Tutorial 3, CS1031

1. Modulation and noise

Which of the three modulation techniques (AM, FM, or PM) is the most susceptible to Gaussian additive noise? Explain your choice.

We can say that the most susceptible technique is AM because it puts the information into the amplitude parameters, which is the one that is most directly affected by the Gaussian additive noise.

2. Signal multiplexing

Assume that a voice channel occupies a bandwidth of 4 kHz. We need to multiplex 10 voice channels with guard bands of 500 Hz using frequency division multiplexing. Calculate the total bandwidth occupied by the signals.

In order to multiplex 10 voice channels, we need nine guard bands. The first signal occupies 4 KHz, but the modulated ones occupy 8KHz each so the required bandwidth is then B = (4 KHz) + (8KHz) * 9 + (500 Hz) × 9 = 80.5 Khz.

The guard bands allow for filter 'roll off' in order to reduce adjacent channel crosstalk.

3. Am modulated signal

Consider the following signals:

- carrier signal: $c(t) = \cos(2\pi 100t)$
- modulating message signal: $m(t) = \cos(2\pi 20t)$

a) plot the spectrum of the modulated signal $s_{am}(t) = [1+m(t)]*c(t)$
b) plot the spectrum of the modulated signal $s_{am}(t) = m(t)*c(t)$
c) what bandwidth is required for AM ?

*Hint for a) if you need to calculate the frequency components you can use cosA*cosB = 1/2[cos(A-B)+cos(A+B)]*

a) $s_{am}(t) = [1+\cos(\pi 20t)]\cos(2\pi 100t) = \cos(2\pi 100t) + \cos(2\pi 20t)\cos(2\pi 100t) =$
$= \cos(2\pi 100t) + 1/2\cos(2\pi(80t) + ½\cos(2\pi(120t)$

The plot has a low component at frequency 80 with amplitude ½ , a central component at frequency 100 with amplitude 1 (this is the carrier), and a high component at frequency 120 with amplitude ½.

Notice that this can also be done more simply graphically by noticing that modulating a signal moves the spectrum around the carrier frequency.

b) This case is the same but without the component at 100 Hz. This modulation has a suppressed carrier.

c) The bandwidth for AM can either be calculated with the formula $B= 2*f_{max}$, where $f_{max}= 20$; or else from the plot shown, B=120 - 80=40