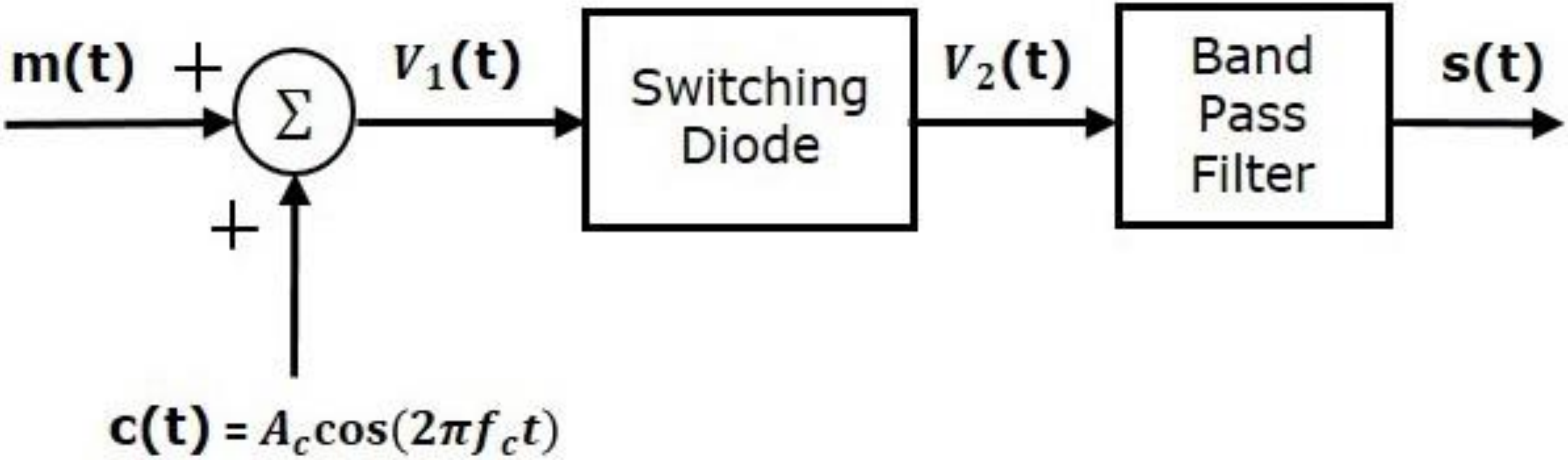
Switching Modulator

Switching modulator is similar to the square law modulator. The only difference is that in the square law modulator, the diode is operated in a non-linear mode, whereas, in the switching modulator, the diode has to operate as an ideal switch.

Switching Modulator



Switching Modulator

Let the modulating and carrier signals be denoted as m(t) and $c(t)=A_c\cos(2\pi f_c t)$ respectively.

These two signals are applied as inputs to the summer (adder) block. Summer block produces an output, which is the addition of modulating and carrier signals. Mathematically, we can write it as

$$V1(t) = m(t)+c(t) = m(t)+A_c\cos(2\pi f_c t)$$

This signal $\boldsymbol{V1(t)}$ is applied as an input of diode.

Assume, the magnitude of the modulating signal is very small when compared to the amplitude of carrier signal $\boldsymbol{Ac}$.

So, the diode's ON and OFF action is controlled by carrier signal $\boldsymbol{c(t)}$. This means, the diode will be forward biased when $\boldsymbol{c(t) > 0}$ and it will be reverse biased when $\boldsymbol{c(t) < 0}$.

Therefore, the output of the diode is

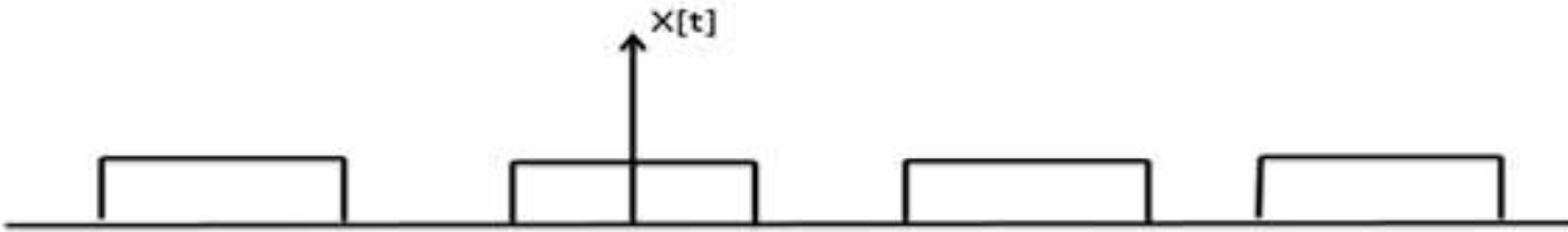
$$V_2(t) = \begin{cases} V_1(t) & if \quad c(t) > 0 \\ 0 & if \quad c(t) < 0 \end{cases}$$

$$V_2(t) = \begin{cases} V_1(t) & if \quad c(t) > 0 \\ 0 & if \quad c(t) < 0 \end{cases}$$

