

Wireless Networks

Lecture 5: Wireless Measurements

The Frequency Spectrum and Wireless LANs

The frequency spectrum ranges from very low frequencies at 1 Hz to gamma rays at 10^{23} Hz. Within that very large range of frequencies, there are three frequency bands used for wireless LANs.

Those three bands are collectively referred to as **I**ndustrial, **S**cientific, and **M**edical (**ISM**) bands.

These three bands represent unlicensed frequency bands on a worldwide basis.

ISM Bands

Although ISM bands are **unlicensed**, they are **not unregulated** and a distinction between the two is important. The fact that an ISM band is unlicensed means that organizations can transmit using ISM equipment without having to obtain a license to use such equipment.

However, both the power and transmission characteristics of equipment, such as the frequencies are regulated for operation in an ISM band. In the United States, the FCC (Federal Communication Commission) is responsible for such regulation.

ISM Bands

Two additional ISM frequency bands are referred to as the 2.4-GHz and the 5.0- GHz bands.

The 2.4-GHz ISM band ranges from 2.4000 to 2.4835 GHz, resulting in 83.5 MHz of available bandwidth.

The IEEE 802.11b standards operate in the 2.4-GHz frequency band.

Measurements

Measurements can be used to qualify the level of received power as well as power gains and losses.

Basic Units of RF Measurement

The basic unit of measure for radio frequency is the **watt**. A wireless access point may be set to an output of 30 mW (milliwatts) of power. A milliwatt is 1/1000 of a watt.

Absolute Measurements of Power

The amount of power leaving a wireless access point is one example of an absolute measure of power. This is an actual power measurement and not a ratio or a relative value.

A typical amount of output power from an access point is 100 mW.

Watt (W)

The watt is a basic unit of power measurement. This is an absolute value or measurable value. Most wireless networks function in the milliwatt range. Power level in watts is a common measurement in long distance point-to-point and point-to-multi point applications.

Milliwatt (mW)

One milliwatt is 1/1000 of a watt. This is a common value used in RF work and IEEE 802.11 wireless LANs. The output power of an access point ranges from 1 mW to 100 mW. Most enterprise-grade access points allow you to change the output power.

The milliwatt is also an absolute unit of power measurement.

Decibel Relative to a Milliwatt (dBm)

dBm represents an absolute measurement of power where the m stands for milliwatts. Effectively, dBm references decibels relative to 1 milliwatt such that 0 dBm equals 1 milliwatt. Once you establish that 0 dBm equals 1 milliwatt, you can reference any power strength in dBm. The formula to get dBm from milliwatts is:

$$\text{dBm} = 10 \times \log_{10}(\text{Power mW})$$

A dB is an example of a change in power or relative measurement of power where dBm is measured power referenced to 1 milliwatt or an absolute measure of power.

dBm is output power measurement

Relative Measurements of Power

Changes in RF power are known as **relative**. dB and dBi are relative measurements of power.

1- An example would be an RF amplifier. If the input power to an amplifier is 10 mW and the output power is 100 mW, the gain of the amplifier is 10 dB—a change in power.

Relative Measurements of Power

2- If the input power to an antenna is 100 mW and the output power is 200 mW, the gain of the antenna is 3 dBi—a change in power.

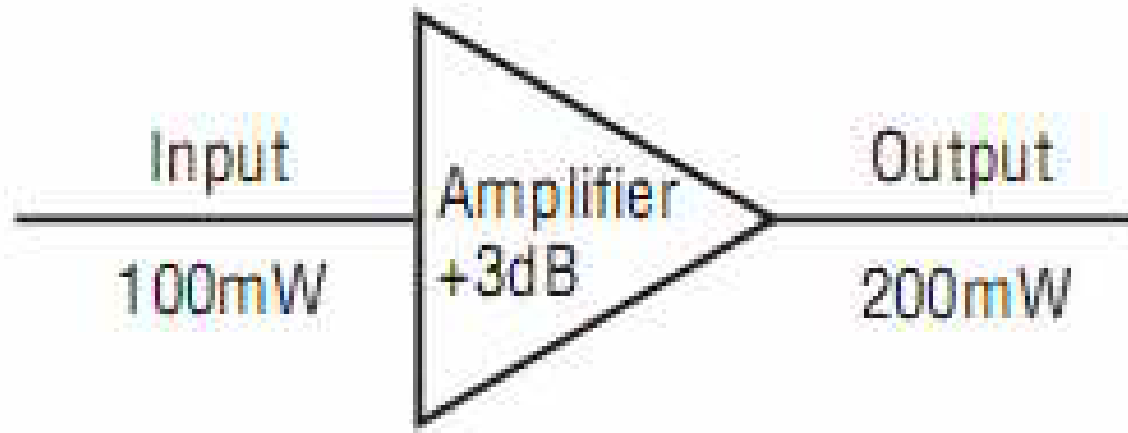
Both of these are examples of changes in power and are known as relative.

