Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	ELECTRONIC COMMUNICATION SYSTEM
COURSE CODE	:	BEB 31803
PROGRAMME CODE	:	BEJ/BEV
EXAMINATION DATE	:	JULY 2020
DURATION	:	4 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

ANSWER ALL QUESTIONS (60 MARKS)

Q1 (a) (i) Explain the importance of analog to digital (A/D) conversion in any modern day communication system.

(2 marks)

(ii) With the aid of a diagram, describe the steps by which this process can be achieved.

(3 marks)

(b) (i) An A/D converter has 4 bits and needs to convert an analog signal of 40 V (peak-to-peak) into a digital signal. Design a suitable scheme and calculate the quantization error in your scheme.

(7 marks)

(ii) A signal has undergone a lengthy quantization process utilizing 776 levels. Determine the quantization signal-to-noise ratio (SNR) for this system.

(3 marks)

(c) The following are specifications of a communication system.

- The input signal fundamental frequency = 4 kHz
- Maximum error probability = 1×10^{-9}
- Bandwidth allowed = 26 kHz
- Energy per bit = 4.55×10^{-3} J
- Noise density = 2×10^{-4} V²/Hz

For Frequency Shift Keying (FSK), the frequency difference between first and second carrier is 1.5 kHz. Transmission has to include the fundamental frequency and the third harmonic, $3f_m$.

(i) Using the information, you need to decide which modulation technique that suits these requirements either amplitude shift keying (ASK), frequency shift keying (FSK) or phase shift keying (PSK). Justify your choice by showing the bandwidth and error probability performance.

(12 marks)

(ii) Based on the answer in c(i), state the minimum storage capacity if the transmission duration is 10 seconds.

(3 marks)

Q2 (a) The characteristic impedance of a transmission line must be equal to load impedance for maximum power transfer.

(i) Discuss the concept of characteristic impedance, with the help of a diagram, by looking into the perspective of a finite length of transmission line.

(2 marks)

(ii) Based on your understanding of a mismatched load, sketch the formation of standing waves from the incident and reflected waves.

(2 marks)

(iii) The load may be terminated with an open-circuit or short-circuit. How would the standing waves differ in both cases? Explain your answer with the help of a sketched standing waves of each case which should take into account the locations of voltage and current at their maximum and minimum.

(3 marks)

(b) An isotropic radiator is a point source that radiates electromagnetic energy at a constant rate in all direction. A true isotropic radiator, however, does not exist but is closely approximated by an omnidirectional antenna.

(i) Given a circumstance that an isotropic radiator is radiating 1.5 W of power into free space, determine the electric field intensity, E and power density, P_d at a distance of 5 km from the radiator.

(3 marks)

(ii) Discuss and sketch the 3-dimensional radiation pattern of an omnidirectional antenna.

(2 marks)

(iii) It is essential that the radiation pattern of an antenna must be measured in its far-field region or also known as the *Fraunhofer* region. If the antenna's radius is 0.75 m, calculate the far-field region of the antenna if it operates at 10 GHz. Predict the far-field region if the operating frequency increases based on the relationship between the wavelength of RF signal with operating frequency.

(4 marks)

(c) A satellite transmitter operates at 4 GHz with an antenna gain of 40 dBi. The receiver, 40,000 km away, has an antenna gain of 50 dBi. If the transmitter has a power of 8 W (ignoring feedline losses and mismatch). Find,

(i) the Effective Isotropic Radiated Power (EIRP) in dBW; and (2 marks)

(ii) the power delivered to the receiver in dBm (3 marks)

(d) A local telco company in Malaysia has decided to set up two base stations to improve the coverage area. The distance between the two stations is measured to be 200 km with line of sight communication link. In order to communication with each other, the requirements below must be fulfilled:

- Use an antenna with a power gain of 10 dB for each station;
- Frequency of operation for the communication link is 1.8 GHz;
- The transmitter produces 9 W of power which is fed to the transmit antenna via a 45-meter transmission line with a characteristic impedance of 50 Ω; and
- The transmission line attenuates 8 dB radio frequency (RF) signal at 1.8 GHz/100 meter.

