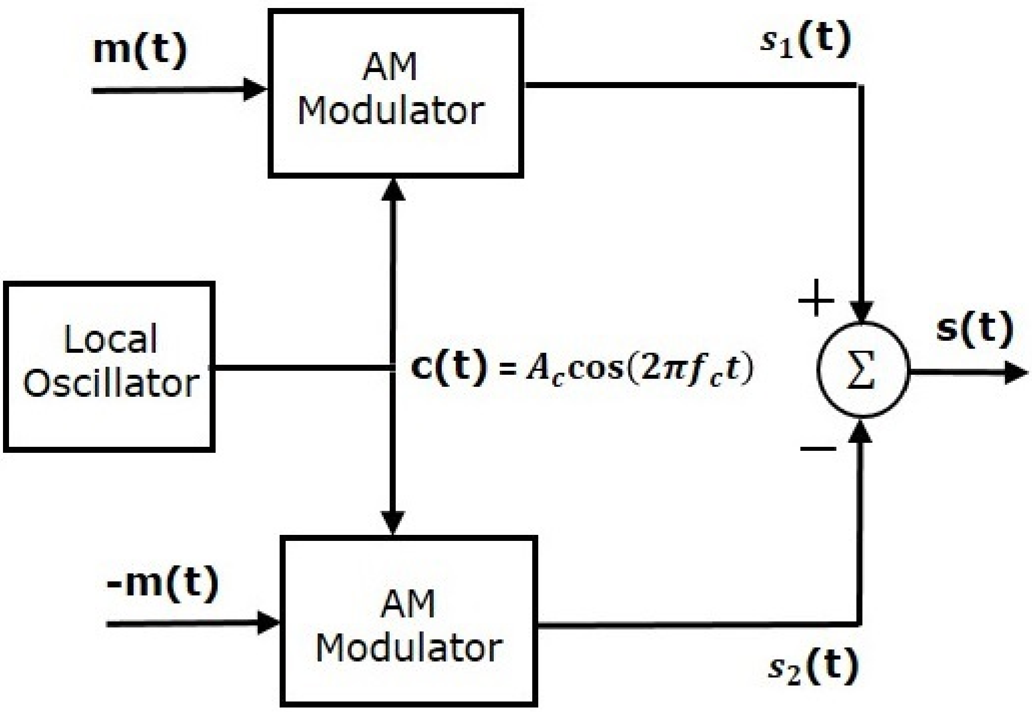
Analog Communication - DSBSC Modulators

In this chapter, let us discuss about the modulators, which generate DSBSC wave. The following two modulators generate DSBSC wave.

- Balanced modulator
- Ring modulator

Balanced Modulator

Following is the block diagram of the Balanced modulator.



Balanced modulator consists of two identical AM modulators. These two modulators are arranged in a balanced configuration in order to suppress the carrier signal. Hence, it is called as Balanced modulator.

The same carrier signal $c\left(t\right) = A_c \cos(2\pi f_c t)$ is applied as one of the inputs to these two AM modulators. The modulating signal $m\left(t\right)$ is applied as another input to the upper AM modulator. Whereas, the modulating signal $m\left(t\right)$ with opposite polarity, i.e., $-m\left(t\right)$ is applied as another input to the lower AM modulator.

Output of the upper AM modulator is

$$s_1(t) = A_c [1 + k_a m(t)] \cos(2\pi f_c t)$$

Output of the lower AM modulator is

$$s_2(t) = A_c [1 - k_a m(t)] \cos(2\pi f_c t)$$

We get the DSBSC wave $s(t)$ by subtracting $s_2(t)$ from $s_1(t)$. The summer block is used to perform this operation. $s_1(t)$ with positive sign and $s_2(t)$ with negative sign are applied as inputs to summer block. Thus, the summer block produces an output $s(t)$ which is the difference of $s_1(t)$ and $s_2(t)$.

