Principle of Communication (BEC-28)

Amplitude Modulation

Dr. Dharmendra Kumar

- Assistant Professor
- Department of Electronics and Communication Engineering
- MMM University of Technology, Gorakhpur–273010.
- Email: dkece@mmmut.ac.in

UNIT-1

- Overview of Communication system
- Communication channels
- Need for modulation
- Baseband and Pass band signals
- Comparison of various AM systems
- Amplitude Modulation
  - Double side-band with Carrier (DSB-C)
  - Double side-band without Carrier
  - Single Side-band Modulation
  - SSB Modulators and Demodulators
  - Vestigial Side-band (VSB)
  - Quadrature Amplitude Modulator.

AM MODULATORS

Generation of AM

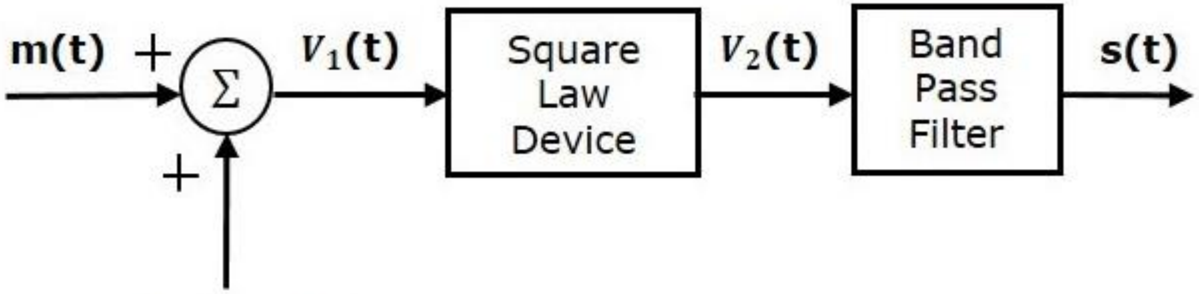
1) SQUARE LAW MODULATOR

2) SWITCHING MODULATOR

<u>SQUARE LAW MODULATR</u>

- BLOCK DIAGRAM

$m(t) = A_m \cos(2\pi f_m t)$

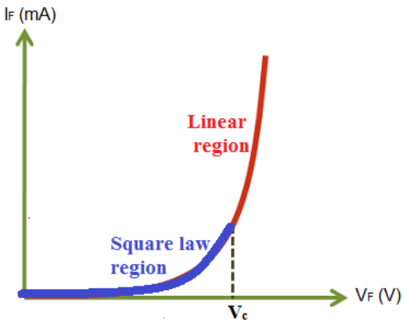


c(t) = $A_c \cos(2\pi f_c t)$

SQUARE LAW MODULATOR....

- Square law characteristics:

$$V_2 = a_1 V_1 + a_2 V_1^2$$



$$V_1(t) = m(t) + A_c \cos(2\pi f_c t)$$

$$V_2(t) = k_1 V_1(t) + k_2 V_1^2(t)$$

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

$$\Rightarrow V_2(t) = k_1 m(t) + k_2 m^2(t) + k_2 A_c^2 \cos^2(2\pi f_c t) +$$

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

- Last term is desired AM signal
- First three terms are unwanted

SQUARE LAW MODULATOR….

- Output of square law modulator is:
- Standard AM equation:

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

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

Problem: For the square law modulator the square law device is characterized by $V_2 = V_1 + 0.1V_1^2$ and pass band of band pass filter lie from 800 Hz to 1200 Hz. Find all the parameters of resulting AM signal. Take $m(t) = 2\cos(200\pi t)$ and $c(t) = 20\cos(2000\pi t)$.

Solution: $V_1 = 2\cos(200\pi t) + 20\cos(8000\pi t)$

$$V_2 = [2\cos(200\pi t) + 20\cos(2000\pi t)] + 0.1[4cos^2 200\pi t + 400cos^2 2000\pi t$$

$$+80\cos(200\pi t)\cos(8000\pi t)]$$

SQUARE LAW MODULATOR….

