Communication Systems

4- Vestigial Side Band Modulation (VSB):

Signals such as TV Video, facsimile and high speed data signal have a very large bandwidth and significant low freq. content.

SSB may be used to conserve bandwidth but practical SSB modulation systems have poor low freq. response.

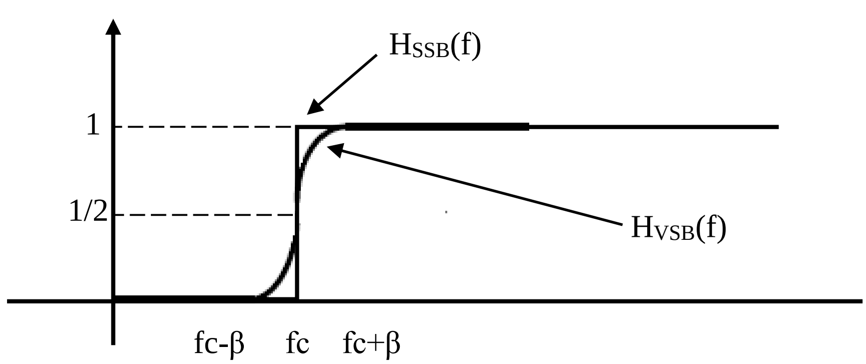
DSB on the other hand works well for messages for significant low freq. continent but transmission is twice that of SSB.

Vestigial side band modulation offers the best compromise between bandwidth conservation improved low freq. response and improved power efficiencies.

Vestigial side band (VSB):

In vestigial side band modulation most of one side band and a vestige (or a trace) of the other side band is transmitted. The typical BW required to transmit a VSB wave is about 1.25 that of SSB. The VSB modulated signal is produced but passing the DSB-SC or normal AM signal through a filter known as a VSB filter, which removes a part of one of the side bands.

A typical T.F of the VSB filter is as shown.



An important and essential requirement of HVSB (f) is:

Communication Systems

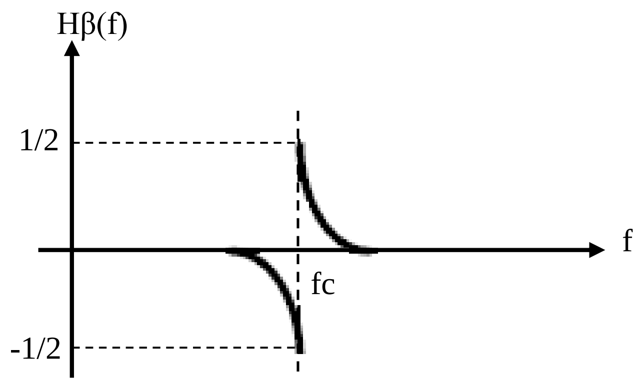
1- It must have a relative response of $\frac{1}{2}$ at fc.

2- It must have odd symmetry about fc.

The transition interval = 2 β Hz.

$\therefore$ The bandwidth of the VSB signal

= fm + β Hz, β < fm.

