

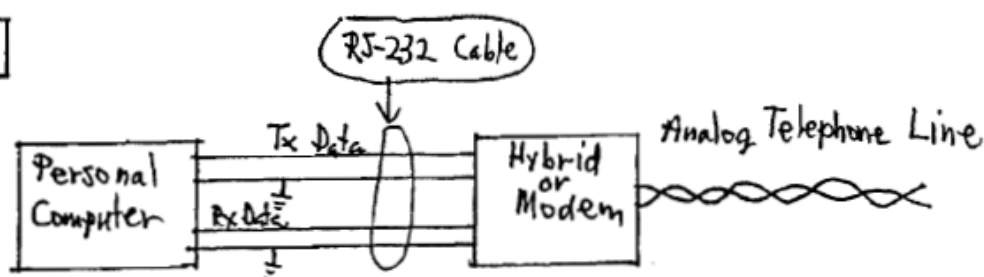
Chapter 8

8-1.

Assuming that the 150 G.Lite subscribers have VF service over the DSL lines, as well as VF service to the 300 VF subscriber lines, we get

$$300 \times 64 \text{ kb/s} + 150 \times 64 \text{ kb/s} + 150 \times 1,500 \text{ kb/s} \\ = 253,800 \text{ kb/s} = \underline{253.8 \text{ Mb/s}}$$

8-5.



Suppose the serial data port on a PC is interfaced to the VF telephone line without a modem. The transmit (Tx) and receive (Rx) serial data from the PC are each represented by a Polar NRZ line code as described by the RS-232 serial port standard in Appendix C. A hybrid (4 wire to 2 wire) circuit could be used to couple the Tx and Rx line-code signals to a single twisted-pair VF telephone line. However, the spectrum of the polar line-code is not compatible with the frequency response of the VF telephone line. That is, as shown in Fig. 3-16b, the dominant frequencies in the Polar NRZ line code are near zero (i.e. baseband) but the telephone line is a bandpass channel with a frequency response from 300 to 2700 Hz. Thus, the Polar NRZ waveform would be distorted by the telephone line so that the data could not be detected at the receiving end. Thus, a modem is needed to provide a bandpass signal that is generated by some sort of modulation technique, such as QAM. That is, the baseband line-code waveform is modulated onto a carrier. This produces a bandpass signal with a spectrum that falls within the bandpass of the VF telephone line.

8-9. $P_{Tx} = 0.1 \text{ W}$, $f_c = 2 \text{ GHz}$, 3.28 ft/meter

(a.) $G_A = \frac{7A}{\lambda^2} = \frac{7.0 \pi \left(\frac{2}{3.28}\right)^2}{\left(\frac{3 \times 10^8}{2 \times 10^9}\right)^2} = 363.4 = 25.6 \text{ dB}$
 $A = \pi r^2$, $\lambda = c/f$ $10 \log(363.4) = 25.6$

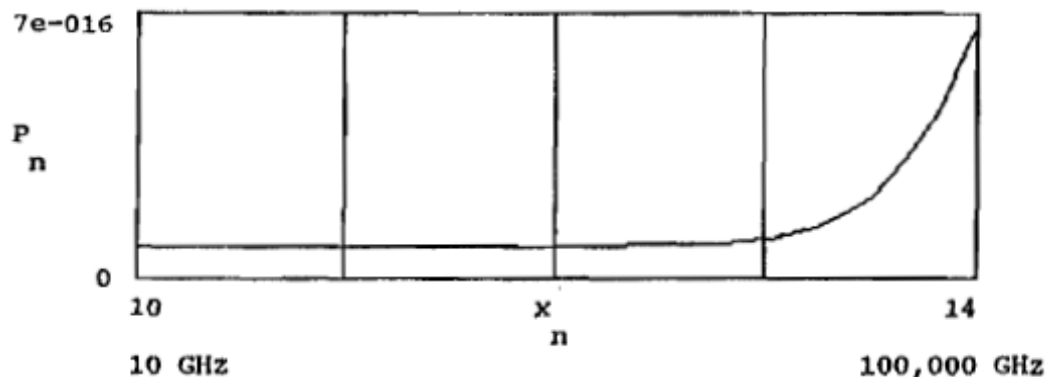
(b.) $P_{EIRP} = P_{Tx} G_A = 0.1 (363.4) = 36.3 \text{ W}$

