South Bristol Amateur Radio Club
Lesson 3 – Transmitters and Receivers
Syllabus sections 4a.1, 4b.1 – 4b.6, 4c.1, 4d.1 – 4d.2

Transmitters
(Syllabus section 4a.1)

Figure 1, below, illustrates the stages in a simple Transmitter.

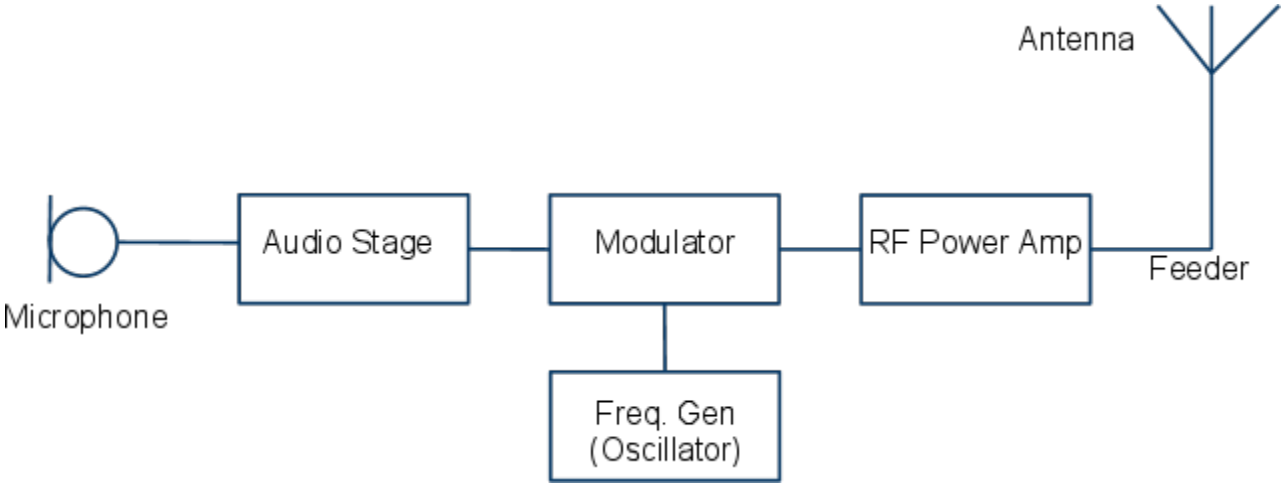

Figure 1 - Block Diagram of a Simple Transmitter

The order of these components is important:

1. Audio Stage
2. Modulator
3. Frequency Generator (Oscillator)
4. Radio Frequency (RF) Amplifier

Sound waves enter the Audio Stage (1) from the microphone. The Modulator (2) picks up the audio and mixes it with the RF signal generated by the Frequency Generator (3). The RF Power Amplifier (4) then amplifies the signal to be radiated by the Antenna.

Technical Requirements of Radio Transmitters
(Syllabus section 4b.1 – 4b.6)

The Frequency Generator (3) is sometimes referred to as the Oscillator, both terms being equally correct. Irrespective of what it is referred to as, its purpose is to set the frequency on which the transmitter operates (the carrier frequency). Effectively when you turn the tuning knob or channel selection switch on the front of a transceiver it is the Frequency Generator or Oscillator that is being adjusted.

Whilst many modern transmitters and transceivers contain interlocks and logic circuitry that prevents the transmitter being operated when the Frequency Generator is set to frequencies outside the allocated amateur bands it remains the responsibility of the operator to ensure that out of band transmissions do not occur.

With older equipment, home brewed equipment, equipment not designed for the UK market or modified for wide band operation it is possible to set the Frequency Generator to a carrier frequency outside of the amateur bands and therefore transmit out of band. Be careful when using unfamiliar or adapted equipment to ensure that this does not occur.

