Lab 3.2.3 Wireless Mathematics

Estimated Time: 25 minutes

Number of Team Members: Students will work in teams of two or individually

Objective

In this lab, the student will learn the importance of the output power of the transmitting wireless device. Students will calculate the amount of power actually transmitted from a wireless transmitting device. This will be done through the antenna element, the Effective Isotropic Radiated Power (EIRP) based on the type of antenna, cabling, connectors, and the transmitting device setting being used.

Scenario

Upon completion of this lab, students will calculate potential range of the radiated wave signal transmitted by wireless devices. Students will also convert all radio frequency (RF) signal ratings into a common decibel (dB) unit in order to calculate power gain or loss.

Preparation:

Prior to the lab, students should review the course materials up to 3.2.3.

Tools and Resources:

3.2.3 Interactive Activity: Calculating Decibels
3.2.3 Interactive Activity: Using Decibels

Additional Materials

http://www.zytrax.com/tech/wireless/calc.htm

http://www.cisco.com/en/US/tech/tk722/tk809/technologies_tech_note09186a00800e90fe.shtml#topic1

http://www.cisco.com/en/US/products/hw/wireless/ps4570/products_installation_guide_chapter09186a0080184b5a.html

http://www.cisco.com/en/US/products/hw/wireless/ps469/products_data_sheet09186a008008883b.html

Students should research the Cisco website for the following information if needed:

- Technical specifications of the power output in decibels (milliwatts) of the wireless devices used. AP and client adapters are examples of these devices.
- Technical specifications of the gain in decibels referenced to an isotropic antenna (dBi) of various wireless device antennas.
- Technical specifications of the gain/loss in decibels (dB) of various wireless device cables
- Technical specifications of the gain/loss in decibels (dB) of various wireless device connectors. These connectors are necessary when cables have to be joined for longer cable lengths.

Maximum Power Levels

ETSI

Band (GHz)	2.4	5.15 – 5.25	5.25 – 5.35	5.470 – 5.725	5.725 – 5.825
EIRP	100 mW 20 dBm	200 mW 22 dBm	200 mW 22 dBm	1000 mW 30 dBm	25 mW 14 dBm

FCC

Band (GHz)	2.4	5.15 – 5.25	5.25 – 5.35	5.470 – 5.725	5.725 – 5.825
Conducted Power	-	40 mW	250 mW	N/A	1000 mW
EIRP	4000 mW 36 dBm	200 mW 22 dBm	1000 mW 30 dBm		P2MP – 4 W (36 dBm) P2P – 200 W (53 dBm)

Step 1 Calculate the decibel rating

The decibel (dB) measures the power of a signal as a function of its ratio to another standardized value. The symbol is often combined with other symbols to represent what values are being compared. For example: dBm where the decibel value is being compared to 1 milliWatt, and dBw where the decibel value is being compared to 1 Watt. For example:

Power (in dB) = 10 * log10 (Signal/Reference)

Where:

Signal is the power of the signal (for example 50 mW)

Reference is the reference power (for example 1 mW)

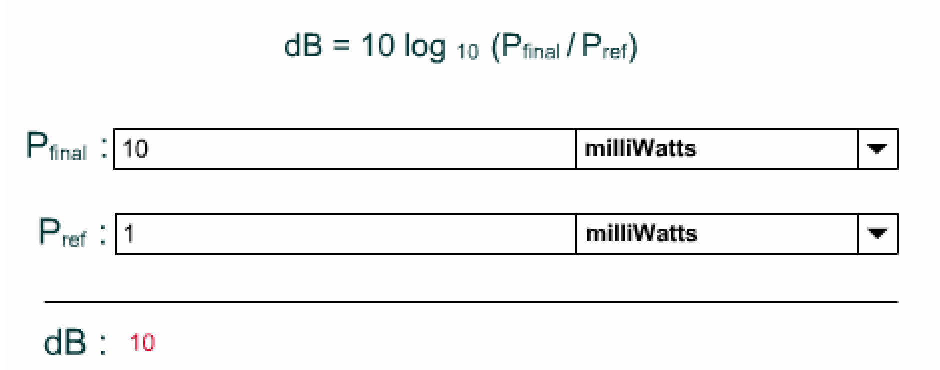
In the example:

Power (in dB) = 10 * log10 (50/1) = 10 * log10 (50) = 10 * 1,7 = 17 dBm

Since decibels are ratios comparing two power levels, simple math can be used to manipulate them for designing and building networks.