(c.) $P_{Rx} = P_{Tx} G_A G_R \left(\frac{\lambda}{4\pi d}\right)^2 = (0.1)(363.4)^2 \left[\frac{(0.15)(3.28)}{4\pi(15)(5280)}\right]^2$

$\Rightarrow P_{Rx} = 3.23 \times 10^{-9} \text{ W}$

or $(P_{Rx})_{\text{dBm}} = 10 \log\left(\frac{3.23 \times 10^{-9}}{10^{-3}}\right) = -54.9 \text{ dBm}$

8-10. $n := 100 \dots 140$ $h := 6.6252 \cdot 10^{-34}$ $k := 1.381 \cdot 10^{-23}$
 $T := 300$
 $R := 10000$ $x_n := \frac{n}{10}$ $f_n := 10^{x_n}$
 $P_n := 2 \cdot R \left[\frac{h f_n}{2} + \frac{h \cdot f_n}{\frac{h \cdot f_n}{k \cdot T} - 1} \right]$



8-13.

$$(P_{av})_{in} = R_s \left(\frac{E_s}{R_s} \right)^2 = \frac{E_s^2}{4R_s}, \quad (P_{av})_{out} = \frac{V_{out}^2}{R_{out}} \text{ where } R_L = R$$

$$V_{out} = (h_{fe} i) \frac{R}{2} = \frac{h_{fe}}{2} \left(\frac{E_s}{R_s + h_{ie}} \right) R$$

$$\Rightarrow (P_{av})_{out} = \frac{\left(\frac{h_{fe}}{2} \right)^2 \left(\frac{E_s}{R_s + h_{ie}} \right)^2 R^2}{R} = \left(\frac{h_{fe}}{2} \right)^2 \left(\frac{E_s}{R_s + h_{ie}} \right)^2 \left(\frac{1}{h_{oe}} \right)$$

$i = E_s / (R_s + h_{ie})$ $R = 1/h_{oe}$

$$\Rightarrow G_a = \frac{(P_{av})_{out}}{(P_{av})_{in}} = \frac{\frac{1}{4} h_{fe}^2 \frac{1}{h_{oe}} \left(\frac{1}{R_s + h_{ie}} \right)^2 E_s^2}{\frac{1}{4} E_s^2 / R_s}$$

$$\Rightarrow G_a = \frac{h_{fe}^2 R_s}{h_{oe} (R_s + h_{ie})^2}$$

8-17.

$$(a.) \quad T_{eff} = T_0 (F-1) \\ = 290 (10^{16} - 1) = \underline{\underline{129^\circ K}}$$

$$(b.) \quad P_{a_{out}} = K T_{in} B G_a$$

$$= (1.38 \times 10^{-23}) (30^\circ + 129^\circ) (10 \times 10^6) (10^3)$$

$$= \underline{\underline{2.2 \times 10^{-11} \text{ W}}}$$

$$= 10 \log_{10} \left(\frac{2.2 \times 10^{-11}}{10^{-3}} \right) = \underline{\underline{-76.6 \text{ dBm}}}$$

8-19.

From Table 7-1 for FSK w/ incoherent detection:

$$P_e = \frac{1}{2} e^{-\frac{1}{2}(E_b/N_{total})}$$

$$N_{total} = k(T_0 + T_{eff}) = k(T_0 + (F-1)T_0) = kFT_0$$

$$\begin{matrix} \uparrow \\ T_{eff} = (F-1)T_0 \end{matrix}$$

$$= (1.38 \times 10^{-23}) (10^{6/10}) (290)$$

$$\frac{E_b}{N_{total}} = \frac{P_s T}{N_{total}} = \frac{P_s}{N_{total} R} = \frac{V_s^2 / R_A}{k F T_0 R} = 28.53$$

$$P_e = \frac{1}{2} e^{-\frac{1}{2}(28.53)} = \underline{\underline{3.2 \times 10^{-7}}}$$