Based on the information given, solve for the followings:

(i) Power at the input of the antenna assuming a matched load in Watt; (3 marks)

(ii) Effective Isotropic Radiated Power (EIRP) of the transmitter in dBW; (1 mark)

(iii) Free space loss in dB; (2 marks)

(iv) Power density at the received antenna; and (2 marks)

(v) Power received at the receiving antenna in Watt. Assume no other losses. (3 marks)

-END OF QUESTIONS-

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2019/2020 PROGRAMME CODE: BEJ/BEV
COURSE NAME : ELECTRONIC COMMUNICATION SYSTEM COURSE CODE : BEB 31803

Complimentary Error Function Table

$$\operatorname{erfc}(x) = 1 - \frac{2}{\sqrt{\pi}}\int_0^x e^{-t^2}\,dt$$

	Hundredths digit of x									
x	0	1	2	3	4	5	6	7	8	9
0.0	1.00000	0.98872	0.97744	0.96616	0.95489	0.94363	0.93238	0.92114	0.90992	0.89872
0.1	0.88754	0.87638	0.86524	0.85413	0.84305	0.83200	0.82099	0.81001	0.79906	0.78816
0.2	0.77730	0.76648	0.75570	0.74498	0.73430	0.72367	0.71310	0.70258	0.69212	0.68172
0.3	0.67137	0.66109	0.65087	0.64072	0.63064	0.62062	0.61067	0.60079	0.59099	0.58126
0.4	0.57161	0.56203	0.55253	0.54311	0.53377	0.52452	0.51534	0.50625	0.49725	0.48833
0.5	0.47950	0.47076	0.46210	0.45354	0.44506	0.43668	0.42838	0.42018	0.41208	0.40406
0.6	0.39614	0.38832	0.38059	0.37295	0.36541	0.35797	0.35062	0.34337	0.33622	0.32916
0.7	0.32220	0.31533	0.30857	0.30190	0.29532	0.28884	0.28246	0.27618	0.26999	0.26390
0.8	0.25790	0.25200	0.24619	0.24048	0.23486	0.22933	0.22390	0.21856	0.21331	0.20816
0.9	0.20309	0.19812	0.19323	0.18844	0.18373	0.17911	0.17458	0.17013	0.16577	0.16149
1.0	0.15730	0.15319	0.14916	0.14522	0.14135	0.13756	0.13386	0.13023	0.12667	0.12320
1.1	0.11979	0.11647	0.11321	0.11003	0.10692	0.10388	0.10090	0.09800	0.09516	0.09239
1.2	0.08969	0.08704	0.08447	0.08195	0.07949	0.07710	0.07476	0.07249	0.07027	0.06810
1.3	0.06599	0.06394	0.06193	0.05998	0.05809	0.05624	0.05444	0.05269	0.05098	0.04933
1.4	0.04771	0.04615	0.04462	0.04314	0.04170	0.04030	0.03895	0.03763	0.03635	0.03510
1.5	0.03389	0.03272	0.03159	0.03048	0.02941	0.02838	0.02737	0.02640	0.02545	0.02454
1.6	0.02365	0.02279	0.02196	0.02116	0.02038	0.01962	0.01890	0.01819	0.01751	0.01685
1.7	0.01621	0.01559	0.01500	0.01442	0.01387	0.01333	0.01281	0.01231	0.01183	0.01136
1.8	0.01091	0.01048	0.01006	0.00965	0.00926	0.00889	0.00853	0.00818	0.00784	0.00752
1.9	0.00721	0.00691	0.00662	0.00634	0.00608	0.00582	0.00557	0.00534	0.00511	0.00489
2.0	0.00468	0.00448	0.00428	0.00409	0.00391	0.00374	0.00358	0.00342	0.00327	0.00312
2.1	0.00298	0.00285	0.00272	0.00259	0.00247	0.00236	0.00225	0.00215	0.00205	0.00195
2.2	0.00186	0.00178	0.00169	0.00161	0.00154	0.00146	0.00139	0.00133	0.00126	0.00120
2.3	0.00114	0.00109	0.00103	0.00098	0.00094	0.00089	0.00085	0.00080	0.00076	0.00072
2.4	0.00069	0.00065	0.00062	0.00059	0.00056	0.00053	0.00050	0.00048	0.00045	0.00043
2.5	0.00041	0.00039	0.00037	0.00035	0.00033	0.00031	0.00029	0.00028	0.00026	0.00025
2.6	0.00024	0.00022	0.00021	0.00020	0.00019	0.00018	0.00017	0.00016	0.00015	0.00014
2.7	0.00013	0.00013	0.00012	0.00011	0.00011	0.00010	0.00009	0.00009	0.00008	0.00008
2.8	0.00008	0.00007	0.00007	0.00006	0.00006	0.00006	0.00005	0.00005	0.00005	0.00004
2.9	0.00004	0.00004	0.00004	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00002
3.0	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00001	0.00001	0.00001
3.1	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
3.2	0.00001	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2019/2020 PROGRAMME CODE: BEJ/BEV
COURSE NAME : ELECTRONIC COMMUNICATION SYSTEM COURSE CODE : BEB 31803

