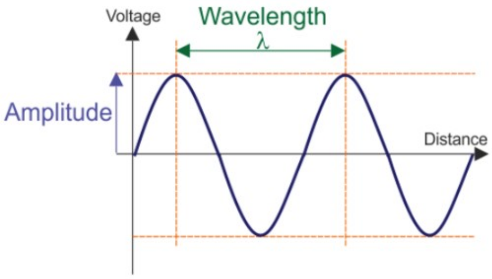
A2-04 Wireless Transmission

Revision sheet

1 Waves

1.1 Wavelength

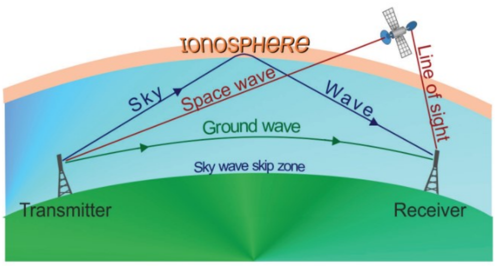


Wavelength is a measure of distance between two adjacent points in a repeating wave. It is measured in meters (m).

1.2 Wave Speed

Wave speed (c) is how fast the wave propagates, this is usually the speed of light which is $3 \times 10^8 ms^{-1}$. Frequency (f) gives number of cycles per second, usually in hertz. Wavelength (λ) gives distance of one cycle, usually in meters. These three factors can be combined to make the following equation.
$c = f\lambda$

1.3 Types Of Waves



1.3.1 Ground Waves

These occur at frequencies below $3MHz$, follow the curvature of the earth and can travel 1000s of miles.

1.3.2 Sky Waves

These occur at 3 to $30MHz$, go up into the sky, bounce off the ionosphere and come back down, can travel a very long distance and has a skip zone (this doesn't get any of the signal).

1.3.3 Line-Of-Sight Waves

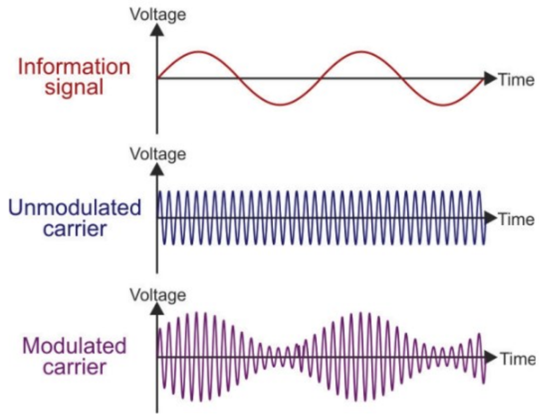
These occur at frequencies above $30MHz$ and the transmitters are often built on hills as you need line of sight from the transmitter to the receiver.

1.3.4 Space Waves

These occur at 1 to $300GHz$.

2 AM Radio

In *Amplitude Modulated* radio, the signal consists of two elements - a high frequency carrier wave and the information signal.

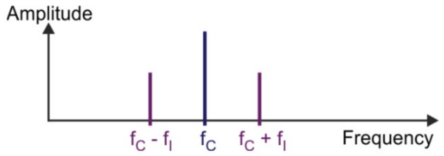


The information signal (f_i) is modulated onto the carrier signal (f_c). The AM modulated signal has the same frequency as the carrier wave.

2.1 Frequency Spectrum

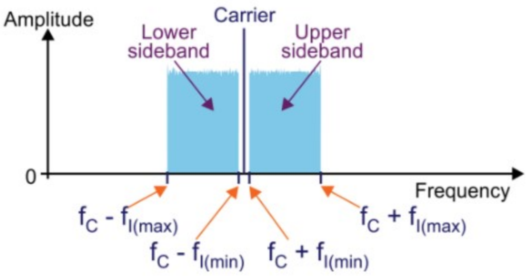
2.1.1 Sine Waves

A pure sinusoidal wave modulated onto a carrier frequency will produce the following frequency spectrum.

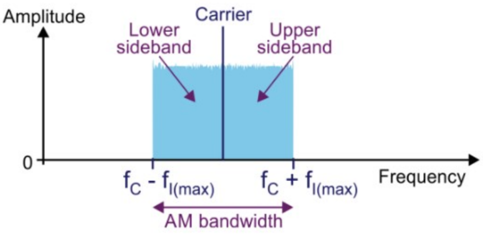


2.1.2 Range Of Frequencies

Real signals will be complex waves made up of a range of frequencies. These can be shown on frequency spectrum graphs like so:

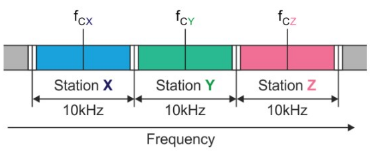


However, the gap between the carrier frequency and the side bands is generally so small that it isn't shown - resulting in a diagram like this:



2.2 Frequency Allocation (FDM)

In UK radio broadcasting, each station is bandwidth limited to $5KHz$ therefore the AM bandwidth is $10KHz$ (this includes a $1KHz$ guard band).