Decibel (dB)

The decibel is a comparative measurement value. In other words, it is a measurement of the difference between two power levels. For example, it is common to say that a certain power level is 6 dB stronger than another power level or that it is 3 dB weaker. These statements mean that there has been 6 dB of gain and 3 dB of loss, respectively.

Decibel (dB)

The decibel (dB) is a ratio of two different power levels caused by a change in power. The following figure shows how an amplifier will provide an increase or change in power.



Decibel (dB)

Because a wireless receiver can detect and process very weak signals, it is easier to refer to the received signal strength in dBm rather than in mW. For example, a signal that is transmitted at 4 W of output power (4000 mW or 36 dBm) and experiences -63 dB of loss has a signal strength of 0.002 mW (-27 dBm). Rather than saying that the signal strength is 0.002 mW, we say that the signal strength is -27 dBm.

Decibel Isotropic (dBi)

Decibel isotropic (dBi) is the unit that represents the gain or increase in signal strength of an antenna.

The term isotropic in the RF world means energy broadcast equally in all directions in a spherical fashion.

Decibel Dipole (dBd)

The gain of some antennas may be measured in decibel dipole (dBd). This unit of measurement refers to the antenna gain with respect to a reference dipole antenna. The gain of most antennas used in wireless LANs is measured in decibel isotropic (dBi); however some manufacturers may reference gain in dBd. The following simple formula derives the dBi value from the dBd value:

$$\text{dBi} = \text{dBd} + 2.14$$

This formula converts from dBi to dBd:

$$\text{dBd} = \text{dBi} - 2.14$$

dBi

The abbreviation dBi (the i stands for isotropic) represents a measurement of power gain used for RF antennas.

It is a comparison of the gain of the antenna and the output of a theoretical isotropic radiator. An isotropic radiator is an ideal antenna that we cannot create with any known technology. This is an antenna that radiates power equally in all directions. In order to do this, the power source would have to be at the center of the radiating element and be infinitesimally small. Since this technology does not exist, we call the isotropic radiator the ideal against which other antennas are measured.

dBd

Antenna manufacturers use both dBi, mentioned previously, and dBd to calculate the directional gain of antennas. Where dBi is a calculation of directional gain compared to an isotropic radiator, dBd is a calculation of directional gain compared to a dipole antenna. Therefore, the last d in dBd stands for dipole. Like dBi, dBd is a value calculated against the input power to determine the directional output power of the antenna.

SNR

One of the most important metrics in the field of communications is the signal-to-noise (S/N) ratio.

Background RF noise, which can be caused by all the various systems and natural phenomena that generate energy in the electromagnetic spectrum, is known as the noise floor. The power level of the RF signal relative to the power level of the noise floor is known as the signal- to- noise ratio or SNR.

you might expect that a higher S/N ratio is preferable to a lower S/N ratio

SNR

the SNR becomes a very important measurement. If the noise floor power levels are too close to the received signal strength, the signal may be corrupted or may not even be detected. It's almost as if the received signal strength is weaker than it actually is when there is more electromagnetic noise in the environment. You may have noticed that when you yell in a room full of people yelling, your volume doesn't seem so great; however, if you yell in a room full of people whispering, your volume seems to be magnified. In fact, your volume is not greater, but the noise floor is less. RF signals are impacted in a similar way.

Thank You