U.S.Robotics®

Wireless Networking

Using Antennas to Extend and Enhance Wireless Connections

4dBi Desktop Antenna, 5dBi Swivel Antenna, 9dBi Directional Antenna

Technical Note

This note was developed to provide practical information about the use of U.S. Robotics antenna accessories with 802.11b/802.11g wireless LAN products. The U.S. Robotics Family of Wireless Antennas described in the following sections is designed to connect to any wireless device that uses Reverse SMA (female) connectors.

Overview

A critical determinant to the successful implementation of a wireless LAN solution often revolves around providing appropriate antennas to support home and office environments. Wireless connection speeds and reliability are dependent on both distance and signal obstructions. These obstructions can be the walls, floors and ceilings of various constructions, as well as other less obvious items such as metal filing cabinets. In real-world use the distances you might attain will vary according to these conditions.

U.S. Robotics developed various antenna options to assist in optimizing wireless LAN solutions based on 802.11g and 802.11b wireless LAN standards. The maximum distance information provided for each antenna is based on engineering computations included in an appendix to this document.

Desktop Computer Wireless Enhancement

Antenna Solution - US Robotics 4dBi Desktop Antenna (USR5480)

The U.S. Robotics 4dBi desktop antenna is designed to attach to 802.11b and 802.11g wireless PCI cards via its reverse polarity SMA (female) connector.

Since PCI cards are normally installed into desktop PCs, the directly attached antenna must deliver a signal through the metal PC case and often compete with the “noisy” behind-the-desktop environment. The 4dBi Desktop Antenna allows for flexible placement on the desktop away from these potential interferences. As a result, the reception level of the wireless signal will improve significantly.
The Desktop Antenna can also be mounted on a wall or window if desired, using included mounting tape.

With the 4dBi antenna, theoretically a distance of about 300 meters can be covered.

Specifications

- Gain: 4dBi
- Nominal impedance: 50 Ohms
- Frequency range: 2.4-2.5 GHz
- VSWR: <2:1
- Omni-directional

Wireless Router, Access Point, Bridge and Repeater Enhancement

Antenna Solution – U.S. Robotics 5dBi Swivel Antenna (USR5481)

The U.S. Robotics 5dBi Swivel Antenna comes standard with the U.S. Robotics Wireless Turbo Multi-Function Access Point but can also be purchased to enhance wireless connectivity for a wide variety of wireless devices. It attaches directly to male reverse SMA connectors and provides for improved range and coverage of 802.11b and 802.11g wireless routers, access points, bridges and repeaters.

In typical situations, signal coverage will allow for wireless connection throughout a home or small business. This antenna would typically replace standard 2dBi antennas, which are normally shipped with this class of wireless device, in order to increase the range and/or expand the coverage area.

With this 5dBi antenna, theoretically a distance of about 500 meters can be covered.

Specifications:

- Gain: 5dBi
- Nominal impedance: 50 Ohms
- Frequency range: 2.4-2.5 GHz
- VSWR: <2:1
- Omni-directional

Delivering Directional Coverage in Large Areas

Antenna Solution – U.S. Robotics 9dBi Directional Panel Antenna (USR5482)

As the requirement for wireless connectivity grows, companies often want to provide focused wireless coverage in large areas like auditoriums, cafeterias or even between buildings. The U.S. Robotics 9dBi Directional Panel Antenna was designed to deliver a broad, focused signal for 802.11b and 802.11g wireless access points, bridges and routers.

It is outdoor-rated so it can support applications outside of buildings. This 9dBi high-gain antenna can deliver links of up to one kilometer. It can be particularly useful to link local area networks of two buildings wirelessly, eliminating the need to run cable or use leased lines. However, careful planning is required to achieve these distances. The user should research link budgets and Fresnal zones[1] to ensure a good connection.

Specifications:

- Gain: 9dBi
- Nominal impedance: 50 Ohms
- Frequency range: 2.4-2.5 GHz
- VSWR: <1.5:1
- Directional antenna
- Polarization
  - Vertical (60°) or horizontal (60°) linear
  - Left-hand circular

[1] In radio communications, one of a (theoretically infinite) number of a concentric ellipsoids of revolution which define volumes in the radiation pattern of a (usually) circular aperture.

Free space loss

Free space loss is one of the initial measurements to be calculated in order to develop distance estimates for wireless solutions.

