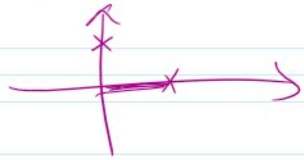
Thursday, November 16, 2023 7:16 PM

Non Coherent →

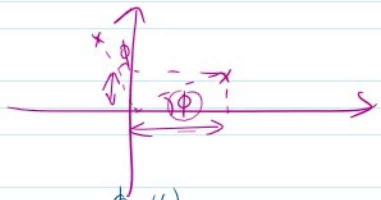
I/p → Modulator → FSK Signal → Channel → Demodulator

FSK $\quad x(t)$

$s(t) \Rightarrow \sqrt{\frac{2E}{T}} \cdot \cos\left(2\pi\left(f_c \pm \frac{1}{2T_b}\right)t\right)$ (+ → 1, − → 0)

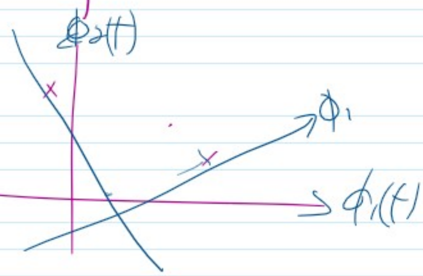


$\sqrt{\frac{2E}{T}} \cdot \cos\left(2\pi\left(f_c \pm \frac{1}{2T}\right)t + \phi\right) \to \hat{\phi}$

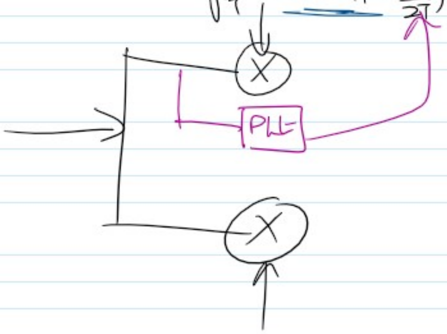


coherently → we use PLL

$\hat{\phi}$

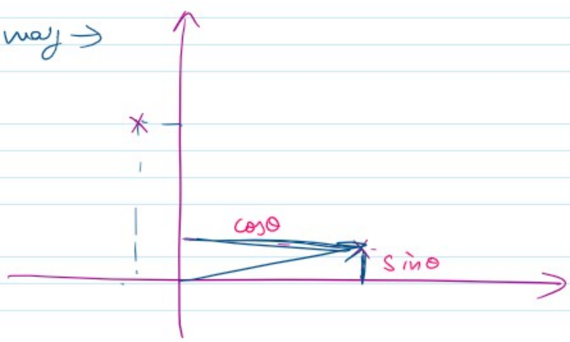


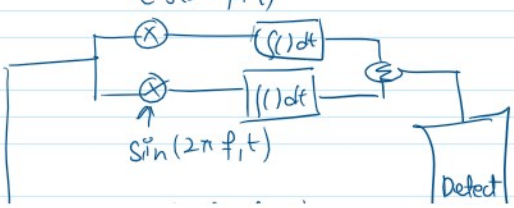
$\sqrt{\frac{2}{T}} \cos\left(2\pi\left(f_c + \frac{1}{2T}\right)t + \hat{\phi}\right)$

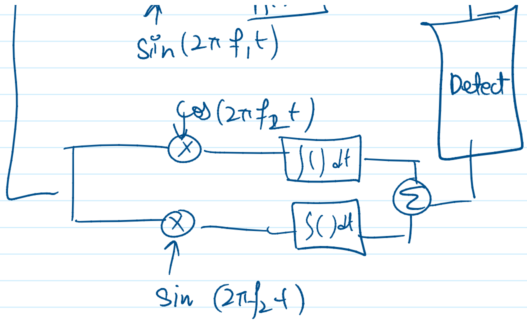


$\sqrt{\frac{2}{T}} \cos\left(2\pi\left(f_c - \frac{1}{2T}\right)t + \hat{\phi}\right)$