We can approximate this as

$$V_2(t) = V_1(t)x(t)$$

Where, $x(t)$ is a periodic pulse train



Fourier series representation of this periodic pulse train is

$$=> x(t) = \frac{1}{2} + \frac{2}{\pi}\cos(2\pi f_c t) - \frac{2}{3\pi}\cos(6\pi f_c t) + \cdots$$

Substitute, $V_1(t)$ and $x(t)$ values

$$V_2(t) = \frac{A_c}{2}\left(1 + \left(\frac{4}{\pi A_c}\right) m(t)\right) cos(2\pi f_c t) + \frac{m(t)}{2} + \frac{2A_c}{\pi} cos^2(2\pi f_c t) - \frac{2m(t)}{3\pi}\cos(6\pi f_c t)$$

$$- \frac{2A_c}{3\pi} cos(2\pi f_c t)\cos(6\pi f_c t) + \cdots$$

The 1st term of the above equation represents the desired AM wave and the remaining terms are unwanted terms. Thus, with the help of band pass filter, we can pass only AM wave and eliminate the remaining terms

the output of switching modulator is

$$s(t) = \frac{A_c}{2}\left(1 + \left(\frac{4}{\pi A_c}\right) m(t)\right) cos(2\pi f_c t)$$

AM Detectors / Demodulators

AM Demodulation

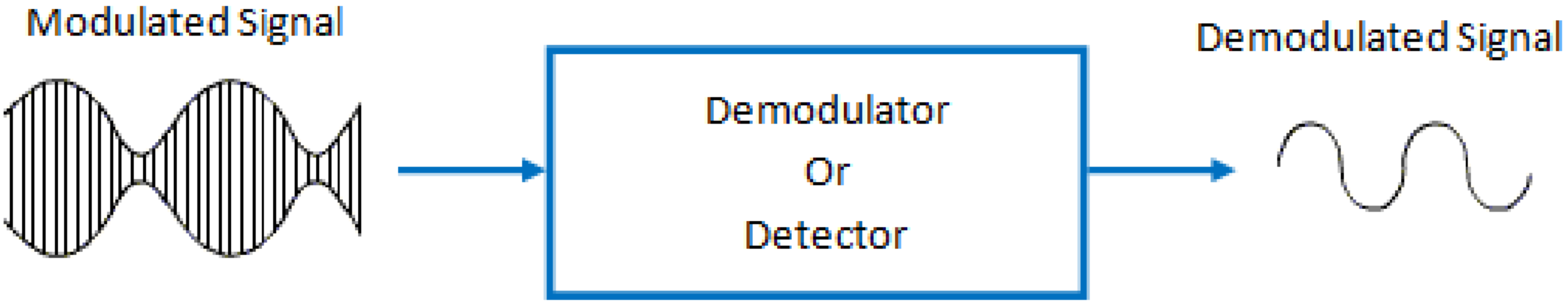
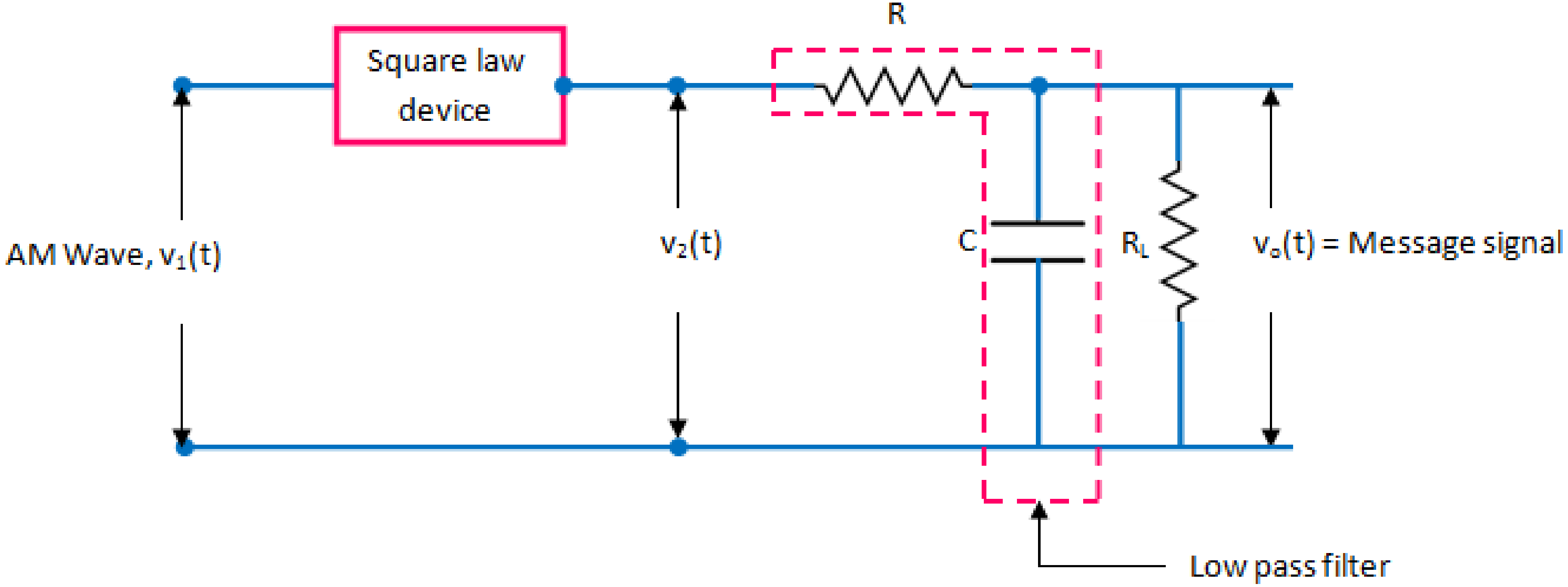
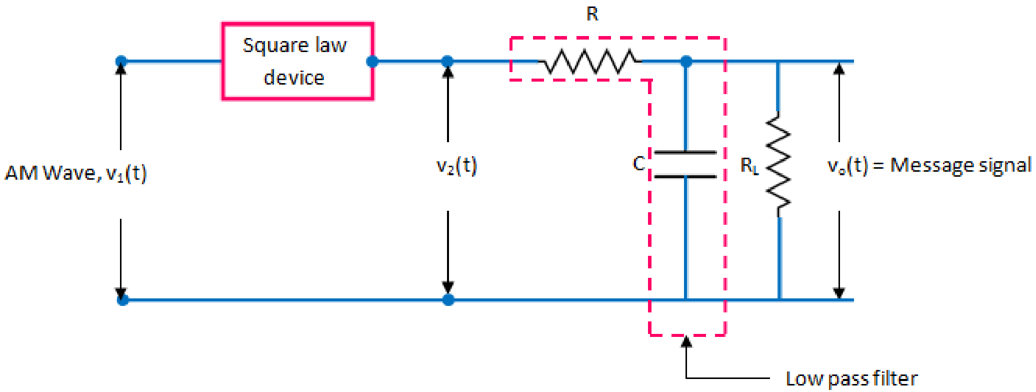


Fig 1 : Process of Demodulation or Detection