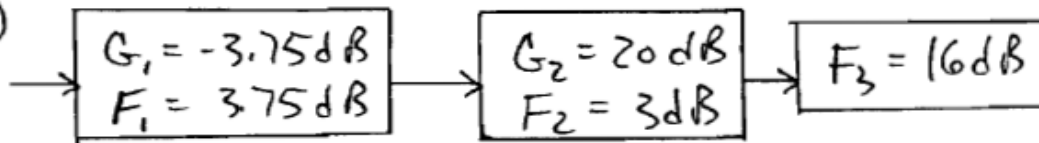
8-22. (a.) $F = F_1 + \frac{F_2 - 1}{G_1}$

$$F_1 = 125 \text{ ft} \left(\frac{3 \text{ dB}}{100 \text{ ft}} \right) = 3.75 \text{ dB} = 10^{.375} = 2.37$$

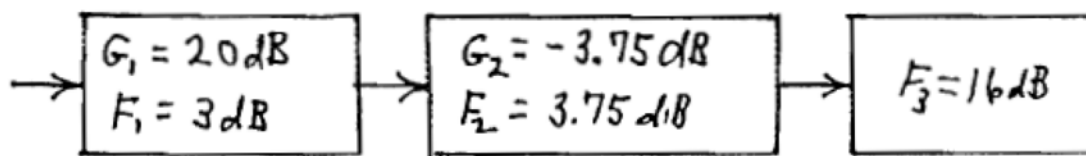
$$F = 2.37 + \frac{10^{1.6} - 1}{1/2.37} = \underline{\underline{94.4}} \Rightarrow \underline{\underline{19.8 \text{ dB}}}$$

8-22, Cont'd.

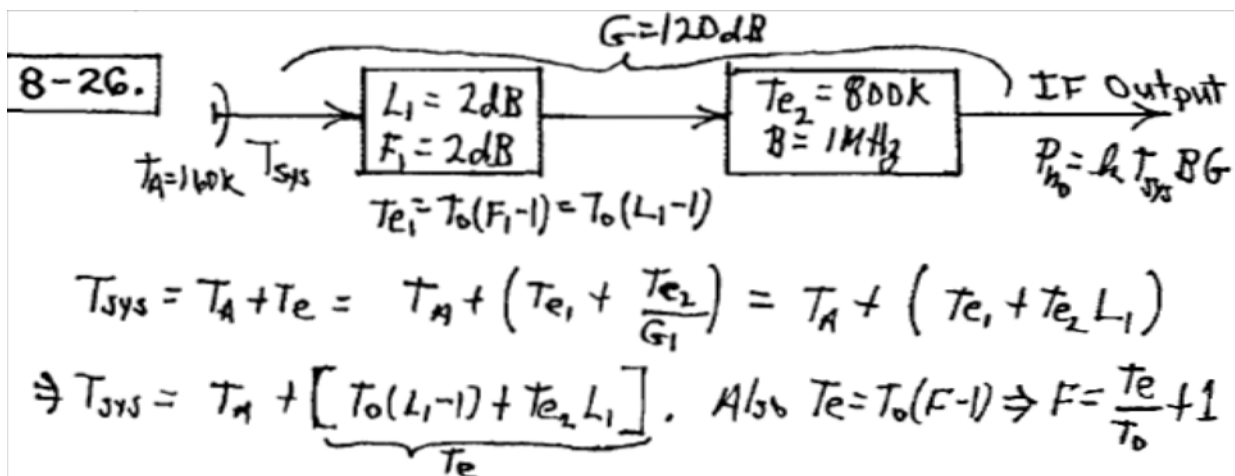
(b)



$$\begin{aligned}
 F &= F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} \\
 &= 2.37 + \frac{(10^{3.75} - 1)}{1/2.37} + \frac{(10^{1.6} - 1)}{10^2/2.37} \\
 &= 2.37 + 2.36 + 0.92 = \underline{\underline{5.65}} \Rightarrow \underline{\underline{7.52 \text{ dB}}}
 \end{aligned}$$



$$\begin{aligned}
 F &= 2 + \frac{2.37 - 1}{100} + \frac{10^{1.6} - 1}{\frac{100}{2.37}} \\
 \Rightarrow F &= 2 + 0.0137 + 0.92 = \underline{\underline{2.93}} = \underline{\underline{4.67 \text{ dB}}}
 \end{aligned}$$



