Modulation - Volume III - Demodulation

An Online Continuing Education Course for Engineers

Course Number: E-3055

Credit: 3 Hours / 3 PDH / 3 CPD

Modulation - Volume III - Demodulation

Lee Layton, P.E.

Introduction

In Volumes I and II of this series we studied how to apply intelligence (modulation) to an RF-carrier wave. Carrier modulation allows the transmission of modulating frequencies without the use of transmission wire as a medium. However, for the communication process to be completed or to be useful, the intelligence must be recovered in its original form at the receiving site. The process of re-creating original modulating frequencies (intelligence) from the RF carrier is referred to as *Demodulation* or *Detection*. Each type of modulation is different and requires different techniques to recover (demodulate) the intelligence. In this course we will discuss ways of demodulating AM, CW, FM, phase, and pulse modulation.

The circuit in which restoration is achieved is called the *Detector* or *Demodulator*. The term demodulator is used because the demodulation process is considered to be the opposite of modulation. The output of an ideal detector must be an exact reproduction of the modulation existing on the RF wave. Failure to accurately recover this intelligence will result in distortion and degradation of the demodulated signal and intelligence will be lost. The distortion may be in amplitude, frequency, or phase, depending on the nature of the demodulator. A nonlinear device is required for demodulation. This nonlinear device is required to recover the modulating frequencies from the RF envelope. Solid-state detector circuits may be either a pn junction diode or the input junction of a transistor. In electron-tube circuits, either a diode or the grid or plate circuits of a triode electron tube may be used as the nonlinear device.

Chapter 1: Continuous-Wave Demodulation

Continuous-wave (CW) modulation consists of on-off keying of a carrier wave. To recover on-off keyed information, we need a method of detecting the *presence or absence of RF oscillations*. The *CW Demodulator* detects the presence of RF oscillations and converts them into a recognizable form. Figure 1 illustrates the received CW in view (A), the rectified CW from a diode detector in view (B), and the DC output from a filter that can be used to control a relay or light indicator in view (C).

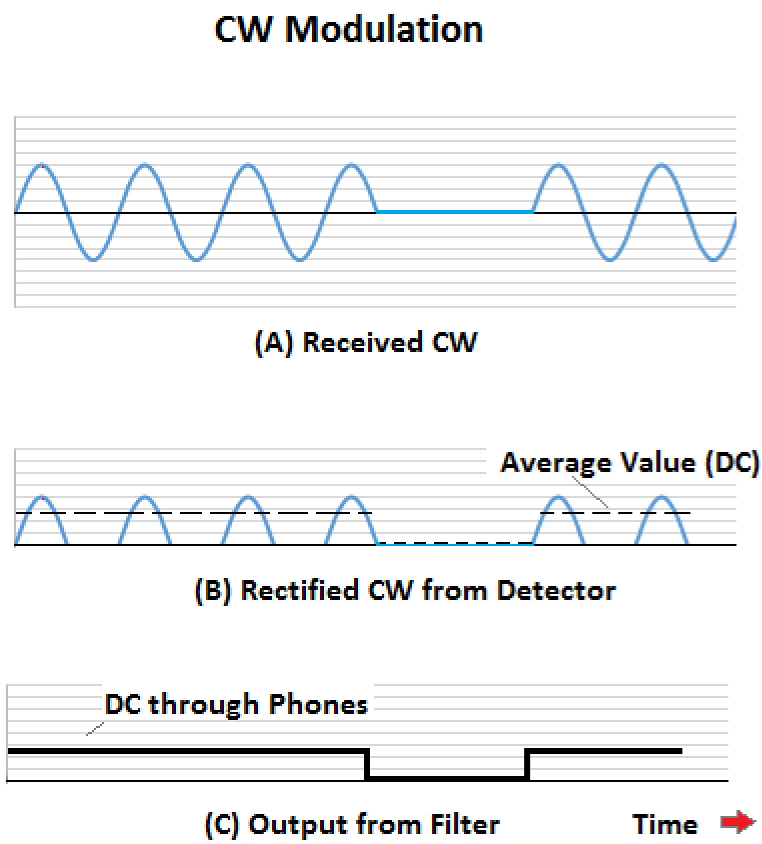


Figure 1

Figure 2 is a simplified circuit that could be used as a CW demodulator. The antenna receives the RF oscillations from the transmitter. The tank circuit, L and C1, acts as a frequency-selective network that is tuned to the desired RF carrier frequency. The diode rectifies the oscillations and C2 provides filtering to provide a constant DC output to control the headset. This demodulator circuit is the equivalent of a wire telegraphy circuit but it has certain disadvantages. For example, if two transmitters are very close in frequency, distinguishing which transmitting station you are receiving is often impossible without a method of fine tuning the desired frequency. Also, if the stations are within the frequency bandpass of the input tank circuit, the tank output will contain a mixture of both signals. Therefore, a method, such as *Heterodyne Detection*, must be used which provides more than just the information on the presence or absence of a signal.

