Generation of SSB signals
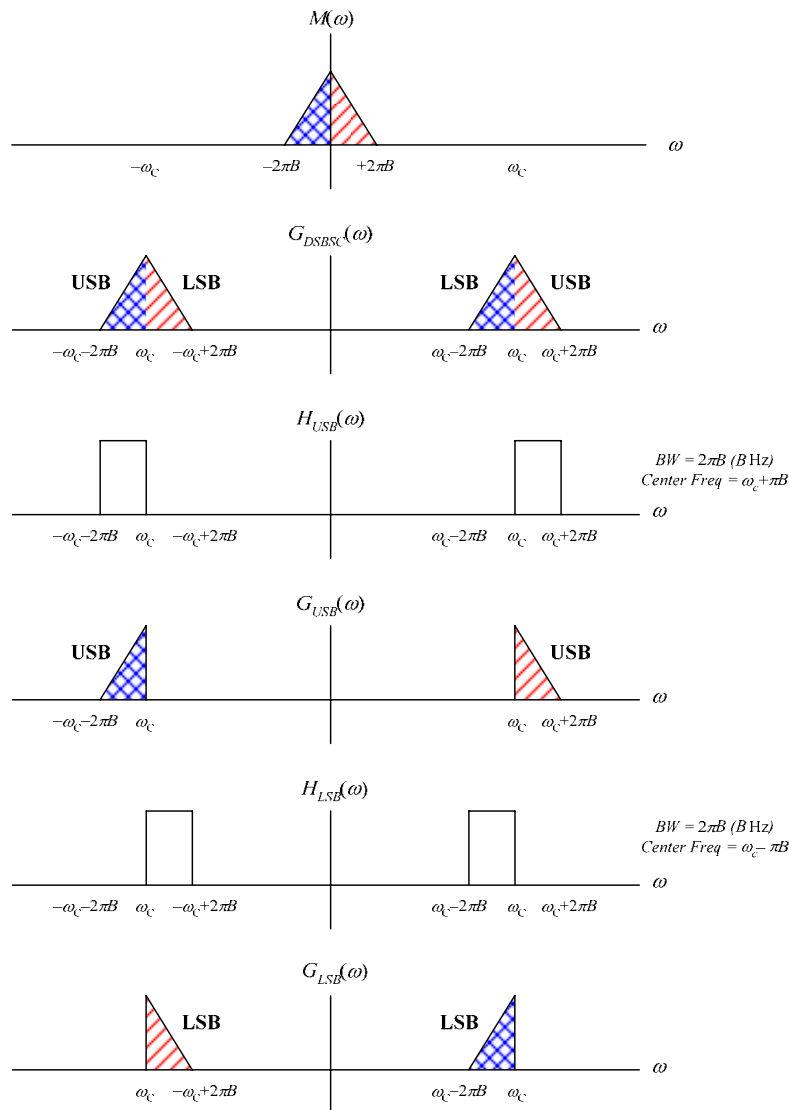
1.   DSBSC Filtering Method: Since SSB modulation is the transmission of the upper or lower side bands, SSB modulation can be generated by filtering the undesired side band of a DSBSC signal and retaining the desired one using a bandpass filter with bandwidth equal that of the message signal (not twice its bandwidth) and a center frequency equal to the center frequency of the desired side band (not the carrier).

       The PROBLEM with this modulation method is that it is suitable only for message signals that have a small guard–band (no signal components) around zero frequency, as it is the case for voice signals. The important components of human voice start from a frequency around 300 Hz. The reason is that ideal filters with sharp edges do not exist and therefore, filters with non–sharp edges must be used. Any non–zero components of the message signals close to zero frequency may be lost or distorted because of the filtering process.

