# Cellular Antennas

## Tech Note LCTN0001

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## This Tech Note applies to LAN-Cell models:

**LAN-Cell 2:**
LC2-411

**CDMA:**
1xMG-401
1xMG-401S

**GSM:**
GPRS-401

**Minimum LAN-Cell Firmware Revision:** N/A

## Document Revision History:

| Date | Comments |
|---|---|
| June 16, 2005 | First release |
| July 16, 2007 | Updated for LAN-Cell 2 & Proxicast Online Web Store.<br>Added Sierra Wireless PC-Card modem specs.<br>Changed title to “Cellular Antennas” to better reflect contents. |

# Introduction

This Tech Note discusses common issues regarding cellular (GSM/CDMA/UMTS) antennas for the LAN-Cell Mobile Gateway. It is intended as a resource to help end-users understand the proper installation of antennas for the LAN-Cell and their options for using external antennas with the LAN-Cell Mobile Gateway.

Proxicast has only tested and certified the LAN-Cell with the specific antenna(s) sold with your unit. Proxicast is unable to provide technical support for third-party antennas and accessory equipment used with the LAN-Cell unless purchased directly from Proxicast. The user is also responsible for ensuring that the combination of the LAN-Cell and any third-party accessories meets FCC regulations and wireless carrier standards.

The antennas sold with your LAN-Cell Mobile Gateway are intended to meet the needs of the majority of users operating in a location with good wireless carrier signal coverage. We suggest that you attempt to use one of these antennas before investigating third-party solutions. Because the best solution for your specific installation depends on many factors such as operating frequency band, signal strength from the carrier, interference sources, and mounting considerations, Proxicast is unable to recommend specific third-party equipment for your application. The information in this Tech Note should help you and an antenna specialist determine the best alternatives to meet your needs.

# Regulatory Information

## Applicable Regulations

The Federal Communications Commission (FCC) is the agency of the Federal Government that oversees all non-governmental radio frequency transmitters that operate within the United States. Unintentional emissions from digital devices are regulated by Part 15 of the FCC Rules and Regulations, which distinguishes between the environments in which these devices may operate. Intentional radiators operating as a PCS-1900 radio transmitter are regulated under Part 24, Subpart E—Broadband PCS of the FCC Rules and Regulations. Intentional radiators operating as a cellular (800 MHz) radio transmitter are regulated under Part 22 – Subpart H: Cellular Radiotelephone Service.

The radio modem components of the LAN-Cell Mobile Gateway have been tested only in conjunction with the supplied antennas and were found to comply with the limits for a Class B digital device, pursuant to Part 15, Part 22 and Part 24 of the FCC Rules (47 CFR) as applicable by model. Use of third-party accessories such as antennas and/or amplifiers must comply with the FCC regulations for maximum radiated power (see below). Exceeding the allowable radiated power output requires additional FCC licensing and is the responsibility of the end-user.

Radio emission regulations differ by country. Please consult your local telecommunications authority for more information on how their rules correspond to the FCC regulations.

Specific wireless operators may impose additional limitations on acceptable radio emissions. Please consult with your carrier regarding your specific installation requirements if you will be using any third-party antenna or amplifier equipment with the LAN-Cell.

## Types of Transmitters

For the purpose of determining compliance with current FCC rules addressing human exposure to radio frequency radiation (47 CFR 2.1091), the FCC has established the following categories of transmitting devices:

- Portable Devices (e.g. cell phone) – devices where the antenna is located within 20 cm (7.87 inches) of any person, including the user, if applicable. The LAN-Cell does not qualify as a portable device.

- Mobile Devices – devices designed to be used in other than fixed locations and generally such that the antenna is located at a minimum of 20 cm from any person, including the user, if applicable.

- Fixed devices – devices in which the antenna, either integral to the product or remotely located, is physically secured at one location and is not able to be easily moved to another location.

The LAN-Cell Mobile Gateway may only be used in fixed and mobile applications. The 20 cm separation distance between the antenna and all persons must be maintained at all times for all fixed and mobile products and applications.

## Definitions

Effective Radiated Power (ERP) is the power supplied to an antenna multiplied by the antenna gain.

