Vestigial Sideband Modulation (VSB):

As discussed earlier, it is rather difficult to generate exact SSB signals. They generally require that the messages signal m(t) have a null around DC. A phase shifter required in the phase shift method which is unrealizable, or partially realizable. On the other hand generation of DSB signals is much simpler but it requires twice the signal BW.

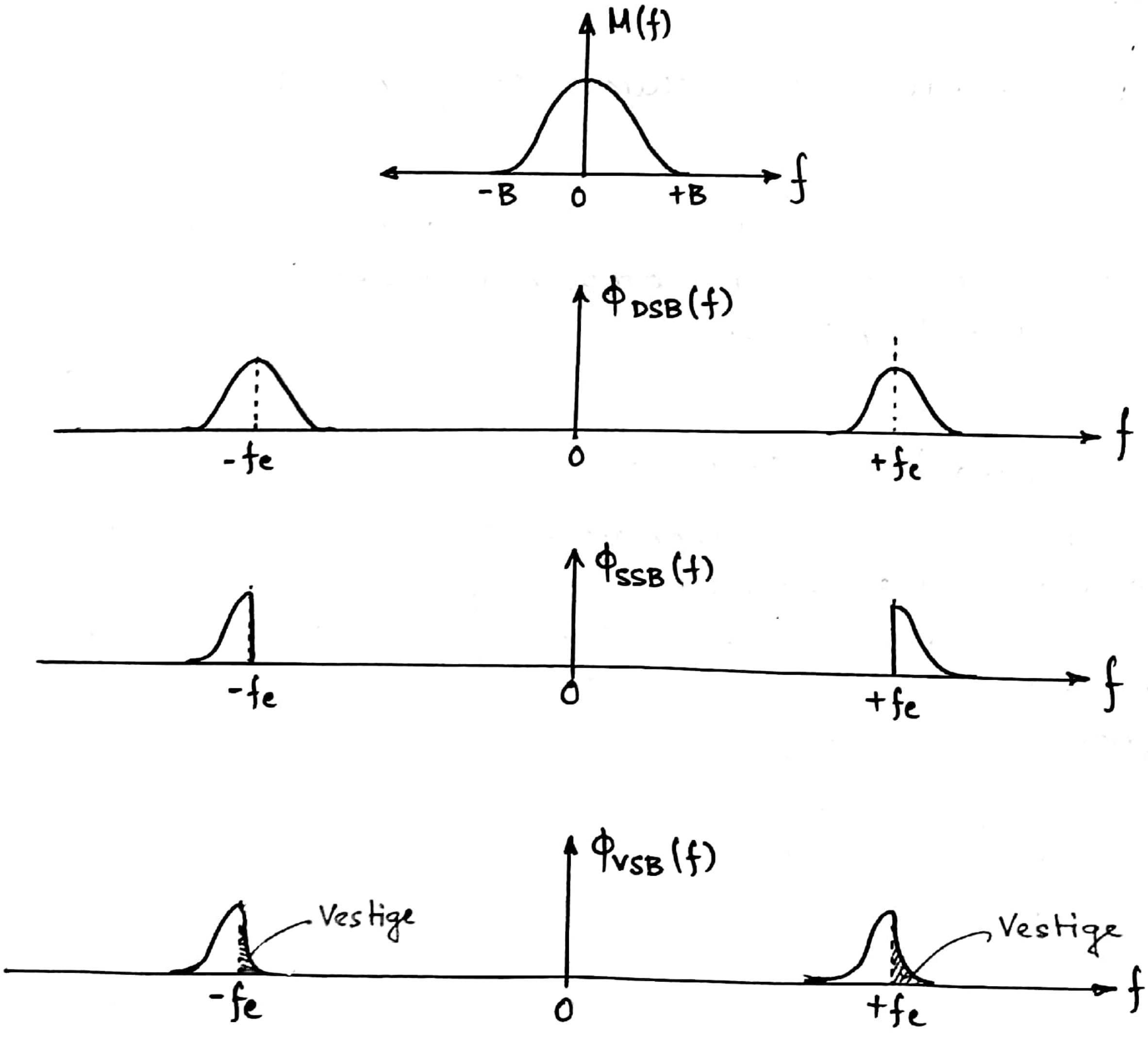
Vestigial side band modulation or VSB which is also known as asymmetric side band system is a compromise between DSB and SSB. It inherits the advantages of DSB and SSB but avoids their disadvantage at a small cost. VSB signals are easy to generate and at the same time their bandwidth is only little (typically 25% to 33%) greater than that of SSB signals.

