

1. FIGURE 1 shows the circuit diagram of an envelope detector. It consists simply of a diode and resistor-capacitor (RC) filter. On a positive half cycle of the input signal, the diode is forward biased and the capacitor C charges up rapidly to a peak value of the input signal. When the input signal falls below this value, the diode becomes reverse biased and the capacitor discharges slowly through the load resistor R_l . The discharging process continues till the next positive half cycle. Thereafter the charging-discharging routine is continued. To answer the questions below assume that the forward resistance of the diode is r_f and bandwidth of the message signal is W .

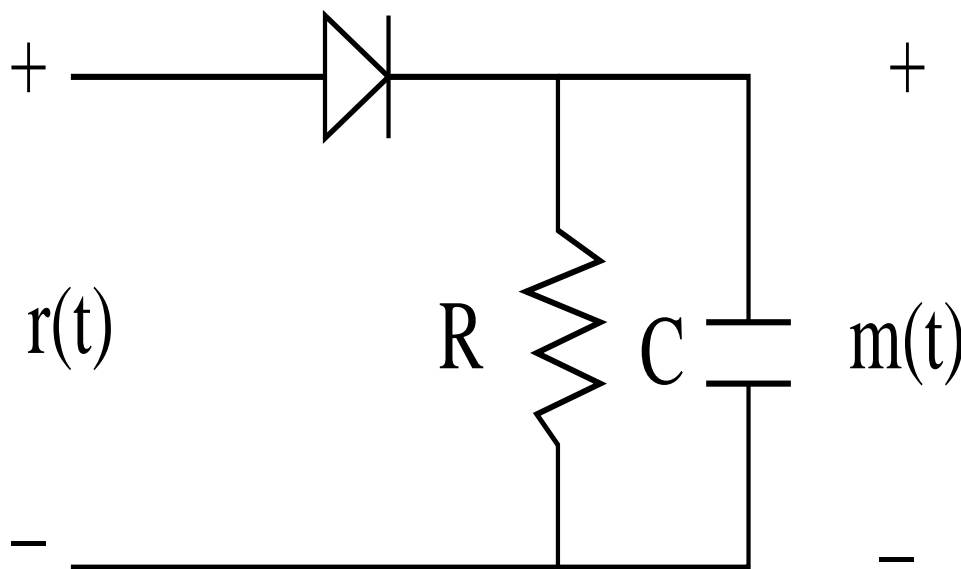


Figure 1: Envelope Detector

- (a) Specify the condition that must be satisfied by the capacitor C for it to charge rapidly and thereby follow the input voltage up to a positive peak when the diode is conducting.
SOLUTION: *The demodulation of an AM wave using envelope detector is highly effective and is widely used in almost all commercial AM radio receivers. For it to function properly, however the AM wave has to be narrow-band, which requires that the carrier frequency be large compared to the message bandwidth. Moreover, the percentage modulation must be less than 100 percent.*

On a positive half cycle of the input signal, the diode is forward biased and the capacitor C charges up rapidly to a peak value of the input signal. When the input signal falls below this value, the diode becomes reverse biased and the capacitor discharges slowly through the load resistor R_l . When the input signal becomes greater than the voltage across the capacitor, the diode conducts again and the process is repeated. We assume that the diode is ideal, presenting resistance r_f to current flow in the forward-biased region and infinite resistance in the reverse-biased region. We further assume that the AM wave applied to the envelope detector is supplied by a voltage source of internal impedance R_s . The charging time constant $(r_f + R_s)C$ must be short compared with the carrier period $\frac{1}{f_c}$, that is

$$(r_f + R_s)C \ll \frac{1}{f_c}$$

so that the capacitor C charges rapidly and thereby follows the applied voltage up to the positive peak when the diode is conducting.

- (b) Specify the condition which the load resistor R_l must satisfy so that the capacitor C discharges slowly between the positive peaks of the carrier wave, but not so long that the capacitor voltage will not discharge at the maximum rate of change of the modulating wave.

SOLUTION: The discharging time constant $R_l C$ must be long enough to ensure that the capacitor discharges slowly through the load resistor R_l between the positive peaks of the carrier wave, but not so long that the capacitor voltage will not discharge at the maximum rate of change of the modulating wave, that is

$$\frac{1}{f_c} \ll R_l C \ll \frac{1}{W}$$

where W is the message bandwidth. The result is that the capacitor voltage or detector output is nearly the same as the envelope of the AM wave.