- Square Law Demodulation
- Envelope Demodulation

Square Law Demodulation





We know that the mathematical relationship between the input and the output of square law device is

$$V_2(t) = k_1 V_1(t) + k_2 V^2{}_1(t)$$

Where,
$V_1(t)$ is the input of the square law device,
$V_2(t)$ is the output of the square law device
k_1 and k_2 are constants

The standard form of AM wave is

$$V_1(t) = A_c[1 + k_a m(t)]cos(2\pi f_c t)$$

$$V_2(t) = k_1 V_1(t) + k_2 V^2{}_1(t)$$

Substitute $V_1(t)$ in Equation 1

$$V_2(t) = k_1\big(A_c[1 + k_a m(t)]cos(2\pi f_c t)\big) + k_2\big(A_c[1 + k_a m(t)]cos(2\pi f_c t)\big)^2$$

$$V_2(t) = k_1 A_c cos(2\pi f_c t) + k_1 A_c k_a m(t) cos(2\pi f_c t) + k_2 A_c{}^2\left[1 + k_a{}^2 m^2(t) + 2k_a m(t)\right]\left(\frac{1 + cos(4\pi f_c t)}{2}\right)$$

In the above equation, the term $k_2 A^2{}_c k_a m(t)$ is the scaled version of the message signal.

It can be extracted by passing the above signal through a low pass filter

and the DC component $\dfrac{k_2 A_c{}^2}{2}$

can be eliminated with the help of a coupling capacitor.