"Spreading" is the principle contributor to signal loss for line of sight signal propagation. As a signal radiates it "spreads" or expands into a spherical surface. The available RF power is distributed over this surface and weakens with increasing range. The signal is reduced by 6 dB every time the distance from the source doubles. To compute the loss path between the source radiators with spherical patterns use the following equation:

$$Lp = 92.45 + 20Log10F + 20Log10d$$

Lp= path loss in decibels
F= frequency in GHz
dB= decibels
d= distance in kilometers

Free Space Loss Example

A distance of 6 kilometers provides a free space loss of -115.67 dB.

Distance/Km	Gain Loss/dB
0.5	94.0
1.0	100.0
1.5	103.5
2	106.0
3	109.5
4	112.0
5	114.0
10	120.0
15	123.5
20	126.0

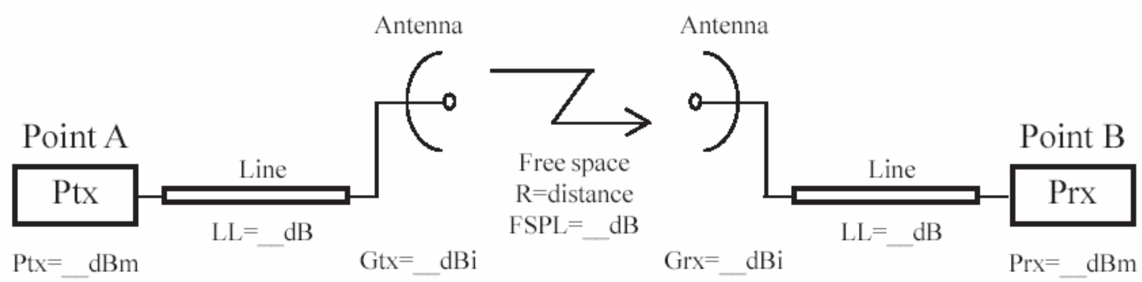
The link budget

For each link a "'link budget" needs to be made. The link budget will calculate the signal level through the link and predict the signal level at the receiver's side. Within the "link budget" there are a few parameters that are influenced by the location of the link: humidity and terrain roughness. The length of the link also has a major influence on the "link budget".

It is best to consider the link in three stages:

1. The transmitting end: Consisting of the transmitter (e.g. access point, router etc.), the antenna cable and the antenna.
2. The middle bit: This is considered the distance between the two sites.
3. The receiving end: The receiver (e.g. access point or wireless device), the antenna cable and the antenna.

The link budget calculation is as follows:



Link budget= Ptx – LL + Gtx + FSPL – LL + Grx –Prx

Where:
Ptx = Output power of transmitter in dBm
LL = Antenna and cable losses at transmitter in dB
Gtx = Transmitter Antenna gain in dBi
FSPL = "Free Space Loss" propagation loss in dB (negative number, see table on previous page)
LL = Antenna and cable losses at receiver in dB
Grx = Receiver antenna gain in dBi
Prx = Receiver sensitivity in dBm (negative number)

Link Budget Example

This example is based on the need to bridge a point-to-point distance of 1 Km over average terrain in a dry climate. The bridge must perform at full speed (e.g. 54Mbps).

To be able to do this, we first select the components we need. Assume that the wireless connections use "standard" access power devices (i.e.32mW or 15dbm) and 9dbi gain USR5482 antenna at each end.

These are the values to be used in the calculation:

Ptx = 15 dBm (Output power of the transmitting access point)
LL = 3 dB (Cable + connector attenuation for a CO 100 cable of 5m at 2.45 GHz)
Gtx = 9 dBi (Antenna gain)
FSPL = -100 dB (see table on page 4 for 1 km)
Prx = -80 dB (Receiver sensitivity value for a typical access point at 54 Mbit/s)
LL = 3 dB (Cable + connector attenuation for a CO 100 cable of 5m at 2.45 GHz)
Grx = 9 dBi (Antenna gain for USR5482)

This gives:
15-3+9-100-3+9+80=7 dB

This means a margin of about 7 dB on the link. This is a good margin with which to work, providing confidence that the connectivity required will be achieved. In general a margin of 5 dB is the lowest level that will provide acceptable results.

This signal is a calculation under ideal circumstances, however, the radio path can be disturbed by weather conditions or antennas can suffer degradations. The user must also ensure that the installation does not infringe upon any local or national laws.