$$S_{AM}(t) = 20\cos(2000\pi t) + 8\cos(200\pi t).\cos(2000\pi t)$$

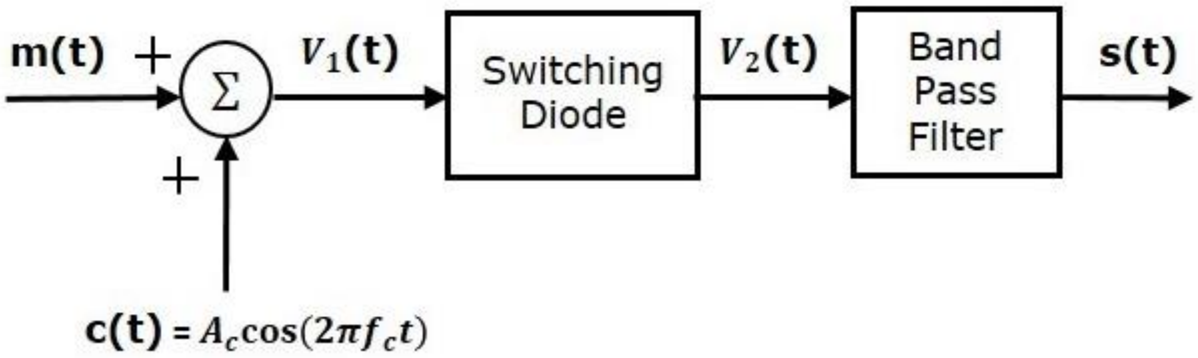
$$= 20[1 + 0.4\cos(200\pi t)]\cos(2000\pi t)$$

$A_c = 20$, $\mu = 0.4$, $f_m = 100$ Hz, $f_c = 1000$ Hz

$$K_a = \frac{2a_2}{a_1} = 0.2$$

Switching Modulator…..

- Block Diagram



- Similar to square law modulator.
- In SLM: Diode operates in non-linear mode.
- In SM: Diode operates as ideal switch.

Switching Modulator…..

$$V_1(t) = m(t) + c(t) = m(t) + A_c \cos(2\pi f_c t)$$

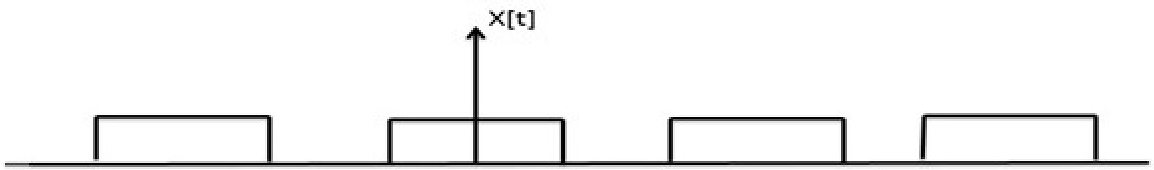
- Magnitude of message signal is small compared to carrier signal amplitude.
- Diode operation controlled by carrier signal.
- Diode is forward biased when $c(t) > 0$
- Diode is reverse biased when $c(t) < 0$

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

- Approximately $V_2(t) = V_1(t)\,x(t)$

Where $x(t)$ is periodic pulse train with time period $T = \frac{1}{f_c}$

Switching Modulator.....



- Fourier series representation of x(t)

$$x\left(t\right)=\frac{1}{2}+\frac{2}{\pi}\sum_{n=1}^{\infty}\frac{\left(-1\right)^{n}-1}{2n-1}\cos(2\pi\left(2n-1\right)f_{c}t)$$

$$\Rightarrow x\left(t\right)=\frac{1}{2}+\frac{2}{\pi}\cos(2\pi f_{c}t)-\frac{2}{3\pi}\cos(6\pi f_{c}t)+\ldots.$$

$$V_{2}\left(t\right)=\left[m\left(t\right)+A_{c}\cos(2\pi f_{c}t)\right]\left[\tfrac{1}{2}+\tfrac{2}{\pi}\cos(2\pi f_{c}t)-\tfrac{2}{3\pi}\cos(6\pi f_{c}t)+\ldots..\right]$$

$$V_{2}\left(t\right)=\tfrac{A_{c}}{2}\left(1+\left(\tfrac{4}{\pi A_{c}}\right)m\left(t\right)\right)\cos(2\pi f_{c}t)+\tfrac{m(t)}{2}+\tfrac{2A_{c}}{\pi}\cos^{2}(2\pi f_{c}t)-$$

$$\tfrac{2m(t)}{3\pi}\cos(6\pi f_{c}t)-\tfrac{2A_{c}}{3\pi}\cos(2\pi f_{c}t)\cos(6\pi f_{c}t)+\ldots..$$

Switching Modulator.....

- First term is desired AM signal.
- Remaining are undesired.
- Use Band pass filter.
- Output of switching modulator

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

- Standard AM signal
- Comparison with stand $s\left(t\right)=A_c\left[1+k_a m\left(t\right)\right]\cos(2\pi f_c t)$

  Scaling factor: 0.5

  $$k_a=\frac{4}{\pi A_c}$$

Thank You