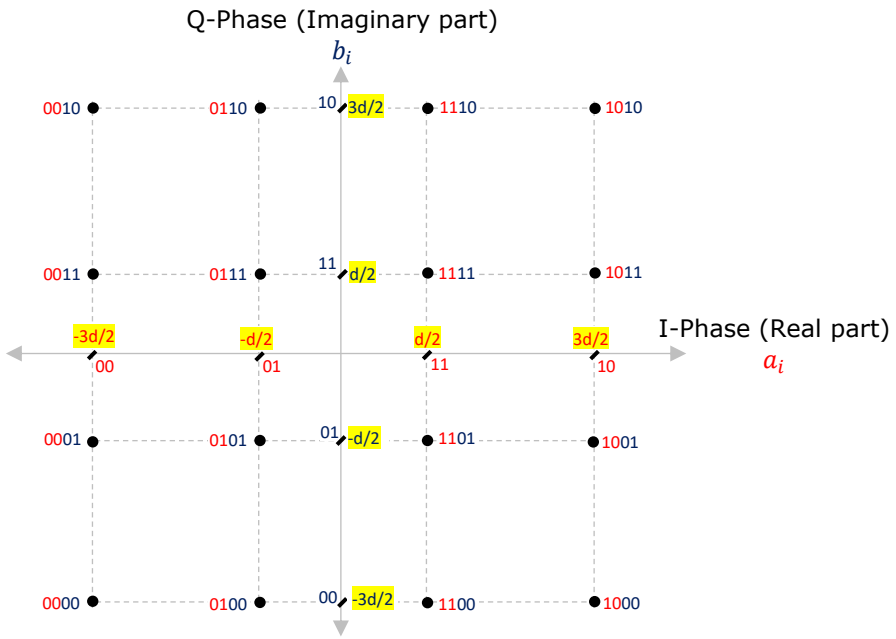
THEORY: EXP-6 Simulation study of performance of 16-Square QAM

▶ 16-Sqaure QAM Constellation Diagram (M=16)



▶ QAM Signal (M-QAM)

$$s_i(t) = a_i\sqrt{\frac{2}{T}}\cos(\omega_c t) + b_i\sqrt{\frac{2}{T}}\sin(\omega_c t), \quad 0 \le t \le T$$

▶ Average Symbol Energy (M-Square QAM)

$$\bar{E}_s = \left[\left(\frac{d}{2}\right)^2 \sum_{p=1}^{\frac{\sqrt{M}}{2}} (2p-1)^2\right]\left(\frac{4}{\sqrt{M}}\right) = \frac{2}{3}(M-1)\left(\frac{d}{2}\right)^2$$

$$= \frac{\sqrt{M}}{6}\left(\sqrt{M}-1\right)\left(\sqrt{M}+1\right)\times\left(\frac{d}{2}\right)^2 = E_b \times \log_2 M$$

▶ Average Symbol Energy (for M=16)

$$\bar{E}_s = \frac{5}{2}d^2 = 4E_b$$

▶ SER Formula (M-Square QAM)

$$\text{SER} \approx 2\left(1-\frac{1}{\sqrt{M}}\right)\text{erfc}\left(\sqrt{\frac{3}{2}\times\frac{\log_2 M}{M-1}\times\frac{E_b}{N_0}}\right)$$

▶ BER Formula for Gray Encoding (M-Square QAM)

$$\text{BER} = \frac{SER}{\log_2 M}$$

$$= \frac{2}{\log_2 M}\left(1-\frac{1}{\sqrt{M}}\right)\text{erfc}\left(\sqrt{\frac{3}{2}\times\frac{\log_2 M}{M-1}\times\frac{E_b}{N_0}}\right)$$

▶ BER Formula for Gray Encoding (16-Square QAM)

$$\text{BER} = \frac{3}{8}\text{erfc}\left(\sqrt{\frac{2}{5}\times\frac{E_b}{N_0}}\right)$$