(a) Compute the system noise temperature T_s evaluated at the antenna input of the waveguide:

$$T_a := 160 \text{ K}$$

$$T_o := 290 \text{ K}$$

$$T_{e2} := 800 \text{ K}$$

$$L_1 := 10^{0.2}$$

$$G := 10^{12}$$

$$B := 10^6 \text{ Hz}$$

$$T_e := T_o \cdot (L_1 - 1) + T_{e2} L_1$$

$$T_s := T_a + T_e$$

$$\underline{\underline{T_s = 1597.534 \text{ K}}}$$

(b) Noise figure F :

$$F := \frac{T_e}{T_o} + 1$$

$$\underline{\underline{F = 5.957}}$$

$$F_{dB} := 10 \cdot \log(F)$$

$$\underline{\underline{F_{dB} = 7.75}}$$

(c) The available output noise power P_{no} :

$$P_{no} := 1.38 \cdot 10^{-23} \cdot T_s \cdot B \cdot G$$

$$\underline{\underline{P_{no} = 0.022 \text{ Watt}}}$$

8-28.

Assume 4 GHz down link

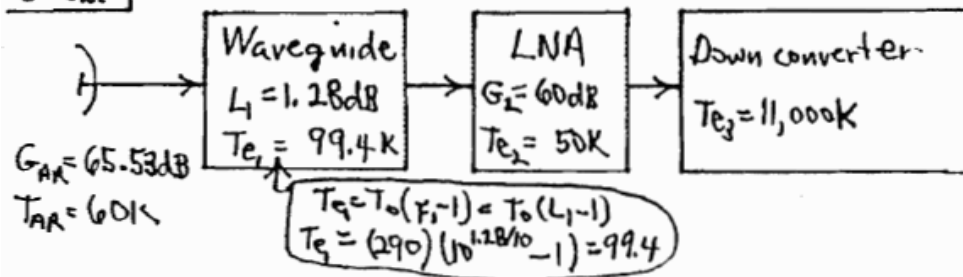
$$\frac{G_{AR}}{T_{sys}} = 10^4 = \frac{4\pi\eta[\pi(15)^2]}{85\left(\frac{3 \times 10^8}{4 \times 10^9}\right)^2} = 1.86 \times 10^4 \eta$$

$$\Rightarrow \underline{\underline{\eta = 54\%}} \text{ for 30m antenna}$$

$$10^4 = 1.86 \times 10^4 \eta \left[\frac{(12.5)^2}{(15)^2} \right] = 1.29 \times 10^4 \eta$$

$$\Rightarrow \underline{\underline{\eta = 77.4\%}} \text{ for 25m antenna}$$

8-32.



$$(a.) T_s = (T_{AR} + T_{e1}) G_1 + \left(T_{e2} + \frac{T_{e3}}{G_2} \right) = \frac{T_{AR} + T_{e1}}{L_1} + \left(T_{e2} + \frac{T_{e3}}{G_2} \right)$$

$$G_s = G_{AR} G_1 = \frac{G_{AR}}{L_1}$$

$$(b.) T_s = T_{AR} + T_e = T_{AR} + \left(T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1 G_2} \right)$$

$$\neq T_s = T_{AR} + \left(T_{e1} + T_{e2} L_1 + T_{e3} \frac{L_1}{G_2} \right)$$

$$G_s = G_{AR}$$

$$(c.) T_s = (T_{AR} + T_{e1}) G_1 G_2 + T_{e2} G_2 + T_{e3} = (T_{AR} + T_{e1}) \frac{G_2}{L_1} + T_{e2} G_2 + T_{e3}$$