Miscellaneous Equations (1)

Trigonometry Identity

sin(A + B) = sinAcosB + cosAsinB	*sin(A - B) = sinAcosB - cosAsinB*
cos(A + B) = cosAcosB - sinAsinB	*cos(A - B) = cosAcosB + sinAsinB*
sin(2A) = 2 sinAcosA	$cos(2A) = cos^2A - sin^2A$
$cos^2A=(1/2)[1+cos2A]$	$sin^2A=(1/2)[1-cos2A]$
SinAsinB=(1/2)[cos(A-B)-cos(A+B)]	*cosAcosB=(1/2)[cos(A-B)+cos(A+B)]*

Constants

$c = 3x10^8$ *m/s*	$k = 1.38 \times 10^{-23}$ *J/K*	$T = \theta^0 + 273$ *K*

Gain, Attenuation, SNR and Noise Parameters

$A_v = \frac{V_o}{V_i}$ $A_T = A_1 \times A_2 \times A_3 \times \cdots \times A_n$	$A_p = \frac{P_o}{P_i}$ $\lambda = \frac{c}{f}$
$T = \frac{1}{f}$	$P(dBm) = 10\log\left(\frac{P}{1\times10^{-3}}\right)$
$SNR(dB) = 10\log\left(\frac{P_1}{P_2}\right)$	$SNR(dB) = 20\log\left(\frac{V_1}{V_2}\right)$
$F_T = F_1 + \frac{F_2 \quad 1}{A_1} + \frac{F_3 \quad 1}{A_1A_2} + \cdots + \frac{F_n \quad 1}{A_1A_2\cdots A_{n-1}}$	$T_e - T(F-1)$
$A = \frac{R_2}{R_1 + R_2}$	$P_N = kTB$ $V_N = \sqrt{4RkTB}$
$\frac{S_{out}}{N_{out}} = \frac{A_pS_i}{A_pN_i + N_d}$	$F = \frac{SNR_{in}}{SNR_{out}}$

Amplitude Modulation Equations

$v_m(t) = V_m \sin 2\pi f_m t$ $v_c(t) = V_c \sin 2\pi f_c t$	$V_c = \frac{V_{max} + V_{min}}{2}$
$V_m = \frac{V_{max} - V_{min}}{2}$	$m = \frac{V_m}{V_c}$
$V_{AM}(t) = V_c \sin 2\pi f_c t + \frac{V_m}{2}\cos 2\pi(f_c - f_m)t - \frac{V_m}{2}\cos 2\pi(f_c + f_m)t$	
$P_c = \frac{V_c^2}{2R}$	$P_T = P_c\left(1 + \frac{m^2}{2}\right)$
$P_{USB} = P_{LSB} = \frac{V_m^2}{8R}$	$I_T = I_c\sqrt{\left(1 + \frac{m^2}{2}\right)}$

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2019/2020
COURSE NAME : ELECTRONIC COMMUNICATION SYSTEM
PROGRAMME CODE: BEJ/BEV
COURSE CODE : BEB 31803

Miscellaneous Equations (2)