Effective isotropically-radiated power (EIRP) is the amount of power that would have to be emitted by an isotropic antenna (that evenly distributes power in all directions) to produce the peak power density observed in the direction of maximum antenna gain. EIRP takes into account the losses in transmission line and connectors and the gain of the antenna.

EIRP(dBm) = (power of transmitter (dBm)) – (losses in transmission line (dBi)) + (antenna gain(dBi))

EIRP (watts) = 1.64 X ERP (watts) assuming a lossless transmission line between the transmitter and antenna

## Maximum Allowable Power Output / Antenna Gain[1]

FCC limits on the maximum allowable output power from a transmitter depend upon the frequency range of operation and the type of antenna installation (mobile or fixed). Also for the LAN-Cell to meet the FCC's maximum permissible exposure (MPE) categorical exclusion requirements of 47 CFR Section 2.1091 for mobile devices, the ERP must be less than 1.5 W for personnel separation distance of at least 20 cm when operating in the 800-900 MHz bands or 3.0 W when operating in the 1800-1900 MHz bands.

| | **FCC Max EIRP** | | **GSM LAN-Cell Maximum Antenna Gain (dBi)** | | **CDMA LAN-Cell Maximum Antenna Gain (dBi)** | |
|---|---|---|---|---|---|---|
| **Band** | **Mobile** | **Fixed** | **Mobile** | **Fixed** | **Mobile** | **Fixed** |
| 800-900 MHz | 2.5 W (34 dBm)[2] | 11.5 W (40.6 dBm)[3] | 1 | 7.6 | 8.5 | 15.1 |
| 1800-1900 MHz | 2 W (33 dBm)[4] | 5 W (37 dBm) [5] | 3 | 7 | 7.5 | 11.5 |

Note: The LAN-Cell 2 uses removable PC-Card (PCMCIA) modems. The specific power output of each PC-Card at various frequencies will vary from card model to model. Please consult the technical specifications for your specific PC-Card modem regarding maximum power output and maximum antenna gain.

Antenna gain is often quoted in dBd (dipole) or just dB. Convert this value to dBi (add 2.15) then subtract the RF loss from the feed cable and connectors when determining the total EIRP for your installation. Add the net gain

[1] Antenna gain is defined as gain in dBi (dB referenced to an isotropic radiator) minus cabling loss.
Antenna gain in dBi (isotropic) = antenna gain in dBd + 2.15 (dipole)
[2] 47 CFR 2.1091
[3] 47 CFR 22.913
[4] 47 CFR 24.232
[5] 47 CFR 2.1091

from your antenna system to the maximum nominal power output (in dBm) of the LAN-Cell's radio in the frequency band of operation and compare this against the FCC limits. See the LAN-Cell radio specifications at the end of this document for the maximum nominal power output of each model.

## Antenna Placement

- Place the antenna a minimum of 20 cm (7.87 inches) from any person.
- Place the antenna outside if possible, or near a window. The antenna supplied with the LAN-Cell is suitable for outdoor or vehicle mounting.
- Place the antenna away from sources of interference such as computer equipment, CRTs, televisions, lights, telephones, appliances and other radio equipment.
- Always elevate the antenna as high as possible so that it has a clear path to the cell site.
- Most cell sites have vertically polarized antennas. Mount the LAN-Cell's antenna vertically for the best performance.
- Attach the LAN-Cell's magnetic mount antenna to a large metal surface to create a suitable ground plane for the antenna.
- Do not place the antenna inside of metal structures (e.g. computer equipment racks/closets/cabinets, ATM machines, or NEMA enclosures).
- Keep all antenna cables as short as possible. Extending the antenna cable to achieve better placement is a trade-off between the improved signal reception and the RF loss due to the longer cable (see below).
- Know the location of the closest cell sites. The cellular carrier can provide the appropriate location information. This information will assist you in positioning the antenna and enable you to do a path check between the cell site and your location for any man-made or natural obstacles.
- Man-made and natural obstacles such as buildings, water towers, mountains, hills and trees can cause the cellular signal to deteriorate or even block the signal. Raising the antenna, relocating the antenna, or choosing a higher gain antenna may improve reception.
- Fixed mount (third-party) antennas often use connectors other than SMA. You may need a "series adapter" to connect the antenna to the LAN-Cell (see below).
- Do not over tighten the LAN-Cell antenna connection (finger tight only). Do not attach series adapters directly to the LAN-Cell antenna connector.

