DSB-SC Generation Circuits

Modulation can be achieved in several ways. In this section, we shall discuss some of them.

a) Multiplier Modulator

Here modulation is achieved directly by multiplying $m(t)$ by $\cos w_c t$ using an analog multiplier, whose output is proportional to the product of two signals. It is rather difficult to maintain linearity in this type of circuitry and generally they tend to be rather expensive. It is best to avoid such kind of modulators.

b) Non-linear Modulator

Modulation can also be achieved by using nonlinear semiconductor devices like PN junction diode and transistor. The following figure in below is one possible scheme which utilizes two identical non-linear elements marked as NL.

Let us assume, the input (i/p) and output (o/p) can be expressed as,

$$y(t) = a\,x(t) + b\,x^2(t)$$

where, $x(t)$: i/p
$y(t)$: o/p.

Hence, the output of the circuitry can be written as,

$$\begin{aligned} z(t) &= y_1(t) - y_2(t) \\ &= [a x_1(t) + b x_1^2(t)] - [a x_2(t) + b x_2^2(t)] \\ &= a(x_1(t) - x_2(t)) + b(x_1^2(t) - x_2^2(t)) \end{aligned}$$

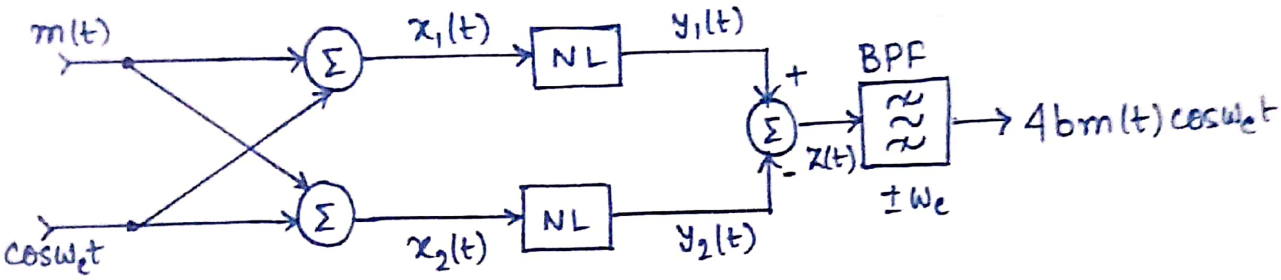
From the figure we can also write,

$$\begin{aligned} x_1(t) &= m(t) + \cos w_c t \\ x_2(t) &= -m(t) + \cos w_c t \end{aligned}$$

Thus,

$$\begin{aligned} z(t) &= a\,[m(t) + \cos w_c t + m(t) - \cos w_c t] + b\,[(m(t) + \cos w_c t)^2 - (-m(t) + \cos w_c t)^2] \\ &= 2a\,m(t) + 4b\,m(t)\cos w_c t. \end{aligned}$$

Recall that, the spectrum of $m(t)$ is centered at origin; while the spectrum of $m(t)\cos w_c t$ is centered around $\pm w_c$. Thus, if we pass $z(t)$ through a band pass filter which is tuned to w_c the part $2a\,m(t)$ will be suppressed and only the desired signal $4b\,m(t)\cos w_c t$ will be allowed at the output.



In this circuitry, we have two inputs: $m(t)$ and $\cos w_c t$. Thus, the summer o/p does not contain one of the i/p(s) which is $\cos w_c t$, as

$$z(t) = 2a\, m(t) + 4b\, m(t) \cos w_c t.$$

As a result, the carrier signal also does not appear at the input of the final BPF. Hence, the circuit acts as a balanced bridge for one of the inputs (i.e. carrier). Circuits having this type of characteristics is referred as balanced circuits. Thus the block diagram will be an example of balanced modulator. Since, the circuitry is balanced w.r.t only one i/p, we shall refer it as single balanced modulator. A circuit which is balanced w.r.t the both inputs will be referred as double balanced modulator. Typical example of double balanced modulator is ring modulator.

* Balanced Modulator Using Diodes.

A balanced modulator using dual diode as a non-linear elements is shown in the figure. The voltages are,

$$e_1 = \cos w_c t + m(t)$$
$$e_2 = \cos w_c t - m(t)$$

Current i_1 and i_2 are obtained using,

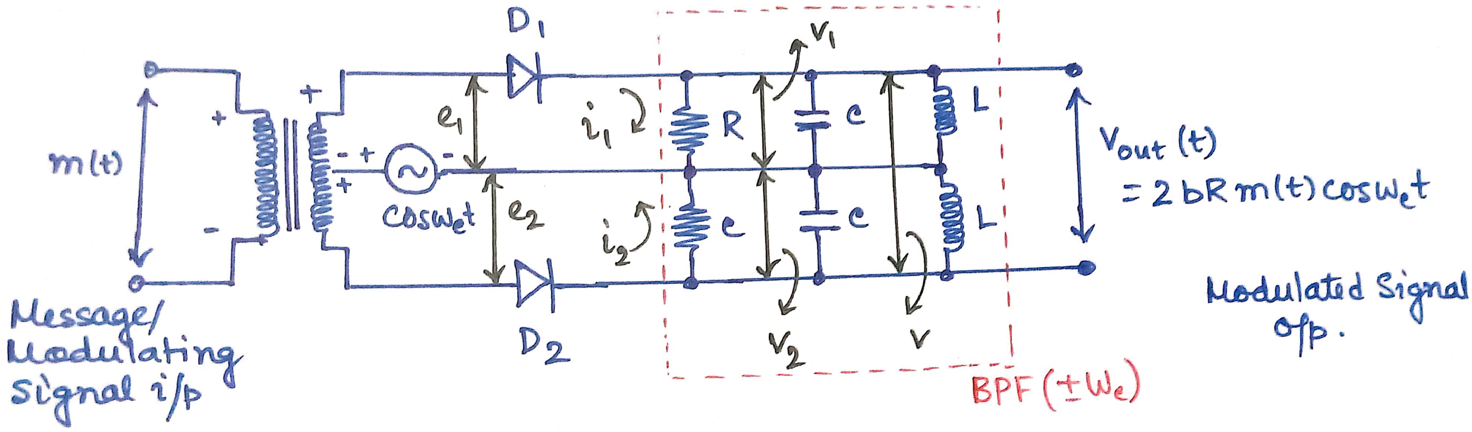
$$i_1 = ae_1 + be_1^2 = a(\cos w_c t + m(t)) + b(\cos w_c t + m(t))^2$$
$$i_2 = ae_2 + be_2^2 = a(\cos w_c t - m(t)) + b(\cos w_c t - m(t))^2$$

The voltage V_o, at the input of the BPF is given by,

$$V_o = V_1 - V_2 = i_1 R - i_2 R$$
$$= 2R[a m(t) + 2b\, m(t) \cos w_c t]$$

The output of BPF centered around $\pm w_c$ is given by,

$$V_{out}(t) = 2bR\, m(t) \cos w_c t$$
$$= K\, m(t) \cos w_c t$$



D1
D2
m(t)
+
-
e1
e2
cosWct
i1
i2
R
c
C
L
v1
v2
v
Vout (t)
= 2bRm(t)cosWct
Message/
Modulating
signal i/p
BPF (±Wc)
Modulated Signal
o/p.