$$G_s = G_{AR} G_1 G_2 = \frac{G_{AR} G_2}{L_1}$$

$$G_{AR} := 10^{\frac{65.53}{10}}$$

$$L_1 := 10^{\frac{1.28}{10}}$$

$$G_2 := 10^{\frac{60}{10}}$$

$$T_{e3} := 11000$$

$$T_{AR} := 60$$

$$T_{e1} := 290 \cdot (L_1 - 1)$$

$$T_{e2} := 50$$

$$(a.) T_s := \frac{T_{AR} + T_{e1}}{L_1} + T_{e2} + \frac{T_{e3}}{G_2}$$

$$T_s = 168.723$$

$$G_s := \frac{G_{AR}}{L_1}$$

$$G_s = 2.661 \cdot 10^6$$

$$GT_{\text{sdB}} := 10 \cdot \log \left(\frac{G_s}{T_s} \right)$$

$$GT_{\text{sdB}} = 41.978$$

(b.)

$$T_s := T_{AR} + T_{e1} + T_{e2} \cdot L_1 + T_{e3} \cdot \frac{L_1}{G_2}$$

$$T_s = 226.555$$

$$G_s := G_{AR}$$

$$G_s = 3.573 \cdot 10^6$$

$$GT_{\text{sdB}} := 10 \cdot \log \left(\frac{G_s}{T_s} \right)$$

$$GT_{\text{sdB}} = 41.978$$

(c.)

$$T_s := (T_{AR} + T_{e1}) \cdot \frac{G_2}{L_1} + T_{e2} \cdot G_2 + T_{e3}$$

$$T_s = 1.687 \cdot 10^8$$

$$G_s := G_{AR} \cdot \frac{G_2}{L_1}$$

$$G_s = 2.661 \cdot 10^{12} \quad GT_{\text{sdB}} := 10 \cdot \log \left(\frac{G_s}{T_s} \right)$$

$$GT_{\text{sdB}} = 41.978$$

8-34. $f_c = 2 \text{ GHz} ; \lambda = \frac{c}{f} = \frac{3 \times 10^8}{2 \times 10^9} = .15 \text{ m}$

$$\frac{E_b}{N_0} = \frac{P_{TX} G_{AT} G_{FS} G_{AR}}{K T_{sys} R}$$

$$G_{AT} = \frac{E_b}{N_0} \frac{K T_{sys} R}{P_{TX} G_{FS} G_{AR}}$$

$$G_{FS} = \left(\frac{\lambda}{4\pi d} \right)^2 \cdot L_{incidental} = \left(\frac{0.15}{4\pi (7.5 \times 10^4)} \right)^2 (10^{-0.2}) = 1.6 \times 10^{-30}$$

$$G_{AR} = 7\pi \left(\frac{r}{\lambda} \right)^2 = 7\pi \left(\frac{32}{0.15} \right)^2 = 1 \times 10^6$$

$$G_{AT} = \frac{10^{0.988} (1.38 \times 10^{-23}) (16/300)}{10 (1.6 \times 10^{-30}) (10^6)} = 4.03 \times 10^4 \xrightarrow{\text{parabolic}} \frac{7A}{\lambda^2} = \frac{7A}{(0.15)^2}$$

$$\Rightarrow A = 129.44 \text{ m}^2 = \pi r^2$$

$$\pm r = \sqrt{\frac{129.44}{\pi}} = 6.42 \text{ m} \neq \underline{D = 2r = 12.84 \text{ m}} \text{ parabolic ant (rather large)}$$

8-37. Using (8-47) and (8-8)

$$P_{dBm}(d) = P_{dBm}(d_0) - 10n \log\left(\frac{d}{d_0}\right)$$

$$\text{where } P_{dBm}(d_0) = (P_T)_{dBm} + (G_{TA})_{dBm} - 20 \log\left(\frac{4\pi d_0}{\lambda}\right) + (G_{AR})_{dBm}$$

$$= 40 + 18 - 20 \log\left(\frac{4\pi (0.25 \text{ miles}) (5280 \text{ ft/mile}) (1 \text{ m})}{3 \times 10^8 / 1.8 \times 10^9}\right) + 0 \rightarrow 89.64$$

$$\Rightarrow P_{dBm}(d_0) = -31.64 \text{ dBm}$$

	Power Received (dBm)				
Distance (miles)	0.25	1	2	5	10
$n=2$ (free space)	-31.6	-43.7	-49.7	-57.7	-63.7
$n=3$	-31.6	-49.7	-58.7	-70.6	-79.7
$n=4$	-31.6	-55.7	-67.8	-83.7	-95.7