The audio (or data) signal is modulated onto the RF carrier in the modulation stage of the transmitter. Where the RF carrier is modulated by varying its amplitude then the signal is said to be Amplitude Modulated (AM), as shown below:

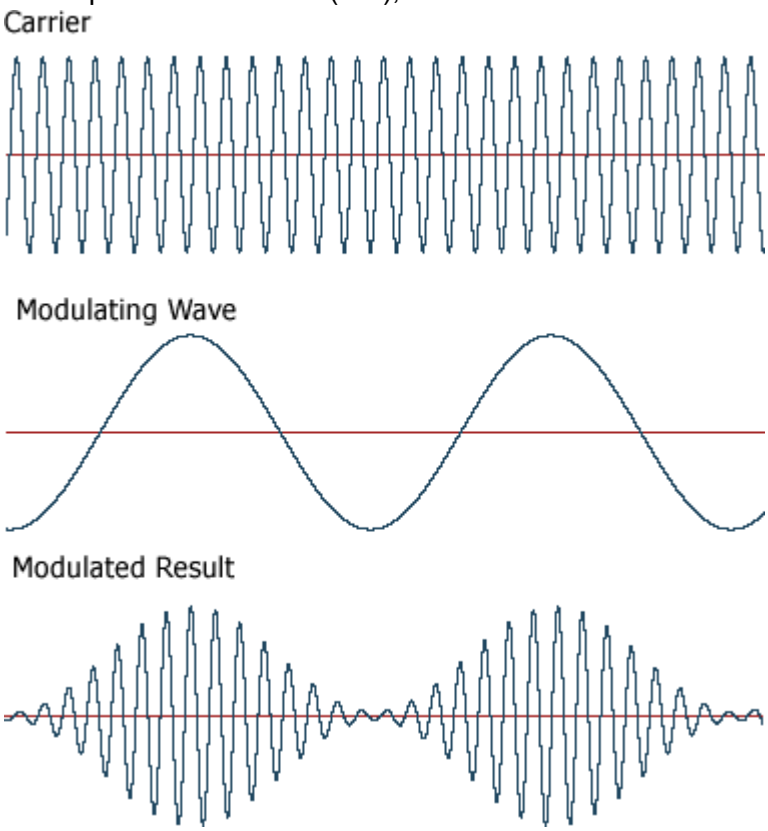

Figure 2 - Amplitude Modulation

Where the RF carrier is modulated by varying its frequency the resulting signal is said to be Frequency Modulated (FM)as shown below:

