NANYANG TECHNOLOGICAL UNIVERSITY
School of Electrical & Electronic Engineering

EE/IM4152 Digital Communications

Tutorial No. 7 (Sem 1, AY2016-2017)

1. (a) For binary polar signalling with the received peak amplitude $A_p = 0.016$, determine the detection error probability if the channel noise is Gaussian distributed with rms value $\sigma_n = 0.004$.
   (b) Suppose the same basic pulse is used for on-off signalling and bipolar signalling. Find the corresponding detection error probabilities.
   (c) In order to achieve the same detection error probability as in the polar case, what must be the peak amplitudes for the on-off and bipolar cases?

2. *M*-ary frequency shift keying (FSK) is usually generated by transmitting one of the sinusoids from the set of *M* elements containing

$$A\cos(2\pi f_i t), \quad i = 1, 2, \ldots, M, \quad 0 \le t \le T_s$$

where A is the common amplitude, T_s is the symbol duration, and f_i is the carrier frequency of the i-th tone. In order for the signal set to be orthogonal, the frequency separation between two adjacent tones must satisfy certain minimum requirement.
   (a) Determine the minimum frequency separation for *noncoherently detected* orthogonal FSK signalling. The orthogonality condition requires that

$$\int_0^{T_s} A\cos(2\pi f_m t + \theta) A\cos(2\pi f_n t)\, dt = 0, \quad m \ne n$$

   where θ is a constant, but unknown, phase angle from 0 to 2π.
   (b) Determine the minimum frequency separation for *coherently detected* orthogonal FSK signalling. The orthogonality condition requires that

$$\int_0^{T_s} A\cos(2\pi f_m t) A\cos(2\pi f_n t)\, dt = 0, \quad m \ne n$$

3. Full-width rectangular pulses are transmitted at a pulse rate of 10^3 pulses/s using an on-off scheme. The decision is based on the sample value and the detection error probability is required to be less than 10^{-6}. The rms value of the channel noise at the receiver input is 1 mV, and the signal attenuation over the channel (from the transmitter to the receiver) is 30 dB. Determine the minimum signal power that must be transmitted. For simplicity, assume that the pulse shape remains unchanged during the baseband transmission. If full-width rectangular pulses are replaced with half-width rectangular pulses, find the corresponding minimum signal power needed to overcome the channel attenuation.