Communication Systems

Power delivered by a pure ac source:

Consider a pure ac source driving any impedance. The sine wave can be decomposed into two rotating spirals (complex domain). Now, power delivered is

Instantaneous power = iv = (v1+v2)(i1+i2)

Where v1, v2 are the spirals moving in opposite directions(clockwise and anti clockwise) and i1 i2 are corresponding current.

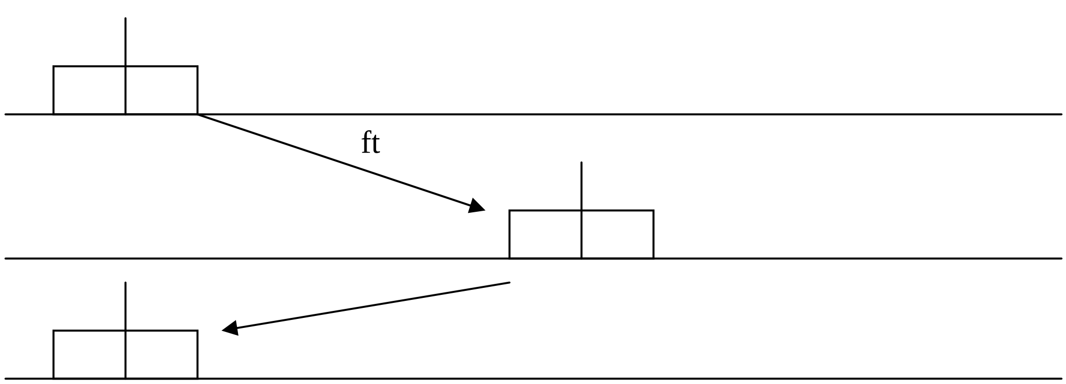
Average of V1i1 =0 = average of v2i2 therefore power is only due to v2i1 and v1i2 and as ‘ω’ i.e the frequency terms add on multiplication, here we will get non rotating spiral whose real resultant is

Avg power = ½(VIcosθ)

Modulation Property

Multiplication can also be thought as rotating a spiral of f1 by frequency f2 (think in time domain).
When we multiply two spirals, the resultant spiral is of frequency f1+f2. (i.e in the fourier transform there is a shift in frequency).

This property is used to solve the very big problem of practical impossibility of baseband transmission through EM waves.



Big problem in practical transmissions in using the above scheme directly, is multiplication by complex spirals. Though we can transmit spirals through air, that throws up some more problems like proper synchronization, and problems due to convolution caused by the environment.

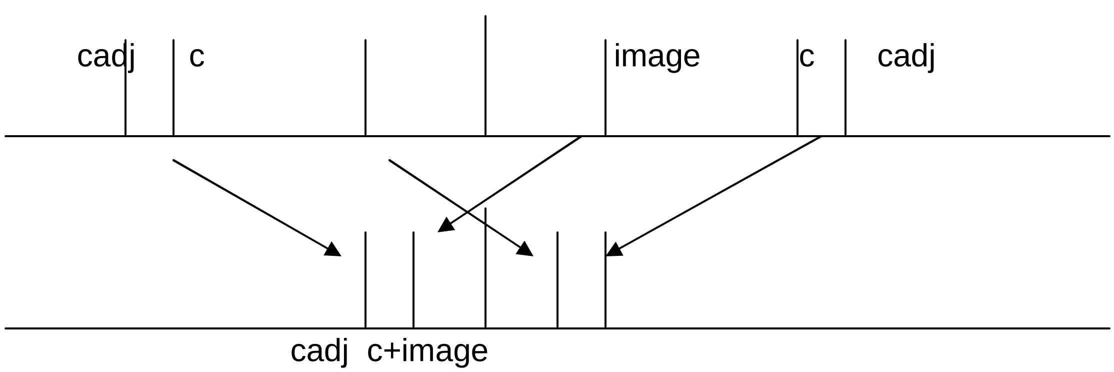
The solution is to use sine wave to modulate it instead of a spiral. Now the sine wave is composed of two spirals of f and –f so the waveform (in frequency domain) will be shifted by –f and +f. i.e. (1<f1+1<-f1)(signal)

At the receiver multiplication by the same sine will give the original back. But things are not so simple in the real world, it is practically impossible for a hand tuned receiver to match a frequency in one part in a million or better (even a 5 Hz shift will create problems (beats will be heard)).

So we use a non linear method for demodulation. Rectify and then pass the signal through a LPF. Thus we will detect the envelope of the signal. Here there is problem that the modulating signal cannot go below zero so introduce a carrier term. Which will give us (1<f1+1<-f2)(1+signal). This is Amplitude modulation.

Some problems in detecting and demodulating AM

Now to reject adjacent channels, we will need tunable filters of very high roll of, which becomes impractical in the RF range. So we need to move the signal to an intermediate frequency (IF lesser than carrier frequency) so that filtering becomes easier. This can be done by multiplying received signal with sine wave of IF but there is a problem of image frequency interfering.



We can use HPF in the RF range but LPF are easier so we multiply the incoming signal with frequency greater than the incoming RF frequency. Now the positive frequency spectrum will get translated to negative frequency and we can do a simple LPF.

SSB

In normal AM we have repetition of information and hence wastage of bandwidth (the transmitted signal is symmetric about carrier frequency) So we can filter out the redundant spectrum and at the receiver get the information back by multiplying with the carrier. (Here for speech signals even if the carrier is not perfectly matched it is okay as we will just get the signal a little squeakier but unlike pure AM, multiple frequencies will not be inferred for the same sound signal frequency).

FM

In FM we move the phasor faster or slower according to the input amplitude, i.e 'ω' of the phasor is changing. Mathematically we can get back the signal by differentiating it and then passing through a LPF.