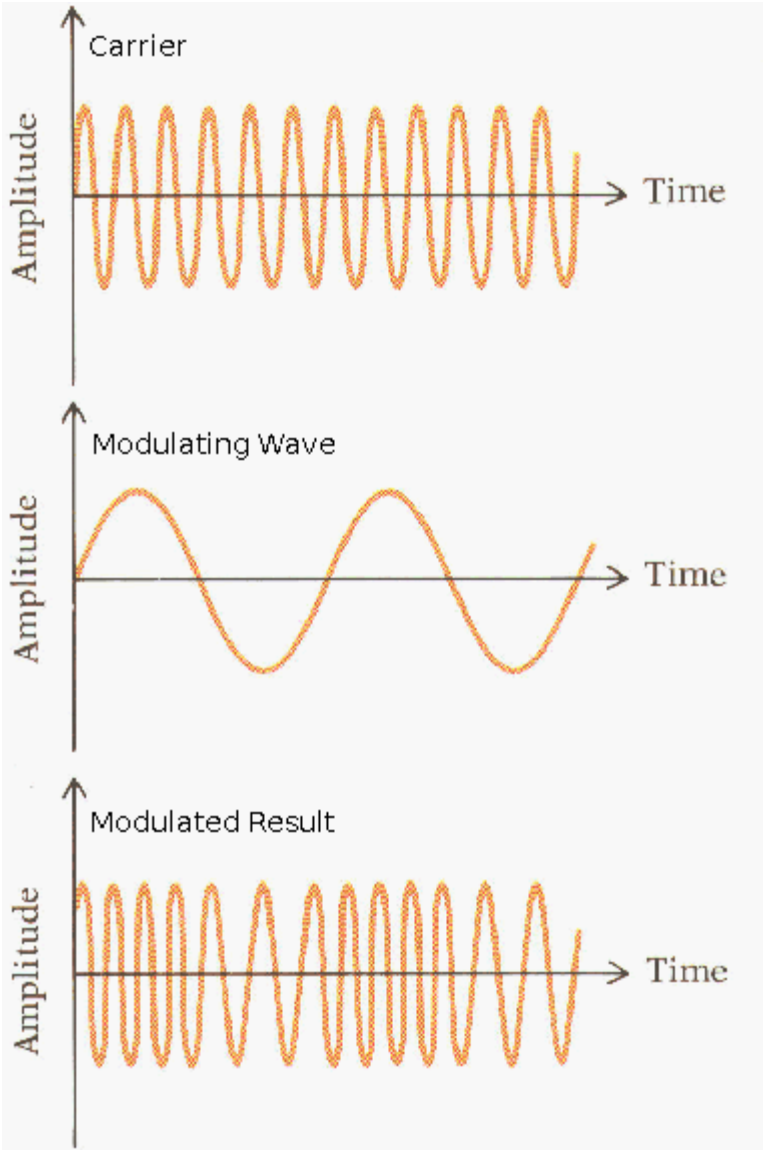

Figure 3 - Frequency Modulation

A variation of AM is a mode called single side band (SSB). Speech can be carried by AM, SSB, or FM and computer data may be transmitted by suitable audio tones generated in a modem or TNC (terminal node controller). This would use frequency shift keying (FSK)

The mode used to send Morse code is called CW (continuous wave) where the unmodulated carrier wave is switched (keyed) on and off.

The transmitter must be connected (loaded) to a correctly matched antenna to ensure that the maximum amount of power is radiated. The wrong kind of antenna can damage the transmitter (more about this in lesson 5).

Excessive amplitude modulation can cause distorted output and interference to adjacent channels. This is often referred to as “over modulation”. Excessive frequency deviation will cause interference to adjacent channels.

Excessive modulation can be prevented by a correctly adjusted microphone gain control (if fitted). This will also apply if a TNC is used. It is also important to remember that settings of the microphone gain control are unique to a single operator and the equipment (microphone, TNC etc.)

in use.

Changes to any of the equipment should be accompanied by a careful resetting of the gain controls. Switching from a microphone input to a TNC should be included in this process, although many modern rigs incorporate a “data” jack allowing the tones from a TNC or soundcard to be introduced separately to the microphone allowing the gain controls to be independently set for both modes.

As a Foundation licensee you can only use type approved transmitting equipment. No home brew is allowed in terms of transmitting equipment. You may, however, home brew accessories, adapters, soundcard interfaces, antennas and other receiving kits. The restriction is solely on the construction of transmitting equipment.

Some terms you need to remember:

- **Carrier** - The RF signal frequency generated by the oscillator (3MHz – 3000MHz).
- **Audio Waveform** - The waveform containing the audio (or data) signal (0.3kHz - 3kHz).
- **Modulation** - The process of applying the audio or data information to a carrier.
- **Modulated Waveform** - The modulated RF wave containing the audio or data signal.

Receivers
(Syllabus section 4d.1 - 4d.2)

