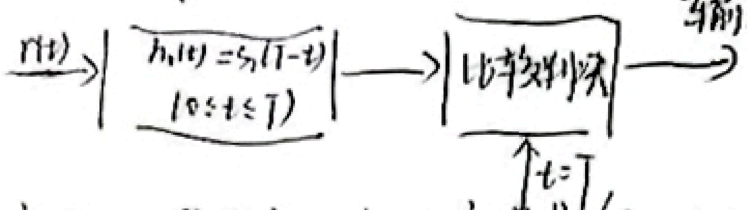
9-2

2ASK信号的最佳接收机结构



判决门限 $E_b/2$

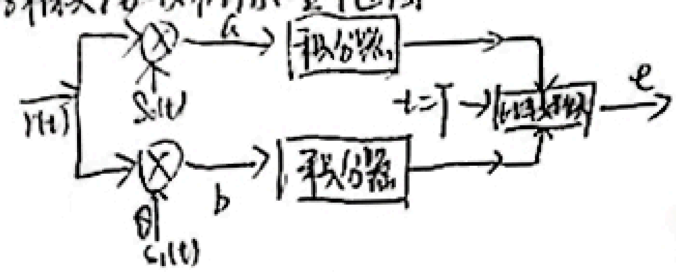
$$E_b=\int_0^T s_1^2(t)dt=A^2\frac{T}{2}$$

设高斯白噪声双边功率谱密度为 $n_0/2$，则2ASK误码率为

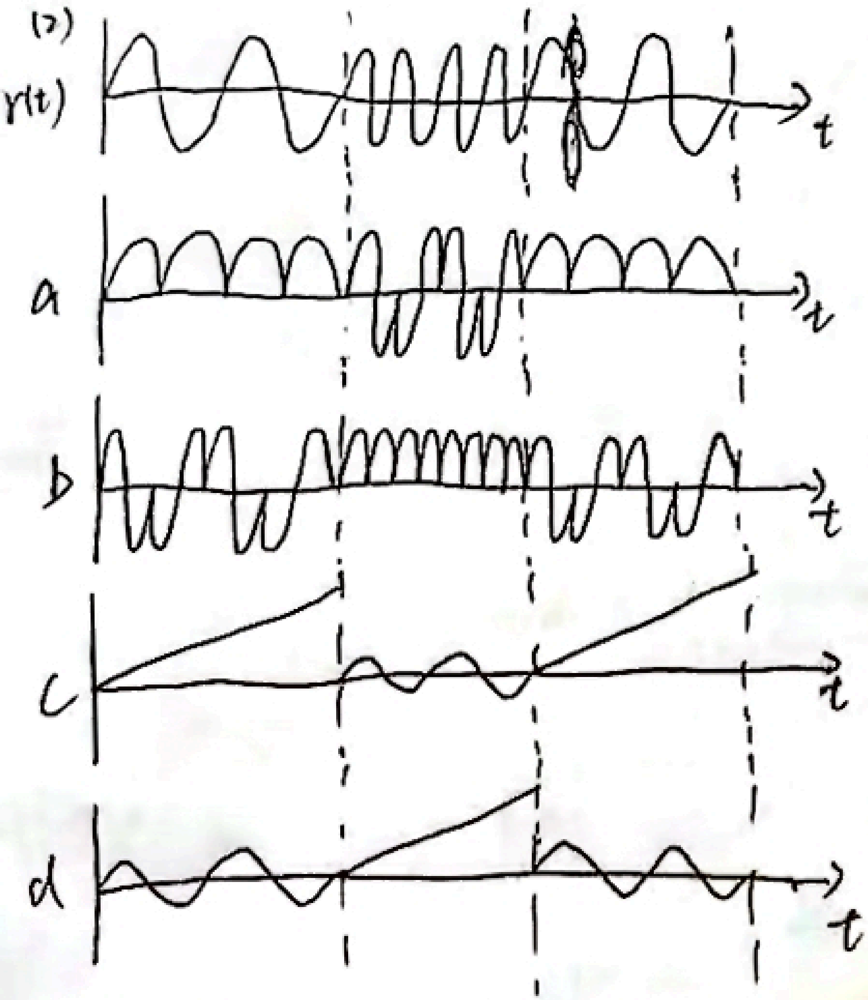
$$P_e=\frac{1}{2}\mathrm{erfc}\sqrt{\frac{E_b}{4n_0}}=\frac{1}{2}\mathrm{erfc}\sqrt{\frac{A^2T}{8n_0}}$$

9-3

解(1) 2FSK的相关接收机原理框图



(2)



(3) $E_b=E_1=E_0$

$$=\int_0^{T_B}s_1^2(t)dt$$

$$=\int_0^{T_B}s_2^2(t)dt=\frac{A^2T_B}{2}$$

系统误码率：

$$P_e=\frac{1}{2}\mathrm{erfc}\sqrt{\frac{E_b}{2n_0}}$$

$$=\frac{1}{2}\mathrm{erfc}\sqrt{\frac{A^2T_B}{4n_0}}$$

9-8

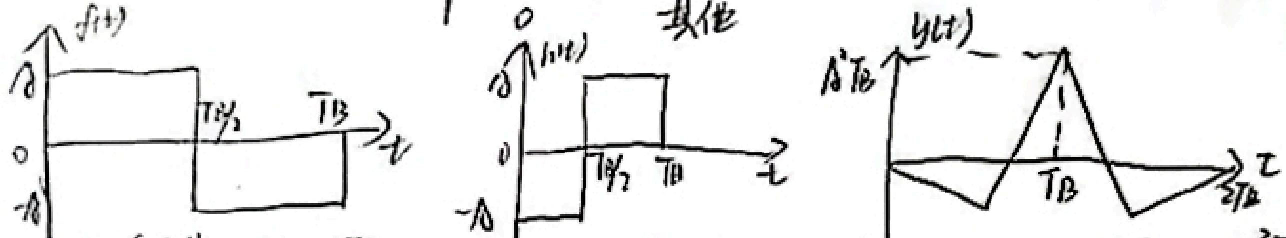
解 (1) 最大输出信噪比时刻应选在信号码元结束时刻或之后，即 $t_0 \geq T_B$

