CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	DIGITAL COMMUNICATION
COURSE CODE	:	BEB 41803
PROGRAMME	:	BACHELOR OF ELECTRONICS ENGINEERING WITH HONOURS
EXAMINATION DATE	:	DECEMBER 2015/JANUARY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

CONFIDENTIAL

Q1 (a) Explain by designing the fundamental features that make a digital communication to take place (from transmitter to receiver end). You may include the essential features that you need to have in your design.

(5 marks)

(b) The term **MODEM** often encompasses several of the signal processing steps and will be assumed as the 'brain' of a system. The input to a modulator is thus a baseband digital signal whilst the output is a bandpass waveform.

(i) Define the meaning of those TWO (2) terms.

(3 marks)

(ii) Differentiate between those TWO (2) terms.

(3 marks)

(c) The term *noise* refers to *unwanted* electrical signals that always present in electrical communication systems. Thermal noise is a natural source of noise that cannot be eliminated. It is often called as 'white noise' and modeled as zero-mean Gaussian random process. Analyze why:

(i) the thermal noise is referred as white noise? and

(2 marks)

(ii) Gaussian distribution is often used as the system noise model?

(3 marks)

(d) Calculate the minimum required bandwidth for the baseband transmission of a 4-level Pulse Amplitude Modulation (PAM) pulse sequence having a data rate of R = 2400 bits/s. The system transfer characteristic consists of a raised-cosine spectrum with 100% excess bandwidth (r = 1).

(4 marks)

Q2 (a) Satellite communication link is generally consists of a transmitter, satellite transponder and an earth receiver.

(i) Illustrate a satellite communication link and label the relevant terms like transmit power, P_t, gain of transmitter, G_t, Free Space Loss (*FSL*), power received , P_r and gain of receiver, G_r.

(3 marks)

(ii) In your understanding, why the loss in the satellite communication link (from an earth station to the satellite transponder) cannot be considered as free space loss?

(2 marks)

(b) A line at temperature $T_0°$=290 K is fed from a source whose noise temperature is $T_g°$=1450 K. The input signal power, S_i, is 100 pW and the signal bandwidth, W is 1 GHz. The line has a loss factor, $L = 2$. Calculate:

(i) the input signal to noise ratio, SNR_i,

(3 marks)

(ii) the output signal power, S_o, and

(2 marks)

(iii) the output signal to noise ratio, SNR_o.

(4 marks)

(c) A receiver front end, shown in **Figure Q2(c)**, has a noise figure of 10 dB, a gain of 80 dB and a bandwidth of 6 MHz. The input signal power, S_i, is 10^{-11} W. Assume that it is a lossless line and the antenna temperature is 150 K. Calculate:

(i) noise temperature, $T_R°$,

(1 marks)

(ii) system temperature, $T_S°$, and

(1 marks)

(iii) output noise, N_{out}.

(2 marks)

(iv) SNR_{out}

(2 marks)

Q3 (a) Distinguish the biorthogonal codeword for 4-bit data set.

(2 marks)

(b) There are THREE (3) methods under the Automatic Repeat Request (ARR) error control procedures. Differentiate in between all those three. You may use diagram to assist your explanation.

(6 marks)

(c) Forward Error Control (FEC) is another method of error detection. State THREE (3) reasons under what circumstances FEC can be used instead of ARR.

(3 marks)

(d) (i) A generator matrix, G, is given as;

$$\begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

Determine the code word for message vector 010, 101 and 111.

(6 marks)

(ii) Assume a codeword U = 101110 is transmitted, and the error vector r = 001110 is received. Evaluate on how a decoder, using **Table Q3**, can correct the error.

(3 marks)

Q4 (a) All digital communication systems requires some degree of syncronization to the incoming signals by the receivers. Being the heart of all syncronization circuits, design and explain the THREE (3) main elements of the phase locked loop (PLL).

(6 marks)

(b) Among the most popular of the closed-loop symbol synchronizers is the early/late-gate synchronizer. The synchronizer operates by performing two separate integrations of the incoming signal energy over two different portions of symbol interval, as shown in **Figure Q4(b)**. Analyse the statement above by referring to the mentioned figure.

