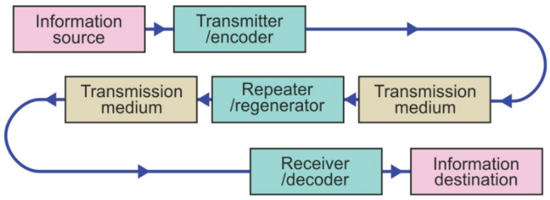
A2-03 Communication Systems

Revision sheet

1 Introduction

Shown below is the generic layout of a communication system.



Over a long distance, the signal quality degrades. To help overcome this, a repeater/ regenerator can be used to 'boost' the signal. This could be an amplifier or another flaming basket on a stick.

1.1 Bandwidth and Capacity

Any transmission medium has *available bandwidth* which it can transmit.

1.1.1 Channel Bandwidth

THe signals we want to transmit have a bandwidth, this is smaller than the available bandwidth therefore we can transmit several 'channels' at once (using different carrier waves). We can calculate the number of channels (N_{CH}) using the following formula.

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

2 Multiplexing

THis is the process of allowing several independent users to share the same transmission medium.

2.1 FDM

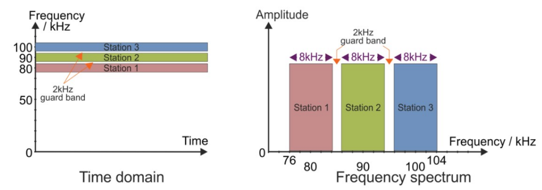
Frequency Division Multiplexing involves assigning non-overlapping frequency ranges to each signal. During transmission, each channel has a *guard band* which prevents interference between bands. In the example shown below, there are three radio stations. have been allocated a bandwidth of $8KHz$, with a guard band of $2KHz$ between them. They are given carrier frequencies 80, 90 and 100 KHz respectively. Their frequency bands are shown below

Station 1 occupies a frequency band of $(80 \pm 4)KHz (= 76 \Rightarrow 84)KHz$

Station 2 occupies a frequency band of $(90 \pm 4)KHz (= 86 \Rightarrow 94)KHz$

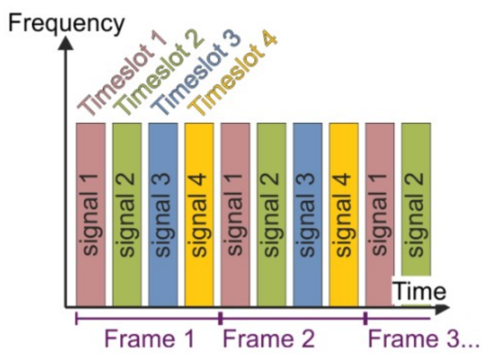
Station 3 occupies a frequency band of $(100 \pm 4)KHz (= 96 \Rightarrow 104)KHz$

The two different types of graphical representation are shown below.



2.2 TDM

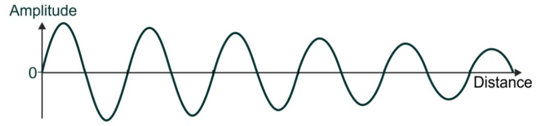
Time Division Multiplexing involves dividing the transmission time into timeslots of fixed length. These timeslots are cycled through, with each signal broadcasting part of its signal in its allocated time slot. During transmission, each signal has access to the full range of frequencies available to the channel.



3 Gain and Attenuation

3.1 Attenuation

Attenuation is the loss of signal strength over time, this means the amplitude of the signal diminishes. It can be thought of as gain which is less than 1.



Attenuation is measured in decibels per kilomiter (dB/Km)

3.2 Gain

Gain is a measure of the ability of a sub-system to increase the voltage, current or power of a signal.

3.2.1 Voltage Gain

$$Gain = \frac{V_{out}}{V_{in}}$$

3.2.2 Power Gain

In communication systems, the decibel (dB) is used to express the power gain of an amplifier or the power loss of a transmission medium.

$G_{dB} = 10 \log_{10} \frac{P_{OUT}}{P_{IN}}$

Un-logging a log

Logs and numbers surrounding them have the following relationships

$\log_{10}(a) = b$

$10^b = a$

3.2.3 Overall Gain

In a system where there are two amplifiers connected in series, with the gains G_1 and G_2 respectively, the overall gain can be calculated using the following equation:

$G_1 \times G_2 = G_{total}$

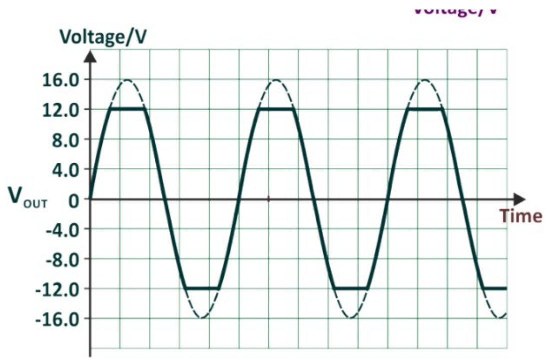
The overall gain in dB can be calculated using the following equation:

$G_1 + G_2 = G_{total}$

4 Noise and Distortion

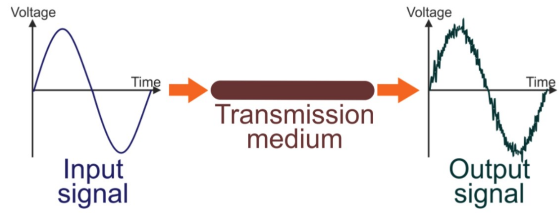
4.1 Distortion

Distortion is where the signal is altered in a non-linear way (not just making it bigger/ smaller). One type of distortion is clipping distortion, shown below.

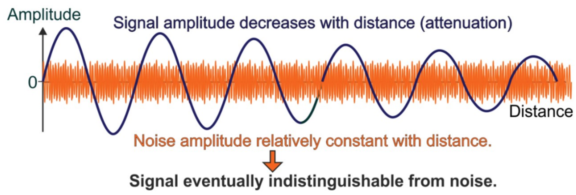


4.2 Noise

This is an external unwanted signal which is added to the signal. It can come from several sources: random noise, interference (from EM waves); cross talk (interference from other transmissions).



Noise limits the distance of a transmission as signal amplitude decreases with distance while noise amplitude stays the same.



5 Signal To Noise Ratio

This is the ratio of signal amplitude to noise amplitude. SNR is calculated in decibels and the higher the value is, the better it is. If the SNR falls below 0dB, the signal power is equal to the noise power and the signal is unrecoverable.

$$\begin{aligned} SNR &= 20 \log_{10} \left(\frac{P_S}{P_N} \right) \\ &= 20 \log_{10} \left(\frac{V_S}{V_N} \right) \end{aligned}$$