(2) 若取 $t_0=T_B$，$K=1$，则匹配滤波器的冲激响应

$$h(t)=Kf(T_B-t)=\begin{cases}-A & 0\le t\le T_B/2\\ A & T_B/2<t\le T_B\\ 0 & \text{其他}\end{cases}$$

输出信号

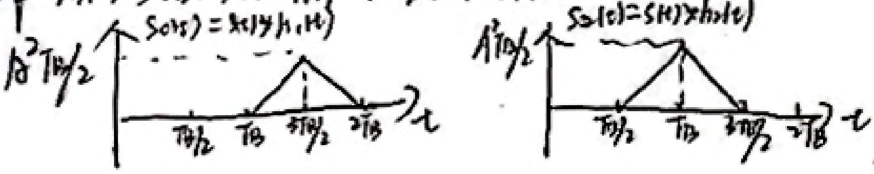
$$y(t)=h(t)*f(t)=\begin{cases}-A^2t & 0\le t\le T_B/2\\ A^2(3t-2T_B) & T_B/2<t\le T_B\\ A^2(4T_B-3t) & T_B<t\le 3T_B/2\\ A^2(t-2T_B) & 3T_B/2<t\le 2T_B\\ 0 & \text{其他}\end{cases}$$



(3) 信号码元能量为 $E=\int_0^{T_B} f^2(t)\,dt=A^2T_B$ 最大输出信噪比为 $r_{0max}=\frac{2E}{n_0}=\frac{2A^2T_B}{n_0}$

9-9

解 $h_1(t)$ 与 $h_2(t)$ 的输出波形如图所示



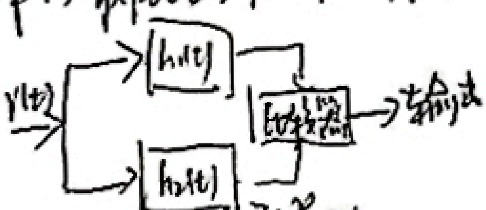
$h_1(t)=s(3T_B/2-t)$

$h_2(t)=s(T_B-t)$

且如果取样时刻为 T_B，所以二者均可作匹配滤波器

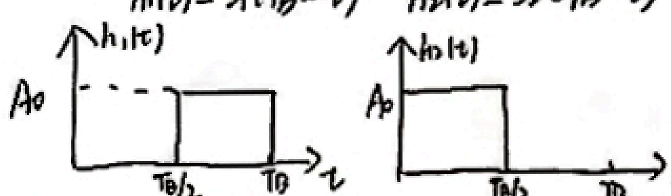
9-10

解 (1) 最佳接收机结构如图所示



(2) 匹配滤波器的单位冲激响应分别为

$h_1(t)=s_1(T_B-t)$ $h_2(t)=s_2(T_B-t)$



(3) 输入信号码元能量为

$E_1=E_2=E_b=\int_0^{T_B} s_1^2(t)\,dt=\int_0^{T_B} s_2^2(t)\,dt=A_0^2T_B/2$

且两波形互相关系数 $\rho=0$

∴ 误码率为

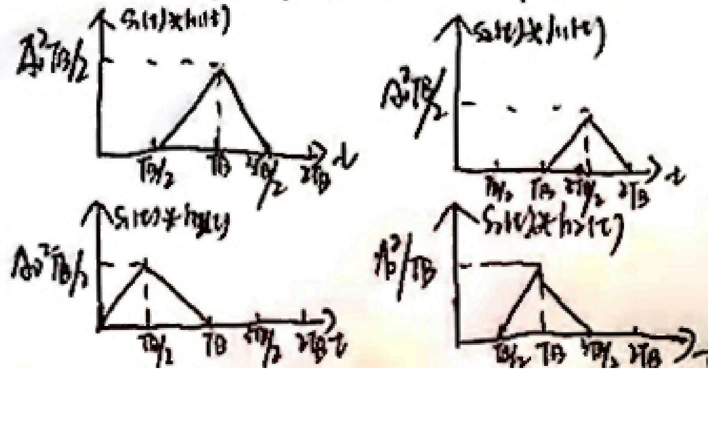
$$P_e=\frac{1}{2}\operatorname{erfc}\left[\sqrt{\frac{E_b(1-\rho)}{2n_0}}\right]$$

$$=\frac{1}{2}\operatorname{erfc}\left[\sqrt{\frac{E_b}{2n_0}}\right]$$

$$=\frac{1}{2}\operatorname{erfc}\left[\sqrt{\frac{A_0^2T_B}{4n_0}}\right]$$

由于输入信号码元可能是 $s_1(t)$ 或 $s_2(t)$，因此共有4种可能的输出波形

a点 $\begin{cases}s_1(t)*h_1(t)\\ s_2(t)*h_1(t)\end{cases}$ b点 $\begin{cases}s_1(t)*h_2(t)\\ s_2(t)*h_2(t)\end{cases}$