# Third-Party Equipment

## Antenna Types

The most common type of antenna is an *omni-directional* (or helical). Omni-directional antennas radiate and receive signals in a 360 degree pattern and are a good general purpose choice, especially when you are in an area of strong cellular signal coverage. Omni-directional antennas can be placed almost anywhere with little regard to orientation (although higher locations are usually preferred).

In some instances, you may require an antenna with more sensitivity (gain) in order to achieve an adequate signal at your location. *Directional* antennas offer higher gains by focusing their energy patterns into a smaller area. Directional antennas range from panels with approximately 180 –270 degree beam widths, to sector antennas with 30 – 120 degree beam widths, to very high gain Yagi antennas with beam widths as small as 10 degrees. Directional antennas must be oriented so that their primary beam points in the direction of the carrier's tower that you plan to communicate with. This requires knowledge of the carrier's antenna placement and a certain amount of trial-and-error with the equipment.

Antennas are "tuned" to operate most efficiently in one or more specific frequency bands. When selecting an antenna, you must specify the operating frequency bands of your wireless service provider. Note that both CDMA and GSM services can be provided in either the 800 MHz or 1900 MHz bands, depending on the licenses that your carrier holds in a specific location. Contact the carrier for information on the frequencies that are in use at your location. You can also purchase a multi-band antenna. See the antenna specifications section below.

When selecting an external antenna, be certain to inquire if a separate ground-plane is required.

You cannot effectively use antennas from other types of equipment (such as 802.11 WiFi products or portable telephones) as these are tuned for bands outside of the GSM/CDMA/UMTS frequencies.

## Antenna Cables

Antennas are connected to the LAN-Cell via coaxial cable specifically designed for RF applications. All coax cables result in some loss of RF signal strength as the length of cable increases. The rate (usually expressed as dB loss/ft) depends on the specifications of the coax cable and the operating frequencies of your RF signal.

In most cases, antennas can be purchased with either a predefined length and type of coax cable attached, or with a short coax "pig-tail" to which a coax "extension" cable can be connected between the antenna and the LAN-Cell.

When selecting coax extension cables, keep these factors in mind:

- In general, thicker coax results in less RF loss per foot (measured in dB).
- Keep the antenna cable as short as possible at all times.
- Use 50 ohm coax with the LAN-Cell.
- Purchase pre-made extension cables with the correct connectors already attached or have an antenna professional crimp the connectors with the proper tools. Bad connections between the connector and the coax are the cause of many antenna/signal issues.
- You cannot effectively "splice" coax cable. If necessary, cut the cable and use male & female connectors to rejoin the pieces.
- Do not place sharp bends in the coax as this will crack the dielectric and/or jacket.
- Factor in the total cable and connector RF loss when calculating EIRP for your installation.

If you just want to extend the length of the LAN-Cell's original antenna, you will need a 50 ohm male-to-female SMA extension cable available from many sources. The LAN-Cell's antenna uses an RG-174 coax lead wire. Other common antenna coax specifications are RG-58, RG-142, RG-316, LMR-100 and LMR-400.

## Connectors

The cellular antenna connector on the LAN-Cell is a 50 ohm female SMA connector with standard polarity. You will need a matching male SMA connector on your antenna.

Many antennas, especially fixed mount types, have other standard antenna connectors such as FME, N, TNC, or BNC attached to their lead wire (coax). You will need an "inter-series adapter" to convert between the LAN-Cell's SMA connector the type on your external antenna. Be sure to match the 50 ohm impedance as well.

Some adapters can covert between series in a single-piece "barrel", however Proxicast recommends using a coax cable with each type of connector attached, rather than attaching a barrel converter directly to the LAN-Cell's SMA connector; it is not designed for the stress caused by the weight of some barrel adapters.