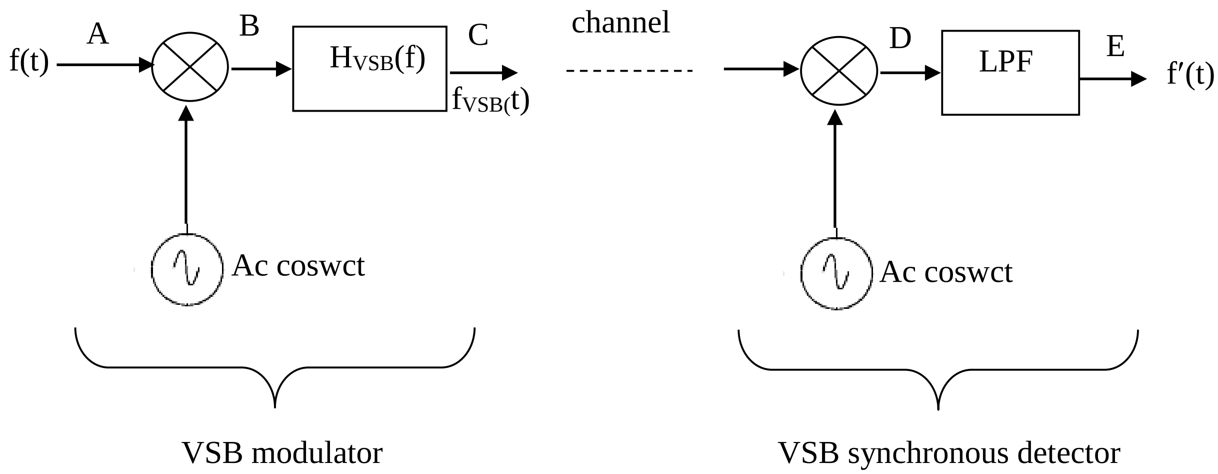


To derive a time domain expression for the VSB signal.

$$H_{VSB}(f) = H_{SSB}(f) - |H_{\beta}(f)|$$

Where: $H_{\beta}(f)$= difference between response of the SSB and VSB filter.

Assume input to the VSB filter to be a DSB-SC signal.



Communication Systems

Vin (f)= f_{DSB} (t) = Ac f (t) cos wct

$$f_{VSB}(t) = \underbrace{\underbrace{\frac{1}{2} Ac\ f(t) \cos wct - \frac{1}{2} AC\ f(t) \sin wct}_{\text{SSB-USB}} - \frac{1}{2} AC\ f_{\beta}(t) \sin wct}_{\text{VSB}}$$

Where:

$\frac{1}{2}$ Ac f_{β}(t) sin wct= response of H_{β}(f) to the input AC f(t) coswct.