In VSB, instead of rejecting one sideband completely (as in case of SSB), a gradual cut-off of one sideband as depicted below, is accepted. The baseband signal can be recovered exactly by a synchronous/coherent detector in conjunction with an appropiate equalizer filter ($H_o(f)$) at the receiver output. If a large carrier signal is transmitted along with the VSB signal, the baseband signal can be recovered by an envelope signal detector or even with a rectifier detector.

Assuming the vestigial shaping filter produces VSB signal from DSB signal and the frequency domain transfer function of such filter is $H_i(f)$ then for the VSB signal we can write,

$$\boxed{\phi_{VSB}(f) = [M(f+f_c) + M(f-f_c)]\, H_i(f)}$$

This VSB shaping filter $H_i(f)$ allows the transmission of one SB but suppress the other sideband (SB), not completely but gradually. This makes easy realization of filter, but the transmission BW is somewhat larger than that of the SSB signal.



Demodulation of VSB signal and Determination of $H_o(f)$

It is already discussed that, m(t) can be recovered from $\phi_{VSB}(t)$ using the synchronous detection method. Mathematically if the incoming VSB signal is multiplied with $2\cos\omega_c t$ then we can write,

$$e(t) = (\varphi_{VSB}(t))(2\cos\omega_c t)$$
$$= \phi_{VSB}(f+f_c) + \phi_{VSB}(f-f_c)$$

Now this signal is passed through a lowpass equalizer filter and the output of this equalizer filter is m(t). Hence the output signal spectrum is given by,

$$M(f) = [\phi_{VSB}(f+f_c) + \phi_{VSB}(f-f_c)]\, H_o(f)$$

Recall that,

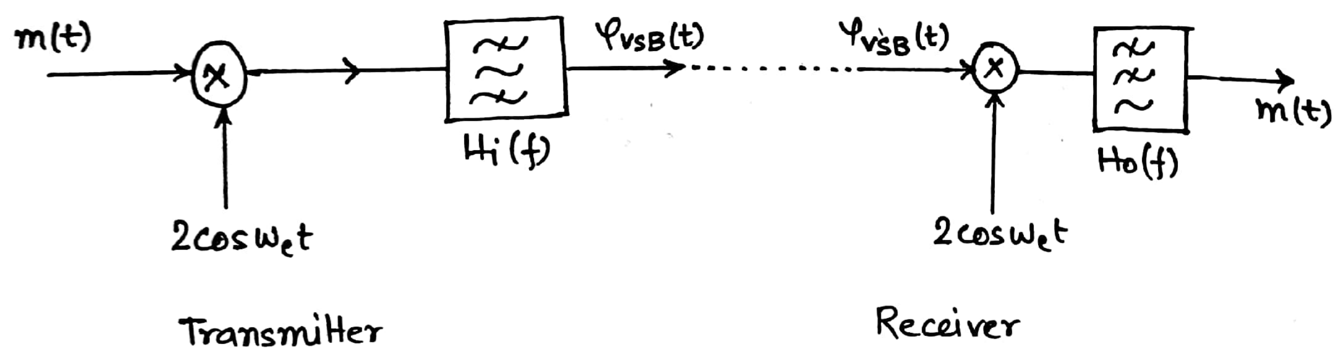
$$\phi_{VSB}(f) = [M(f+f_c) + M(f-f_c)]\, H_i(f)$$

Substituting $\phi_{VSB}(f)$ in the above expression and eliminating the spectra at $\pm 4f_c$ (as it will be suppressed by a LPF $H_o(f)$) we can write,

$$M(f) = M(f)\,[H_i(f+f_c) + H_i(f-f_c)]\, H_o(f)$$

or, $$\boxed{H_o(f) = \frac{1}{H_i(f+f_c) + H_i(f-f_c)} \;;\; |f| \leq B}$$

Note that, generally $H_i(f)$ is a Band-Pass filter or BPF and thus the terms $H_i(f \pm f_c)$ contains lowpass components.
Hence the transmitter and receiver block diagram for VSB transmission and reception is shown below.



* Comparison between DSB-FC/AM, DSB-SC, SSB-SC and VSB modulation Schemes:-

Parameters	AM/DSB-FC	DSB-SC	SSB	VSB
Carrier Suppression	No	Yes	Yes	Yes
Sideband Suppression	No	No	One sideband is completely suppressed	Partial suppression to one side band.
Transmission Bandwidth	$2f_m$	$2f_m$	f_m	$f_m + f_v$
Power efficiency	Minimum	Moderate	Maximum	Moderate.
Receiver Design	Simple & cheap	Complex and costly	More complex and expensive	Complex and expensive
Applications	Radio broadcast	Point to point comm$^{\underline{n}}$.	Long distance communication	Picture/Video transmission in commercial TV