$M(\omega)$

$-\omega_C$ $-2\pi B$ $+2\pi B$ ω_C ω

$G_{DSBSC}(\omega)$

USB   **LSB**   **LSB**   **USB**

$-\omega_C-2\pi B$ ω_C $-\omega_C+2\pi B$ $\omega_C-2\pi B$ ω_C $\omega_C+2\pi B$ ω

$H_{USB}(\omega)$

$BW = 2\pi B\ (B\,\text{Hz})$
$Center\ Freq = \omega_c+\pi B$

$-\omega_C-2\pi B$ ω_C $-\omega_C+2\pi B$ $\omega_C-2\pi B$ ω_C $\omega_C+2\pi B$ ω

$G_{USB}(\omega)$

USB   **USB**

$-\omega_C-2\pi B$ ω_C ω_C $\omega_C+2\pi B$ ω

$H_{LSB}(\omega)$

$BW = 2\pi B\ (B\,\text{Hz})$
$Center\ Freq = \omega_c-\pi B$

$-\omega_C-2\pi B$ ω_C $-\omega_C+2\pi B$ $\omega_C-2\pi B$ ω_C $\omega_C+2\pi B$ ω

$G_{LSB}(\omega)$

LSB   **LSB**

ω_C $-\omega_C+2\pi B$ $\omega_C-2\pi B$ ω_C ω