(8 marks)

(c) Almost all digital data streams have some sort of frame structure; data stream is organized into uniformly sized groups of bits. With the relevant illustration, explain on how syncronization takes place in frame transmission.

(6 marks)

Q5 (a) Shannon uses a correction factor called *equivocation*. This can be used to determine the uncertainty in the received signal. Consider a binary sequence, X, where the source probabilities are P(X=1) = P(X=0) = 0.5, where on average the channel produces one error in a received sequence of 100 bits (P_B = 0.01). Calculate:

(i) the equivocation, $H(X|Y)$,

(3 marks)

(ii) effective entropy of the received signal, H_{eff}, and

(3 marks)

(iii) effective information bit rate, R_{eff}, if symbol rate, R = 1000 symbols/second.

(3 marks)

(b) Given a bandwidth-limited AWGN radio channel with an available bandwidth of W = 4 kHz. The ratio of received signal power to noise-power spectral density (P_r/N_0) = 53 dB-Hz. The data rate, R = 9600 bits/s. In order to have a greater bandwidth efficiency, the modulation scheme's level, M, has been fixed to 8. Calculate:

(i) the symbol energy over noise spectral density (E_s/N_0),

(3 marks)

(ii) probability of symbol error, $P_E(M)$, and

(4 marks)

(iii) probability of bit error, P_B.

(3 marks)

(c) From the calculation made in **5(b)** above, name the modulation scheme that meets the required performance.

(1 mark)

Q6 (a) Code Division Multiple Access (CDMA) is always referred to as '*all of the bandwidth, all of the time*'. Assess the statement above based on your own understanding.

(2 marks)

(b) Two CDMA users (A and B) are transmitting signal at the same time. Given that the output data from speech coder for CDMA user A and B are 1111000000001111 and 1111111111111111 respectively. Walsh Code 1 and 2 (refer to **Table Q6 (b)**) are employed at spreading code A and B respectively. Distinguish that the interference between the users will be minimized, if:

(i) user B is transmitting at user A power level.

(6 marks)

(ii) user B is transmitting at three times user A power level.

(6 marks)

(c) A binary Phase Shift Keying (PSK) system using CDMA requires a data rate for each user of 10 kbps and has a spread spectrum bandwidth (90% in-band power) of 200 kHz.

(i) Calculate the processing gain of the system.

(2 marks)

(ii) If an SNR of 2 dB is required for adequate performance, calculate the number of users can the system support.

(2 marks)

(iii) Calculate the minimum SNR if the system support at least 10 users.

(2 marks)

- END OF QUESTION –

FINAL EXAMINATION

SEMESTER/SESSION: SEM I/2015/2016
COURSE NAME : DIGITAL COMMUNICATION

PROGRAMME : BEJ
COURSE CODE: BEB 41803

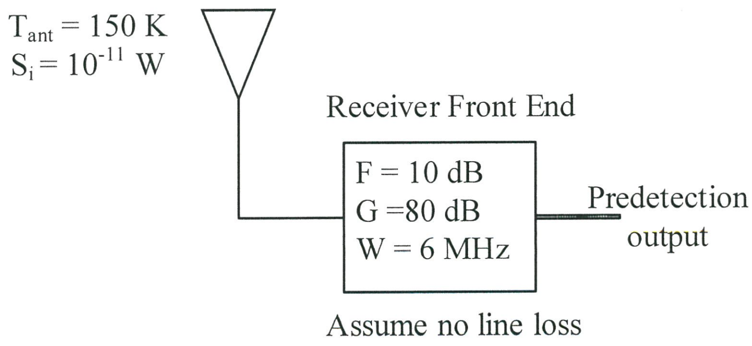

Figure Q2(c)

Table Q3: Syndrome Look-Up Table

Error Patern	Syndrome
000000	000
000001	101
000010	011
000100	110
001000	001
010000	010
100000	100
010001	111

