and part of 9

$\boxed{5\text{-}18.}$ (a.)

Ⓐ $v_A(t) = m(t)\cos\omega_{if}t \mp \hat{m}(t)\sin\omega_{if}t$ (upper sign: USSB, lower sign: LSSB)

Ⓓ $v_D(t) = \cos\omega_{if}t$

Ⓑ $v_B(t) = v_A(t)v_D(t) = m(t)\cos^2\omega_{if}t \mp \hat{m}(t)\sin\omega_{if}t\cos\omega_{if}t$

$$= \frac{m(t)}{2}(1+\cos 2\omega_{if}t) \mp \frac{\hat{m}(t)}{2}\sin 2\omega_{if}t$$

Ⓒ $v_C(t) = \frac{m(t)}{2}$

Ⓔ $v_E(t) = \sin\omega_{IF}t$

Ⓕ $v_F(t) = v_A(t)\,v_E(t)$

$$= m(t)\sin\omega_{IF}t\cos\omega_{IF}t \mp \hat{m}(t)\sin^2\omega_{IF}t$$

$$= \frac{m(t)}{2}\sin 2\omega_{IF}t \mp \frac{\hat{m}(t)}{2}(1-\cos 2\omega_{IF}t)$$

Ⓖ $v_G(t) = \mp\frac{\hat{m}(t)}{2}$

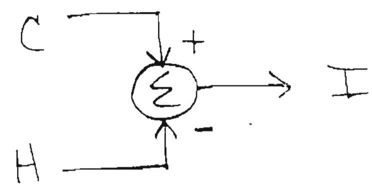
Ⓗ $v_H(t) = \pm\frac{m(t)}{2}$

Ⓘ $v_I(t) = v_C(t) + v_H(t)$

$$= \frac{m(t)}{2} \pm \frac{m(t)}{2}$$

$$v_I(t) = \begin{cases} m(t), & \text{USSB} \\ 0, & \text{LSSB} \end{cases}$$

5.18 Cont'd) To receive LSSB signals, <u>subtract</u> $v_H(t)$ from $v_c(t)$ at the summer.



(b.) see part (a.)

(c.) see part (a.)

(d.) IF should be centered at $f_c \pm 1.5\,KHz$, (+ USSB, − LSSB) have 3KHz BW and as small a roll-off factor as is economically feasible.

LPF should have 3KHz BW and as small a roll-off factor as is feasible, also.

$\sqrt{}$ $\boxed{5\text{-}20}$ (a.) $\underline{\underline{0\%\ AM}}$

(b.) $P_{norm} = A_c^2/2 = 10^2/2 = \underline{\underline{50W}}$

(c.) $\Delta\theta_{max} = \underline{\underline{10 \text{ radians}}}$

(d.) $\omega_d(t) = \dfrac{d\theta(t)}{dt} = -10(2000\pi)\sin(2000\pi t)$

$\Delta F = \dfrac{\Delta\omega_d}{2\pi} = \dfrac{10(2000\pi)}{2\pi} = 10^4 = \underline{\underline{10\,kHz}}$

$\boxed{5\text{-}22.}$ $m(t) = A_m \cos(2\pi f_m t) = 4 \cos(2\pi \times 10^3 t)$

(a.) $f_i(t) = f_c + \Delta F \cos(2\pi \times 10^3 t)$

$\Delta F = k_f A_m = \left(\frac{50\,Hz}{V}\right)(4V) = \underline{200\,Hz}$

(b.) $\beta = \frac{\Delta F}{f_m} = \frac{200\,Hz}{1\,kHz} = \underline{\underline{0.2}}$

$\checkmark\ \boxed{5\text{-}24.}$ (a.) $f_{BPF} = \frac{103.7}{8}\,mHz = \underline{\underline{12.96\ mHz}}$

$\Delta F_{BPF} = \frac{75\,KHz}{8} = 9.375\,KHz$

$BW_{BPF} = 2(\Delta F + f_m) = 2(9.375 + 15)\,KHz$

$= \underline{\underline{48.75\ KHz}}$

(b.) $f_{BPF} = f_c + f_o \Rightarrow f_o = 12.96 - 5 = \underline{\underline{7.96\ mHz}}$