8-41. First determine the value of K

by using the average power reading:

$$s(t) = m(t) \cos \omega_c t \quad ; \quad m(t) \text{ shown in figure P8-41}$$

$$S_{rms}^2 = \frac{1}{2} \langle m^2(t) \rangle$$

$$= \frac{1}{2T} \int_0^T m^2(t) dt$$

$$\left\{ \begin{array}{l} T = 63.5 \mu\text{sec} \\ 0.835 T = 53 \mu\text{sec} \\ 0.165 T = 10.5 \mu\text{sec} \\ .075 T = 4.76 \mu\text{sec} \end{array} \right.$$

$$\begin{aligned}
&= \frac{1}{2T} \left[(.75K)^2 (.165T - .075T) + K^2 (.075T) \right. \\
&\quad \left. + (.5K)^2 (.835T) \right] \\
&= \frac{K^2}{2} \left[(.75)^2 (.09) + 1 (.075) + (.5)^2 (.835) \right] \\
&= \frac{K^2}{2} [.0506 + .075 + .2087] = \frac{K^2}{2} (.3343) \\
\Rightarrow S_{rms}^2 &= 0.1672 K^2 \\
P_{AV} &= 6.9 \times 10^3 = \frac{.1672 K^2}{50} = \frac{S_{rms}^2}{50} \\
\Rightarrow K &= \sqrt{\frac{50(6.9 \times 10^3)}{.1672}} = 1436.6 \\
P_{PEP} &= \frac{V_{max}^2}{2(50)} = \frac{K^2}{100} = \frac{(1436.6)^2}{100} = \underline{\underline{20.64 \text{ Kw}}}
\end{aligned}$$

8-43. The available bandwidth is

$$B_T = \frac{1}{2} f_h = \frac{1}{2} (15.734) = 7.867 \text{ kHz}$$

Referring to Fig. 8-33, the spectrum of the professional subcarrier (PSC) needs to roll off fast enough so that it does not interfere with the SAP FM subcarrier and the DSB-SC stereo subcarrier. Since the SAP subcarrier is FM, the capture effect of the FM detector will suppress the PSC interference when the PSC spectrum is, say, 10 to 15 dB below the SAP spectrum (in the SAP band). Referring to Fig. 5-33, it is seen that these interference specifications are easily satisfied if the first-null bandwidth criterion is used. Thus, for the M-ary signal class,