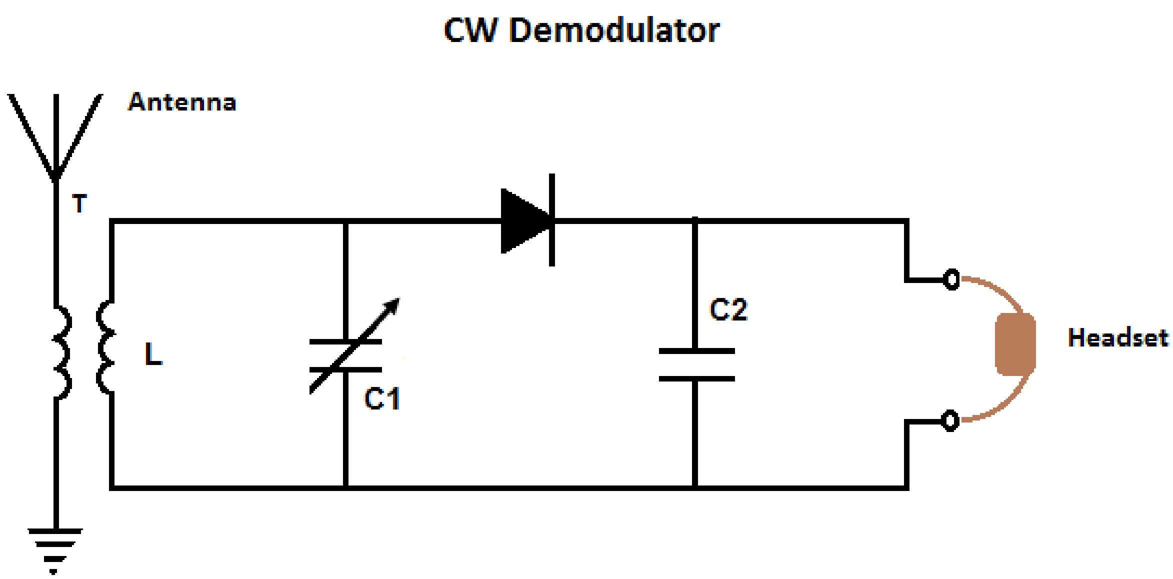


Figure 2

Heterodyne Detection
The use of an audio frequency (AF) voltage in the detector aids the operator in distinguishing between various signals. Since the carrier is un-modulated, the audio frequency voltage can be developed by using the heterodyne procedure discussed in Volume I. The procedure is to mix the incoming CW signal with locally generated oscillations. This provides a convenient difference frequency in the AF range, such as 1,000 hertz. The AF difference frequency then is rectified and smoothed by a detector. The AF voltage is reproduced by a telephone headset or a loudspeaker.

Consider the heterodyne reception of the Morse code letter "A", as shown in Figure 3, view (A). The code consists of a short burst of CW energy (dot) followed by a longer burst (dash). Assume that the frequency of the received CW signal is 500 kilohertz. The locally generated oscillations are adjusted to a frequency which is higher or lower than the incoming RF signal (501 kilohertz in this case), as shown in view (B). The voltage resulting from the heterodyning action between the CW signal [view (A)] and the local oscillator signal [view (B)] is shown in view (C) as the mixed-frequency signal. *envelope* (intelligence) amplitude varies at the *beat* (difference) frequency of 1,000 hertz (501,000 – 500,000). The negative half cycles of the mixed frequency are rectified, as shown in view (D). The peaks of the positive half cycles follow the 1,000-hertz beat frequency.