10.2

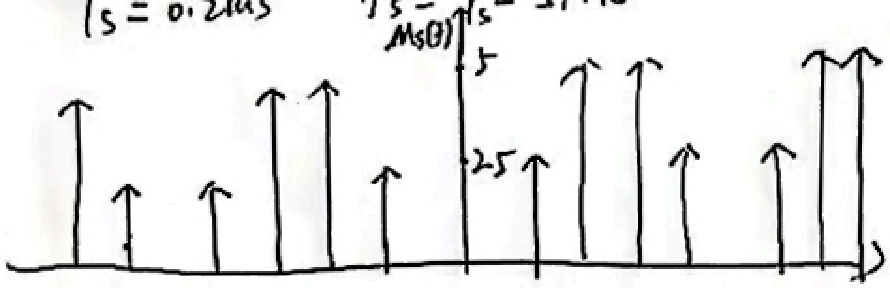
(1) 由 $f_s > 2f_H = 4000Hz$

$T_s = \frac{1}{f_s} < 0.25ms$

(2) m(t) 频谱

$M(f) = \frac{1}{2}[\delta(f-1)+\delta(f+1)] + [\delta(f-2)+\delta(f+2)]$

$T_s = 0.2ms \quad f_s = \frac{1}{T_s} = 5KHz$



10.10

(1) $6350 = 5120 + 320\times3 + 270$

编码为：1 1100011

编码电平：$5120+320\times3=6080$

量化误差：270

(2) $608 = 2^9+2^6+2^5 \quad \therefore \ 01001100000$

(3) $5120 + 320\times3 + \frac{320}{2} = 6240$

$6350-6240 = 110 <$ 半个量化级.

10.11 (1) $-(2560+160\times3+\frac{160}{2})=-3120$

(2) 256 64 32 16 8 4 2 1

0 001 001 1000

10-12

(1) $-(640+40\times7+30)$

00110111 量化误差 30

(2) $640+40\times7=920$

00001011100

10-13 证明：首先使增量调制不过载 → $\left|\frac{dm(t)}{d(t)}\right|_{max} \le \sigma f_s$

则 $2\pi f_0 A \le \sigma f_s$

同时使信号峰值A大于增量调制的起始编码电平

即 $\sigma < 2A$ $\therefore f_s < 2\pi f_0$

10-15 (1) $f_s=8kHz$ $T_s=\frac{1}{f_s}=\frac{1}{8000}s$

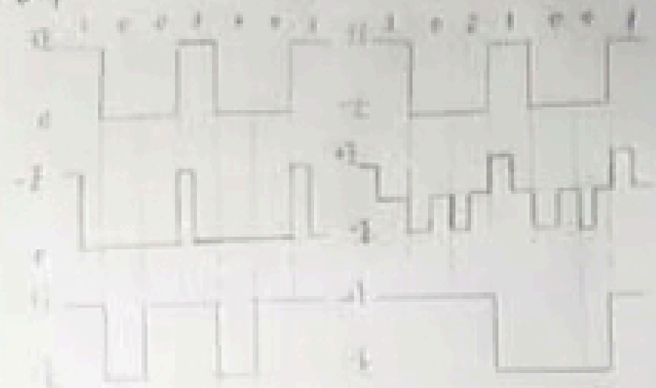
$T_1=\frac{T_s}{10}=\frac{1}{80000}s$ $T_b=\frac{T_1}{3}=\frac{1}{3\times80000}=\frac{1}{240000}s$

$R_b=\frac{1}{T_b}=240kb/s$

(2) $B=\frac{1}{\tau}=R_b=240kHz$

$B_{min}=\frac{1}{2\tau}=R_b=240kHz$

6-1



6-5

(1) 由图P6-2可写出

$$g(t)=\begin{cases} A\left(1-\frac{2}{T_B}|t|\right), & |t|\le \frac{T_B}{2} \\ 0, & 其他 \end{cases}$$

∴ g(t)的傅里叶变换

$$G(f)=\frac{AT_B}{2}Sa^2\left(\frac{\pi f T_B}{2}\right)$$

由题意可知 $P(0)=P(1)=P=\frac{1}{2}$

$g_1(t)=g(t)$, $g_2(t)=0$

∴ $G_1(f)=G(f)$, $G_2(f)=0$

(1.5) ∴ 由单极性基带信号的双边功率谱密度公式

可得 $P_s(f)=f_B P(1-P)|G(f)|^2+\sum_{-\infty}^{\infty}|f_B(1-P)G(mf_B)|^2\delta(f-mf_B)$

$$=\frac{A^2T_B}{16}Sa^4\left(\frac{\pi f T_B}{2}\right)+\frac{A^2}{16}\sum_{-\infty}^{\infty}Sa^4\left(\frac{m\pi}{2}\right)\delta(f-mf_B)$$

(2) 当 $m=\pm1$ 时，该基带信号的离散谱为

$$P_v(f)=\frac{A^2}{16}Sa^4\left(\frac{\pi}{2}\right)\delta(f+f_B)+\frac{A^2}{16}Sa^4\left(\frac{\pi}{2}\right)\delta(f-f_B)$$