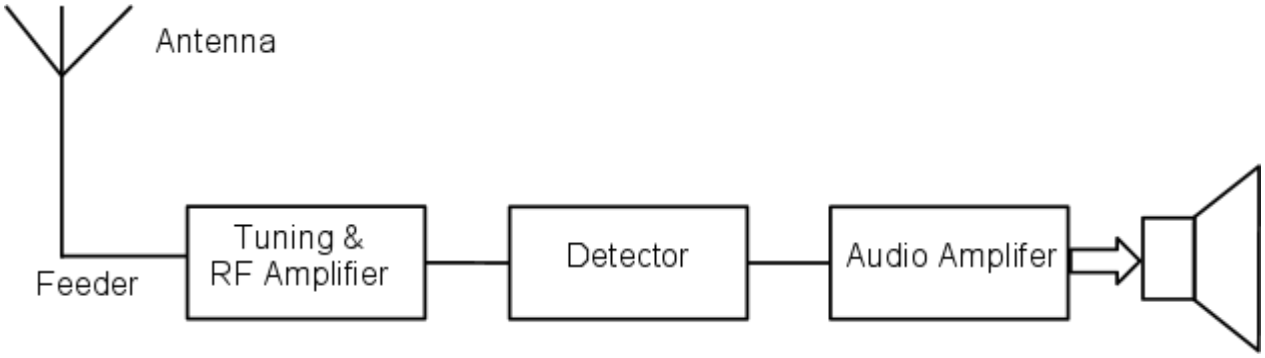

Figure 4 - Block Diagram of a Simple Receiver

The order of these components is important:

1. Tuning and RF Amplifier
2. Detection
3. Audio Amplifier
4. Loudspeaker (or headphones)

The antenna picks up Radio Frequencies that impinge upon it and convert all of the received signals into electrical signals passed along the feeder to the input to the receiver. The tuning stage (1) tunes to the required frequency, isolating it from the other signals received, and amplifies the incoming signal to a level that can be used in the next stage. The modulated RF waveform is passed to the Detection stage (2) which recovers the original audio (or data) waveform from the modulated RF carrier, a process sometimes referred to as demodulation. The output is passed on to the Audio Amplifier (3), which then sends the audio signal to the Loudspeaker (4).

Note that:
The tuning stage selects one signal from many on different frequencies by a tuned circuit.
A tuned circuit consists of a coil (inductor) and a capacitor.
It is important that the demodulation method is compatible with the original modulation method otherwise partial or no information may be received if a FM signal is received using AM demodulation for example.

Next Lesson
Technical Basics 02
Prefixes and Ohms Law

Lesson 3 – Summary

At the end of this lesson you should be able to:

- Identify the items in a simple transmitter block diagram and recall their order of interconnection: Microphone → Audio Amplifier → Modulator, Frequency Generator → Modulator, Modulator → RF Power Amplifier → Feeder → Antenna
- Recall that the Frequency Generation stage in a transmitter defines the frequency on which the transmitter operates
- Recall that incorrect setting of the Frequency Generator can result in operation outside the amateur band and interference to other users
- Recall that the audio (or data) signal is modulated onto the Radio Frequency or Carrier in the modulation stage of the transmitter
- Recall that modulation is by varying the amplitude or frequency or frequency of the carrier resulting in AM or FM modulation modes
- Recall that speech can be carried by AM/SSB or FM and that data may be transmitted by means of suitable audio tones generated in a radio modem or TNC (terminal node controller)
- Identify drawings of an RF carrier and amplitude modulated, frequency modulated and CW radio signals.
- Understand the terms carrier, audio, waveform and modulated waveform
- Recall that power amplification of the radio signal is carried out in the final stage of the transmitter (RF power amplifier)
- Recall that the RF power amplifier output must be connected to a correctly matched antenna to work properly and that the use of the wrong antenna can result in damage to the transmitter
- Understand that excessive amplitude modulation causes distorted output and interference to adjacent channels
- Understand that excessive frequency deviation will cause interference to adjacent channels
- Recall the need to make sure that the microphone gain control (where fitted) is correctly adjusted
- Identify the items in a simple receiver block diagram and recall their order of interconnection. Antenna → feeder → radio tuning and RF amplification → detection/ demodulation → audio amplification → loudspeaker or headphones
- Recall that tuning of receiver is carried out in the first stages of the receiver
- Recall that detection/demodulation (recovery of the original modulating signal) is carried out in the second stage of the block diagram and that audio amplification is achieved in the third stage of a receiver