8.11 Amplitude Demodulator Circuits

At the receiver, a circuit must be provided that recovers the information signal from the modulated carrier. The most common circuit in use is the *diode envelope detector,* which produces an output voltage proportional to the envelope, which is the modulating or information signal. The basic circuit is shown in Fig. 8.11.1(a). The diode acts as a rectifier and can be considered an ON switch when the input voltage is positive, allowing the capacitor C to charge up to the peak of the RF input. During the negative half of the RF cycle, the diode is off, but the capacitor holds the positive charge previously received, so the output voltage remains at the peak positive value of RF. There will, in fact, be some discharge of C, producing an RF ripple on the output waveform, which must be filtered out.

As the input voltage rises with the modulating cycle, the capacitor voltage has no difficulty in following this, but during the downward swing in modulation the capacitor may not discharge fast enough unless an additional discharge path is provided by the resistor R. The time constant of the CR load has to be short enough to allow the output voltage to follow the modulating cycle and yet long enough to maintain a relatively high output voltage. The constraints on the time constant are determined more precisely in the next section.

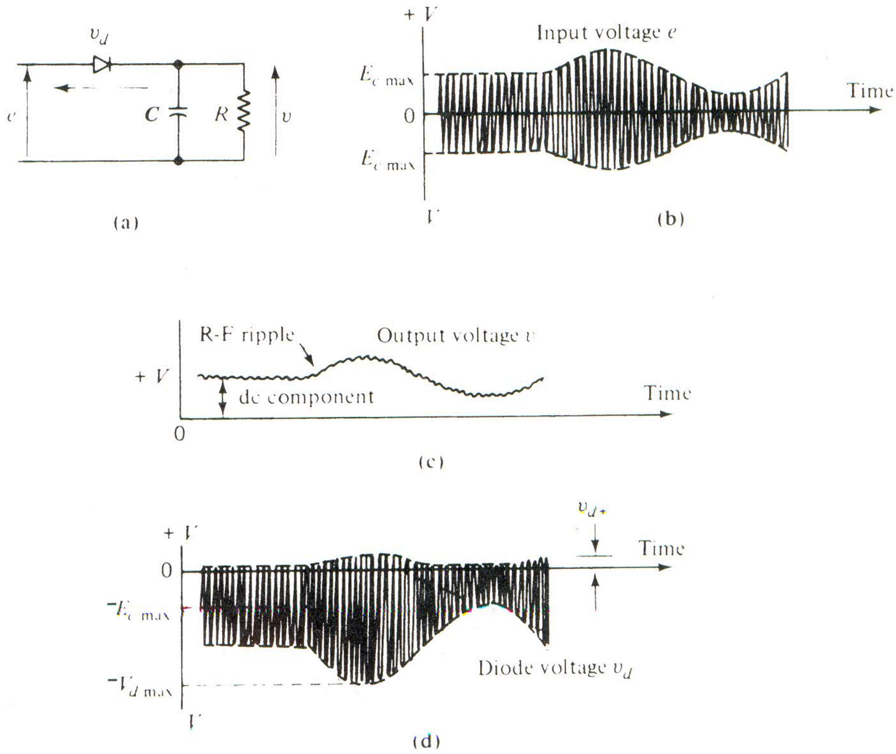

Figure 8.11.1 (a) Basic diode envelope detector. (b) Voltage input waveform. (c) Voltage output waveform. (d) Voltage across the diode.

Applying Kirchhoff's voltage law to the circuit, the diode voltage v_d is found to be

$$v_d = e - v \tag{8.11.1}$$

where e is the input voltage and v the output voltage. Figure 8.11.1(b) shows e, and Fig. 8.11.1(c) shows v, both for sinusoidal modulation. By graphically subtracting v from e the graph of v_d in Fig. 8.11.1(d) is obtained. It is interesting to see that v_d is positive only for very short periods, as indicated by the peaks v_d^+, and it is during these peaks that the capacitor is charged to make up for discharge losses. The peak voltage across the diode can rise to $4E_{c\,\max}$ at 100% sinusoidal modulation, a condition that should be compared with the condition at the collector of the modulator described in the previous section.

Diagonal Peak Clipping. This is a form of distortion that occurs when the time constant of the *RC* load is too long, thus preventing the output voltage from following the modulation envelope. The output voltage is labeled V_{AV} in Fig. 8.11.2(a), to show that it is the average voltage that follows the modulation envelope (that is, the RF ripple is averaged out). The curve of V_{AV} for sinusoidal modulation is shown in Fig. 8.11.2(b). At some time t_A the modulation envelope starts to decrease more rapidly than the capacitor discharges. The output voltage then follows the discharge curve of the *RC* network until time t_B, when it meets up with the modulation envelope as it once again increases.

For sinusoidal modulation the condition necessary for the avoidance of diagonal peak clipping is found as follows. Because of the capacitive nature of the *RC* load, the current leads the voltage as shown in Fig. 8.11.2(c). The average current consists of two components, a dc component I_{DC} and an ac component that has a peak value I_P, as shown in Fig. 8.11.2(c). The dc component of voltage is approximately equal to the maximum unmodulated carrier voltage or $V_{DC} \cong E_{c\,\max}$ and the direct current is $I_{DC} = V_{DC}/R$. The peak value of the average output voltage is $V_P \cong mE_{c\,\max}$, and the corresponding value of the peak current is $I_P = V_P/Z_p$, where Z_p is the impedance of the *RC* load at the modulating frequency.

If the envelope falls faster than the capacitor discharges, the diode ceases to conduct (since the capacitor voltage biases it off), and the current I_{AV} supplied by the diode goes to zero. This is shown in Fig. 8.11.2(c). During the period the current is zero, the load voltage follows the discharge law of the *RC* network, resulting in the diagonally clipped peak shown in Fig. 8.11.2(b). From Fig. 8.11.2(c), it is seen that for the avoidance of diagonal peak clipping the direct current has to be greater than the peak current, or $I_{DC} \geq |I_P|$. Hence

$$\frac{V_{DC}}{R} \geq \frac{mV_{DC}}{|Z_p|}$$

$$\therefore m \leq \frac{|Z_p|}{R} \tag{8.11.2}$$