$f_{BPF} = f_c - f_o \Rightarrow f_o = 12.96 + 5 = \underline{\underline{17.96\ mHz}}$

$\uparrow$

$f_c = 5\,mHz$

(c.) $\Delta F_{FME} = \frac{75\,KHz}{8} = \underline{\underline{9.38\ KHz}}$

$\boxed{5\text{-}26.}$ (a.) $\Theta(t) = D_p m_p(t) = 20 \cos \omega_1 t$

$$\Rightarrow m_p(t) = \frac{20}{D_p} \cos \omega_1 t = \underline{\underline{0.2 \cos(2000\pi t)}}$$

$$m_p(t)_{peak} = \underline{\underline{0.2\ V}} \; ; \quad f_m = \underline{\underline{1\,KHz}}$$

(b.) $\Theta(t) = D_f \int_{-\infty}^{t} m_f(\lambda)\, d\lambda = 20 \cos \omega_1 t$

$$\Rightarrow m_f(t) = \frac{20}{D_f} \frac{d}{dt}\left[\cos \omega_1 t\right]$$

$$= \frac{-20}{10^6}(2000\pi) \sin \omega_1 t$$

$$m_f(t) = \underline{\underline{-.1257 \sin \omega_1 t}}$$

$$m_f(t)_{peak} = \underline{\underline{.1257\ V}} \; ; \quad f_m = \underline{\underline{1\,KHz}}$$

(c.) $P_{AV} = \frac{V_{rms}^2}{R} = \frac{(500)^2}{2(50)} = \underline{\underline{2.5\,KW}}$

$$PEP = \underline{\underline{2.5\,KW}}$$

3.24)

$$s(t) \longrightarrow \boxed{\text{ENV. DET.}} \longrightarrow a(t)$$

$$s(t) = m(t)\cos 2\pi f_c t + A_c \cos(2\pi f_c t + \varphi)$$

$$= m(t)\cos 2\pi f_c t + A_c \cos\phi \cos 2\pi f_c t - A_c \sin\phi \sin 2\pi f_c t$$

$$= \underbrace{(m(t) + A_c \cos\varphi)}_{\text{In phase comp.}} \cos 2\pi f_c t - \underbrace{A_c \sin\phi}_{\text{quadrature component}} \sin 2\pi f_c t$$

$$a(t) = \sqrt{(m(t) + A_c\cos\phi)^2 + A_c^2 \sin^2\phi}$$

$$= \sqrt{m^2(t) + A_c^2\cos^2\phi + 2A_c\cos\phi\, m(t) + A_c^2\sin^2\phi}$$

$$= \sqrt{m^2(t) + A_c^2 + 2A_c\cos\phi\, m(t)} \qquad (1)$$

a) If $\varphi = 0 \Rightarrow a(t) = \sqrt{m^2(t) + A_c^2 + 2A_c m(t)} = \sqrt{(m(t)+A_c)^2}$

$\Rightarrow a(t) = |m(t) + A_c| = m(t) + A_c$ if $|m(t)| < A_c$

b) For $\phi \neq 0$ and $|m(t)| \ll A_c/2$ using eq (1)

$$a(t) = A_c\sqrt{1 + \frac{2}{A_c}\cos\phi\, m(t) + \frac{m^2(t)}{A_c^2}}$$

$$\simeq A_c\sqrt{1 + \frac{2}{A_c}\cos\phi\, m(t)}$$

we can neglect $\frac{m^2(t)}{A_c^2}$ since $|m(t)| \ll A_c/2$

$$= A_c\left[1 + \frac{1}{2}\cdot\frac{2}{A_c}\cos\phi\, m(t)\right]$$

using $(1+x)^\alpha \simeq 1 + \alpha x$ if $x \ll 1$

$$= A_c + \cos\phi\, m(t)$$