UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	ELECTRONIC COMMUNICATION SYSTEM
COURSE CODE	:	BEB 31803
PROGRAMME CODE	:	BEJ/BEV
EXAMINATION DATE	:	JUNE/JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	SECTION A: ANSWER **ALL** QUESTIONS SECTION B: ANSWER **THREE (3)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **THIRTEEN (13)** PAGES

SECTION A: ANSWER ALL QUESTIONS (40 MARKS)

Q1 (a) A three-stage system has an input power P_{in} = -20 dBm and power gains of the three stages are A_{P1} = 13 dB, A_{P2} = 5 dB, and A_{P3} = -6 dB. The noise at the input of the first amplifier is 1.2 x 10^{-12} W and the noise factor of the 3 amplifiers are 2.3, 2.2 and 2.5, respectively. Calculate:

(i) the total noise figure; and (3 marks)

(ii) the output signal to noise ratio (in dB). (3 marks)

(b) An amplifier has gain of 45,000, which is too much for the amplification. If the input voltage is 20 μV, determine the attenuation factor (in dB) that is needed to keep the output voltage from exceeding 100mV.

(4 marks)

Q2 (a) What is Amplitude Modulation (AM)? (2 marks)

(b) Explain each of the following type of AM using a suitable diagram.

(i) Under Modulation. (2 marks)

(ii) Ideal Modulation. (2 marks)

(iii) Over Modulation. (2 marks)

(c) A 108 MHz carrier is frequency modulated by a 7 kHz sine wave. The resultant Frequency Modulation (FM) signal has a frequency deviation of 50 kHz.

(i) Determine the carrier swing of the FM signal.

(1 mark)

(ii) Determine the highest and lowest frequencies attained by the modulated signal.

(4 marks)

(iii) What is the modulation index of the FM wave?

(2 marks)

Q3 (a) There are three processes involved in converting the analog signal to digital signal. Briefly explain each process.

(3 marks)

(b) A television signal has a bandwidth of 4.5 MHz.

(i) Determine the sampling rate if the signal is to be sampled at a rate of 20 % above the Nyquist rate.

(2 marks)

(ii) If the samples are quantized into 1024 levels, determine the number of bits required to encode each sample.

(1 mark)

(iii) Determine the bit rate of the coded signal. (2 marks)

(c) Given an isotropic radiator with 10 W of radiating power.

(i) Calculate the power density 20 km away from the radiator.

(4 marks)

(ii) The electric field strength is found to become 2 times stronger if the radiator is replaced with an antenna. Determine the gain of the antenna in dBi.

(3 marks)

SECTION B: ANSWER THREE (3) QUESTIONS ONLY (60 MARKS)

Q4 **Figure Q4** shows the AM double-sideband Full Carrier (DSB-FC) transmitter and superheterodyne receiver. The carrier and modulating signals are given by $v_c(t) = 6sin(1800\pi \times 10^3)t$ and $v_m(t) = 5sin(10\pi \times 10^3)t$ respectively. The transmitter transmits DSB-FC signal, $v_{DSB-FC}(t)$ to the receiver. The preselector of the receiver is tuned to the RF frequency of $f_{RF} = 900$ kHz with a bandwidth of 10 kHz.

(a) Write the full equation of DSB-FC AM signal at point **X**.

(2 marks)

(b) Draw and label the amplitude spectrum at point **X**.

(3 marks)

(c) Find the total transmitted power, P_T if the resistance of the antenna is 50 Ω.

(3 marks)

(d) State **ONE (1)** reason why the $v_{DSB-FC}(t)$ signal produced by the transmitter is inefficient in terms of bandwidth and power efficiency as compared to the single sideband (SSB) signal.

(2 marks)

(e) Find the quality factor, Q of the filter in the preselector.

(1 mark)

(f) The mixer/converter uses high-side injection for the Radio Frequency to Intermediate Frequency (RF-to-IF) conversion. The local oscillator has the frequency, $f_{LO} = 1355$ kHz. Determine the IF center frequency, IF upper-side frequency and IF lower-side frequency for the received RF signal $v_{DSB-FC}(t)$.

