6.1 AM Detectors/ Demodulators (DSB-FC Detectors)

6.1.1 Simple Detector/ Peak Detector/ Envelope Detector

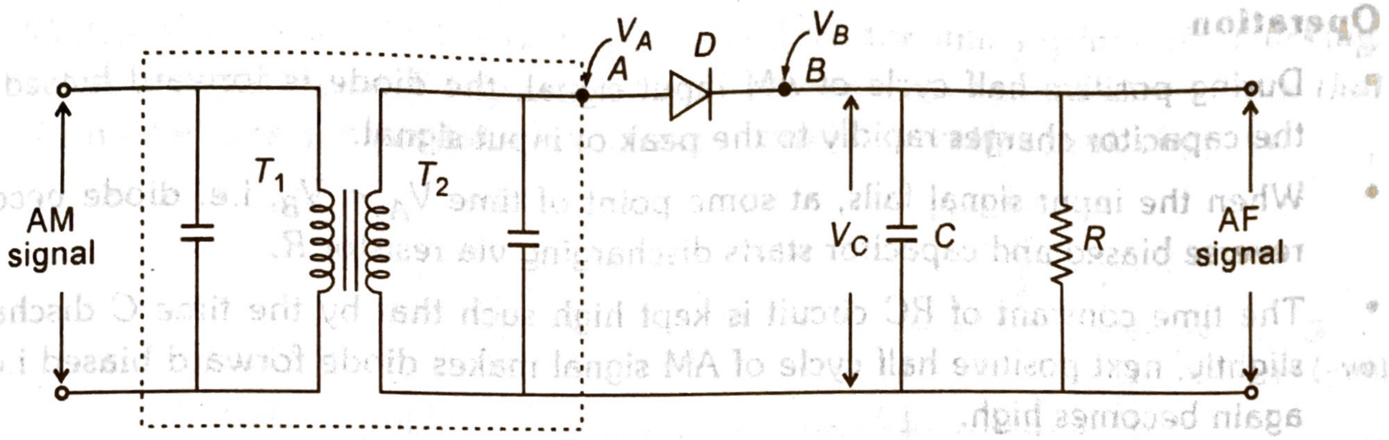
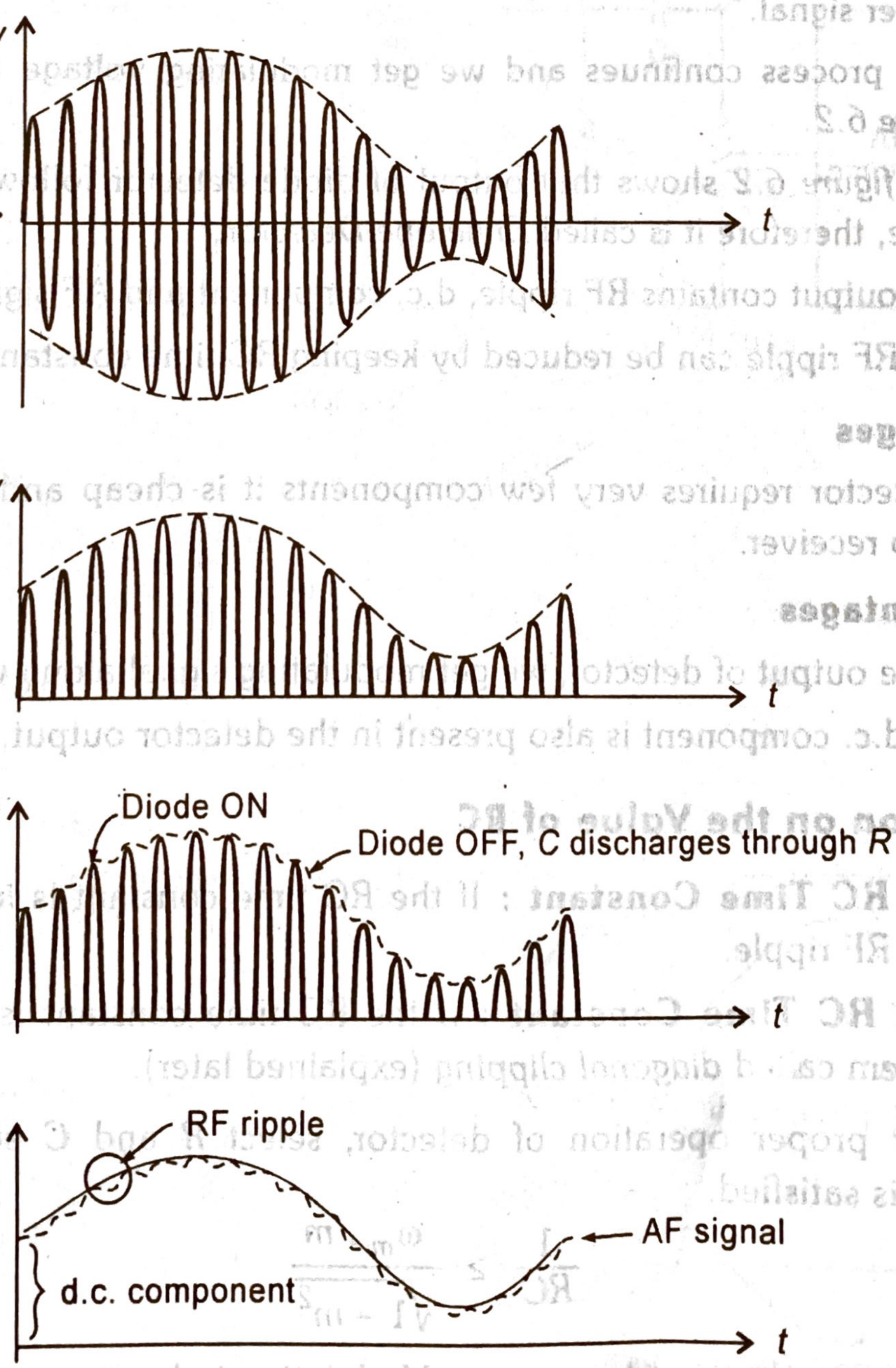