∴ 信号存在频率为 $f_B=1/T_B$ 的位定时分量

该频率分量的功率为上式的积分值

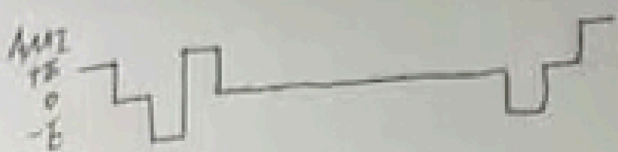
$$S=\frac{A^2}{16}Sa^4\left(\frac{\pi}{2}\right)+\frac{A^2}{16}Sa^4\left(\frac{\pi}{2}\right)=\frac{A^2}{\pi^4}+\frac{A^2}{\pi^4}=\frac{2A^2}{\pi^4}$$

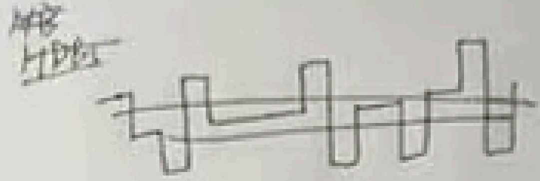
6-7

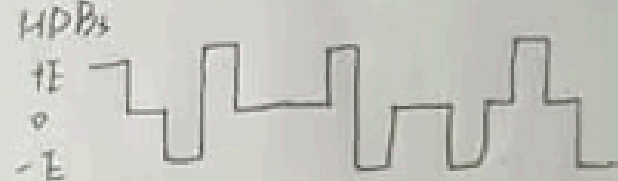
信码 1 0 1 1 0000 0000 0 0 1 0 1

AMI码 +1 0 -1 +1 0000 0000 0 -1 0 +1

HDB3码 +1 0 -1 +1 000+V B00-V 0 +1 0 -1

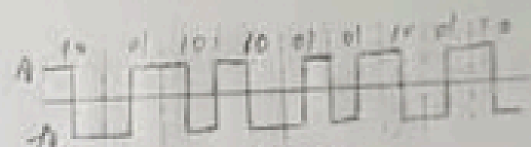




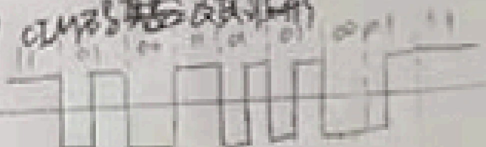


6-8

双相码及其波形



CMI码及其波形



6-11

解：根据奈奎斯特准则，当传码率 $R_B=\frac{1}{T_B}$ Baud 时，无码间串扰的传输特性 $H(\omega)$ 应满足 $\sum_i H(\omega+\frac{2\pi i}{T_B})=C \quad |\omega|\le\frac{\pi}{T_B}$

同理，当 $R_B=\frac{2}{T_B}$ 时，无码间串扰的 $H(\omega)$ 应满足

$$\sum_i H(\omega+\frac{4\pi i}{T_B})=C \quad |\omega|\le\frac{2\pi}{T_B}$$

∴ 除(c)以外，(a)(b)和(d)均不满足上式所述的无码间串扰条件

6-12

解：① 根据奈奎斯特准则，借助 6-11 题中的分析方法可知，三种传输函数都能够满足无码间干扰条件

② (a) $B=\frac{2\times10^3\pi}{2\pi}=10^3Hz \quad \eta=\frac{R_B}{B}=\frac{10^3}{10^3}=1\ (Baud/Hz)$

(b) $B=\frac{2\times10^3\pi}{2\pi}=10^3Hz \quad \eta=\frac{R_B}{B}=\frac{10^3}{10^3}=1\ (Baud/Hz)$

(c) $B=\frac{2\times10^3\pi}{2\pi}=10^3Hz, \quad \eta=\frac{R_B}{B}=\frac{10^3}{10^3}=1\ (Baud/Hz)$

③ (b)是理想低通特性，冲激响应为 Sa 型，难以实现

而(a)(c)三角形特性 —— Sa^2 型 容易实现

综上 选(c)较好

6-13

(1) 此系统可以等效成理想矩形低通特性

$$H_{eq}(\omega)=\begin{cases}1 & |\omega|\le\omega_0\\ 0 & |\omega|>\omega_0\end{cases}$$

∴ 可以实现无码间串扰传输

(2) 最高码元速率：$R_B=\frac{2\omega_0}{2\pi}=\frac{\omega_0}{\pi}$ 带宽 $B=\frac{(1+\alpha)\omega_0}{2\pi}$

$$\therefore \eta=\frac{R_B}{B}=\frac{2}{1+\alpha}$$

6-23 输入波形的峰值畸变为 $D_x=\frac{1}{x_0}\sum_{k=-2,k\neq0}^{2}|x_k|=\frac{1}{8}+\frac{1}{3}+\frac{1}{4}+\frac{1}{16}=\frac{37}{48}$

由 $y_k=\sum_{i=-N}^{N}C_ix_{k-i}$ 可得 $y_{-3}=C_{-1}x_{-2}=-\frac{1}{24}$ $y_{-2}=C_{-1}x_{-1}+C_0x_{-2}=-\frac{1}{72}$ $y_{-1}=C_{-1}x_0+C_0x_{-1}+C_1x_{-2}=-\frac{1}{32}$

$y_0=C_{-1}x_1+C_0x_0+C_1x_{-1}=\frac{5}{6}$ $y_1=C_{-1}x_2+C_0x_1+C_1x_0=-\frac{1}{48}$ $y_2=C_0x_2+C_1x_1=0$ $y_3=C_1x_2=-\frac{1}{64}$

其余 y_k 均为0

∴ 输出波形的峰值畸变为 $D_y=\frac{1}{y_0}\sum_{k=-3,k\neq0}^{3}|y_k|=\frac{6}{5}(\frac{1}{24}+\frac{1}{72}+\frac{1}{32}+\frac{1}{48}+0+\frac{1}{64})=\frac{71}{480}$

