

Name: _____

Student Number: _____

EE3101 Communication Engineering**Quiz 2a****Attempt ALL Questions [Total: 16 marks]**

- (1) Find the average bit energy of the following binary system with 1b/s. The probabilities of “1” and “0” are equal.

“1”: 4V for $0 \leq \text{time} < 0.2\text{sec}$, 0V for $0.2\text{sec} \leq \text{time} < 1.0\text{sec}$,

“0”: 0V for $0 \leq \text{time} < 0.4\text{sec}$, and -2V for $0.4\text{sec} \leq \text{time} < 1\text{sec}$.

[2 marks]

Average $E_b =$ _____ Joule

$$\text{Ans: } 4^2 \times 0.2 \times \frac{1}{2} + (-2)^2 \times 0.6 \times \frac{1}{2} = 2.8$$

- (2) Consider an ideal 50Mb/s NRZ-L system operates under an AWGN channel with double-sided power spectral density of $N_o/2$. The bit error probability of the current system is $P_B = 10^{-9}$.

(a) What is the minimum bandwidth without ISI of this system?

(b) Determine the $\frac{E_b}{N_o}$ value in dB of the current system.

(c) Determine the new average bit energy E'_b in terms of E_b if the transmission power is increased by 50% and the bit rate is doubled, and hence estimate the new P_B value.

Given: (i) $P_B = Q\left[\sqrt{\frac{2E_b}{N_o}}\right]$ for an ideal NRZ-L system, where E_b is the average bit energy.

$$(ii) Q(x) \approx \frac{1}{x\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right) \quad \text{for } x > 3.3 \quad \text{and} \quad Q(6.00) \approx 10^{-9} \quad [6 \text{ marks}]$$

(a) 50/2 MHz = 25MHz

1 mark

0.5 marks deduction for (i) without unit, (ii) use Mb/s

$$(b) \sqrt{\frac{2E_b}{N_o}} = 6.00, \text{ i.e. } \frac{E_b}{N_o} = 18$$

$$\frac{E_b}{N_o} = 12.6 \text{ dB}$$

1 mark

0.5 marks for $\frac{E_b}{N_o} = 18$ only

$$(c) E'_b = E_b \frac{1.5 \times 50 \text{ M}}{100 \text{ M}} = \frac{3E_b}{4}$$

2 marks

$$P_B = Q\left[\sqrt{\frac{2 \times \frac{3E_b}{4}}{N_o}}\right] = Q[5.20]$$

$$P_B \approx 1.03 \times 10^{-7}$$

2 marks, 1 mark for only getting Q[5.20]

- (3) The followings are **TRUE/FALSE** questions. Circle the correct answer. **+1 mark and -0.8 marks are given for each correct answer and wrong answer respectively.** Minimum mark in (3) is **ZERO**.

[8 marks]

- (a) A proper raised cosine filter is used for a 4-level NRZ system and can achieve zero ISI with minimum bandwidth. Is it true that it can still maintain zero ISI if the system is changed to be a 8-level NRZ and with the same raised cosine filter. Assume that the same bit rate is used in both cases. (True/False)
- (b) If a $\alpha = 0.3$ raised cosine filter is cascaded with a $\alpha = 0.5$ raised cosine filter with the same minimum Nyquist bandwidth of f_0 , the 100% power bandwidth of the combined filters becomes $1.5f_0$. (True/False)
- (c) A BPSK signal can be obtained by multiplying the NRZ-L signal with a sinusoidal carrier signal. (True/False)
- (d) For a 64-QAM signal, the number of level in I-channel is 32. (True/False)
- (e) In 2-FSK modulation, orthogonal transmission can be guaranteed if the frequency separation of the two frequencies (f_1 and f_2) is greater than the minimum frequency separation, i.e. $|f_1 - f_2| \geq f_{\text{min separation}}$. (True/False)
- (f) Since QPSK systems only change the phase angle of the carrier. The transmitted signal of all QPSK systems has constant envelope. (True/False)
- (g) Theoretically, we can use 0 and $2\pi/3$ to represent the 2 states in BPSK systems. (True/False)
- (h) At the receiver, the ratio between the received signal power and the ISI power can not be reduced by increasing the transmission power of the signal. (True/False)

- (a) F
- (b) F
- (c) T
- (d) F
- (e) F
- (f) F
- (g) T
- (h) T

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EE3101 Communication Engineering**Quiz 2b****Attempt ALL Questions [Total: 16 marks]**

- (1) Find the average bit energy of the following binary system with 1b/s. The probabilities of “1” and “0” are equal.