Fig. 6.1



(a) AM wave at the input.

(b) Half wave rectified signal.

(c) Output of the diode.

(d) Output of envelope detector.

Fig. 6.2

The detector detects the AF signal i.e. separates out modulating signal from AM wave.

Operation

- During positive half cycle of AM input signal, the diode is forward biased and the capacitor charges rapidly to the peak of input signal.
- When the input signal falls, at some point of time $V_A < V_B$, i.e. diode becomes reverse biased and capacitor starts discharging via resistor R.
- The time constant of RC circuit is kept high such that by the time C discharges slightly, next positive half cycle of AM signal makes diode forward biased i.e. V_A again becomes high.
- The diode becomes forward biased and capacitor charges to new peak of input carrier signal.
- This process continues and we get modulating voltage across R as shown in *figure 6.2*.
- The *figure 6.2* shows that output of diode detector follows the envelope of AM wave, therefore it is called *Envelope Detector*.
- The output contains RF ripple, d.c. component and AF signal.
- The RF ripple can be reduced by keeping RC time constant large.

Advantages

Since detector requires very few components it is cheap and normally used in low cost radio receiver.

Disadvantages

(1) At the output of detector, we get modulating signal along with large RF ripple.

(2) The d.c. component is also present in the detector output.

Limitation on the Value of RC

(1) Low RC Time Constant : If the RC time constant is low the output contains large RF ripple.

(2) High RC Time Constant : If the RC time constant is high then it creates a problem called *diagonal clipping* (explained later).

Hence for proper operation of detector, select R and C such that the following condition is satisfied.

$$\frac{1}{RC} \geq \frac{\omega_m \cdot m}{\sqrt{1 - m^2}}$$

where m = Modulation index

ω_m = Modulating frequency

6.1.2 Practical Diode Detector

Q.1. Sketch the circuit diagram of practical diode detector and explain its working.

Q.2. Sketch the circuit of a practical diode detector and explain its working. What is negative peak clipping ? Calculate maximum modulation index that the above detector can tolerate without causing negative peak clipping.