The following signal is a representation of a human voice signal. It is seen that this signal has a guard band that separates the two halves of the signal. Crating a SSB signal from this message signal is possible since a guard band of 2*300 Hz is obtained, which means that the transition of the edge of the BPF can take place in this 600 Hz.

$M(\omega)$ (an example of an audio signal)

Guard Band of 600 Hz

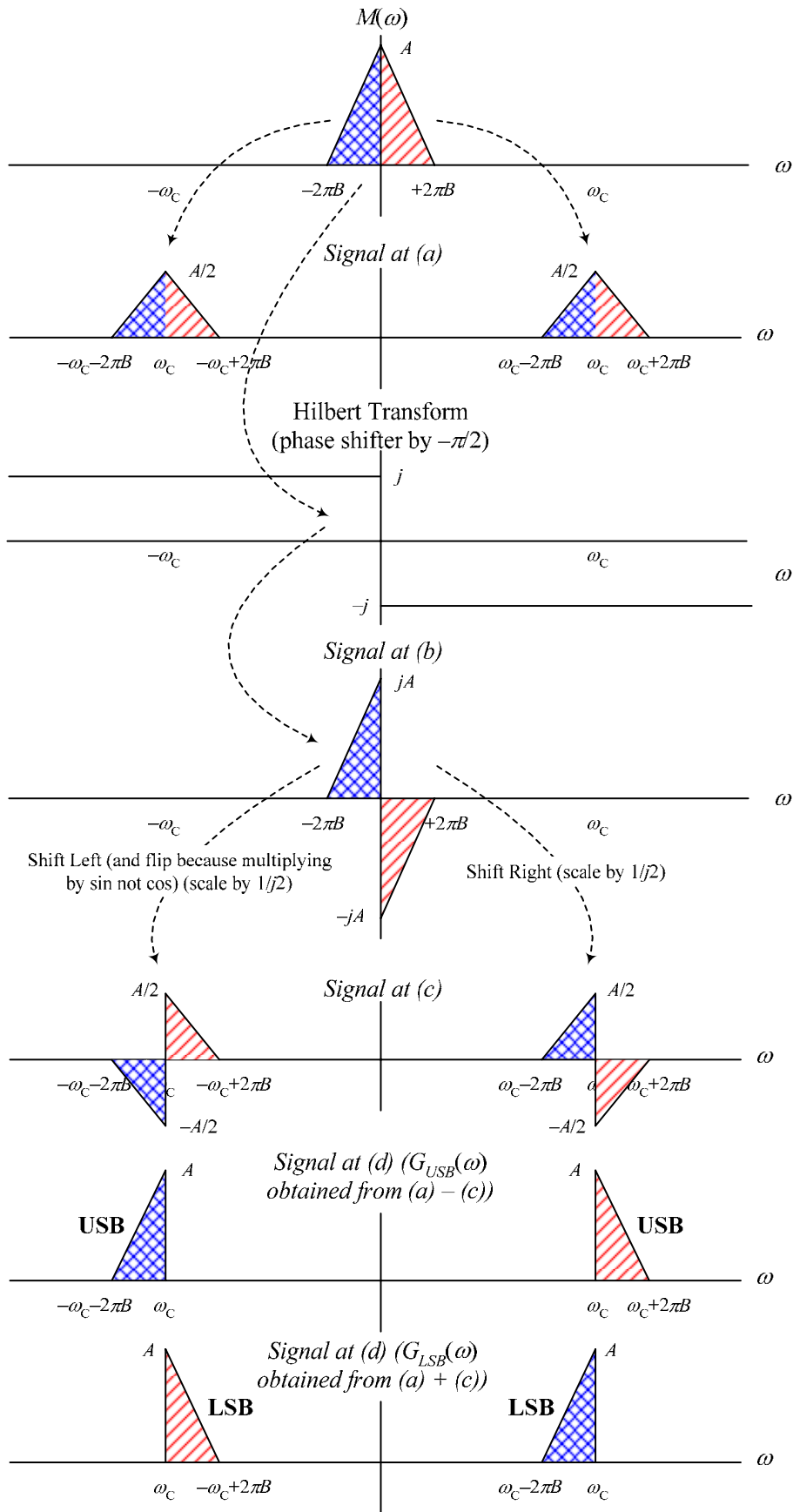−5000 Hz   −300 Hz   300 Hz   5000 Hz ω
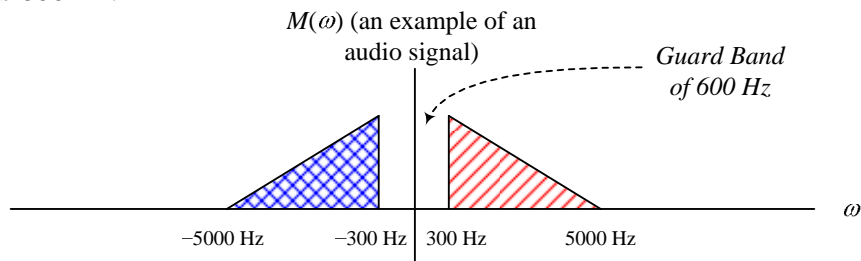
1.   Phase–Shifting Method: The basic idea of equations (12) above can be used where the Hilbert transform of the message signal is simply obtained using a a

