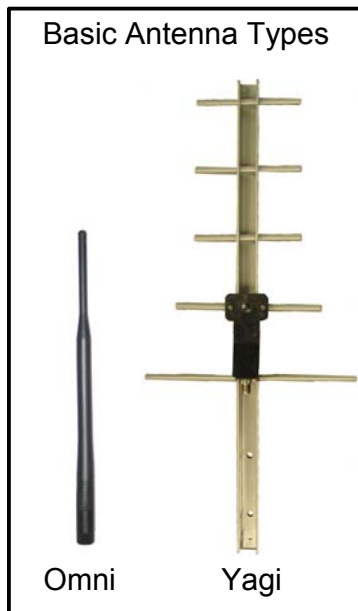


Figure II. Antenna Types

New digital (GSM and CDMA) cellular radios have the capability to operate in two different bands, 800 or 1900MHz. Because it is not easy to determine which band will be used Telemetric recommends that dual-band antennas be used. Dual-band antennas should specify the gain in both bands so users understand the performance in each band. The old analog (AMPS) system operated in the 800MHz band only so a single band antenna is used for these applications.

*Omni-directional Antenna* – Omni antennas transmit radio waves of equal strength in all directions as shown in Figure III (360 degrees). Their ability to receive signals is also equal in all directions. Omni-directional antennas are the best choice for areas with good signal strength because you do not have to worry about aiming the antenna.

The standard antennas for Telemetric devices are dual-band, omni-directional,  $\frac{1}{2}$  wave antennas because they can be installed without concern for directional orientation and they are ground plane independent. The standard antenna has 3dBi of gain in both bands and is shown in Figure IV on the next page. The standard connector is SMA male.

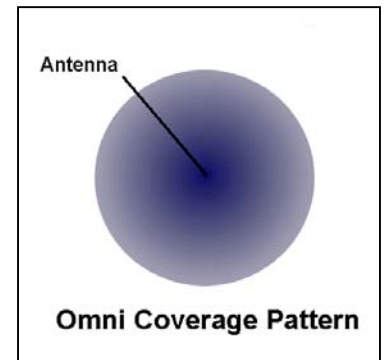


Figure III. Radiation Pattern

When a Telemetric Remote Telemetry Module (RTM)

integration kit is ordered for a recloser or similar device it includes a dual-band, omni, Phantom antenna as shown in Figure V on the next page. The Phantom has a gain of 3 dB MEG in both bands. The standard connector is N female.

As an option the Type RM body mount antenna is available. It is similar to the Phantom, but slightly larger and has 3 dBi gain at 800MHz and 5 dBi gain at 1900MHz. It is only available with a cable lead with an SMA male connector as shown in Figure VI.



Figure IV. Dual-Band, 3dBi, Omni Blade Antenna, SMA male connector

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Figure V. Dual-Band, 3dB MEG, Omni, Phantom Antenna, N female connector



Figure VI. Dual-Band, 3dBi/5dBi, Omni, Type RM Body Mount Antenna, cable with SMA male connector

*Directional Antennas* – There are several types of directional antennas, but this discussion will focus on panel and yagi antennas. These are the types most often used in our application.

To receive or transmit a message in an area of low signal strength or over a long distance, it becomes appropriate to use a directional antenna.

Directional antennas focus their transmitted (and received) signal strength in one direction, typically between 35 and 100 degrees as shown in Figure VII. The tighter the focus the more gain, and the further the message can be transmitted and received. Because the transmission is directional, it is critical to know the location of the selected cellular tower when installing a directional antenna.

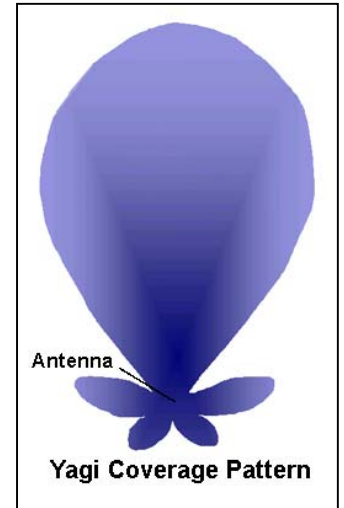


Figure VII. Radiation Pattern

Figure VIII below shows dual-band panel antenna that can be supplied when a digital device is located in an area with a weak cellular signal. This particular antenna has a gain of 8.5dBi/10.5dBi in the 800/1900MHz bands. The standard connector is an N female. Figure IX shows the panel mounting bracket that is suitable for 1" to 4" pipe or the holes can be used to bolt it to a structure.

Figure X shows a single band directional Yagi antenna with 8.6dBd of gain.

Table IV lists standard accessories and directional antenna kits available from Telemetric.

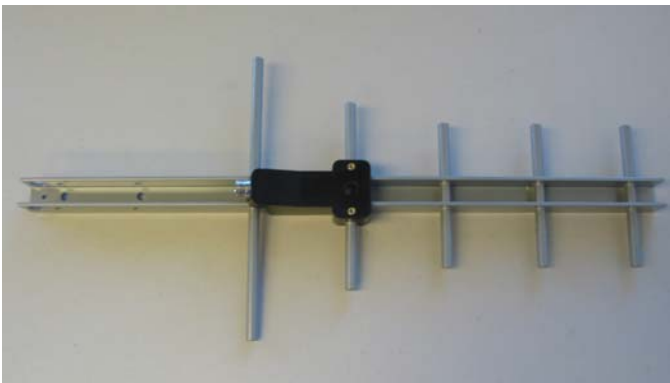
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**Figure VIII. Dual-Band, 8.5dBi/10dBi, Directional, Panel Antenna, N female connector**



**Figure IX. Panel Antenna Mounting Bracket with Elevation and Azimuth Adjustments**



**Figure X. Single-Band (800MHz) 8.6dBd, Directional, Yagi Antenna, N female connector**

## Security Concerns

In applications where the Telemetric device is installed in an unsecured location, users are often concerned about vandalism or theft of the standard flexible antenna. Telemetric offers both external and internal mounting high security antennas to maintain the integrity of the communications



**Figure XI. Phantom Mounted on IED**

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device. A low profile, Phantom antenna can be securely mounted to the top or bottom of an IED enclosure as shown in Figure XI. This is typically used when a Telemetric RTM is mounted within the IED such as a Cooper Form 6 recloser or EnergyLine IntelliCap PLUS™ capacitor control. Phantom antennas can also be mounted on the Telemetric MicroRTU.

For pad-mounted switchgear a Lo-Pro® antenna is often used to provide a higher degree of security.



**Figure XII. Lo-Pro® Antenna**

H. Because the unit is small and unobtrusive it is less prone to vandalism. Figure XII shows a Lo-Pro® with a white radome.

## RSSI

At times you will hear references to Receiver Signal Strength Indication (RSSI). You should not confuse this with the received signal strength in dBm used by Telemetric. RSSI is a term defined in the IEEE 802.11 standard. This numeric value is an integer with an allowable range of 0-255, although no manufacturer has chosen to actually measure 256 different signal levels. As an example Cisco chooses to measure 101 separate values which give s them a maximum RSSI value of 100. Symbol uses a maximum value of 31. Therefore, as can be seen you must know the maximum range used by the manufacturer to understand the relative strength of the received signal. Notice that nothing has been said about measurement of RF energy in dBm or mW. Some

manufacturers will provide information allowing you to correlate RSSI values to dBm or mW.

*Numerous factors play into radio signal strength and antenna selection. To help make the decision of what antenna is best for your application, please contact Telemetric Technical Support at 208.658.1292 x21. Also, we may be able to assist you in finding the nearest cell tower.*