Non Coherent way →

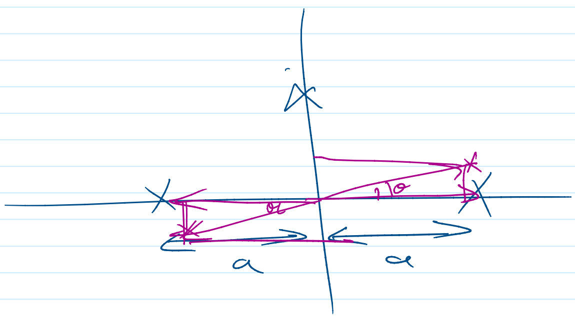


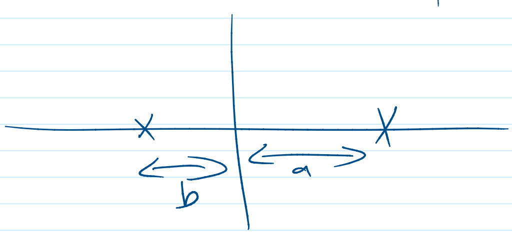




Error probability BER

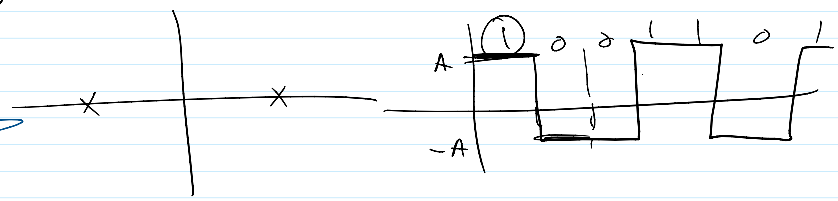
FSK, NC → $\frac{1}{2} e^{-\frac{E_b}{2N_0}}$

