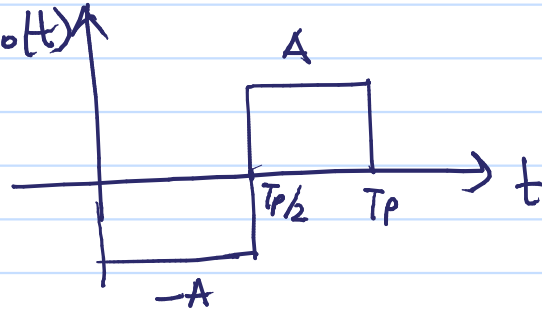
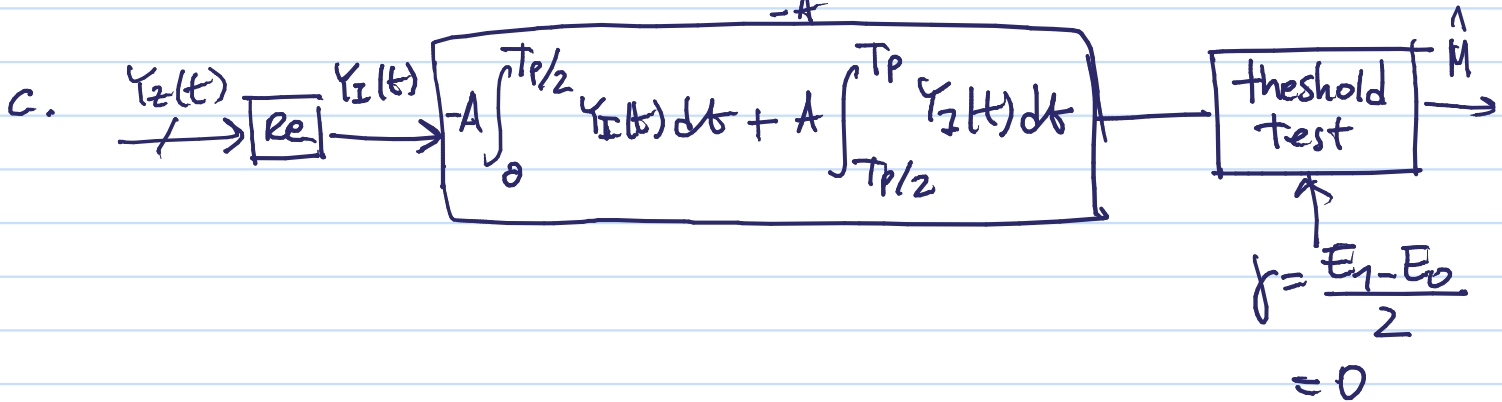
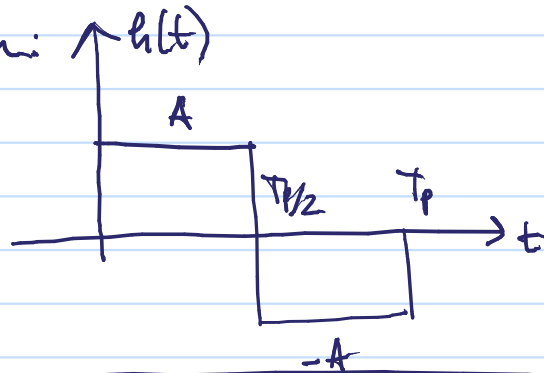


$$1. a. E_0 = E_1 = \frac{A^2 T_p}{2} = E_b \Rightarrow A = \sqrt{\frac{2E_b}{T_p}}$$

b. Effective signal: $x_{z1}(t) - x_{z0}(t)$



\Rightarrow matched filter: $h(t)$



$$d. \int_0^{T_p} x_{21}(t) x_{20}^*(t) dt = 0 \Rightarrow \rho_{10} = 0 \Rightarrow \Delta E(1,0) = 2E_b$$