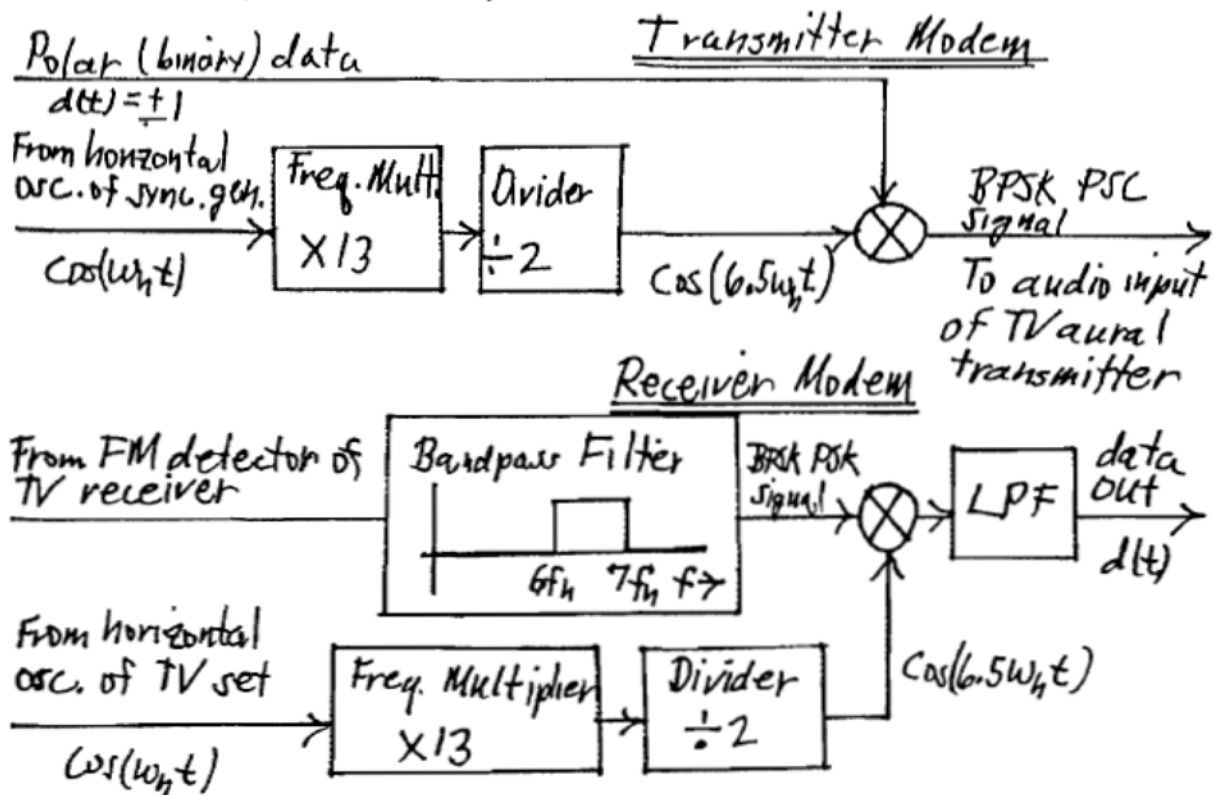
8-43. Cont'd

$$B_T = 2 \left(\frac{R}{\ell} \right) \leq 7.867 \text{ or } \ell \geq \left(\frac{2R}{7.867} \right)$$

(a) For $R = 1.2 \text{ kb/s}$, $\ell \geq \left(\frac{2(1.2)}{7.867} \right) = 0.305$.

\Rightarrow Choose $\ell = 1 \Rightarrow$ Use BPSK signaling

A $R = 1200 \text{ b/s}$ BPSK system is shown below.