If any connectors will be located outdoors, ensure that the connectors are properly protected from moisture. Sealing the connections against moisture is critical in preventing water from shorting out the cable or being absorbed by the inner insulating materials and degrading performance. Multiple layers of vinyl and rubber electrical tape and/or liquid rubber sealing compounds are commonly used to protect RF connectors from moisture.

Each antenna connector between the LAN-Cell and its antenna introduces a loss of RF signal. The exact loss depends upon the properties of the connector and the operating frequencies. Consult the specifications for your connectors when calculating RF loss due to connectors and cables in your EIRP calculations.

## Antenna Mounts

Most cellular, PCS and GSM antennas are designed for desktop, mobile, or vehicle use and typically have a magnetic mount base similar to the one on the standard LAN-Cell antenna. Higher gain and directional antennas often used for fixed location applications can be pole (mast) or wall mounted.

For fixed antenna installations, lightening protection and proper grounding may be required to meet local safety codes. Please consult with the antenna manufacturer or a qualified antenna installation contractor regarding requirements for proper safety precautions when mounting to masts, towers, buildings, walls or other surfaces.

## Amplifiers/Boosters

In certain installation situations, an amplifier (signal booster) may be necessary to provide sufficient RF signal strength between the LAN-Cell and the wireless carrier's cell site. Proxicast assumes no responsibility for damage to the LAN-Cell caused by amplifiers.

If an amplifier is utilized, the combination of radio (LAN-Cell), amplifier, and antenna is still subject to the FCC limits for EIRP in the frequencies of operation. Operating at EIRP levels beyond FCC regulations is prohibited without additional FCC licensing by the end-user.

Amplifiers increase the noise level by the same factor that they increase the signal. If you have low signal due to high noise, you may need an RF filter instead of (or in addition to) the amplifier.

## Antenna Equipment Suppliers

Proxicast offers a variety of cellular antennas, jumper cables, connectors, amplifiers and related accessories for the LAN-Cell family of cellular routers. Please visit our online store at http://www.proxicast.com or contact sales@proxicast.com for more information.

There are a large number of manufacturers and distributors of cellular, PCS and GSM antennas and related equipment that can be used with the LAN-Cell. Proxicast does not endorse these manufacturers or distributors and has not tested or certified any of their products.

TESSCO (http://www.tessco.com 800-472-7373) is a leading distributor of radio infrastructure and accessory equipment ranging from vehicle antennas and specialty custom cables to complete cell towers. Their sales and technical staff can assist you in selecting equipment that will be compatible with the LAN-Cell and your wireless carrier. Other manufacturers of Cellular, PCS, and GSM antennas include:

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|---|---|
| Cushcraft | http://www.cushcraft.com |
| HyperLink Technologies | http://www.hyperlinktech.com |
| MaxRad (PCTEL) | http://www.maxrad.com |
| Radiall Larsen | http://www.radialllarsen.com |

## Specifications

The following tables summarize the radio and antenna specifications for the LAN-Cell Mobile Gateways as shipped by Proxicast.

### LAN-Cell CDMA Radio Specifications (1xMG-401, 1xMG-401S)

| **Parameter** | **Value** | |
|---|---|---|
| Frequencies | Cellular | Tx: 824 - 849 MHz |
| | | Rx: 869 - 896 MHz |
| | PCS | Tx: 1.85 -1.91 GHz |
| | | Rx: 1.93 - 1.989 GHz |
| Nominal Max Power | 0.32 W (24.7 dBm) | |
| Peak Power in Operation Mode | 0.35 W (25.5 dBm) | |
| Antenna | 50 ohm SMA female (standard polarity) | |

### Dual Band CDMA Antenna Specifications (1xMG-401, 401S Antenna)

| **Parameter** | **Value** | |
|---|---|---|
| Pattern | 1/4 wave omni-directional, vertical polarization | |
| Frequencies | Cellular | Tx: 824 - 849 MHz |
| | | Rx: 869 - 896 MHz |
| | PCS | Tx: 1.85 -1.91 GHz |
| | | Rx: 1.93 - 1.989 GHz |
| Gain | 1 dBi | |
| VSWR | Less than 1:1.9 | |
| Impedance | 50 ohm (nominal) | |
| Length | 1.5 m (approx) | |
| Connector | SMA male (standard polarity) | |
| Mount | Magnetic | |