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

$$\Rightarrow s(t) = A_c \cos(2\pi f_c t) + A_c k_a m(t) \cos(2\pi f_c t) - A_c \cos(2\pi f_c t) + A_c k_a m(t) \cos(2\pi f_c t)$$

$$\Rightarrow s(t) = 2A_c k_a m(t) \cos(2\pi f_c t)$$

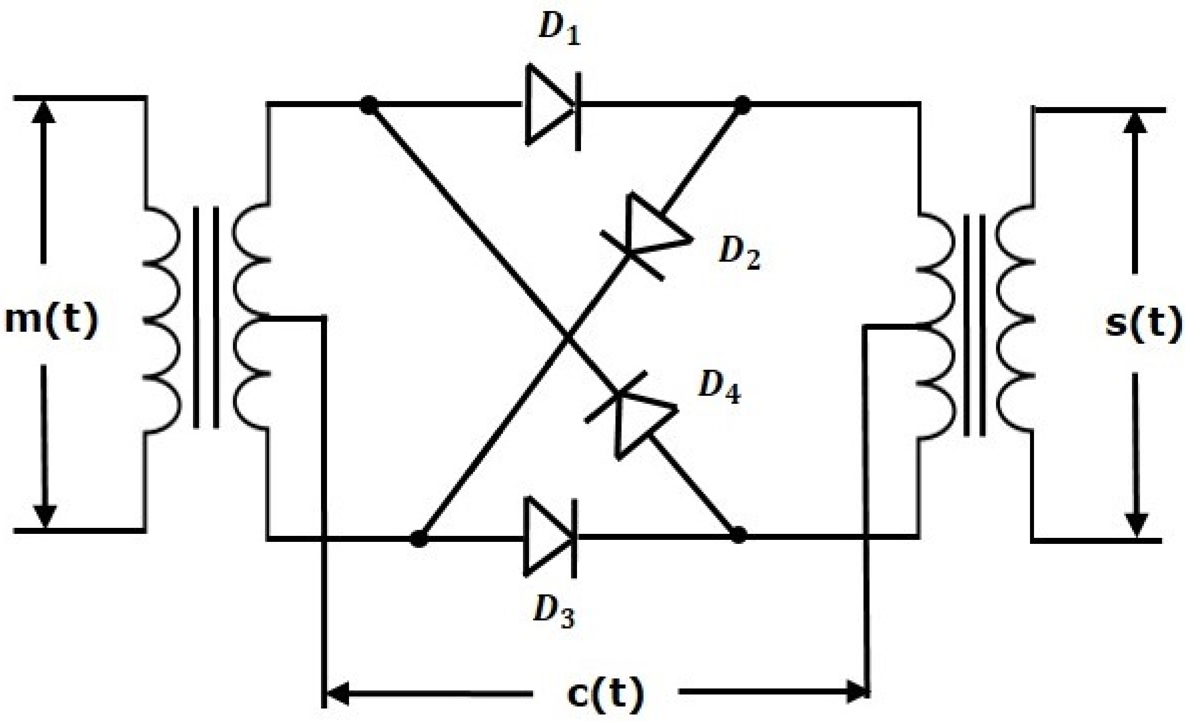
We know the standard equation of DSBSC wave is

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

By comparing the output of summer block with the standard equation of DSBSC wave, we will get the scaling factor as $2k_a$

Ring Modulator

Following is the block diagram of the Ring modulator.



In this diagram, the four diodes D_1 , D_2 , D_3 and D_4 are connected in the ring structure. Hence, this modulator is called as the **ring modulator**. Two center tapped transformers are used in this diagram. The message signal $m(t)$ is applied to the input transformer. Whereas, the carrier signals $c(t)$ is applied between the two center tapped transformers.

For positive half cycle of the carrier signal, the diodes D_1 and D_3 are switched ON and the other two diodes D_2 and D_4 are switched OFF. In this case, the message signal is multiplied by +1.

For negative half cycle of the carrier signal, the diodes D_2 and D_4 are switched ON and the other two diodes D_1 and D_3 are switched OFF. In this case, the message signal is multiplied by -1. This results in 180^0 phase shift in the resulting DSBSC wave.

From the above analysis, we can say that the four diodes D_1 , D_2 , D_3 and D_4 are controlled by the carrier signal. If the carrier is a square wave, then the Fourier series representation of $c(t)$ is represented as

$$c(t) = \frac{4}{\pi}\sum_{n=1}^{\infty}\frac{(-1)^{n-1}}{2n-1}\cos[2\pi f_c t(2n-1)]$$

We will get DSBSC wave $s(t)$, which is just the product of the carrier signal $c(t)$ and the message signal $m(t)$ i.e.,

$$s(t) = \frac{4}{\pi}\sum_{n=1}^{\infty}\frac{(-1)^{n-1}}{2n-1}\cos[2\pi f_c t(2n-1)]m(t)$$

The above equation represents DSBSC wave, which is obtained at the output transformer of the ring modulator.

DSBSC modulators are also called as **product modulators** as they produce the output, which is the product of two input signals.