7-1

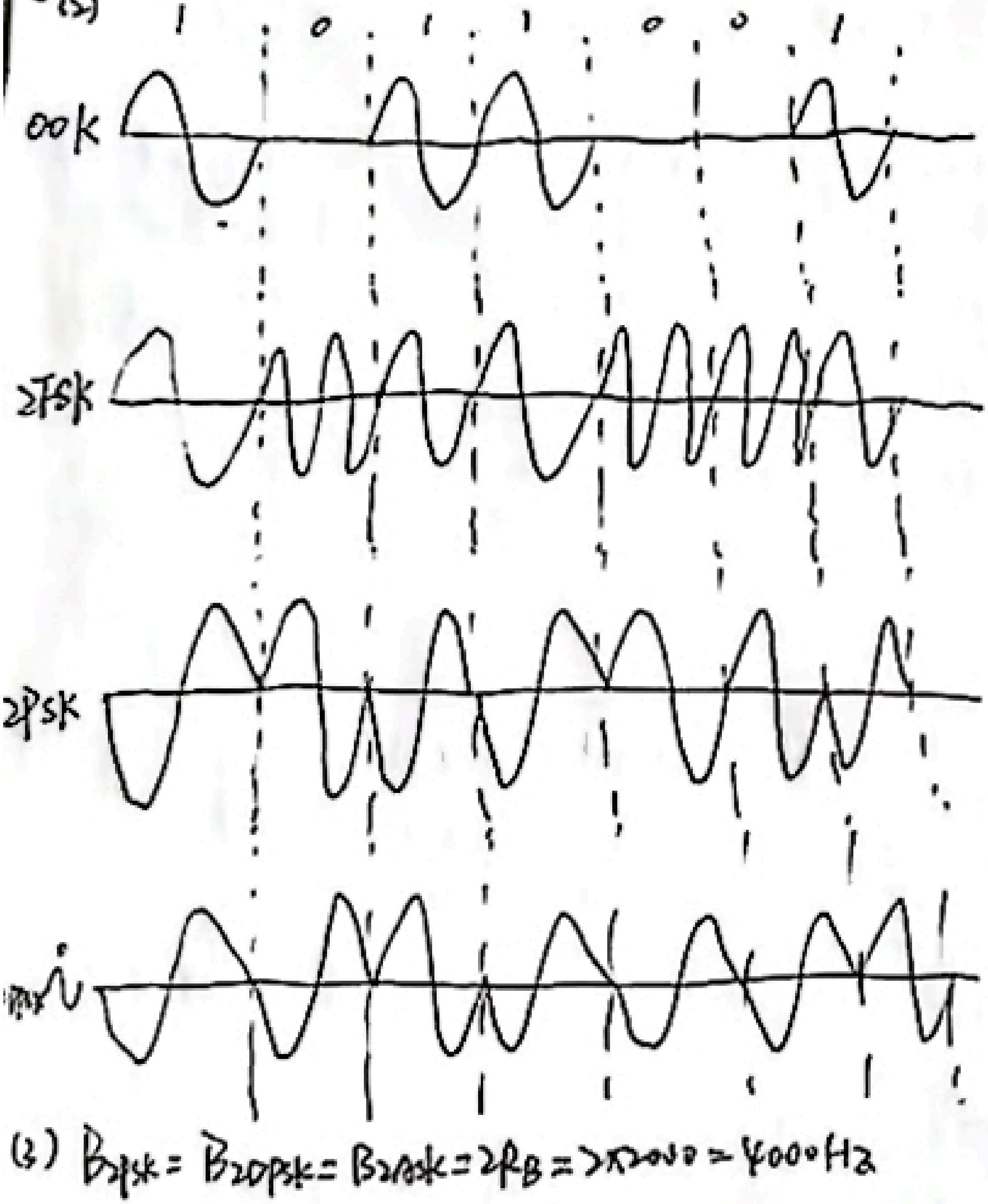
(1) $f_c = \dfrac{8\pi\times10^3}{2\pi} = 4000\,(Hz)$