Using the previous example:

Power (in dB) = 10 * log10 (5 * 10) = (10 * log10 (5)) + (10 * log10 (10)) = 7 + 10 = 17 dBm



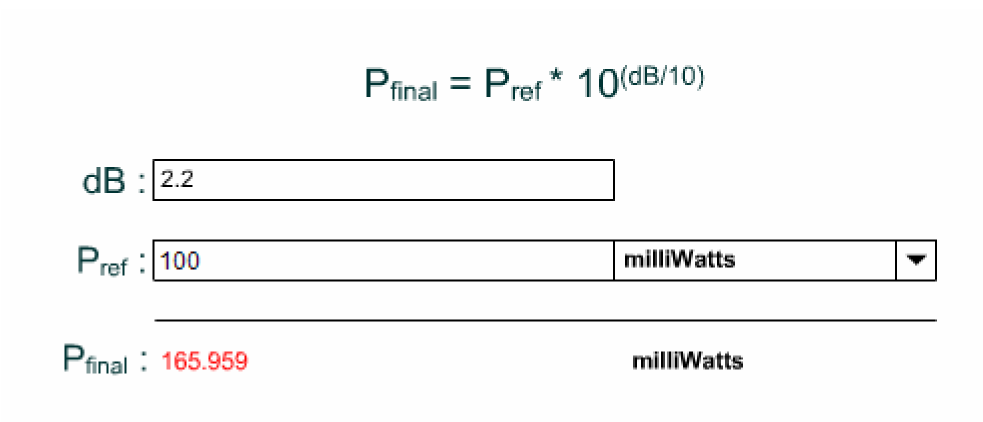
Complete the missing values below. If help is needed, use the “Calculating Decibels” Interactive Activity.

An increase of:	A decrease of:	Produces:
3dB		Double transmit power
	3dB	Half transmit power
10dB		10 times the transmit power
	10dB	Decreases transmit power 10 times
15dB		32 times the transmit power
	15dB	Decreases transmit power 32 times
20dB		100 times the transmit power
	20dB	Decreases transmit power 100 times
25dB		316 times the transmit power
	25dB	Decreases transmit power 316 times
30dB		1000 times the transmit power
	30dB	Decreases transmit power 1000 times

Additional Practice:

An increase of:	A decrease of:	Produces:
5dB		3 times the transmit power
	5dB	Decreases transmit power 3 times
40dB		10000 times the transmit power
	40dB	Decreases transmit power 10000 times

Step 2 Calculate the delivered power



Another way to look at this formula is where Pfinal = Pref * 10 (dB/10). In the example above, a 2.4 GHz AP is set to 100mW and has a 2.2 dBi antenna.

Now calculate the following scenarios. Use the “Using Decibels” Interactive Activity

AP Power	Antenna	Power output (in mW)
1 mW	2.2 dBi	1.66
5 mW	6 dBi	20
50 mW	9 dBi	397
100 mW	6 dBi	398
100 mW	22 dBi	15849

a. What is the maximum allowable output power in dBm and Watts for the 2.4 GHz band?

   FCC

   ____

   ETSI

   ____

   ____________ (Other Regulatory domain)

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b. What is the maximum allowable output power in dBm and Watts for the 5 GHz band?

   FCC

   ____

   ETSI

   ____

   ____________ (Other Regulatory domain)

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c. Why is it necessary for regulatory bodies to define maximum power levels?

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d. What power levels can be set for the 2.4 GHz radio on an AP 1100? 350? 1200?

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e. What power levels can be set for the 2.4 GHz radio on an PCM 350 NICs?

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f. What power levels can be set for the 5 GHz radio on an AP 1200?

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g. What are the approximate dBm values for each of the following power levels?

dBm	mw
___dBm	1mW
___dBm	5mW
___dBm	20mW
___dBm	30mW
___dBm	50mW
___dBm	100mW

Step 3 Calculate the total power output of the wireless device

The radiated (transmitted) power is rated in either dBm or Watts. Power coming 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 wireless equipment. EIRP is calculated by adding the transmitter power (in dBm) to antenna gain (in dBi) and subtracting any cable losses (in dB.)

The dB notation can also be used to describe the power level rating of antennas: dBi for use with isotropic antennas (theoretical antennas that send the same power density in all directions) and dBd when referring to dipole antennas. Antennas are compared to this ideal measurement, and 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, 0dBd = 2.2dBi. Therefore, an antenna rated at 3dBd is rated by the FCC (and Cisco) as 5.2dBi.

Example 1:

Description	**Cisco Part Number**	**Power**
AP	AIR-AP1200-A-K9	20 dBm
Antenna gain:	AIR-ANT2012	6 dBi
Antenna Cable loss:	AIR-CAB050LL-R	-3.35 dBi

20dBm + 6dB – 3.35dBi = 34dBm

EIRP = 22.65 dBm

Example 2:

Description	**Cisco Part Number**		**Power**
A Cisco Aironet Bridge	AIR-BR350-A-K9		20 dBm
50 foot antenna cable	AIR-CAB050LL-R		3.35 dB loss
solid dish antenna	AIR-ANT3338		21 dBi gain
		EIRP	**37.65 dBm**

a. Which example is permissible according to local regulatory guidelines?

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Calculate the EIRP for the following:

AP Output	Antenna Gain	EIRP
20-dBm	12 dBi	
17-dBm	5.2 dBi	
15-dBm	21 dBi	
13-dBm	8.5 dBi	
7-dBm	2.2 dBi	
0 dBm	2.2 dBi	

b. What are the primary hardware factors involved that affect signal distance?

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