# Assignment 7 Solution

Digital Communication System-I

May 2023

1. (d) Error probability decreases with increasing M for orthogonal signaling with non-coherent detection.

2. (b) The equivalent baseband model is written as

$$r_l(t) = e^{j\phi} s_{ml}(t) + n_l(t).$$

   Therefore, the equivalent baseband model does not have a phase shift component $e^{j\phi}$ corresponding to the noise term.

3. (a) $\Delta f = 1/T_s = 30\text{KHz}$. Hence the other transmitted frequency is $800 + \Delta f = 830\text{KHz}$

4. (b) If $X \sim \mathcal{N}\left(v\cos(\theta), \sigma^2\right)$ and $Y \sim \mathcal{N}\left(v\sin(\theta), \sigma^2\right)$ then, $Z = \sqrt{X^2 + Y^2} \sim \text{Rice}\left(v, \sigma^2\right) = \text{Rice}\left(\sqrt{(1^2 + 4^2)}, 1\right)$

5. (a) Please see lecture slides.

6. (b) For binary orthogonal signalling, including binary orthogonal FSK with noncoherent detection (with noncoherent detection), the probability of error is $= 0.5\exp\left(-\frac{E_b}{2N_0}\right) = 0.5\exp(-5) = 3.4 \times 10^{-3}$.

7. (d) For option (a) and (c), please see lecture slides. For option (b), the condition for orthogonality under noncoherent detection is $\Delta f = \frac{1}{T}$. The condition for orthogonality under coherent detection is $\Delta f = \frac{1}{2T}$. Hence, the orthogonality under non-coherent detection guarantees orthogonality under coherent detection

8. (b) Please see lecture slides.

9. (d) We know for any $M$-ary DPSK, the carrier phase angle of the modulator for the $n$-th symbol interval is given by

$$\theta_n = \left(\theta_{n-1} + c_n \frac{2\pi}{M}\right) \text{ modulo } 2\pi$$

   where $M = 2$ for binary case.

   For the transmitted binary data $x$ = 0 0 1 0 0 1, the carrier Phase at Modulator Output is 0 0 $\pi$ $\pi$ $\pi$ 0 with the initial phase being 0.

10. (b) In DPSK the information is in the phase transitions and not in the absolute phase.