$R_B = 2000$ Baud,

$n = \dfrac{\frac{1}{R_B}}{\frac{1}{f_c}} = 2$

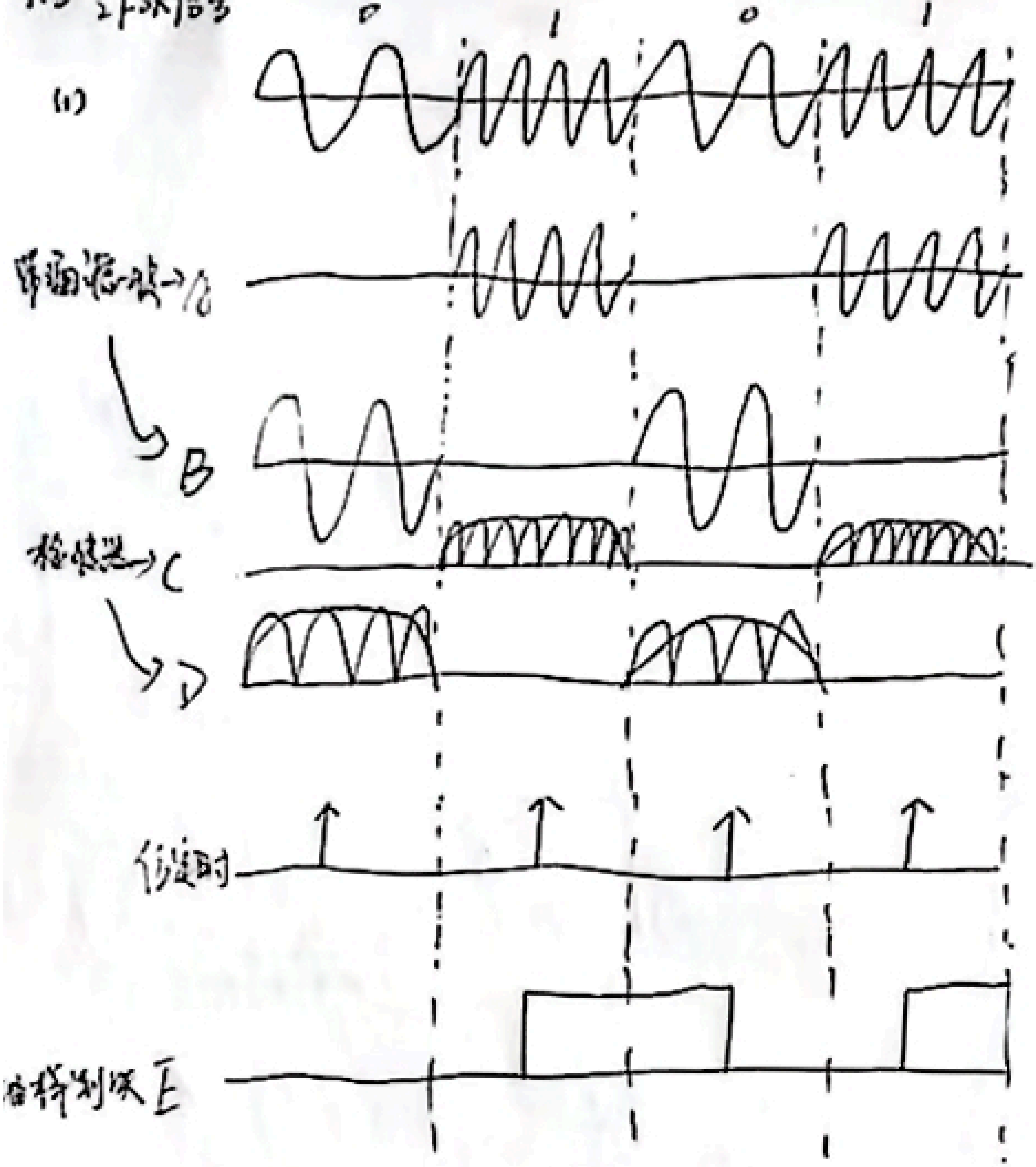
∴包含两个载波周期

(2)