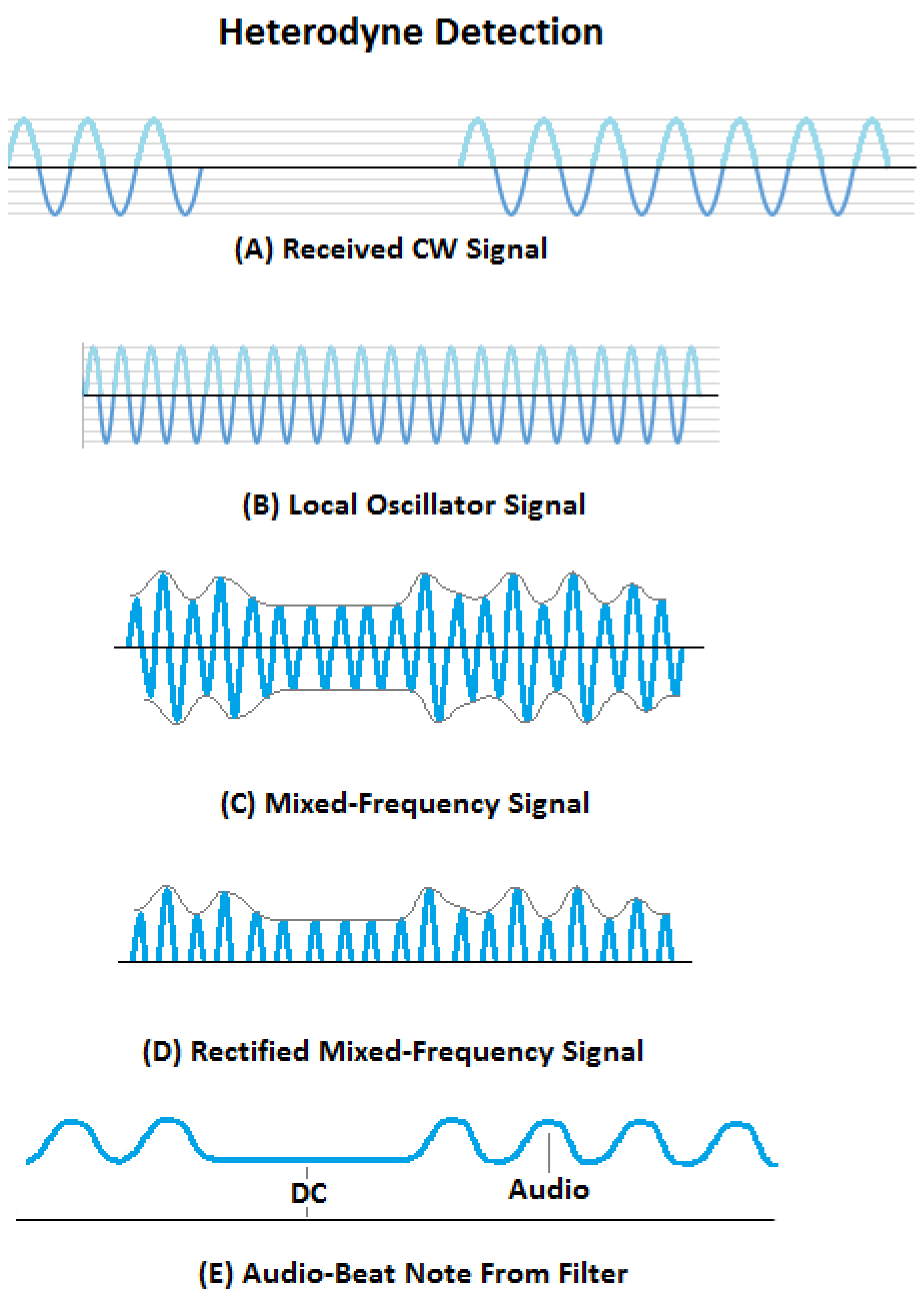


Figure 3

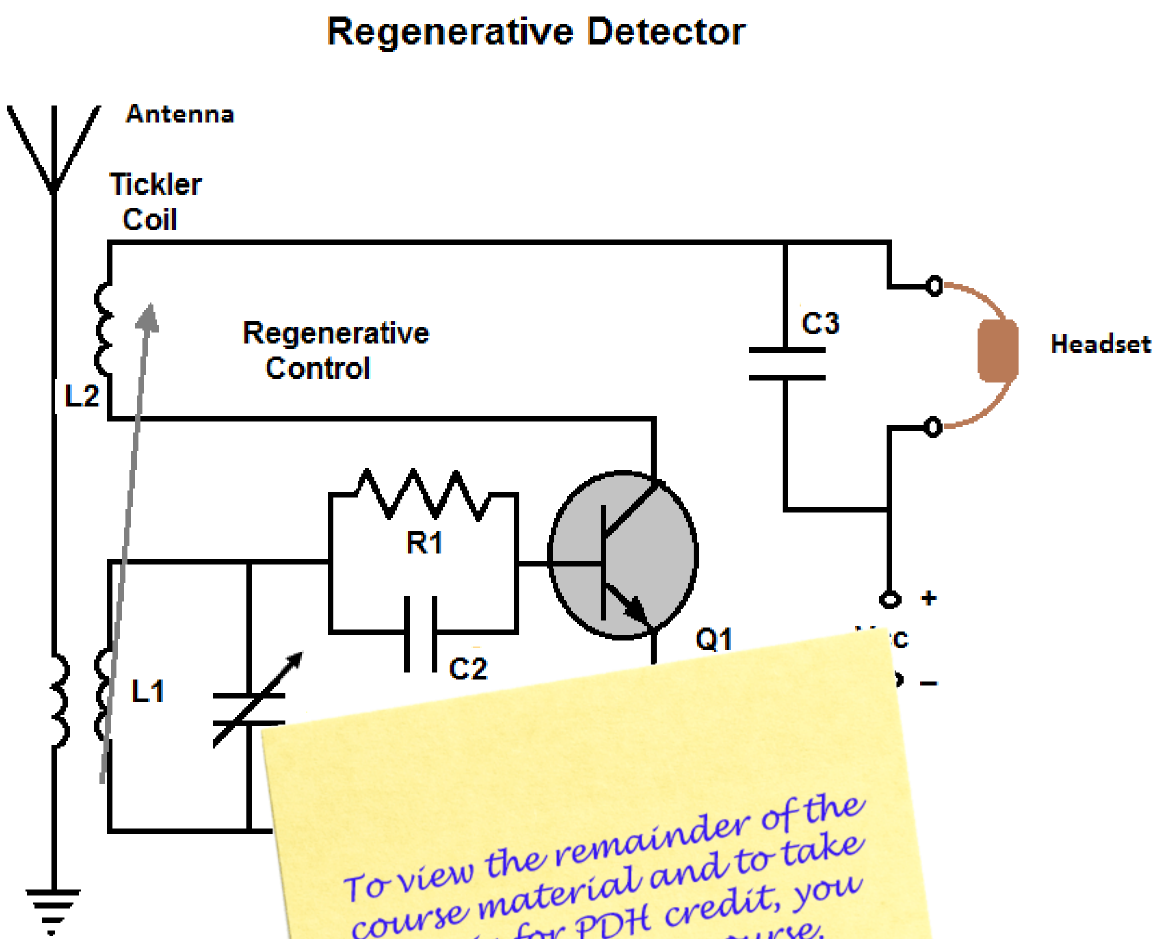
The CW signal pulsations are removed by the RF filter in the detector output and only the envelope of the rectified pulses remains. The envelope, shown in view (E), is a 1,000-hertz audio-beat note. This 1,000 hertz, dot-dash tone may be heard in a speaker or headphone and identified as the Morse letter "A" by the operator.

The heterodyne method of reception is highly selective and allows little interference from adjacent CW stations. If a CW signal from a radiotelegraph station is operating at 10,000,000 hertz and at the same time an adjacent station is operating at 10,000,300 hertz, a simple detector cannot clearly discriminate between the two stations because the signals are just 300 hertz apart. This is because the bandpass of the tuning circuits is too wide and allows some of the other signal to interfere. The two carrier frequencies differ by only 0.003 percent and a tuned tank circuit cannot easily discriminate between them. However, if a heterodyne detector with a local-oscillator frequency of 10,001,000 hertz is used, then beat notes of 1,000 and 700 hertz are produced by the two signals. These are audio frequencies, which can be distinguished easily by a selective circuit because they differ by 30 percent (compared to the 0.003 percent above).

Even if two stations produce identical beat frequencies, they can be separated by adjusting the local-oscillator or *Beat-Frequency Oscillator* (BFO) frequency. For example, if the second station in the previous example had been operating at 10,002,000 hertz, then both stations would have produced a 1,000-hertz beat frequency and interference would have occurred. Adjusting the local-oscillator frequency to 9,999,000 hertz would have caused the