Tutorial 8, CS1031

1. Modulation and multiplexing of digital signals

You need to design a phone transmission system that first digitises and then multiplexes 5 different phone lines into one common cable, using frequency division multiplexing. The digitisation should be carried out using values for sampling rate and quantisation bit numbers that are typical for phone signals, and the digital modulation used should be 2-ASK, with a value for the modulation coefficient d equal to 1.

(a) What is the bit rate of each digitised phone signal?

a typical phone line with cutoffe frequency of 4KHz requires a bit rate of 2 x 4 KHx x 8 = 64 Kbit/s

(b) Considering that the minimum frequency to be used in the cable is 50 KHz, what is the maximum frequency of the multiplexed signal, if you use a guard band interval of 10KHz between adjacent signals?
The bandwidth of each modulation is B=(1+d) x rate/number-bits = 2 x 64 = 128KHz. The total is 128 x 5 + 10 x 4=680 KHz. The max frequency is 680+50 = 730KHz

(c) What are the frequency values of the carriers used to implement the frequency division multiplexing?

the carrier is at half the frequency band, so 64 KHz after the beginning of each signal. The first carries is at 64+50 = 114KHz, all the others are at 10+128 = 138 after the previous one, so 252KHz, ...

2. Fourier analysis

A square wave with frequency f=10 Hertz is approximated with its Fourier series using the first and third spectral components:

$$\sum_{n=1,3} 1/n * \sin(2\pi nft)$$

(a) Show the amplitude frequency spectrum of the signal The plot should show a line of amplitude 1 at frequency 10Hz and another of amplitude 0.33 at frequency 30Hz. The plot should also be mirrored on the negative axis.

(b) Show the plot of the signal when it is amplitude modulated with a carrier sinusoid of frequency 100 Hz. The plot should be the previous one (including the negative axis) shifted around the 100 Hz point. A mirror copy is expected on the negative axis.

(c) What would be the minimum frequency to use for the carrier sine wave? Explain why

The minimum carrier frequency should be 30 Hz. If the frequency was lower, then the amplitude spectrum would not clear the negative axis and the negative spectrum would be mirrored back into the positive axis