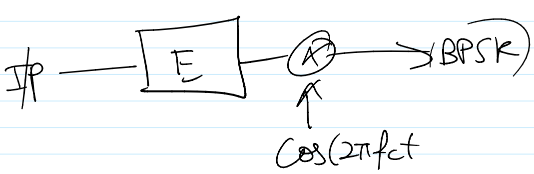


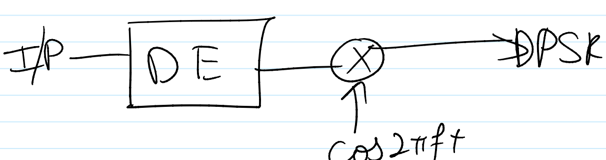


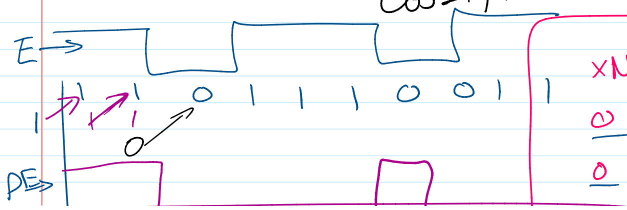
DPSK →

BPSK →







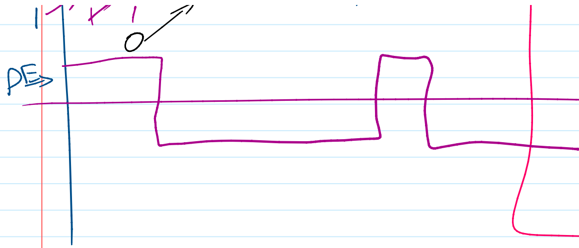


XNOR table

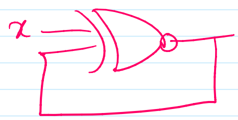
0	0	1
0	1	0

XOR Table

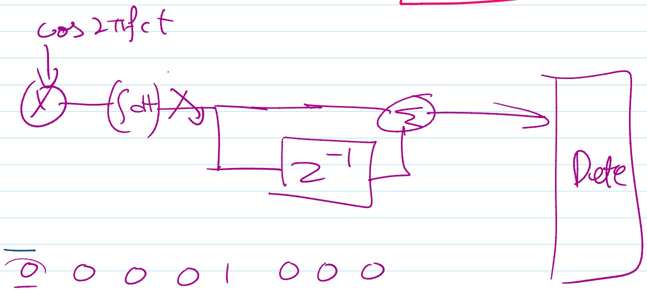
0	0	0
0	1	1



0	0	1	0	0	0
0	1	0	0	1	1
1	0	0	1	0	1
1	1	1	1	1	0

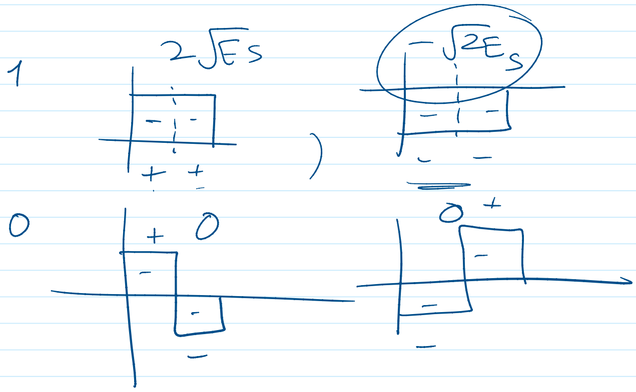


Rx →



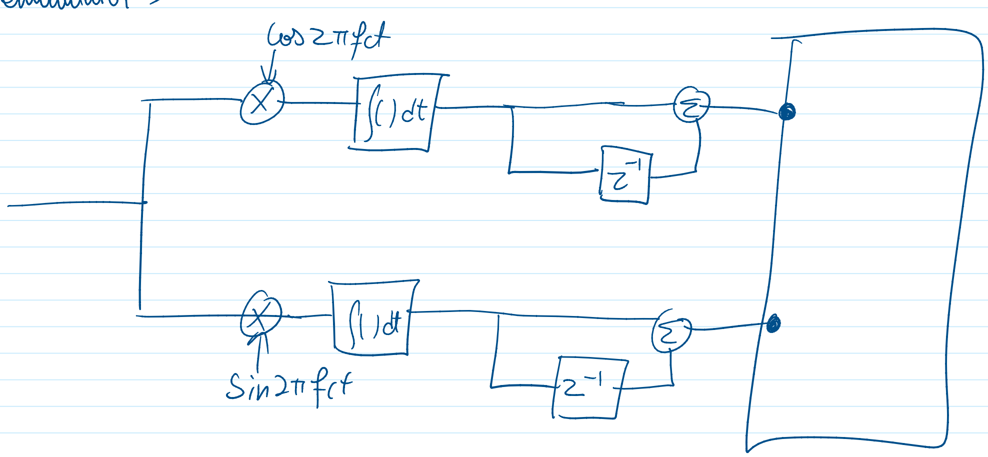
1 1 0 0 0 0 1 0 0 0

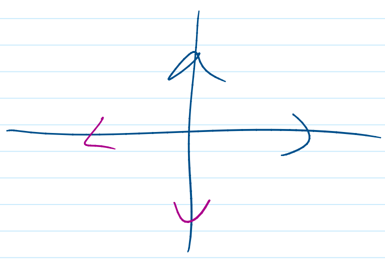
1 1 0 1 1 1 0 0 1 1

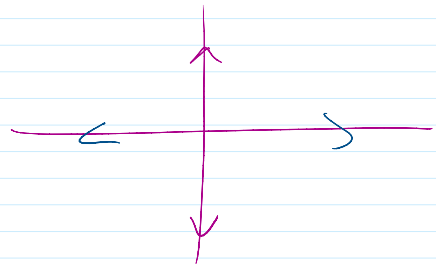


$x \underset{0}{\overset{1}{\gtrless}} 2\sqrt{E_s}$

Demodulator →







DPSK BER = $\frac{1}{2} e^{-\frac{E_b}{N_0}}$

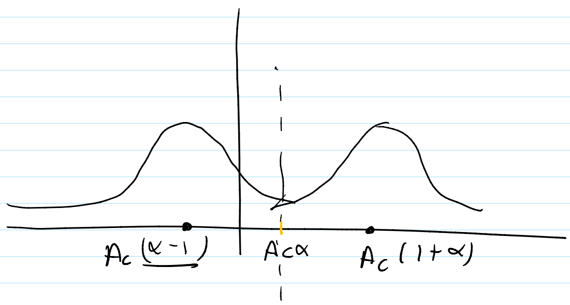
BPSK

$s_1(t) = A_c \cos 2\pi f_c t + \alpha A_c \cos 2\pi f_c t \qquad 0 \le t \le T_b$

$s_2(t) = -A_c \cos 2\pi f_c t + \alpha A_c \cos 2\pi f_c t \qquad 0 \le t \le T_b$

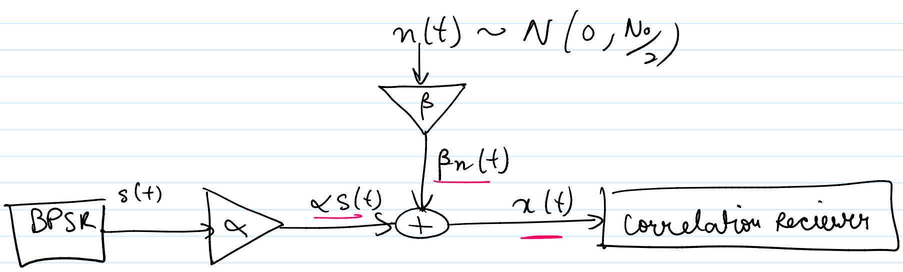
$s_1(t) = A_c \cos 2\pi f_c t\,(1+\alpha) \qquad 0 \le t \le T_b$