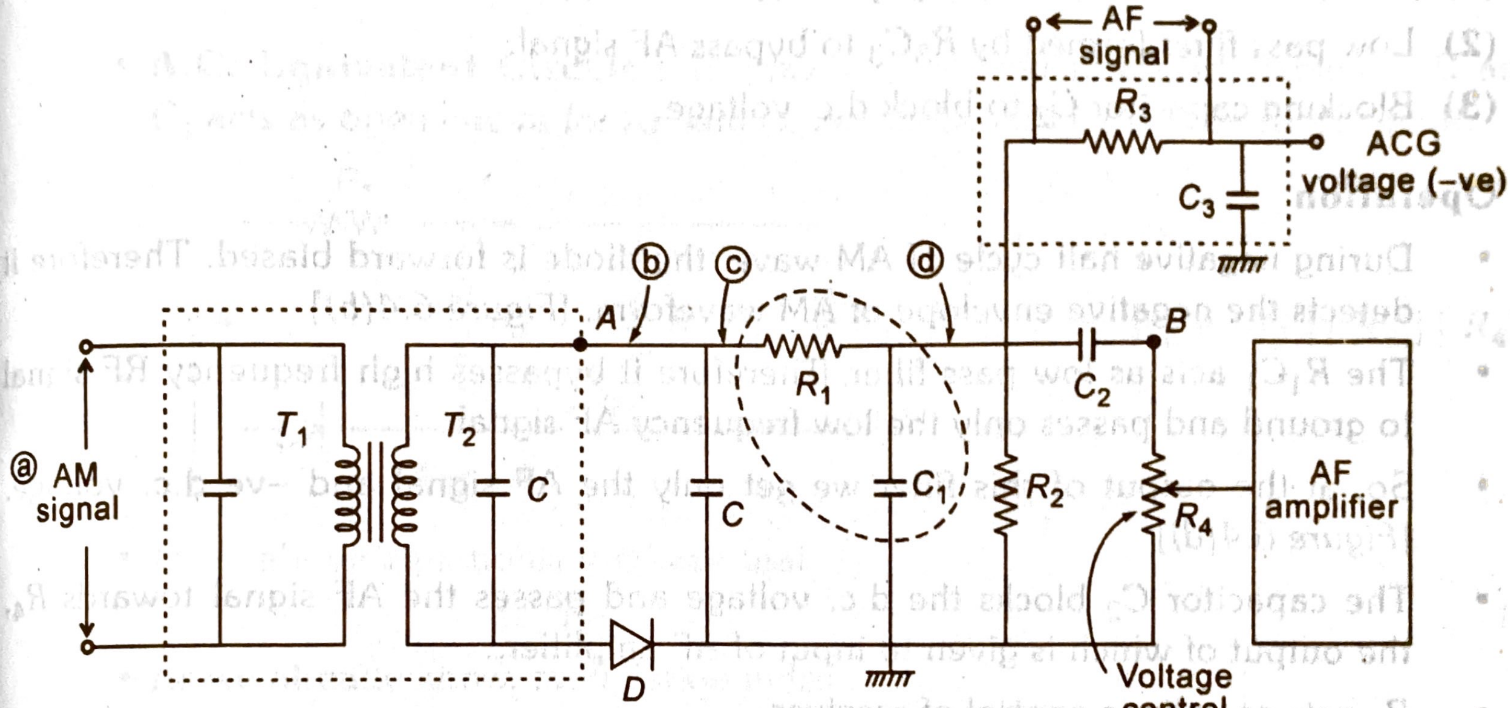