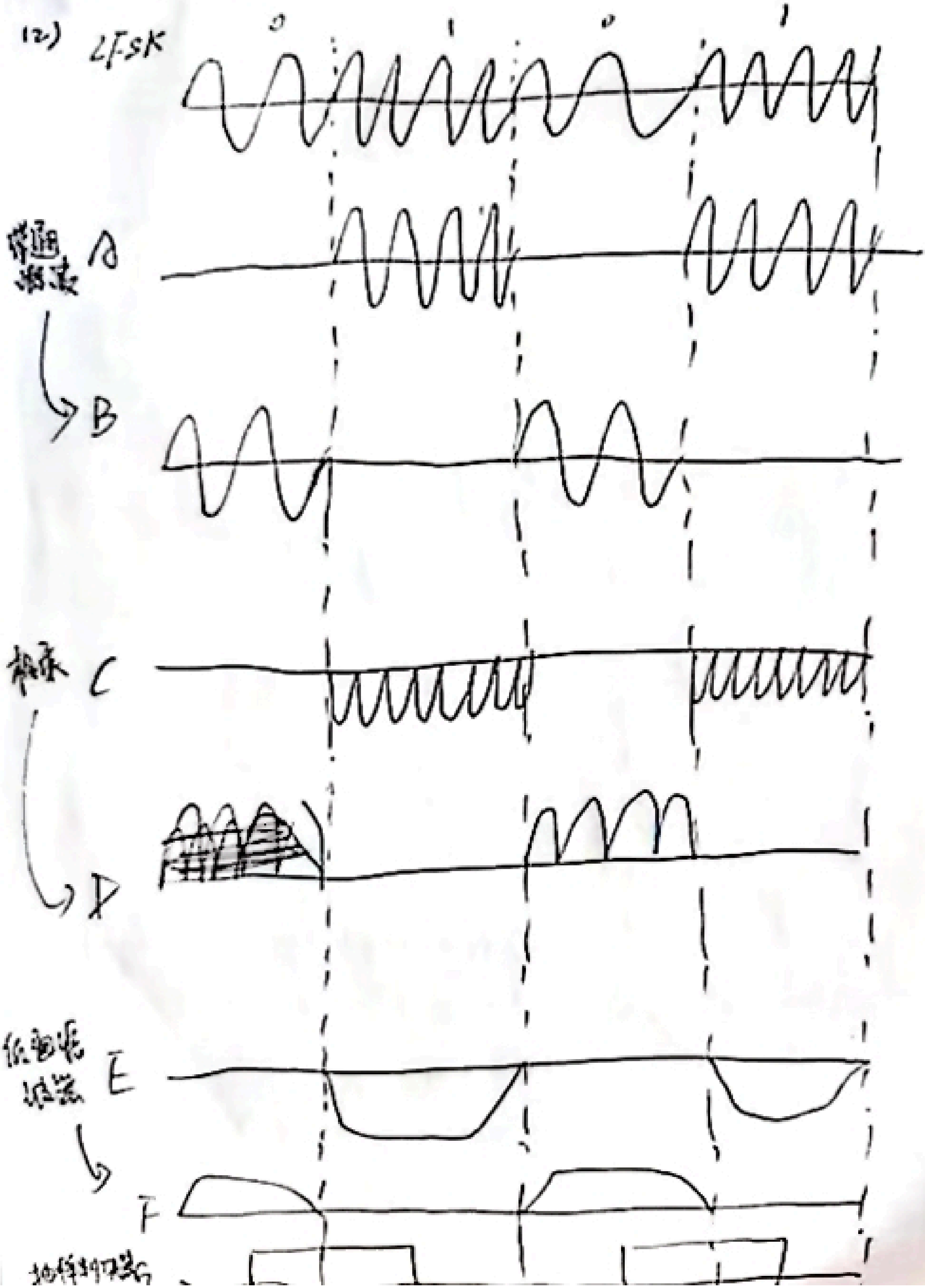


(3) $B_{2PSK} = B_{2DPSK} = B_{2ASK} = 2R_B = 2\times2000 = 4000\,Hz$

7.3 2FSK信号

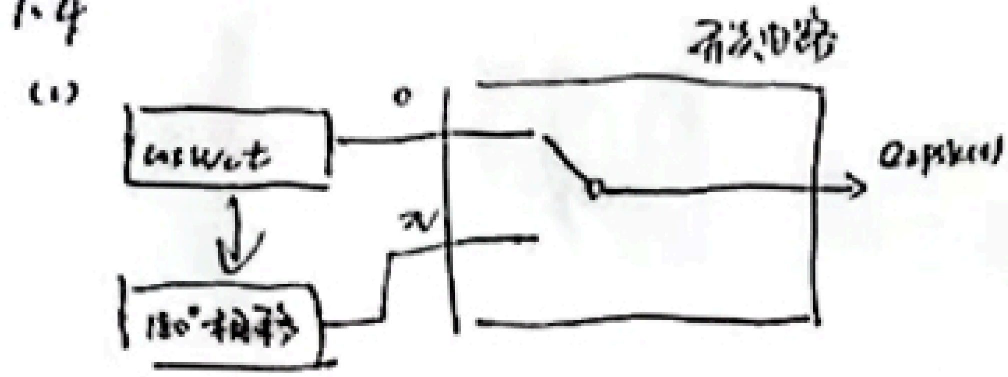


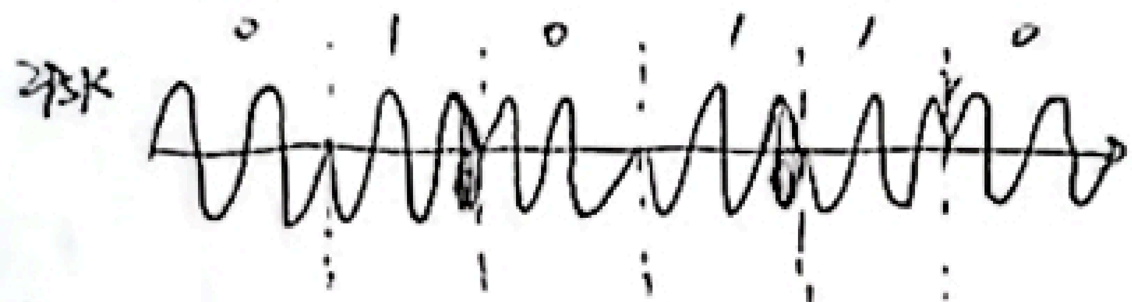
(2)



7.4

(1)

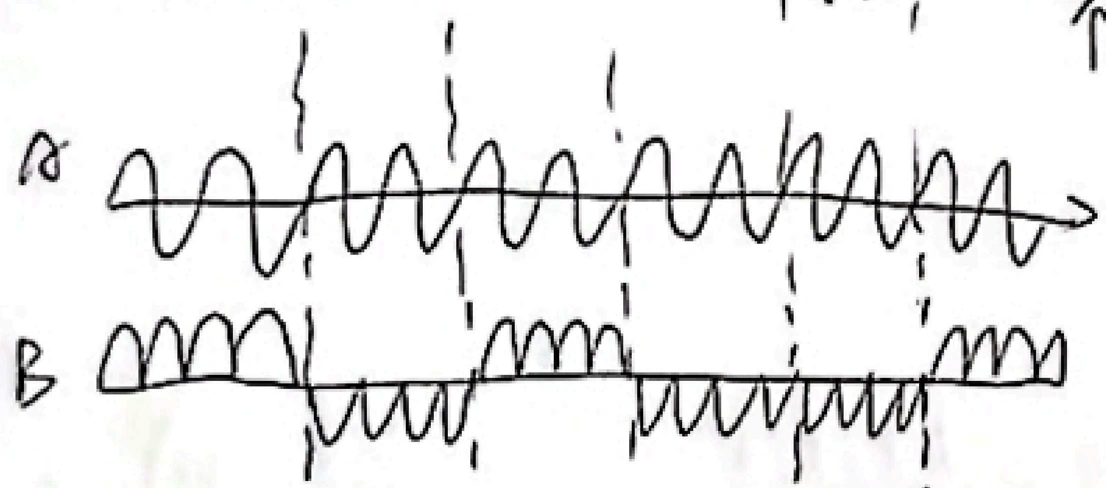




(2)