$s_2(t) = A_c \cos 2\pi f_c t\,(-1+\alpha) \qquad 0 \le t \le T_b$



BER → $Q\left(\frac{2A_c}{\sqrt{2N_0}}\right)$

Q4 →



$x(t) = \alpha . s(t) + \beta n(t)$ ⇒ AWGN $(0, \frac{N_0}{2})$

$x(t) = \alpha . s(t) + \beta . n(t)$

⇒ AWGN$(0, \beta \frac{N_0}{2})$

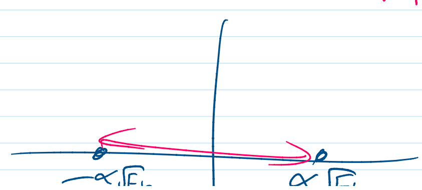
α AWGN$(\alpha\sqrt{E_s}, \beta\frac{N_0}{2})$

$x(t) = \alpha\left(\sqrt{\frac{2E}{T_b}} \cos(2\pi f_c t)\right) + \beta . n(t)$

$x(t) \Rightarrow \alpha\sqrt{E_b} + \beta(n)$

↓

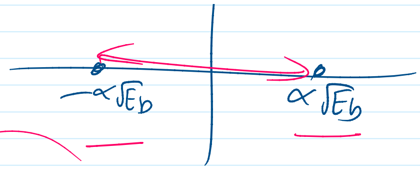
R.V → Mean → $\alpha\sqrt{E_b}$



$\downarrow$

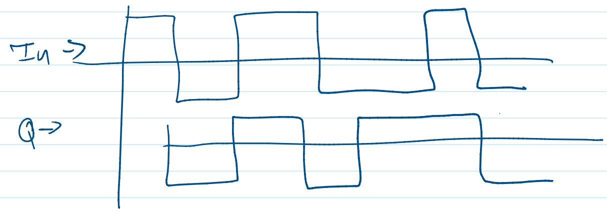
r.V $\rightarrow$ Mean $\rightarrow$ $\alpha\sqrt{E_b}$

variance $\Rightarrow$ $\left(\beta \frac{N_0}{2}\right)$



SNR $\Rightarrow$ $Q\left(\frac{2\alpha\sqrt{E_b}}{\sqrt{2 N_0 \times \beta}}\right)$

$\Rightarrow$ OQPSK



$$PSD \Rightarrow \frac{|P(f)|^2}{T_b} \cdot \sum_{n=-\infty}^{\infty} R_b(n) \cdot e^{j2\pi f T_b n}.$$

$$= \frac{\left(\text{Sinc}\left(\pi f T_b\right)\right)^2}{T_b} \cdot \sum_{n=-\infty}^{\infty} 2 \cdot e^{2\pi f T_b \cdot 0}$$

$$= \frac{T_b^{2}\,\text{sinc}^2\left(\pi f T_b\right)}{\cancel{T}_b} \cdot 1$$

$$PSD \Rightarrow \frac{|P(f)|^2}{T_b} \cdot \sum_{n=-\infty}^{\infty} R_b(k) \cdot e^{j2\pi f T_b \cdot n}$$

$$P(f) \xrightleftharpoons{F.T} p(t)$$

$$p(t) = \begin{cases} 1 & 0 \le t \le T_b \\ 0 & o.w \end{cases}$$

$$P(f) = \int_0^{T_b} p(t) \cdot e^{-2jft} \, dt$$

$$= \int_0^{T_b} e^{-2\pi j f t} \, dt$$

$$= \int_0^{T_b} \cos(2\pi f t)\, dt + j\left(\cancel{- \quad -}\right)$$

$$= \int_0^{T_b} \cos(2\pi f t)\, dt$$

$$= \left. \left(\frac{t \times \sin(2\pi f t)}{2\pi f \times t} \right) \right|_0^{T_b}$$

$n = 0$

$n \neq 0$

$b_m \cdot b_{m-n} = A^2$

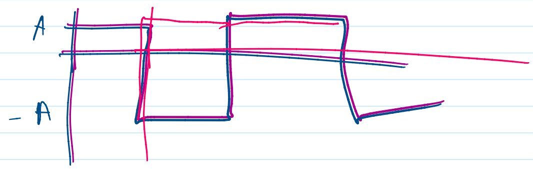
$$= T_b \cdot \text{sinc}(2 f T_b)$$

$n \neq 0 \rightarrow$

$$|P(f)|^2 = T_b^2 \cdot \text{sinc}^2 (2 f T_b)$$

$$\frac{|P(f)|^2}{T_b} \cdot \sum_{n=-\infty}^{\infty} R_b[n] \cdot e^{2\pi j f T_b \cdot n} \rightarrow$$