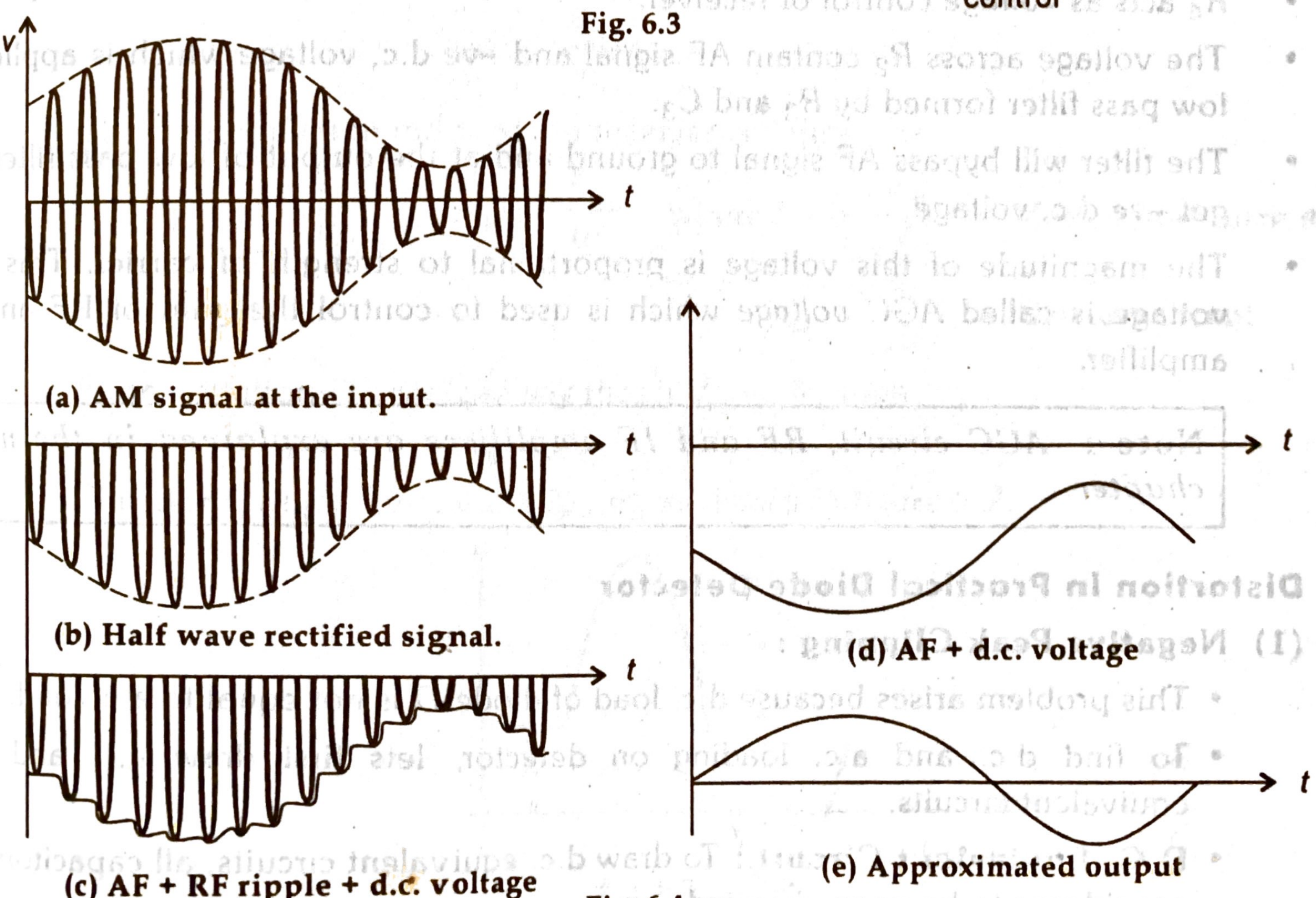


