

RF Power Values

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Introduction

This document defines radio frequency (RF) power levels and the most common measure, the decibel (dB). This information can be very useful when you troubleshoot intermittent connectivity.

Prerequisites

Requirements

Cisco recommends that you have knowledge of basic mathematics, such as logarithms and how to use them.

Components Used

This document is not restricted to specific software and hardware versions.

Conventions

Refer to Cisco Technical Tips Conventions for more information on document conventions.

Power Level

The dB measures the power of a signal as a function of its ratio to another standardized value. The abbreviation dB is often combined with other abbreviations in order to represent the values that are compared. Here are two examples:

- dBm The dB value is compared to 1 mW.
- dBw The dB value is compared to 1 W.

You can calculate the power in dBs from this formula:

$$\text{Power (in dB)} = 10 * \log_{10} (\text{Signal/Reference})$$

This list defines the terms in the formula:

- \log_{10} is logarithm base 10.
- Signal is the power of the signal (for example, 50 mW).
- Reference is the reference power (for example, 1 mW).

Here is an example. If you want to calculate the power in dB of 50 mW, apply the formula in order to get:

$$\text{Power (in dB)} = 10 * \log_{10} (50/1) = 10 * \log_{10} (50) = 10 * 1.7 = 17 \text{ dBm}$$

Because decibels are ratios that compare two power levels, you can use simple math in order to manipulate the ratios for the design and assembly of networks. For example, you can apply this basic rule in order to calculate logarithms of large numbers:

$$\log_{10} (A*B) = \log_{10}(A) + \log_{10}(B)$$

If you use the formula above, you can calculate the power of 50 mW in dBs in this way:

$$\text{Power (in dB)} = 10 * \log_{10} (50) = 10 * \log_{10} (5 * 10) = (10 * \log_{10} (5)) + (10 * \log_{10}(10)) = 7 + 10 = 17 \text{ dBm}$$

These are commonly used general rules:

An Increase of:	A Decrease of:	Produces:
3 dB		Double transmit power
	3 dB	Half transmit power
10 dB		10 times the transmit power
	10 dB	Divides transmit power by 10
30 dB		1000 times the transmit power
	30 dB	Decreases transmit power 1000 times

This table provides approximate dBm to mW values:

dBm	mW
0	1
1	1.25
2	1.56
3	2
4	2.5
5	3.12
6	4
7	5
8	6.25
9	8
10	10

11	12.5
12	16
13	20
14	25
15	32
16	40
17	50
18	64
19	80
20	100
21	128
22	160
23	200
24	256
25	320
26	400
27	512
28	640
29	800
30	1000 or 1 W

Here is an example:

1. If 0 dB = 1 mW, then 14 dB = 25 mW.
2. If 0 dB = 1 mW, then 10 dB = 10 mW, and 20 dB = 100 mW.
3. Subtract 3 dB from 100 mW in order to drop the power by half (17 dB = 50 mW). Then, subtract 3 dB again in order to drop the power by 50 percent again (14 dB = 25 mW).

Note: You can find *all* values with a little addition or subtraction if you use the basic rules of algorithms.

Antennas

You can also use the dB abbreviation in order to describe the power level rating of antennas:

- dBi For use with isotropic antennas.

Note: Isotropic antennas are theoretical antennas that transmit equal power density in all directions. They are used only as theoretical (mathematical) references. They do not exist in the real world.

- dBd With reference to dipole antennas.

Isotropic antenna power is the ideal measurement to which antennas are compared. All FCC calculations use this measurement (dBi). Dipole antennas are more real-world antennas. While some antennas are rated in dBd, the majority use dBi.

The power rating difference between dBd and dBi is approximately 2.2 that is, 0 dBd = 2.2 dBi. Therefore, an antenna that is rated at 3 dBd is rated by the FCC (and Cisco) as 5.2 dBi.

Effective Isotropic Radiated Power

The radiated (transmitted) power is rated in either dBm or W. Power that comes off an antenna is measured as effective isotropic radiated power (EIRP). EIRP is the value that regulatory agencies, such as the FCC or European Telecommunications Standards Institute (ETSI), use to determine and measure power limits in applications such as 2.4-GHz or 5-GHz wireless equipment. In order to calculate EIRP, add the transmitter power (in dBm) to the antenna gain (in dBi) and subtract any cable losses (in dB).

Part	Cisco Part Number	Power
A Cisco Aironet Bridge	AIR- BR350-A-K9	20 dBm
That uses a 50 foot antenna cable	AIR- CAB050LL-R	3.35 dB
And a solid dish antenna	AIR-ANT3338	loss, 21 dBi gain
Has an EIRP of		37.65 dBm

Path Loss

The distance that a signal can be transmitted depends on several factors. The primary hardware factors that are involved are:

- Transmitter power
- Cable losses between the transmitter and its antenna
- Antenna gain of the transmitter
- Localization of the two antennas

This refers to how far apart the antennas are and if there are obstacles between them. Antennas that can see each other without any obstacles between them are in line of sight.

- Receiving antenna gain
- Cable losses between the receiver and its antenna
- Receiver sensitivity

Receiver sensitivity is defined as the minimum signal power level (in dBm or mW) that is necessary for the receiver to accurately decode a given signal. Because dBm is compared to 0 mW, 0 dBm is a relative point, much like 0 degrees is in temperature measurement. This table shows example values of receiver sensitivity:

dBm	mW
10	10
3	2
0	1
-3	0.5
-10	0.1
-20	0.01

-30	0.001
-40	0.0001
-50	0.00001
-60	0.000001
-70	0.0000001

The receiver sensitivity of the radios in Aironet products is **-84 dBm** or 0.000000004 mW.

Estimate Outdoor Ranges

Cisco has an Outdoor Bridge Range Calculation Utility to help determine what to expect from an outdoor wireless link. Because the outputs of the calculation utility are theoretical, it is helpful to have some guidelines on how to help counteract outside factors.

- For every increase of 6 dB, the coverage distance doubles.
- For every decrease of 6 dB, the coverage distance is cut in half.

In order to make these adjustments, choose antennas with higher (or lower) gain. Or use longer (or shorter) antenna cables.

Given that a pair of Aironet 350 Bridges (with 50 feet of cable that connects to a dish antenna) can span 18 miles, you can modify the theoretical performance of that installation:

- If you change to 100-foot cables instead of 50-foot (which adds 3 dB of loss on each end), the range drops to 9 miles.
- If you change the antenna to 13.5-dBi yagis instead of the dishes (which reduces gain by 14 dBi overall), the range drops to less than 4 miles.

Estimate Indoor Ranges

There is no antenna calculation utility for indoor links. Indoor RF propagation is different than outdoor propagation. However, there are some quick calculations that you can do in order to estimate performance.

- For every increase of 9 dB, the coverage area doubles.
- For every decrease of 9 dB, the coverage area is cut in half.

Consider the typical installation of an Aironet 340 Access Point (AP) with the rubber ducky 2.2-dBi dipole antenna. The radio is approximately 15 dBm. If you upgrade to a 350 AP and replace the rubber duckies with a high-gain omni-directional antenna that is rated at 5.2 dBi, the range nearly doubles. The increase in power from a 340 AP to a 350 AP is +5 dBi. And the antenna upgrade is +3 dBi, for a total of +8 dBi. This is close to the +9 dBi that are required to double the distance.

Related Information

- [Cisco Aironet Antenna Reference Guide](#)
- [Outdoor Bridge Range Calculation Utility](#)
- [Intermittent Connectivity Issues in Wireless Bridges](#)
- [Troubleshooting Connectivity in a Wireless LAN Network](#)
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