## LAN-Cell GSM/GPRS Radio Specifications (GPRS-401)

| **Parameter** | **Value** | |
|---|---|---|
| Frequencies | GSM0107 | 900 (EGSM),<br>1800 MHz (DCS)<br>1900 MHz (PCS) |
| | GSM0108 | 850 (GSM)<br>900 (EGSM)<br>1800 MHz (DCS)<br>1900 MHz (PCS) |
| Nominal Max Power | 850 & 900 MHz: Class 4 (2 W or 33 dBm) | |
| | 1800 & 1900 MHz: Class 1 (1 W or 30 dBm) | |
| Antenna | 50 ohm SMA female (standard polarity) | |

## Quad Band GSM/GPRS Antenna Specifications (GPRS-401 antenna)

| **Parameter** | **Value** |
|---|---|
| Pattern | 1/4 wave omni-directional, vertical polarization |
| Frequencies | GSM 850, EGSM 900, DCS 1800, PCS 1900 MHz |
| Gain | 2.15 dBi |
| VSWR | 2:1 @ specified frequency |
| Impedance | 50 ohm (nominal) |
| Length | 2.5 m (approx) |
| Connector | SMA male (standard polarity) |
| Mount | Magnetic |

## LAN-Cell 2

The LAN-Cell 2 uses removable PC-Card (PCMCIA) modems. The specific power output of each PC-Card at various frequencies will vary from card model to model. Please consult the technical specifications for your specific PC-Card modem regarding maximum power output and maximum antenna gain. Listed below are the specifications for several popular PC-Card modems.

### Sierra Wireless AirCard 875 (GSM/GPRS/EDGE/HSDPA/UMTS/WCDMA)

| **Parameter** | **Value** | |
|---|---|---|
| Frequencies | WCDMA | 850, 1900, 2100 MHz<br>1800 MHz (DCS)<br>1900 MHz (PCS) |
| | GSM/GPRS/ EDGE | 850 (GSM)<br>900 (EGSM)<br>1800 MHz (DCS)<br>1900 MHz (PCS) |
| Nominal Max Power | 850, 1900, 2100 MHz: Class 3 (250mW or 24 dBm) | |
| | 850, 900 MHz: Class 4 (2 W or 33 dBm) | |
| | 1800, 1900 MHz: Class 1 (1 W or 30 dBm) | |
| Antenna | 50 ohm SSMB female | |

The maximum antenna gain for the AC875 must not exceed 8 dBi in the Cellular band (800-900 MHz) and 4 dBi in the PCS band (1800-1900 MHz).

### Sierra Wireless AirCard 595 (CDMMA/EV-DO)

| **Parameter** | **Value** | |
|---|---|---|
| Frequencies | Cellular | Tx: 824 - 849 MHz |
| | | Rx: 868- 894 MHz |
| | PCS | Tx: 1.85 -1.91 GHz |
| | | Rx: 1.93 - 1.989 GHz |
| Max Power | 200 mW (23 dBm) | |
| Antenna | 50 ohm proprietary RF switch connector | |

The maximum antenna gain for the AC595 must not exceed 5.65 dBi in the Cellular band (800-900 MHz) and 4.35 dBi in the PCS band (1800-1900 MHz).

## Multi-Band GSM/CDMA/UMTS Antenna Specifications (ANT-120-001)

| **Parameter** | **Value** |
|---|---|
| Pattern | 1/4 wave omni-directional, vertical polarization |
| Frequencies | AMPS 824-896 MHz, GSM 890-960 MHz,<br>PCS 1850-1990 MHz, DCS 1710-1880 MHz |
| Gain | 2 dBi |
| VSWR | 2:1 @ specified frequency |
| Impedance | 50 ohm (nominal) |
| Length | 130 mm (approx) |
| Connector | SMA male (standard polarity) |
| Mount | Optional magnetic base or mount to Card-Guard chassis |

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