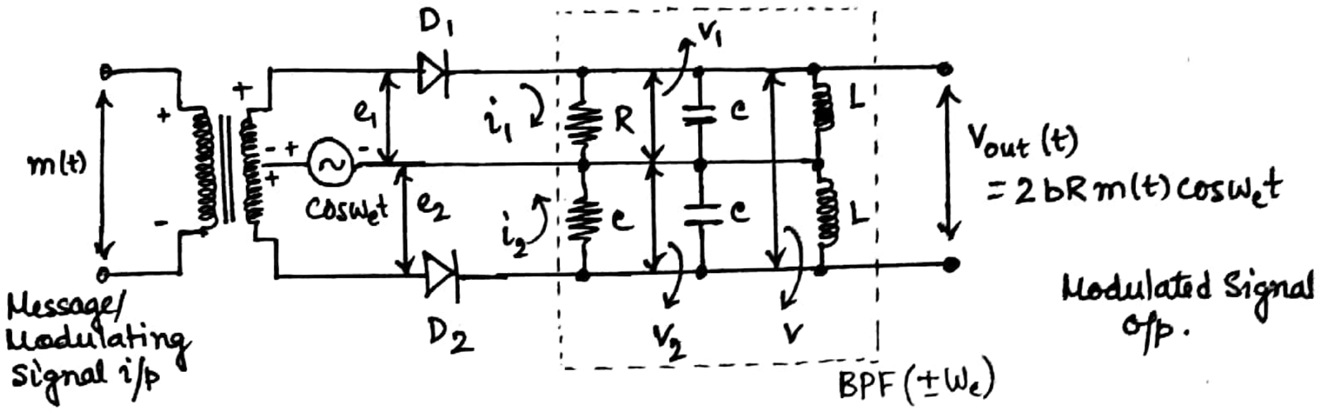


(c) <u>Switching Modulators.</u>

The multiplication operation required for modulation can be replaced by a simpler switching operation if we realize that a modulated signal can be obtained by multiplying $m(t)$ not only by a pure sinusoidal signal but by any periodic signal $\phi(t)$ of fundamental frequency ω_c.

Mathematically, such a signal can be represented in terms of Fourier Series as,

$$\phi(t) = \sum_{n=0}^{\infty} C_n \cos(n\omega_c t + \theta_n)$$

Multiplying $m(t)$ and $\phi(t)$ we get,

$$m(t)\,\phi(t) = \sum_{n=0}^{\infty} C_n\, m(t) \cos(n\omega_c t + \theta_n)$$

From the above relation we can write, the spectrum of the product signal will now be shifted to $\pm\omega_c$, $\pm 2\omega_c$, $\pm 3\omega_c$, ..., $\pm n\omega_c$, ... Now if the product signal is passed through a BPF of BW = 2B Hz and if it is tuned to ω_c; then the output of the BPF will be our desired signal i.e. $c_1 \cos(\omega_c t + \theta_1)$. Note that the phase '$\theta_1$' is not important.

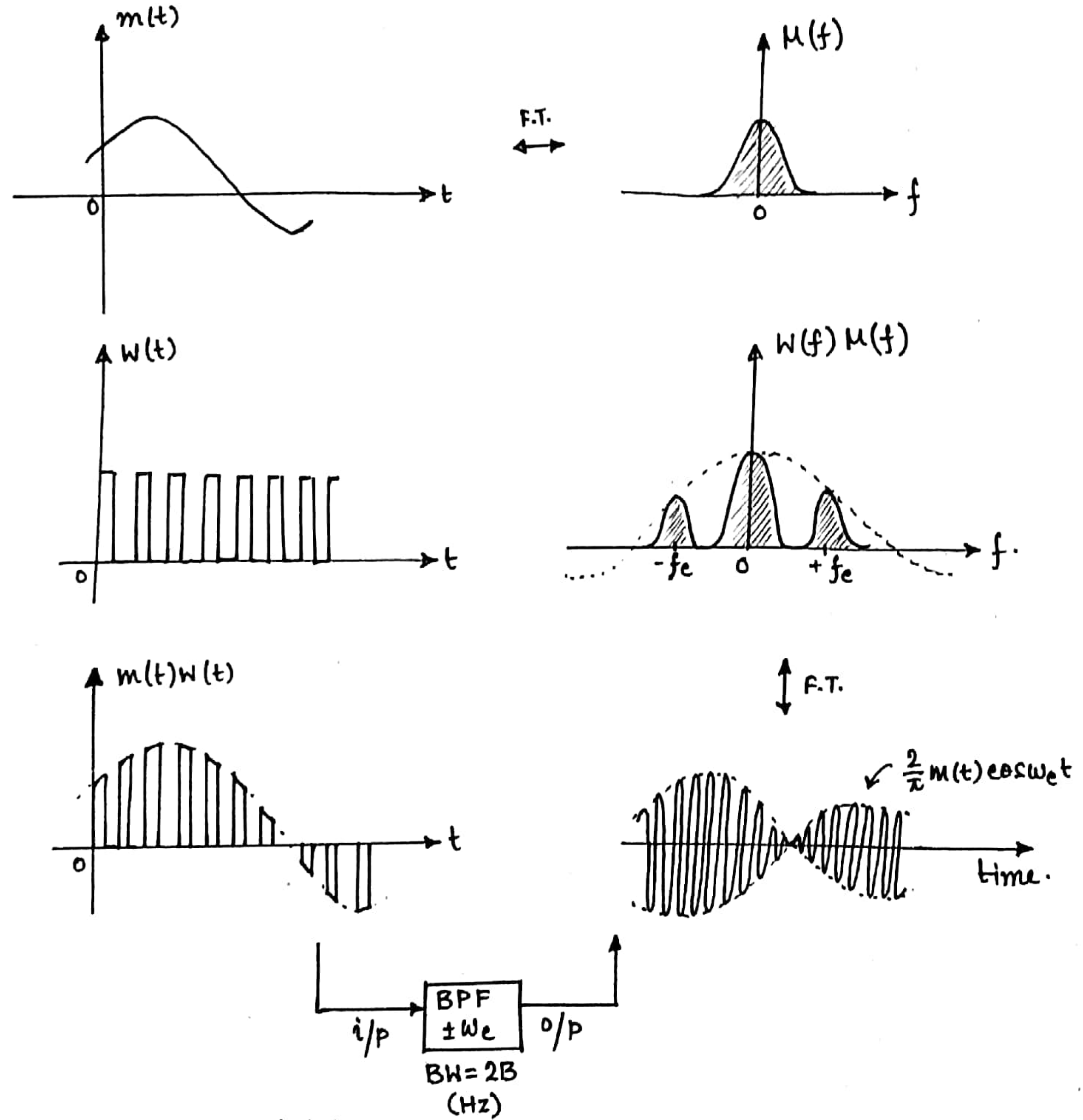
Recall from our concept from Fourier Series, that the square wave pulse train signal or $w(t)$ can be represented as,

