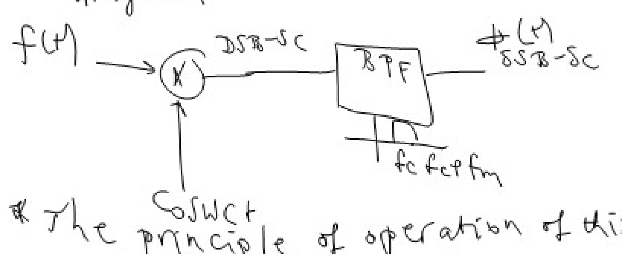
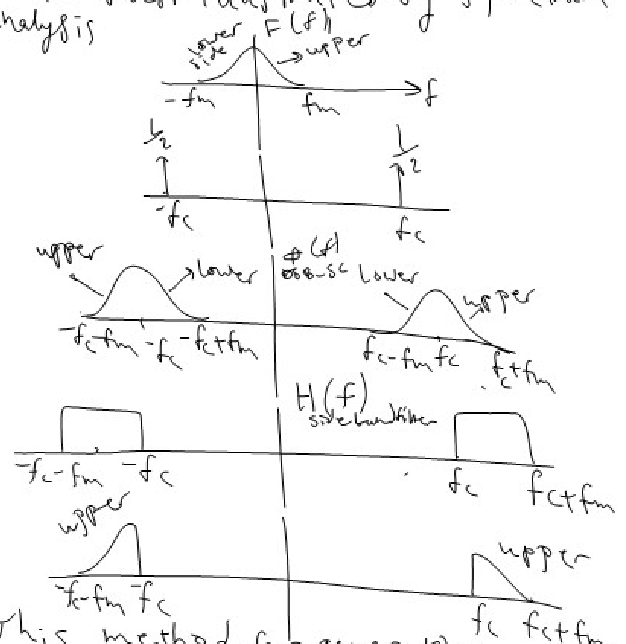
5.4.1 Generation of SSB–SC

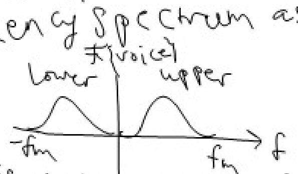
* There are two ways to generate a single side band signals
  1. Generate a double side band signal followed by a side band filter as shown by the following block diagram



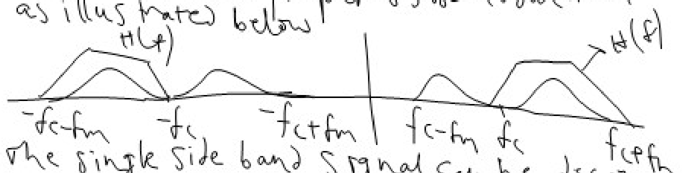
* The principle of operation of this method is best illustrated by spectrum analysis



* This method for generating SSB modulation is suitable for signals that does not contain frequency down to zero because the side band filter is not ideal
* for example voice signals have frequency spectrum as the one shown below



* for this of signals If the filter is not ideal we can still have a proper SSB-modulation as illustrated below



* The single side band signal can be described mathematically by the following equations

$\phi_{SSB-SC}(t) = f(t)\, e^{j\omega_c t}$

* If $f(t) = e^{j\omega_m t}$

$\phi_{DSB-SC}(t) = e^{j\omega_c t}\, e^{j\omega_m t}$

by taking the real part of $\phi_{SSB-SC}(t)$, we have the following equation

$$\text{Real}\left\{ e^{j\omega_c t}\, e^{j\omega_m t} \right\} = \cos\omega_m t \cos\omega_c t - \sin\omega_m t \sin\omega_c t$$

* The above mentioned equation represents an upper single side band modulated signal
* for lower side band modulated signal, we have $f(t) = e^{-j\omega_m t}$
* The resulting expression for the lower side band modulated signal is given by

$$\text{Real}\left\{ e^{j\omega_c t}\, e^{-j\omega_m t} \right\} = \cos\omega_m t \cos\omega_c t + \sin\omega_m t \sin\omega_c t$$