(5 marks)

(g) Determine the image frequency, f_{image} produced from the RF-to-IF conversion.

(2 marks)

(h) Calculate the image frequency rejection ratio (IFRR) of the receiver in dB.

(2 marks)

Q5 (a) Derive the FM signal using cosine wave.

(3 marks)

(b) Given that the carrier has the peak amplitude of 10 V with an angular frequency of $2\pi\times10^{7}$ rads^{-1}. The modulating signal has an angular frequency of $10\pi\times10^{4}$ rads^{-1}. The modulation index of the FM signal is 2. Determine:

(i) the frequency of the carrier signal,

(1 mark)

(ii) the frequency of the modulating signal,

(1 mark)

(iii) the peak frequency deviation,

(2 marks)

(iv) the modulation sensitivity if 400 mV is required to achieve part (b)(iii),

(2 marks)

(v) the carrier power if the impedance of the antenna is 50 Ω,

(2 marks)

(vi) the Bessel bandwidth and compare it using Carson's rule,

(3 marks)

(vii) the power spectrum and sketch it, and

(5 marks)

(viii) the total information power.

(1 mark)

Q6 (a) Discuss uniform and non- uniform quantization with proper example and diagram.

(5 marks)

(b) As a telecommunication engineer, you are assigned to design a Pulse Code Modulation (PCM) signal for a telephone system. Assume that an analog audio voice frequency signal occupies a band from 300-3400 Hz. The signal is to be converted to a PCM signal for transmission over a digital telephone system. Each sample is represented by 8 bits. Determine:

(i) the bandwidth using a sinc function; (4 marks)

(ii) the bandwidth using rectangular pulse; (2 marks)

(iii) the dynamic range in dB of this system; and (2 marks)

(iv) discuss the performance of PCM if number of bits per sample is reduce to 3 bits per sample.

(1 mark)

(c) The following are the specifications of a communication system:

Input signal fundamental frequency = 4 KHz
Bandwidth allowed = 26 KHz
Energy per bit = $4.55\times10^{-3}\ J$
Noise density = $4\times10^{-4}\ Volts^2 / Hz$

For frequency shift keying (FSK), the difference between the first and second carrier is 1.5 kHz. Transmission has to include the fundamental frequency and the third harmonic.

Compare the bandwidth and error probability performance for ASK and FSK signals.

(6 marks)

Q7 A 105 MHz with 90 V peak signal is incident on a 50 Ω transmission line. The velocity factor of the line is 0.85. The line is 125 m long and is terminated in a 300 Ω load.

(a) Determine the wavelength of the signal on the transmission line.
(1 mark)

(b) Define Standing Wave Ratio (SWR) and what is the SWR for that situation?
(3 marks)

(c) Determine the reflection coefficient.
(1 mark)

(d) Calculate the peak value of the reflected voltage.
(1 mark)

(e) What percent of the incident power is returned as reflected power?
(2 marks)

(f) Determine the peak value of the voltage standing wave at the voltage antinodes.
(2 marks)

(g) Determine the peak value of the voltage standing wave at the voltage nodes.
(2 marks)

(h) Determine the peak value of the current standing wave at the current antinodes.
(6 marks)

(i) Determine the peak value of the current standing wave at the current nodes.
(2 marks)