$$w(t) = \frac{1}{2} + \frac{2}{\pi}\left(\cos\omega_c t - \frac{1}{3}\cos 3\omega_c t + \frac{1}{5} \quad 5\omega_c t - \cdots\right)$$

Thus the output of the switching modulator prior to the BPF is given by,

$$m(t)\, w(t) = \frac{m(t)}{2} + \frac{2}{\pi}\left(m(t)\cos\omega_c t - \frac{m(t)}{3}\cos 3\omega_c t + \frac{m(t)}{5}\cos 5\omega_c t - \cdots\right)$$

Finally, the product signal can be passed through a BPF to get the desired signal. We now discuss the real advantage of this technique. Multiplication by a square wave pulse train is in reality a simple switching operation In which m(t) is periodically on and off. It can be achieved by switching element like diode controlled by the signal W(t). Such a circuit will be easy to design, and maintainance will be less compared to the other circuitry. We now discuss two of the such circuitry which can be categorized to switching modulators.

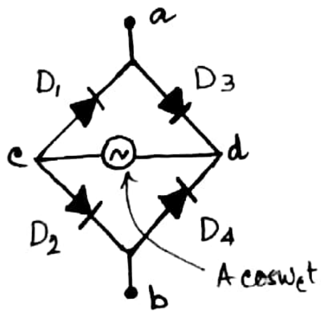


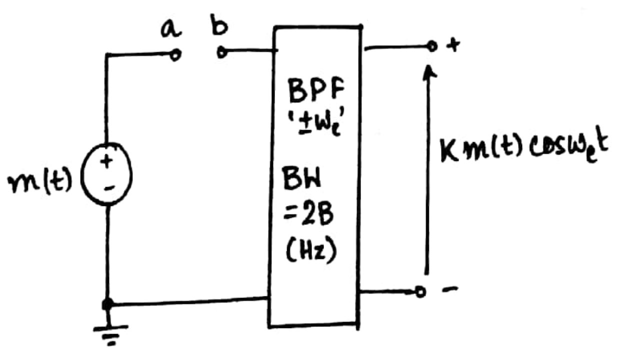
(i) <u>Diode Bridge Modulator</u>

An electronic example of switching modulator is diode bridge modulator. The circuit diagram of switching modulator is shown in Fig-1. As per the circuit diagram, it is clear that the circuit is driven by the sinusoidal signal $A \cos W_c t$, to produce the switching action.