Fig. 6.3



(a) AM signal at the input.

(b) Half wave rectified signal.

(c) AF + RF ripple + d.c. voltage

(d) AF + d.c. voltage

(e) Approximated output

Fig. 6.4

Circuit Description

Circuit diagram of practical diode detector is shown in *figure 6.3.*

Here detector diode D is connected such that –ve d.c. voltage is available for Gain Control of amplifier.

The detector consists of

(1) Low pass filter formed by R_1C_1 to bypass RF ripples.

(2) Low pass filter formed by R_3C_3 to bypass AF signal.

(3) Blocking capacitor C_2 to block d.c. voltage.

Operation

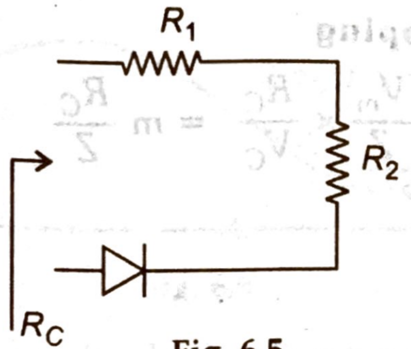
- During negative half cycle of AM wave, the diode is forward biased. Therefore it detects the negative envelope of AM waveform. [*Figure 6.4(b)*]
- The R_1C_1 acts as low pass filter. Therefore it bypasses high frequency RF signal to ground and passes only the low frequency AF signal.
- So, at the output of this filter we get only the AF signal and –ve d.c. voltage. [*Figure 6.4(d)*]
- The capacitor C_2 blocks the d.c. voltage and passes the AF signal towards R_4, the output of which is given to input of AF amplifier..
- R_4 acts as voltage control of receiver.
- The voltage across R_2 contain AF signal and –ve d.c. voltage which is applied o low pass filter formed by R_3 and C_3.
- The filter will bypass AF signal to ground and at the output of low pass filter we get –ve d.c. voltage.
- The magnitude of this voltage is proportional to strength of carrier. This –ve voltage is called *AGC voltage* which is used to control the gain of RF and IF amplifier.

> **Note :** *AGC circuit, RF and IF amplifiers are explained in the next chapter.*

Distortion in Practical Diode Detector

(1) Negative Peak Clipping :

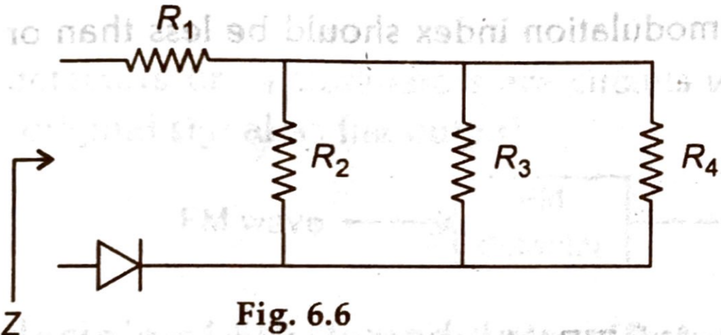
- This problem arises because d.c. load of diode D is not equal to a.c. load.
- To find d.c. and a.c. loading on detector, lets first draw a.c. and d.c. equivalent circuits.
- **D.C. Equivalent Circuit :** To draw d.c. equivalent circuits, all capacitors are considered to be open circuited



$$\therefore\ R_C = R_1 + R_2$$

Fig. 6.5

- **A.C. Equivalent Circuit :** To draw a.c. equivalent circuit, capacitor C and C_1 acts as open circuit for AF and capacitor C_2 and C_3 acts as short circuit.



$$\therefore\ Z = R_1 + (R_2 \,||\, R_3 \,||\, R_4)$$

Fig. 6.6

- From above equations, it is seen that

$$\therefore\ R_C > Z \qquad \text{..... (1)}$$

- As we already know, modulation index is

$$m = \frac{V_m}{V_C}$$

- The demodulation index at the receiver is defined as

$$m_d = \frac{I_m}{I_C} \quad \text{where } I_m = \frac{V_m}{Z} = \text{Modulating current}$$

$$I_C = \frac{V_C}{R_C} = \text{Carrier current}$$

From equation (1), we can say that if $V_m \approx V_c$ then,

$$I_m > I_C$$

Therefore we get –ve peak clipping as shown in *figure* 6.7.

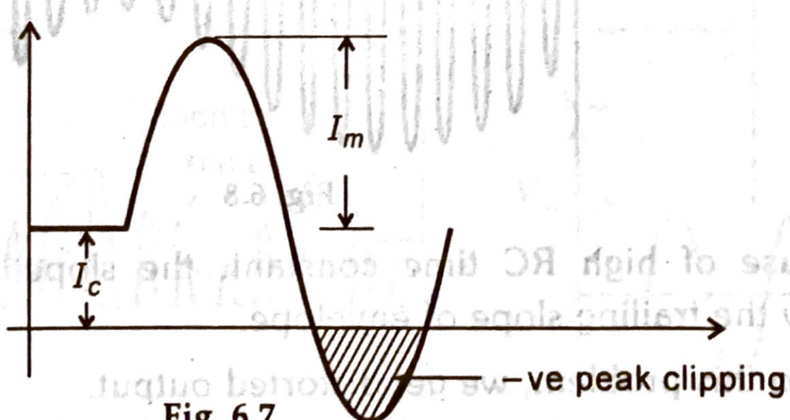


Fig. 6.7

To avoid −ve peak clipping

$$m_d = \frac{I_m}{I_C} = \frac{V_m}{Z} \times \frac{R_C}{V_C} = m\frac{R_C}{Z}$$