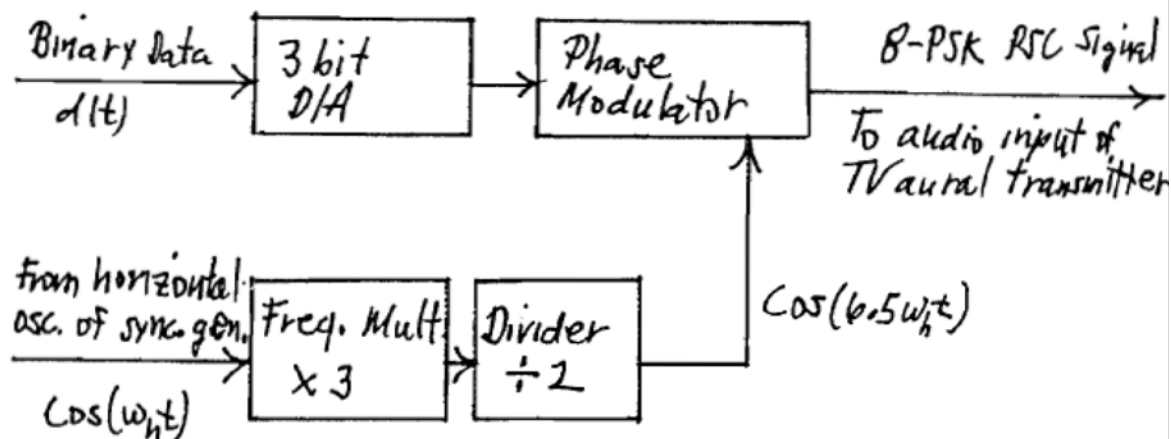
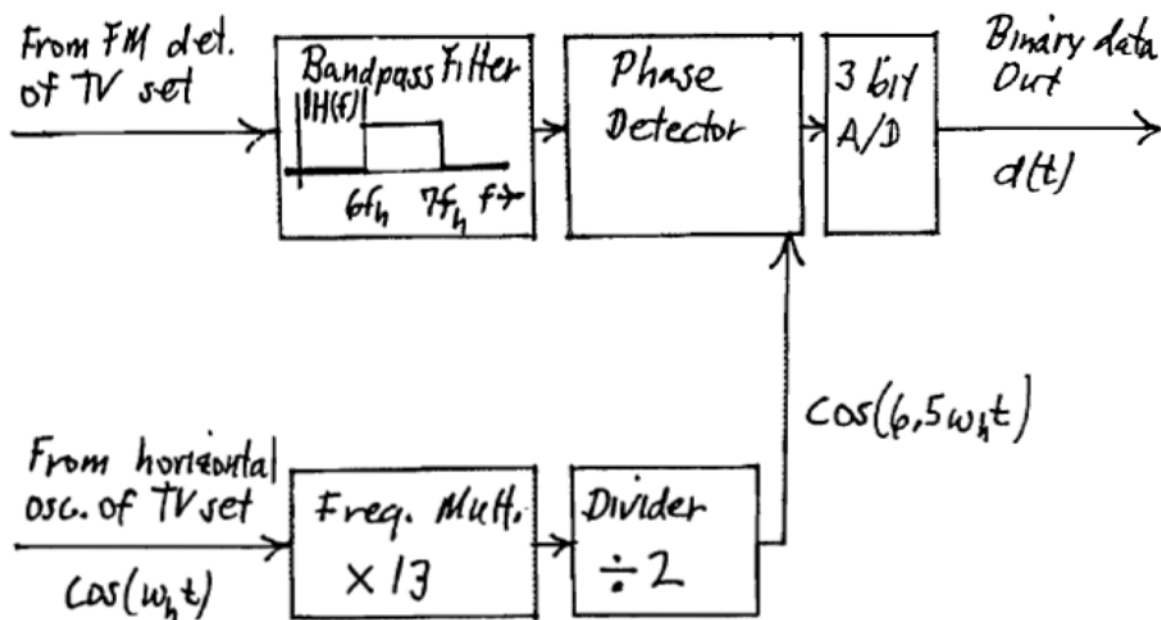


(b) For $R = 9.6 \text{ kb/s}$, $\ell \geq \left(\frac{2(9.6)}{7.867} \right) = 2.44$

\Rightarrow Choose $\ell = 3 \Rightarrow M = 2^3 = 8$

\Rightarrow Use 8-PSK

8-43.(b) Cont'd

A $R=9600$ b/s 8-PSK system is shown belowTransmitter ModemReceiver Modem

8-45.

$$R_{\text{with Coding}} = (R_{\text{without Coding}}) \left(\frac{1}{R_{\text{TCM}}} \right) \left(\frac{1}{R_{\text{RS}}} \right) = 19.39 \left(\frac{3}{2} \right) \left(\frac{207}{187} \right)$$

$$\Rightarrow R_{\text{with Coding}} = 32.20 \text{ Mb/s}$$

$$\Rightarrow D_{\text{with Coding}} = \frac{R_{\text{with Coding}}}{l} = \frac{32.2}{3} = 10.73 \text{ Mbaud}$$

$(l=3 \text{ for } 8 \text{ levels})$

The segment sync replaces the payload sync at the beginning of each segment. One segment of training data is added after 312 segments.

Thus,

$$D_{\text{overall}} = (D_{\text{with Coding}}) \left(\frac{312+1}{312} \right) = 10.73 \left(\frac{312+1}{312} \right) = \underline{\underline{10.76 \text{ Mbaud}}}$$