desired station at 10,000,000 hertz to produce a 1,000-hertz beat frequency. The other station, at 10,002,000 hertz, would have produced a beat frequency of 3,000 hertz. Either selective circuits or the operator can easily distinguish between these widely differing tones. A trained operator can use the variable local oscillator to distinguish between stations that vary in frequency by only a few hundred hertz.

Regenerative Detector

A simple, one-transistor *Regenerative Detector* circuit that uses the heterodyning principle for CW operation is shown in Figure 4. The circuit can be made to oscillate by increasing the amount of energy fed back to the tank circuit from the collector-output circuit (by physically moving tickler coil L2 closer to L1 using the regeneration control). This feedback overcomes losses in the base-input circuit and causes self-oscillations which are controlled by tuning capacitor C1. The received signal from the antenna and the oscillating frequency are both present at the base of transistor Q1. These two frequencies are heterodyned by the nonlinearity of the transistor. The resulting beat frequencies are then rectified by the emitter-base junction and produce a beat note which is amplified in the collector-output circuit. The AF currents in the collector circuit actuate the phones. The Regenerative Detector (Figure 4) produces its own oscillations, heterodynes them with an incoming signal, and rectifies or detects them.



The regenerative detector ... e it is easy to adjust and has high sensitivity an ... t of signal detuning necessary to produce an a ... requency and causes no trouble. The use ... de reception, however, is usually avoided ... uce the proper audio-beat frequency is a c ... Although this type detector may be used for A ... and is not often used.