* In gener the expression for single side band signal is given by

$$\phi_{SSB-SC}^{\mp}(t) = f(t)\cos\omega_c t \pm \hat{f}(t)\sin\omega_c t$$

where $\hat{f}(t)$ is a 90° phase shifted version of $f(t)$

* Note that $\hat{f}(t)$ can be obtained from $f(t)$ by using Hilbert transform

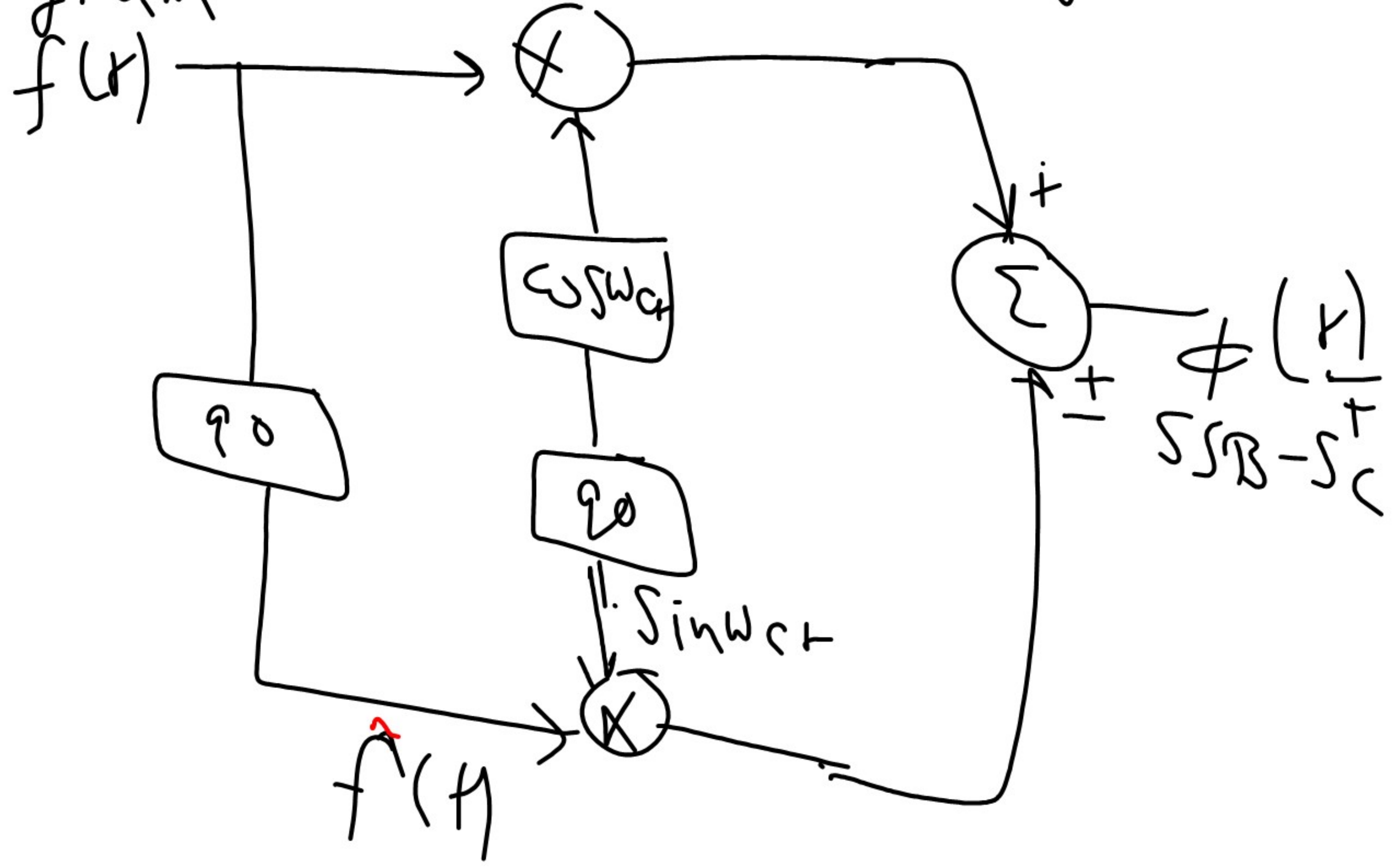
* Hilbert transform can be expressed mathematically by

$\hat{f}(t) = f(t) \circledast \frac{1}{\pi t}$ time domain

or $\hat{F}(\omega) = -j F(\omega) \, \text{Sgn}(\omega)$ frequency domain

$\text{Sgn}(\omega) = \begin{cases} 1 & \omega > 0 \\ -1 & \omega < 0 \end{cases}$

* The SSB equation $\phi_{SSB-SC}^{\mp}(t) = f(t)\cos\omega_c t \pm \hat{f}(t)\sin\omega_c t$ can be implemented by using the following block diagram



Ex A DSB-LC is generated using a 1 kHz carrier and the input signal $f(t) = \cos 200\pi t$. The modulation index $m = 80\%$. The lower side band is attenuated using a side band filter. Find an expression for the resulting single side band modulated signal if it develops 0.58 watt across 1Ω

Solution

$$\phi_{DSB-LC}(t) = A(1 + m\cos\omega_m t)\cos\omega_c t$$

$$= A\cos\omega_c t + mA\cos\omega_m t\cos\omega_c t$$

$$= A\cos\omega_c t + mA\tfrac{1}{2}\cos(\omega_c - \omega_m)t + mA\tfrac{1}{2}\cos(\omega_m + \omega_c)t$$

$$\phi^{+}_{SSB-LC}(t) = A\cos\omega_c t + \frac{mA}{2}\cos(\omega_c + \omega_m)t$$

The power is given by

$$0.58 = \frac{A^2}{2} + \frac{1}{2}\frac{m^2A^2}{4}$$

$$0.58 = \frac{A^2}{2}\left[1 + \frac{(0.8)^2}{4}\right] \Rightarrow A = 1$$

$$\phi^{+}_{SSB-LC}(t) = \cos 2000\pi t + 0.4\cos 2200\pi t$$