$f_{VSB}(t)= \frac{1}{2} AC\ f(t) \cos wct - \frac{1}{2} AC\ \gamma(t) \sin wct$

Where $\gamma(t) = \hat{f}(t) + f_{\beta}(t)$

if $\gamma(t)= 0$ then $f_{VSB}(t) \rightarrow f_{SSB}(t)$

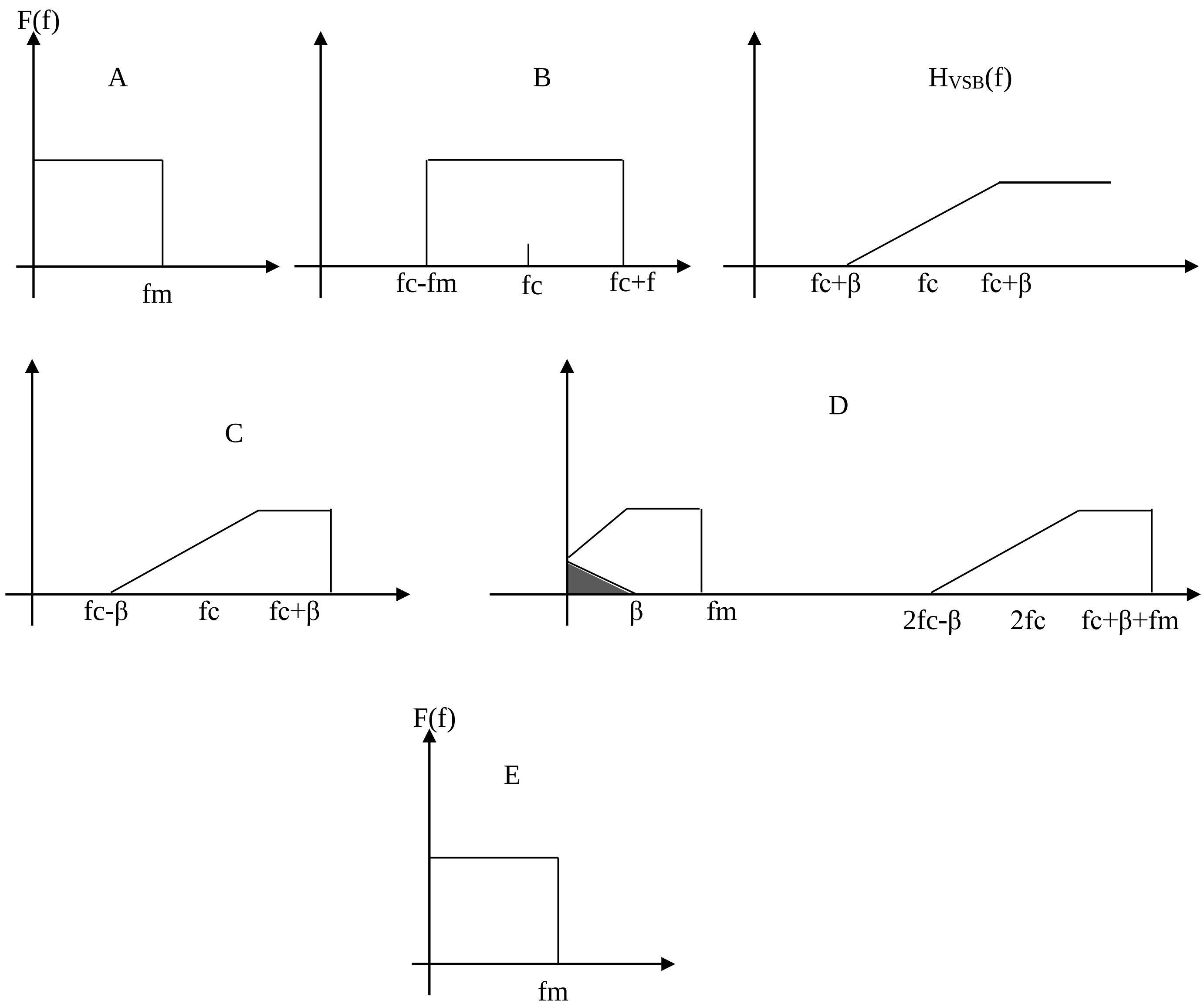
if $\gamma(t)= \hat{f}(t)$ then $f_{VSB}(t) \rightarrow f_{SSB}(t)$

The transmitted power is bounded by:

$$\frac{1}{4} AC^2\ \overline{f(t)^2} < P_{VSB} < \frac{1}{2} AC^2\ \overline{f(t)^2}$$

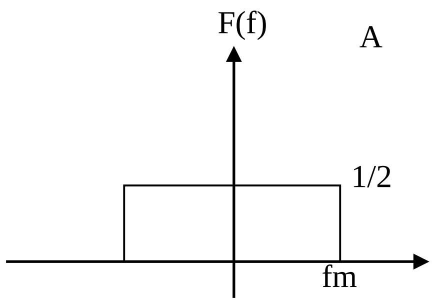
$$P_{SSB} < P_{VSB} < P_{DSB}$$

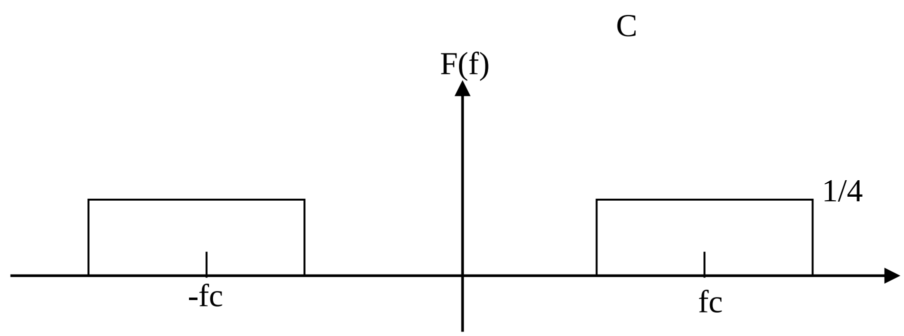
Let the spectrum of the message to be vestigial sideband modulated be as shown.

