# EE 484
## PSK Notes

Reference: P.J. Lee, "Computation of the Bit Error Rate of Coherent M-*ary* PSK with Gray Code Bit Mapping," *IEEE Trans. Commun.*, vol. COM34, no. 5, May 1986, pp. 488-491.

**BPSK**

$$s_i(t) = \sqrt{\frac{2E_b}{T}} \cos(\omega_0 t + \phi_i), \quad 0 \le t \le T$$

where $\phi_i \in \{0,\ \pi\}$ and $E_b$ is the energy per bit. The probability of bit error for coherent detection is

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right).$$

**QPSK**

$$s_i(t) = \sqrt{\frac{2E_s}{T}} \cos(\omega_0 t + \phi_i), \quad 0 \le t \le T$$

where $\phi_i \in \{(2k-1)\pi/4,\ k = 1, 2, 3, 4\}$ and $E_s$ is the energy per symbol. The probability of bit error for coherent detection is the same as for BPSK

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$$

where $E_b = E_s/2$.

**MPSK**

$$s_i(t) = \sqrt{\frac{2E_s}{T}} \cos(\omega_0 t + \phi_i), \quad 0 \le t \le T$$

where $\phi_i \in \{(2k-1)\pi/M,\ k = 1, 2, \ldots, M\}$. The probability of symbol error for coherent detection and high SNR is

$$P_s \approx 2Q\left(\sqrt{\frac{2E_s}{N_0}} \sin\frac{\pi}{M}\right).$$

If Gray coding is utilized in assigning bits to constellation points then

$$P_b \approx \frac{P_s}{\log_2 M}, \quad (P_s \ll 1).$$

Note that the result above for 8PSK was for high SNR. There is an exact expression for BER for 8PSK in the reference. In general it is best to either simulate MPSK (for large M) or else look up simulation results from reputable sources.

You can also find the architecture for the demodulators for each of these cases in textbooks or on the web.