Assignment 1
Due Date: January 25th at noon via WebCT
Submission Format: pdf or ascii text

1) You have a WiFi basestation that broadcasts with a power level of 26 dBm and after taking some measurements of the signal received by your laptop's antenna, you conclude that the signal has been attenuated down to ¼ of the original transmitted power.

a) What would be the received signal power that you measure (in dBm)?

Easy way:

¼ means ½*1/2, so we can just take off 3dBm twice (6dBm) to get 20 dBm.

Harder way:

1. Convert 26dBm to linear: 10^(26/10) = 398 mW
2. Divide by 4 = 99.5mW
3. Convert back to dBm: 10*log(99.5) = 20 dBm.

b) What is the received signal power in dBW?

Easy way: subtract 30dB: 20dBm - 30dB = -10dBm

(division by 1000 is subtraction of 30 in dB)

Harder way:

-convert part 2 of part a to W: 99.5mW x 1000mW/W = 0.0995W

-convert to dBW: 10log(0.0995) = -10dBW

2) Examine the dotted signal in Fig. 2.14 (in the text book). Assume that the x-axis is in microseconds (1 us = 10^{-6} seconds) and the y-axis is in Volts.

a) What is the peak amplitude?

Vp = 2.0V

b) What is the phase?

+/- π

c) What is the frequency?

By observation of the waveform, a complete cycle takes 0.5us.

$f = \frac{1}{T} = \frac{1}{0.5 \times 10^{-6}} = 2 \times 10^{6}$ Hz, or 2 MHz.

The frequency is 2 MHz

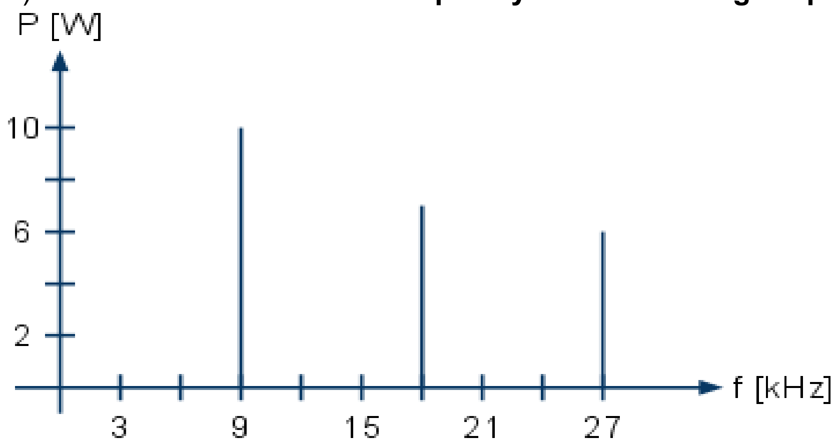
d) **What would be the wavelength of this signal if it were propagating in air, assuming that the velocity of propagation is the speed of light (c = 3x10^8 m/s)**

$\lambda = c / f$, so given c and 2MHz, $\lambda = \frac{3 \times 10^{8}}{2 \times 10^{6}} = 1.5 \times 10^{2} = 150$ m

The wavelength would be 150m.

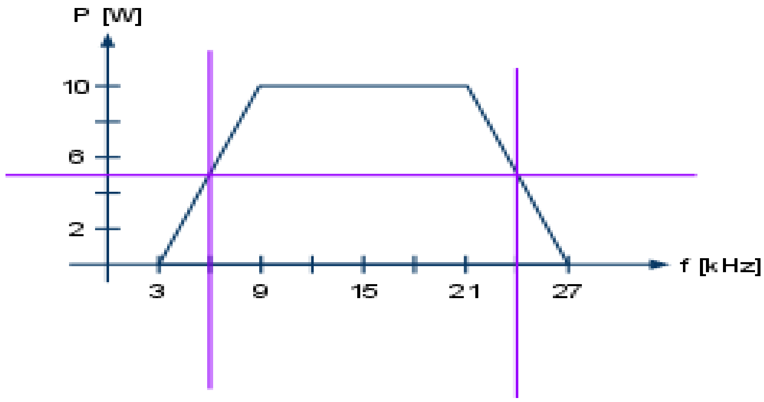
3)

a) **What is the fundamental frequency in the following frequency spectrum?**



The fundamental frequency is 9kHz

b) What is the half-power bandwidth of the signal with the frequency spectrum as shown below?



Since maximum power is at 10W, the half power is at 5 W. The signal gets to 5W at 6kHz and then again at 24kHz. The bandwidth is 18kHz.

(note: answers may be very slightly different depending on their approximations when looking at the diagram)

4) A WiMax system is running with a 10MHz channel bandwidth and is designed to provide an error-free maximum data rate of 30 Mbps

a) Given a noisy system, what signal to noise ratio (in dB) would be necessary to achieve the given channel capacity?

By Shannon's maximum capacity equation:

$$C = B\log_s(1+SNR)$$
$$C / B = \log_2(1+SNR)$$
$$2^{\frac{C}{B}} = 1+SNR$$
$$SNR = 2^{\frac{C}{B}} - 1$$

C/B = 30Mbps /10MHz = 3
SNR = 2^3 - 1 = 7

SNR[dB] = 10log(SNR) = 10log(7) = 8.5 dB

b) Given an ideal digital system, how many voltage levels would be required?

By Nyquist,

$$C = 2B\log_2 M$$
$$\frac{C}{2B} = \log_2 M$$
$$M = 2^{\frac{C}{2B}}$$

C/2B = 3/2, so M = 2^ 3/2 = 2.888
There is no such thing as a fraction of a voltage level, so we will have to round up to 3.
3 voltage levels are required.

5) A frequency band from 76 MHz to 86 MHz is available for wireless transmission. Design a frequency division multiplexing system with 2 MHz wide channels and 2 MHz guard bands (assume that guard bands aren't necessary at the lower and upper ends of the band). Indicate where each channel begins and ends, as well as its centre frequency. How many channels fit inside the given frequency band?

FDM design:
Start at 76 MHz:
Channel 1: 76 MHz - 78 MHz, fc = 77 MHz
guard band: 78 MHz - 80 MHz, fc = 79 MHz
Channel 2: 80 MHz - 82 MHz, fc = 81 MHz
guard band: 82 MHz - 84 MHz, fc = 83 MHz
Channel 3: 84 MHz - 86 MHz, fc = 85 MHz

We can fit 3 channels inside the given band.