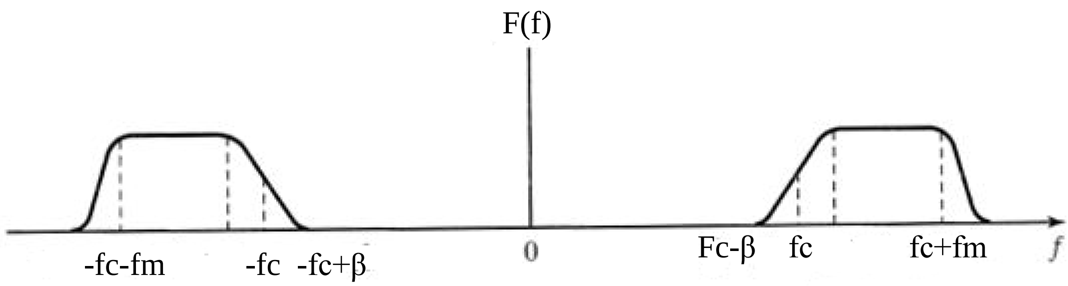


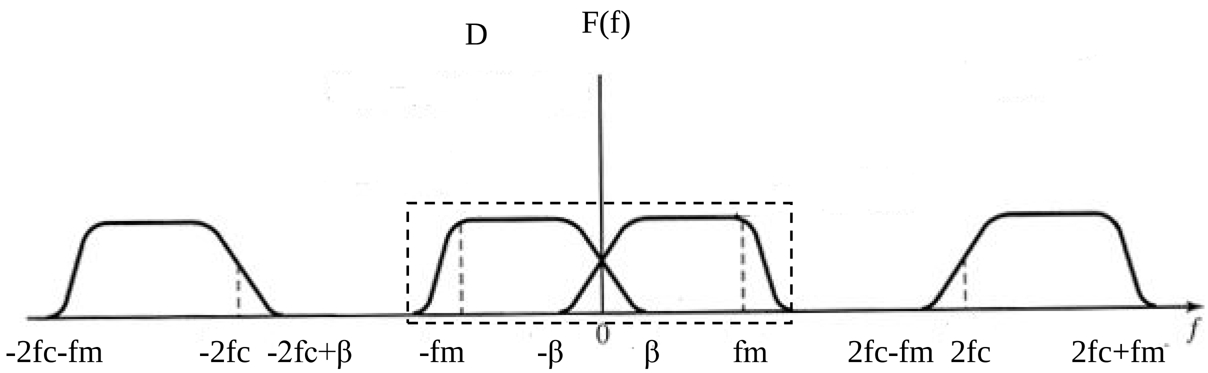
Communication Systems

Two Side Spectrums









Envelope Demodulation of VSB Signals:

It is often desirable to combine the envelope demodulation of AM with bandwidth conservation of VSB signals. Adding a carrier to a VSB signal.

$f_{VSB}(t)$ + carrier= Ac f(t) coswct – Ac γ (t) sinwc+ Ac coswct

For normal AM: γ(t)= 0

Communication Systems

For SSB with carrier $\gamma(t) = \hat{f}(t)$

For VSB + carrier, $\gamma(t)$ takes an intermediate value.

The envelope of fVSB(t) + carrier is:

$f_{VSB}(t) = R(t)\cos[wct + \varnothing(t)] +$ carrier

Where R(t)= envelope

$$= Ac\sqrt{[1+f(t)]^2+\gamma^2(t)}$$

$$= Ac\,[1+f(t)]\sqrt{1+\frac{\gamma^2(t)}{[1+f(t)]^2}}$$

It can be seen that R(t) is distorted if $\gamma(t) \ll 1$, the distortion is negligible and

$R(t) \approx AC\,[1+f(t)]$

as in the normal AM case, for VSB with carrier, average transmitted power.

$$P_T \cong Pc + Pc\,\overline{f(t)^2}$$

Commercial TV broad cast use VSB+ carrier with 30% vestigial side band. e.g. TV video signal Bw= 4.5 MHz for normal AM transmission BW_{AM}= 9 MHz. for VSB transmission BW_{VSB}= 6MHz.

∴Saving one third of bandwidth.