device that shifts the message signal by $-\pi/2$ as shown in the following block diagram.

In fact, even the phase shifter shown in the block diagram below for a general signal is an unrealizable block. It only can be approximated. Therefore, this modulation technique is only a theoretical modulation method.
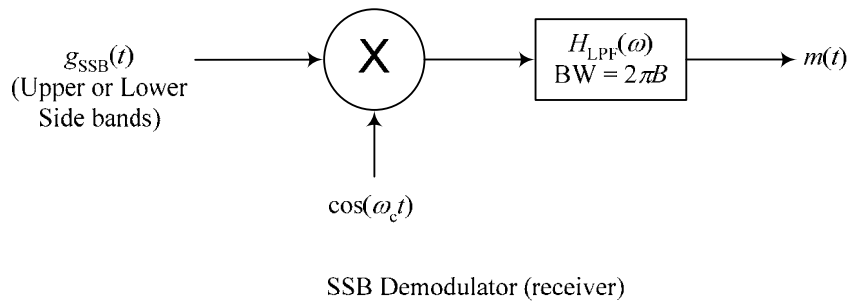

SSB Modulator
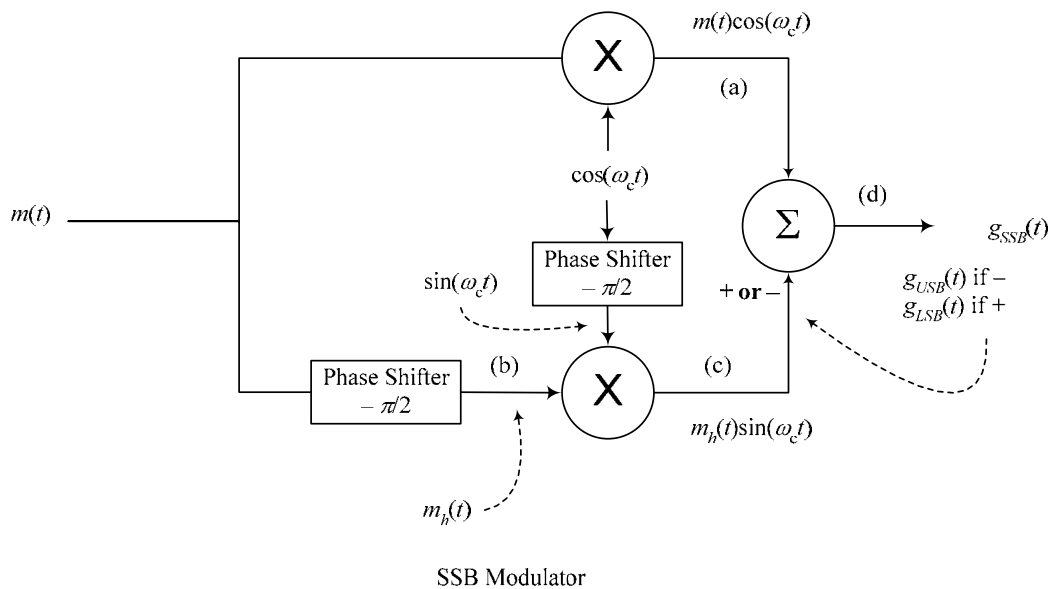
The above block diagram can also be described in frequency–domain. The following figure show the different signals in frequency–domain at points (a), (b), (c), and (d) in the block diagram.

$M(\omega)$

A

ω

$-\omega_C$ $-2\pi B$ $+2\pi B$ ω_C

Signal at (a)

$A/2$ $A/2$

$-\omega_C-2\pi B$ ω_C $-\omega_C+2\pi B$ $\omega_C-2\pi B$ ω_C $\omega_C+2\pi B$

ω

Hilbert Transform
(phase shifter by $-\pi/2$)

j

$-\omega_C$ ω_C

ω

$-j$

Signal at (b)

jA

$-\omega_C$ $-2\pi B$ $+2\pi B$ ω_C

ω

Shift Left (and flip because multiplying   Shift Right (scale by $1/j2$)
by sin not cos) (scale by $1/j2$)

$-jA$

Signal at (c)

$A/2$ $A/2$

$-\omega_C-2\pi B$ ω_C $-\omega_C+2\pi B$ $\omega_C-2\pi B$ ω_C $\omega_C+2\pi B$

ω

$-A/2$ $-A/2$

Signal at (d) ($G_{USB}(\omega)$
obtained from (a) − (c))

A A

USB   **USB**

$-\omega_C-2\pi B$ ω_C ω_C $\omega_C+2\pi B$

ω

Signal at (d) ($G_{LSB}(\omega)$
obtained from (a) + (c))

A A

LSB   **LSB**

ω_C $-\omega_C+2\pi B$ $\omega_C-2\pi B$ ω_C

ω

Demodulation of SSB signals

For demodulation, the same block diagram of a simple DSBSC demodulator can be used. The sideband at the positive and negative frequencies merge (recombine) at zero frequency when the SSB signal is multiplied by the carrier. (Try the exercise of finding the output of the DSBSC demodulator in time– and frequency–domain when its input is a either an USB or a LSB signal).

$$g_{SSB}(t)$$
(Upper or Lower Side bands) ⟶ **X** ⟶ $\boxed{\begin{array}{c} H_{LPF}(\omega) \\ BW = 2\pi B \end{array}}$ ⟶ $m(t)$

$\cos(\omega_c t)$

SSB Demodulator (receiver)

If the SSB signal includes a LARGE carrier, it can be demodulated using an envelope detector similar to that used for full AM signals (see page 178 of your textbook for details).