$$m_0 = -E_0 = -E_b$$

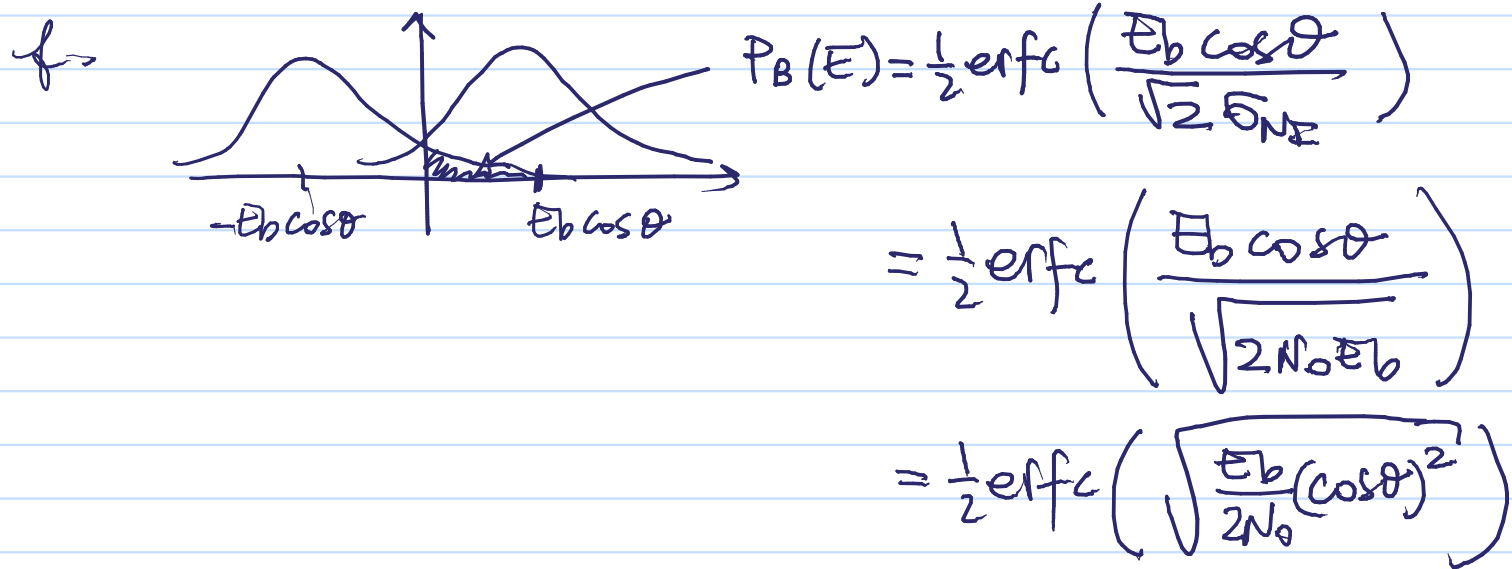
$$m_1 = E_1 = E_b$$

$$\sigma_{N_I}^2 = \frac{N_0}{2} \Delta E(1,0) = N_0 E_b$$

$$e. Y_I(t) = X_2(t) \cos \theta + W_2(t)$$

$$\Rightarrow V_I(T_p) = \begin{cases} -E_b \cos \theta + N_I & \text{if } M=0 \\ E_b \cos \theta + N_I & \text{if } M=1 \end{cases}$$

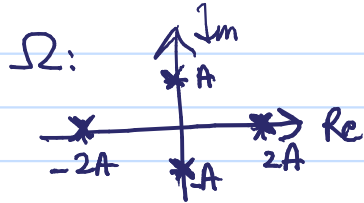
$$\text{with } N_I \sim \mathcal{N}(0, \sigma_{N_I}^2)$$



$$g. \text{Loss} = 10 \log_{10} \left(\frac{E_b / N_0}{E_b / (2 N_0) (\cos \theta)^2} \right) = 10 \log_{10} 2 - 20 \log_{10} \cos \theta$$

$$= 3 - 20 \log_{10} \frac{1}{\sqrt{2}} = 6 \text{ dB}$$

2.



$$a. \frac{1}{4} (2A^2 + 2 \cdot 4A^2) = \frac{10}{4} A^2 = \frac{5}{2} A^2 = 2 \Rightarrow A = \sqrt{\frac{4}{5}} = \frac{2}{\sqrt{5}}$$

b. For $M=0$

$$\left\{ \left(E_b |2A - jA|^2, 2 \right), \left(\frac{16A^2}{5}, 1 \right) \right\}$$

$$E_b (4A^2 + A^2) \qquad \frac{16 \cdot 4 E_b}{5}$$

$$= 5 E_b \frac{4}{5} = 4 E_b \qquad = \frac{64 E_b}{5}$$

For $M=2$

$$\left\{ (4 E_b, 2), \left(\frac{64}{5} E_b, 1 \right) \right\}$$

For $M=1$ and $M=3$

$$\left\{ (4 E_b, 2), \left(\frac{E_b \cdot 4 A^2}{5}, 1 \right) \right\}$$

$$\frac{16 E_b}{5}$$

$$c. P_{wUB}(E) = \frac{1}{4} \left(\frac{8}{2} \operatorname{erfc} \left(\sqrt{\frac{E_b}{N_0}} \right) + \operatorname{erfc} \left(\sqrt{\frac{4E_b}{5N_0}} \right) + \operatorname{erfc} \left(\sqrt{\frac{16E_b}{5N_0}} \right) \right)$$

d. Union bound approximation

$$P_{wUB}(E) \approx \frac{1}{4} \operatorname{erfc} \left(\sqrt{\frac{4E_b}{5N_0}} \right)$$

3.