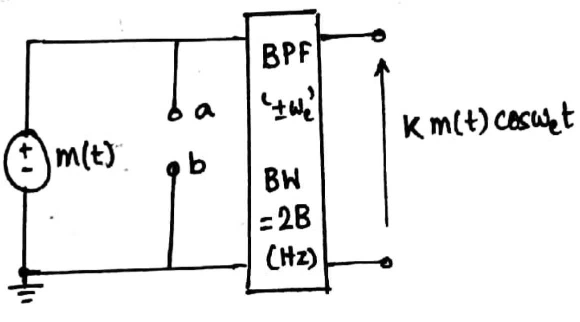
Prior to the explanation of the circuit diagram and circuit operation, note that diodes D_1, D_2 and D_3, D_4 are matched pair. Now when the signal $\cos\omega_c t$ is of a polarity that will make terminal 'c' positive then all the four diodes will conduct. As diodes D_1 and D_2 are matched, terminal 'a' and 'b' will have the same potential and are effectively shorted. During the next-half cycle, terminal 'd' is positive w.r.t. 'c' and in such condition all the four diodes will open and thus terminal 'a' to 'b' will also be in open condition. Thus the diode bridge circuit as depicted in Fig-1 will be serving as a switch with switching frequency $= \omega_c$. To obtain the signal $m(t)\,w(t)$, one can place this electronic switch in series or in parallel across the message signal as shown in Fig-2. If the switching circuitry is placed in series w.r.t the message signal, we can call the modulator as series-bridge diode modulator. Similarly, if the switching circuitry is placed in parallel with the $m(t)$, then the circuitry will be referred as shunt-bridge diode modulator. This switching on-and-off on $m(t)$ repeats for each cycle of the carrier, resulting in the switched signal $m(t)\,w(t)$. This is then band-pass filtered which then finally yields the desired modulated signal,

$$\varphi_{out}(t) \simeq \frac{2}{\pi}\, m(t)\cos\omega_c t$$





Series-bridge diode modulator



Shunt-bridge diode modulator.

Fig-1

(ii) Ring Modulator

Another variant of the switching modulator is the ring modulator. The circuit diagram of the modulator is shown in Fig-2.

During the +ve half-cycles of the carrier, diodes D_1 and D_3 conduct and diode D_2 and D_4 are open. Hence, terminal 'a' is connected to 'e' and terminal 'b' is connected to 'd'.

Similarly during -ve half-cycles of the carrier, diodes D_1, D_3 are in open condition while diodes D_2 and D_4 are in conducting state. Therefore terminal 'a' is connected to 'd' and terminal 'b' to 'e'. Hence, the output is proportional to m(t) during +ve half cycle and proportional to -m(t) during -ve half cycle. Thus overall effect is m(t) is multiplied by a square wave pulse train $w_0(t)$. Mathematically,

$$w_0(t) = \frac{4}{\pi}\left[\cos w_c t - \frac{1}{3}\cos 3w_c t + \frac{1}{5}\cos 5w_c t - \cdots\right]$$

Hence, we have

$$v_i(t) = m(t)\, w_0(t)$$
$$= \frac{4}{\pi}\left[m(t)\cos w_c t - \frac{m(t)}{3}\cos 3w_c t + \frac{m(t)}{5}\cos 5w_c t - \cdots\right]$$

Note that in the circuitry there are two inputs : m(t) and $\cos w_c t$. The input to the BPF doesn't contain either of these two inputs. Hence the circuitry is an example of double balanced modulator.

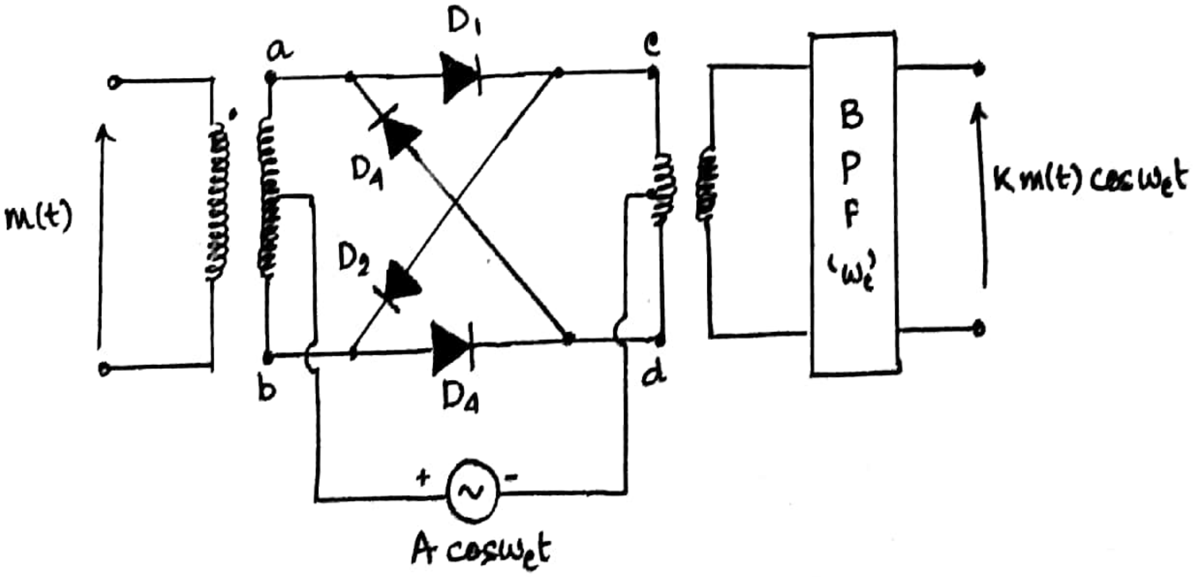


Fig-2.