“1”: 0V for $0 \leq \text{time} < 0.2\text{sec}$, 3V for $0.2\text{sec} \leq \text{time} < 1.0\text{sec}$,

“0”: -2V for $0 \leq \text{time} < 0.4\text{sec}$, and 0V for $0.4\text{sec} \leq \text{time} < 1\text{sec}$.

[2 marks]

Average $E_b =$ _____ Joule

$$\text{Ans: } 3^2 \times 0.8 \times \frac{1}{2} + (-2)^2 \times 0.4 \times \frac{1}{2} = 4.4$$

- (2) Consider an ideal 10Mb/s NRZ-L system operates under an AWGN channel with double-sided power spectral density of $N_o/2$. The bit error probability of the current system is $P_B = 10^{-7}$.

(a) What is the minimum bandwidth without ISI of this system?

(b) Determine the $\frac{E_b}{N_o}$ value in dB of the current system.

(c) Determine the new average bit energy E'_b in terms of E_b if the transmission power is increased by 20% and the bit rate increases to 15Mb/s, and hence estimate the new P_B value.

Given: (i) $P_B = Q\left[\sqrt{\frac{2E_b}{N_o}}\right]$ for an ideal NRZ-L system, where E_b is the average bit energy.

(ii) $Q(x) \approx \frac{1}{x\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right)$ for $x > 3.3$ and $Q(5.20) \cong 10^{-7}$ [6 marks]

(a) 10/2 MHz = 5MHz

1 mark

0.5 mark deduction for (i) without unit, (ii) use Mb/s

(b) $\sqrt{\frac{2E_b}{N_o}} = 5.20$, i.e. $\frac{E_b}{N_o} = 13.5$ $\frac{E_b}{N_o} = 11.3\text{dB}$

1 mark

0.5 marks for $\frac{E_b}{N_o} = 13.5$ only

(c) $E'_b = E_b \frac{1.2 \times 10\text{M}}{15\text{M}} = 0.8E_b$

2 marks

$$P_B = Q\left[\sqrt{\frac{2 \times 0.8E_b}{N_o}}\right] = Q[4.65]$$

$$P_B \approx 1.73 \times 10^{-6}$$

2 marks, 1 mark for only getting Q[4.65]

- (3) The followings are **TRUE/FALSE** questions. Circle the correct answer. **+1 mark and –0.8 marks are given for each correct answer and wrong answer respectively.** Minimum mark in (3) is **ZERO**.

[8 marks]

- (a) A proper raised cosine filter is used for a 4-level NRZ system and can achieve zero ISI with minimum bandwidth. Is it true that it can still maintain zero ISI if the system is changed to be a 16-level NRZ and with the same raised cosine same filter. Assume that the same bit rate is used in both cases. (True/False)
- (b) For a given NRZ-L system, raised cosine filters with minimum bandwidth are used to achieve zero ISI. Is it true that the 3dB bandwidth of a $\alpha = 0.3$ raised cosine filter is always wider than a $\alpha = 0.5$ raised cosine filter. (True/False)
- (c) At the receiver, the ratio between the received signal power and the ISI power can be reduced by increasing the transmission power of the signal. (True/False)
- (d) An OOK (or 2-ASK) signal can be obtained by multiplying the Uni-polar NRZ signal with a sinusoidal carrier signal. (True/False)
- (e) For a 16-QAM signal, the number of level in I-channel is 8. (True/False)
- (f) For 2-FSK systems, orthogonal transmission must be used for reliable transmission. (True/False)
- (g) If traditional QPSK system is replaced by an offset-QPSK system, the overall PSD of the transmitted signal remains the same. (True/False)
- (h) Theoretically, we can **ONLY** use φ and $\varphi + \pi$, where φ is an arbitrary phase angle, to represent the 2 states in BPSK systems. (True/False)

- (a) T
- (b) T
- (c) F
- (d) T
- (e) F
- (f) F
- (g) T
- (h) F