FINAL EXAMINATION

SEMESTER/SESSION : SEM I/2015/2016 PROGRAMME : BEJ
COURSE NAME : DIGITAL COMMUNICATION COURSE CODE: BEB 41803

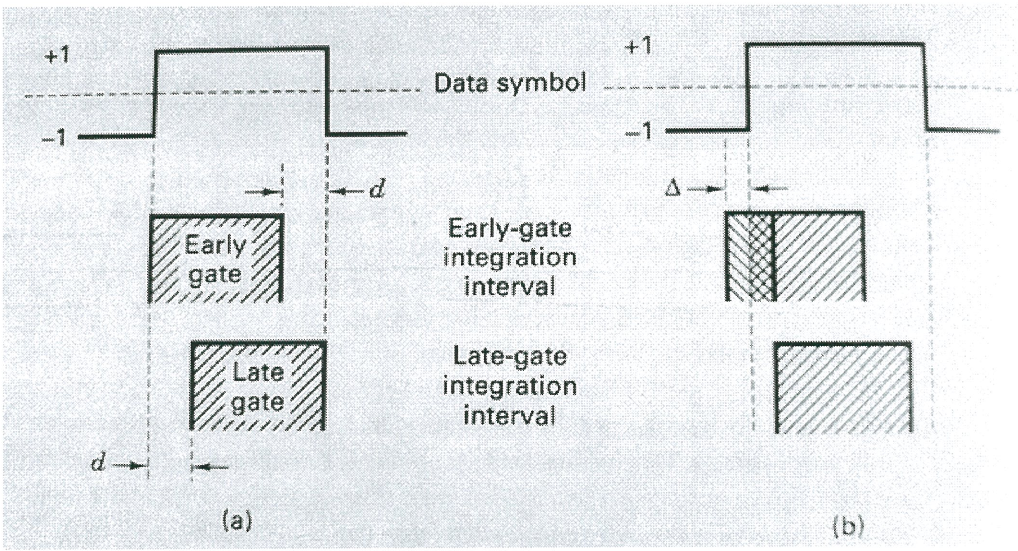

Figure Q4(b)

Table Q6

Code 0	1	1	1	1	1	1	1	1
Code 1	1	1	1	1	-1	-1	-1	-1
Code 2	1	1	-1	-1	1	1	-1	-1
Code 3	-1	-1	1	1	-1	-1	1	1
Code 4	1	-1	-1	1	1	-1	-1	1
Code 5	1	-1	-1	1	-1	1	1	-1
Code 6	1	-1	1	-1	1	-1	1	-1
Code 7	1	-1	-1	1	1	-1	1	-1

CONFIDENTIAL

FINAL EXAMINATION

SEMESTER/SESSION: SEM I/2015/2016 PROGRAMME : BEJ
COURSE NAME : DIGITAL COMMUNICATION COURSE CODE: BEB 41803

Table 3: Probability of Symbol Error and Probability of Bit-Error Equations

Modulation Type	Parameter	Equation
M-FSK	Probability of symbol error, $P_E(M)$	$P_E(M) \le \frac{M-1}{2}\exp\left(-\frac{1}{2}\frac{E_s}{N_0}\right)$
	Probability of bit-error, P_b *(Uncoded system)*	$P_b = \left(\frac{2^{k-1}}{2^k - 1}\right)P_E$
M-PSK	Probability of symbol error, $P_E(M)$	$P_E(M) \approx 2Q\left[\sqrt{\frac{2E_s}{N_0}}\sin\left(\frac{\pi}{M}\right)\right]$
	Probability of bit-error, P_b *(Uncoded system)*	$P_b \approx \frac{P_E}{\log_2 M} \quad (for\ P_E << 1)$
M-QAM	Probability of bit-error, P_b *(Uncoded system)*	$P_b \approx \frac{2(1-L^{-1})}{\log_2 L}Q\left[\sqrt{\left(\frac{3\log_2 L}{L^2-1}\right)\frac{2E_b}{N_0}}\right]$ where $L = \sqrt{M}$
Coded System (All Modulation Type)	Probability of bit-error, P_b	$P_b \approx \frac{1}{n}\sum_{j=t+1}^{n} j\binom{n}{j}p_c^j(1-p_c)^{n-j}$
Complementary Error Function (approximation)	Q(x)	$Q(x) \approx \frac{1}{x\sqrt{2\pi}}\exp\left(-\frac{x^2}{2}\right)$ where x > 3

CONFIDENTIAL