-END OF QUESTIONS –

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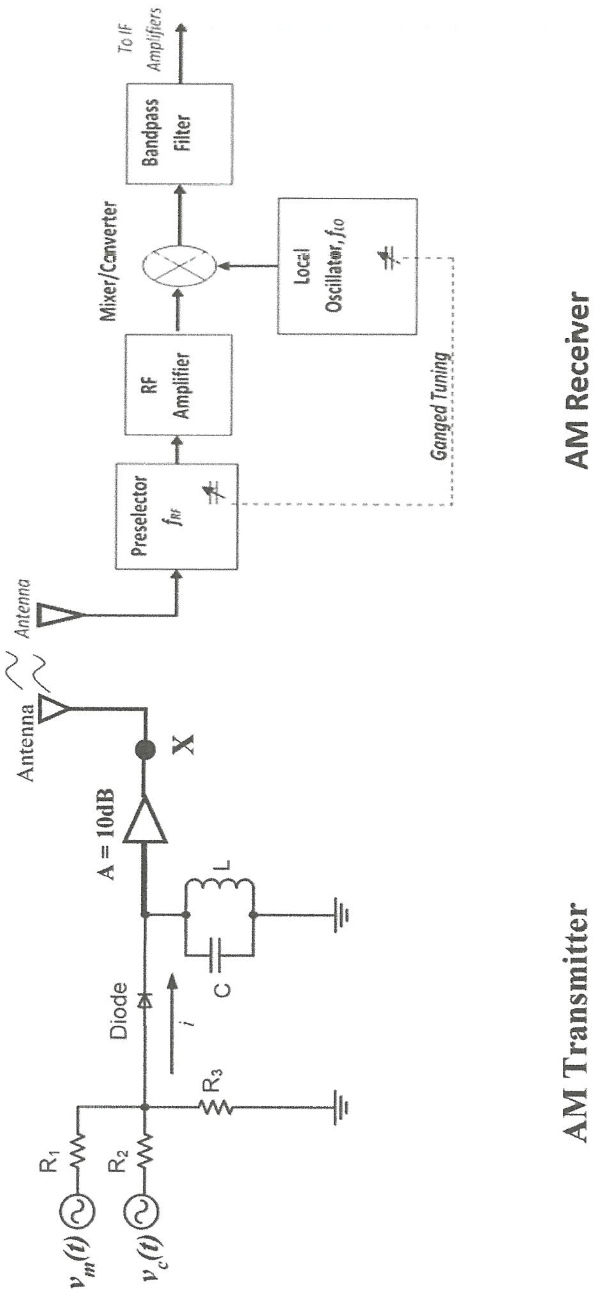

Figure Q4

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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

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Bessel Function Table

Modulation index	Carrier	Sidebands									
	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}
0.0	1.00	—	—	—	—	—	—	—	—	—	—
0.25	0.98	0.12	—	—	—	—	—	—	—	—	—
0.5	0.94	0.24	0.03	—	—	—	—	—	—	—	—
1.0	0.77	0.44	0.11	0.02	—	—	—	—	—	—	—
1.5	0.51	0.56	0.23	0.06	0.01	—	—	—	—	—	—
2.0	0.22	0.58	0.35	0.13	0.03	—	—	—	—	—	—
2.5	−0.05	0.50	0.45	0.22	0.07	0.02	—	—	—	—	—
3.0	−0.26	0.34	0.49	0.31	0.13	0.04	0.01	—	—	—	—
4.0	−0.40	−0.07	0.36	0.43	0.28	0.13	0.05	0.02	—	—	—
5.0	−0.18	−0.33	0.05	0.36	0.39	0.26	0.13	0.06	0.02	—	—
6.0	0.15	−0.28	−0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02	—
7.0	0.30	0.00	−0.30	−0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02
8.0	0.17	0.23	−0.11	−0.29	0.10	0.19	0.34	0.32	0.22	0.13	0.06

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Miscellaneous Equations (1)

Trigonometry Identity	
$\sin(A+B) = \sin A\cos B + \cos A\sin B$	$\sin(A-B) = \sin A\cos B - \cos A\sin B$
$\cos(A+B) = \cos A\cos B - \sin A\sin B$	$\cos(A-B) = \cos A\cos B + \sin A\sin B$
$\sin(2A) = 2\sin A\cos A$	$\cos(2A) = \cos^2 A - \sin^2 A$
$\cos^2 A = (1/2)[1+\cos 2A]$	$\sin^2 A = (1/2)[1-\cos 2A]$
$\sin A\sin B = (1/2)[\cos(A-B) - \cos(A+B)]$	$\cos A\cos B = (1/2)[\cos(A-B) + \cos(A+B)]$

Constants		
$c = 3\times10^8$ m/s	$k = 1.38 \times 10^{-23}$ J/K	$T = \theta^0 + 273$ K

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

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

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Miscellaneous Equations (2)

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

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Miscellaneous Equations (3)

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

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