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6.35.

$$f = 10^6$$

$$\frac{N_0}{2} = 10^{-10}$$

(a) coherent BPSK

$$P_e = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right) = 10^{-4}$$

$$\Rightarrow \sqrt{\frac{E_b}{N_0}} \approx 2.629$$

$$\Rightarrow \frac{E_b}{N_0} \approx 6.911$$

$$\Rightarrow E_b \approx 3.4555 \times 10^{-10}$$

$$\Rightarrow P_{\text{ave}} \approx 3.4555 \times 10^{-4} \text{ (W)}$$

(b) DPSK

$$P_e = \frac{1}{2} e^{-\frac{E_b}{N_0}} = 10^{-4}$$

$$\Rightarrow \frac{E_b}{N_0} \approx 8.517$$

$$\Rightarrow E_b \approx 4.258 \times 10^{-10}$$

$$\Rightarrow P_{\text{ave}} \approx 4.258 \times 10^{-4} \text{ (W)}$$

6.36.

$$\text{erfc}(u) \approx \frac{e^{-u^2}}{\sqrt{\pi}u}$$

(a) Coherent BPSK and DPSK

For coherent BPSK

$$\frac{E_b}{N_0} = 7.2 \text{ is given}$$

For DPSK

$$P_e = \frac{1}{2} e^{-\frac{E_b}{N_0}} = 10^{-4}$$

$$\Rightarrow \frac{E_b}{N_0} \approx 8.517$$

Thus the separation is  $10 \log \frac{8.517}{7.2} \approx 0.72 \text{ dB} \#$

(b) Coherent BPSK and QPSK

For coherent QPSK

$$P_e = \text{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right) \approx \frac{1}{\sqrt{\pi}} e^{-\frac{E_b}{N_0}} = 10^{-4}$$

$$\Rightarrow \frac{E_b}{N_0} \approx 7.56$$

Thus the separation is  $10 \log \frac{7.56}{7.2} \approx 0.21 \text{ dB} \#$

(c) Coherent BPSK and noncoherent BPSK

For noncoherent BPSK

$$P_e = \frac{1}{2} e^{-\frac{E_b}{2N_0}} = 10^{-4}$$

$$\Rightarrow \frac{E_b}{N_0} \approx 17.03$$

Thus the separation is  $10 \log \frac{17.03}{7.2} \approx 1 \text{ dB} \#$

(d) Coherent BPSK and coherent MSK

For coherent MSK

$$P_e = \frac{1}{2} \text{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$$

and for coherent BPSK

$$P_e = \frac{1}{2} \text{erfc}\left(\sqrt{\frac{E_b}{2N_0}}\right)$$

Thus the separation is approximate  $3 \text{ dB} \#$