Amplitude Modulation Equations	
$SF = \frac{BW_{(-60dB)}}{BW_{(-3dB)}}$	$Q = \frac{f_r}{BW}$
$BI = \frac{B_{RF}}{B_{IF}}$	$Q = \frac{X_L}{R}$
$f_{LO} = f_{RF} \pm f_{IF}$	$f_{image} = f_{LO} + f_{IF}$
$\alpha = \sqrt{1 + Q^2\rho^2}$ $IFRR(dB) = 20\log\alpha$	$\rho = \frac{f_{image}}{f_{RF}} - \frac{f_{RF}}{f_{image}}$
Angle Modulation Equations	
$v(t) = V_c \sin(2\pi f_c t + \theta(t))$	$\theta(t) = k_p v_m(t)$ rad
$\theta'(t) = k_f v_m(t)$ rad / s	$\theta(t) = \int \theta'(t)dt$
$v_{PM}(t) = V_c \sin[\omega_c t + \theta(t)]$	$v_{FM}(t) = V_c \sin[\omega_c t + \int \theta'(t)dt]$
$\beta_p = k_p V_m$ radians	$\beta_f = \frac{k_f V_m}{\omega_m}$ or $\frac{k_f V_m}{f_m}$
$\Delta f_c = k_f V_m$ Hz	$\Delta\theta = k_p V_m$ rad
$\%\text{ modulation} = \frac{\Delta f_{actual}}{\Delta f_{max}} \times 100\%$	$BW_{Bessel} = 2(n\, x\, f_m)$ Hz
$BW_{Carson} = 2(\Delta f + f_m)$ Hz	$DR = \frac{\Delta f_{max}}{f_{m(max)}}$
$P_t = P_0 + 2(P_1 + P_2 + P_3 + \dots + P_n)$ Watt	$P_n = \frac{(J_n \times V_c)^2}{2R}$ Watt
$\Delta\theta_{peak} = \frac{V_n}{V_c}$ radian	$\Delta f_{peak} = \frac{V_n}{V_c} f_n$ Hz
Digital Modulation Equations	
$Q_e = \lvert Sampled\ value - Quantized\ value \rvert$ $SQR = \frac{V}{Q_n}$ $DR = \frac{V_{max}}{V_{min}} = \frac{V_{max}}{Resolution}$ $DR = 2^n - 1$	$y = y_{max} \frac{\ln[1 + \mu(\frac{\lvert x \rvert}{x_{max}})]}{\ln(1+\mu)} \operatorname{sgn} x$ $\operatorname{sgn} x = \begin{cases} +1 & x \ge 0 \\ -1 & x < 0 \end{cases}$

FINAL EXAMINATION

SEMESTER / SESSION : SEM II / 2019/2020	PROGRAMME CODE: BEJ/BEV
COURSE NAME : ELECTRONIC COMMUNICATION SYSTEM	COURSE CODE : BEB 31803

Miscellaneous Equations (3)

Digital Modulation Equations	
$y = \begin{cases} y_{\max}\dfrac{A(\frac{\lvert x\rvert}{x_{\max}})}{1+\ln A}\operatorname{sgn} x & 0<\dfrac{\lvert x\rvert}{x_{mac}}\le\dfrac{1}{A} \\ y_{\max}\dfrac{1+\ln[A(\frac{\lvert x\rvert}{x_{\max}})]}{1+\ln A}\operatorname{sgn} x & \dfrac{1}{A}<\dfrac{\lvert x\rvert}{x_{\max}}<1 \end{cases}$	$\text{Coding efficiency} = \dfrac{\text{minimum number of bits}}{\text{actual number of bits}}\times 100\%$
$E_b = P_R T_b$	$N_o = kT_N$
$C - 2BW\log_2 M$	$BW = (\dfrac{B}{\log_2 M})$
$Baud = \dfrac{C}{k}$	$erfc(z) = 1 - erf(z)$
$P_{be} = \dfrac{1}{2}erfc\sqrt{\dfrac{E_b}{2N_o}}$	$P_{be} = \dfrac{1}{2}e^{\frac{-E_b}{2N_o}}$
$BR = SR \times n$	$BW_{min} \le \dfrac{1}{2}BR$ $BW_{pcm} = BR$
Transmission Line, Antenna & Propagation Equations	
$P_R = \left(\dfrac{P_T G_T G_R}{\left(\frac{4\pi d}{\lambda}\right)^2}\right)\times\dfrac{1}{L_t L_r} \quad W$	$P_d = \dfrac{EIRP}{4\pi d^2} \quad \dfrac{W}{m^2}$
$\Gamma = \dfrac{VSWR-1}{VSWR+1}$	$Z_0 = \sqrt{\dfrac{L}{C}} \quad \Omega$
$Z_{in} = Z_0\dfrac{Z_L\cos\beta l + jZ_0\tan\beta l}{Z_0\cos\beta l + jZ_L\tan\beta l} \quad \Omega$	$\gamma = \alpha + j\beta = \sqrt{(R+j\omega L)(G+j\omega C)} \quad \dfrac{Np}{m} \text{ or } \dfrac{rad}{m}$