$$\because R_C > Z$$

$$\therefore m_d > m$$

- It means after detection, the demodulation index increases, i.e. if m is 100%, then $m_d > 100\%$.
- Therefore during −ve half cycle, AF signal gets clipped.
- To avoid −ve peak clipping demodulation index should be less than or equal to 1 i.e. $m_d \leq 1$

$$\therefore m\frac{R_C}{Z} < 1$$

$$\therefore m \leq \frac{Z}{R_C}$$

- If the signal is transmitted with $m \leq Z/R_C$ then −ve peak clipping is avoided.

(2) Diagonal Clipping :

- In diode detectors, the RC time constant should be small such that the capacitor does not discharge by large amount.
- The capacitor's charging and discharging should follow the envelope of AM wave.
- If the RC time constant is too high, then the output of detector does not follow the fast changes in envelope of AM wave.
- This results in diagonal clipping as shown in *figure 6.8*.

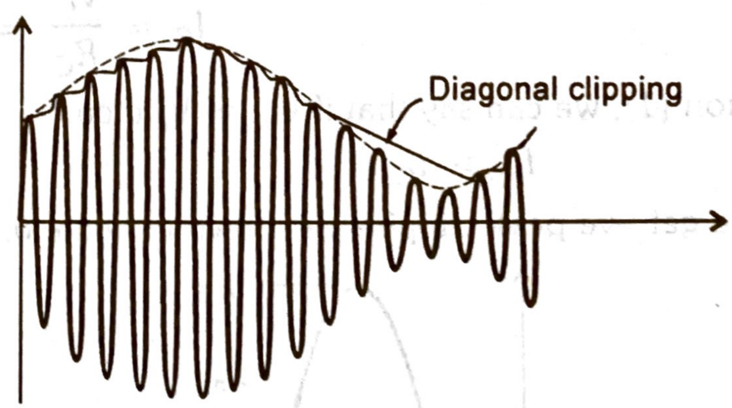


Fig. 6.8

- Because of high RC time constant, the slope of output waveform cannot follow the trailing slope of envelope.
- Due to this problem, we get distorted output.

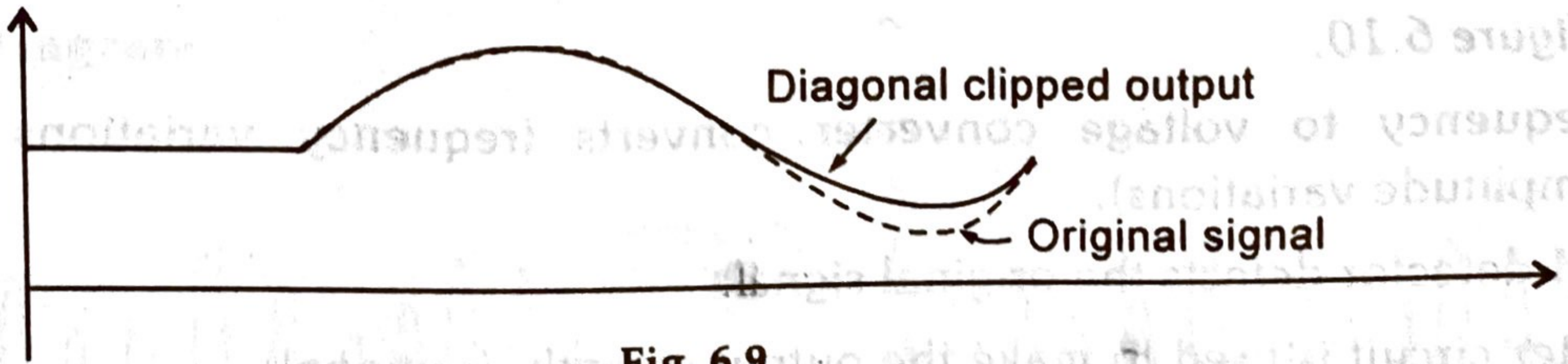


Fig. 6.9

- To avoid diagonal clipping, the discharging time constant should not be too high.
- Also, the modulating index used at transmitter should be less than 60%.