$\longrightarrow$ 带通滤波器 $\xrightarrow{A}$ 相乘器 $\xrightarrow{B}$ 低通滤波器 $\xrightarrow{C}$ 抽样判决器 $\xrightarrow[D]{输出}$

定时脉冲



(3) $P_{2PSK}(f) = \frac{1}{4}[P_s(f+f_c) + P_s(f-f_c)]$

$$P_s(f) = 4f_B P(1-P)|G(f)|^2 + \sum_{m=-\infty}^{\infty} |f_B(2P-1)G(mf_B)|^2 \delta(f-mf_B)$$

$$G(f) = T_B\left(\frac{\sin \pi f T_B}{\pi f T_B}\right) = T_B Sa(\pi f T_B)$$

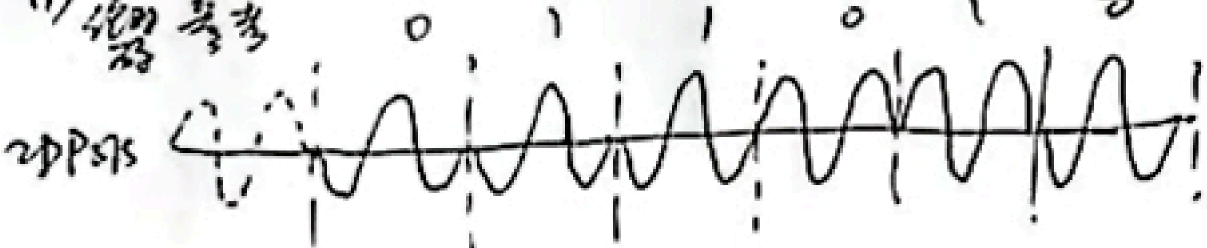
$f=mf_B$时 $G(mf_B) \to m=0$ $G(0) = T_B Sa(0) = T_B \neq 0$ m不为零整数时 $G(mf_B) = T_B Sa(m\pi) = 0$

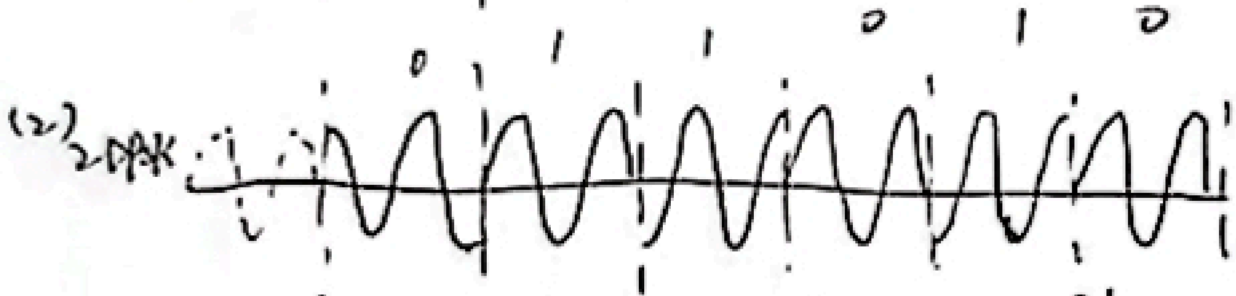
$\therefore P_s(f) = 4f_B P(1-P)|G(f)|^2 + f_B^2 |2P-1|^2 |G(0)|^2 \delta(f)$

$\therefore P_{2PSK}|_{P=0.6,\ f_B=1200,\ G(0)=T_B} = 288[|G(f+f_c)|^2 + |G(f-f_c)|^2] + 0.01[\delta(f+f_c) + \delta(f-f_c)]$

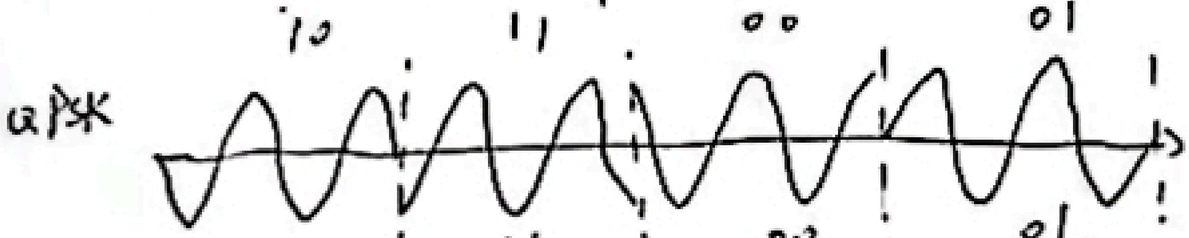
7-5

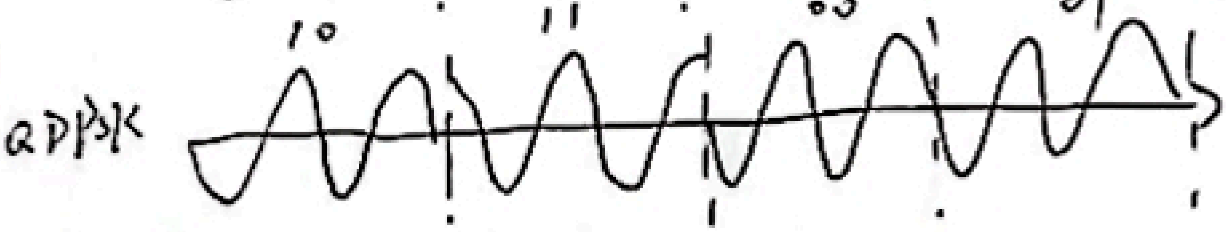
(1) 编码参考





7-13





7-14