NRZ



$$\left.\begin{matrix} \frac{1}{2}^+ \\ \frac{1}{2}^- \end{matrix}\right) \rightarrow 0$$

$n = 0$

$* \cos(2\pi f_c t)$

$$\frac{T_b^2 \, \text{sinc}^2 (2 f T_b)}{T_b} \cdot R_b(0) \cdot e^{2\pi f T_b \cdot 0}$$

$$A^2 \; T_b \; \text{sinc}^2 (2 f T_b)$$

Q6 $\rightarrow$

$$G(f) = \begin{cases} 2j \, T_b \sin 2\pi f T_b , & |f| \leq \frac{1}{2T_b} \\ 0 & \text{o, w} \end{cases}$$

Soln $G(f) \rightleftarrows g(t)$

$$g(t) = \int_{-\infty}^{\infty} G(f) \, e^{2\pi j f t} \, df$$

$$= \int_{-\frac{1}{2T_b}}^{\frac{1}{2T_b}} 2j \, T_b \sin(2\pi f T_b) \, e^{2\pi j f t} \, df$$

$$= \int 2j \, T_b \cdot \sin(2\pi f T_b) \cdot \left(\cos(2\pi f t) + j \sin(2\pi f t) \right) df$$

$$= \int_{-\frac{1}{2T_b}}^{\frac{1}{2T_b}} 2j \, T_b \sin(2\pi f T_b) \cdot \cos(2\pi f t) - 2 T_b \sin(2\pi f T_b) \sin(2\pi f t) \, df$$

$$= \int_{-\frac{1}{2T_b}}^{\frac{1}{2T}} 2j \, T_b \left(\frac{1}{2} \left(\sin(2\pi f t + 2\pi f T_b) + \sin(2\pi f t - 2\pi f T_b) \right) \right) - 2 T_b \frac{1}{2} \left(\cos(2\pi f T_b + 2\pi f t) - \cos(2\pi f T_b - 2\pi f t) \right)$$

$$= \int_{-\frac{1}{2T_b}}^{\frac{1}{2T_b}} j T_b \left(\sin(2\pi f (t+T_b)) + \sin(2\pi f (t - T_b)) \right) - T_b \left(\cos(2\pi f (t+T_b)) + \cos(2\pi f (t - T_b)) \right)$$

$$= j T_b \left(\left[-\frac{\cos(2\pi f (t+T_b))}{2\pi (t+T_b)} \right]_{-1/2T_b}^{1/2T_b} + \left[\frac{-\cos(2\pi f (t-T_b))}{-2\pi (t-T_b)} \right]_{-1/2T_b}^{1/2T_b} + j \left[\frac{\sin(2\pi f (t+T_b))}{2\pi (t+T_b)} - \frac{\sin(2\pi f (t-T_b))}{2\pi (t-T_b)} \right]_{-1/2T_b}^{1/2T_b} \right)$$

$$= j T_b \left(2 \times \cancel{\left[-\frac{\cos(2\pi f (t+T_b))}{2\pi (t+T_b)} \right]_{-1/2T_b}^{1/2T_b}}^{\,0} + 2 \cancel{\left[\frac{\cos(2\pi f (t-T_b))}{2\pi (t-T_b)} \right]_{-1/2T_b}^{1/2T_b}}^{\,0} + j \left[2 \times \left[\frac{\sin(2\pi f (t+T_b))}{2\pi (t+T_b)} \right]_0^{1/2T_b} - 2 \times \left[\frac{\sin(2\pi f (t-T_b))}{2\pi (t-T_b)} \right] \right] \right)$$

$$= -\frac{T_b}{2}\left(2 \times \frac{\sin\left(2\pi \frac{1}{2T_b}(t+T_b)\right)}{2\pi(t+T_b)} + 2\,\frac{\sin\left(2\pi \frac{1}{2T_b}(t-T_b)\right)}{2\pi\,(t-T_b)}\right)$$

$$= \frac{-T_b \times 2}{2\pi}\left[\frac{\sin\left(2\pi \cdot \frac{1}{2T_b} \cdot (t+T_b)\right)}{t+T_b} + \frac{\sin\left(2\pi \frac{1}{2T_b}(t-T_b)\right)}{t-T_b}\right]$$

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