The number of available channels can be calculated using the following equation:

$$N_{CH} = \frac{\text{Available Bandwidth}}{\text{Channel Bandwidth}}$$

2.3 Depth Of Modulation

This is how much the carrier wave is affected by the information wave. If the information signal is greater than the carrier signal ($A_i > A_c$), overmodulation occurs, this gives distortion.

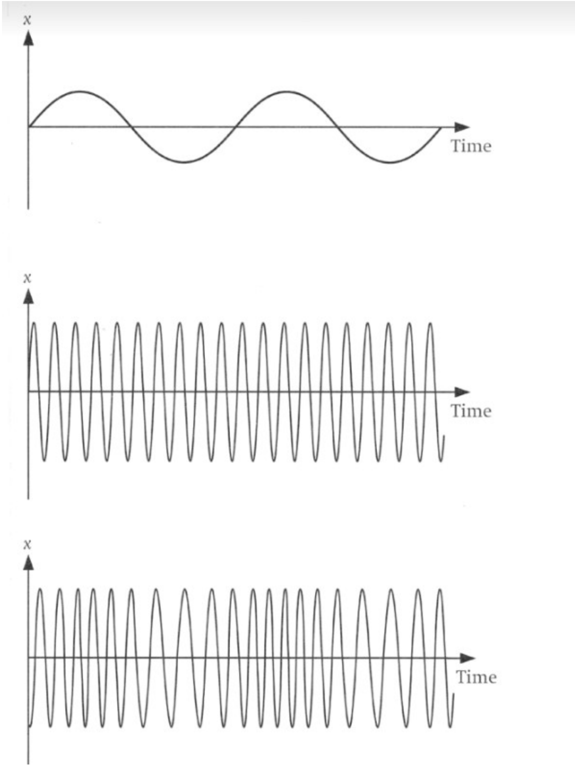
$$\text{Depth Of Modulation} = m = \frac{A_i}{A - c} \times 100$$

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \times 100$$

Overmodulation would give $m > 100$, generally you shouldn't exceed 80% to leave a safety margin.

3 FM Radio

Frequency Modulated radio sounds better than AM radio. It is broadcast in the very high frequency range and the amplitude of the wave stays the same, the frequency changes.



The amplitude of the carrier wave changes the frequency of the carrier. If $A = 0$, frequency is unchanged. If $A > 0$, frequency increases (max. frequency at max. amplitude). If $A < 0$, frequency decreases (min. frequency at min. amplitude).

3.1 Frequency Deviation

This is the maximum change in frequency from the carrier's base value f_c which is given the symbol Δf_c.

3.2 Modulation Index

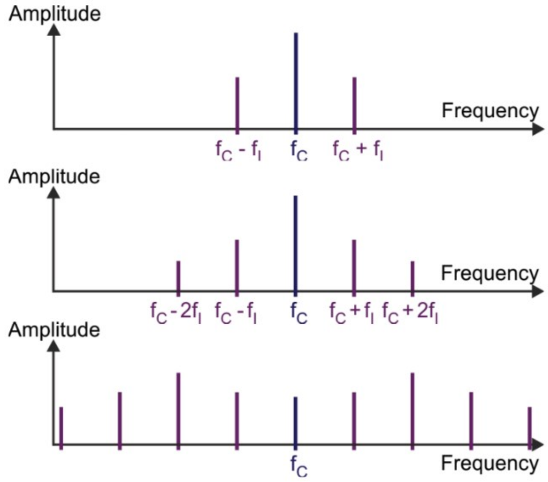
This describes how modulated the signal is.

$$\text{Modulation Index} = \beta = \frac{\Delta f_c}{f_i}$$

3.3 Frequency Spectrum

Frequency Modulated signals have infinite sidebands, but some are small enough to ignore. We just care about the 'significant' sidebands. The

number of sidebands can be calculated using the following formula: $No = 2(1 + \beta)$.
In the first graph, $\beta < 1$, the second $\beta = 1$ and the third $\beta = 3$.



If $\beta < 1$ the signal is said to be narrow band whereas if $\beta > 1$ the signal is said to be wideband.

3.4 Bandwidth

FM bandwidth $= 2(f_i + \Delta f_c)$

3.5 Important To Note

FM Signals are at a constant power because amplitude is always the same and frequency changes are symmetrical. In wideband FM, all the information is in the side bands, therefore the size of the carrier doesn't matter (this is why it can be so small). FM is more efficient than AM.