UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	ELECTRONIC COMMUNICATION SYSTEMS
COURSE CODE	:	BEJ 30103 / BEV 30103 / BEB 31803
PROGRAMME CODE	:	BEJ / BEV
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK** 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

Q1 (a) List **FOUR (4)** types of external noise.

(4 marks)

(b) Define the term of correlated noise in electronic communication systems. Then, describe **TWO (2)** examples of correlated noise.

(7 marks)

(c) A radio receiving system incorporates an amplifier that has a gain of 28 dB. The receiver contributes an additional 3.84 pW of noise. The input delivers a signal power of 2 nW to the amplifier. If the available noise power from the input is -110 dBm. Determine

(i) the input Signal-to-Noise ratio (SNR) in dB.

(2 marks)

(ii) the output Signal-to-Noise ratio (SNR) in dB.

(3 marks)

(iii) the noise factor and noise figure.

(2 marks)

(d) An analog receiver system consists of an antenna and three cascaded RF amplifiers as shown in **Figure Q1(d)**. The system operates in the 27°C of environment temperature. The receiver received a signal, $v_A(t) = 100sin(1.9\pi \times 10^6)t + 40\cos(1.86\pi \times 10^6)t - 40cos(1.94\pi \times 10^6)t$. Given the antenna resistance is 50Ω, calculate the output signal to noise ratio, SNR_0 in decibel (dB).

(7 marks)

Q2 (a) **Figure Q2(a)** shows a Frequency Modulation (FM) generator circuit which is based on direct FM system. The circuit produces

$$V_{FM}(t) = 15\cos\left(3\pi \times 10^6 t + 4\sin(2\pi \times 10^3 t)\right)$$

(i) Explain what is direct FM system?

(2 marks)

(ii) Name the component that define direct FM modulator.

(1 mark)

(iii) Identify the modulation index.

(1 mark)

(iv) Write the carrier instantaneous equation for the circuit.

(2 marks)

(v) Calculate the actual and approximate bandwidths.

(4 marks)

(vi) Analyze the total FM power if a 50 Ω cable is connected to a spectrum analyzer.

(6 marks)

(vii) Conclude your analysis of **Q2 (a) (vi)** by comparing with the unmodulated carrier power.

(1 mark)

(b) FM demodulation is a process of recovering the original signal. A slope detector is one on the simplest demodulator as shown in **Figure Q2(b)**.

(i) Name other **TWO (2)** types of demodulators.

(2 marks)

(ii) Explain the function of La, Ca, Di, Ci and Ri in **Figure Q2(b).**

(5 marks)

(iii) List **ONE (1)** disadvantage of slope detector

(1 marks)

Q3 (a) List **FOUR (4)** advantages of digital communication over analog communication.

(4 marks)

(b) For a random analog signal that contains both very low and very high amplitude, state the most suitable characteristic for quantization process.

(1 mark)

(c) **Figure Q3(c)** shows the block diagram of analog to digital signal conversion. The sampling of output's adder signal is fixed at minimum Nyquist rate. The encoder uses Pulse Code Modulation within folded binary code. The uniform quantization voltage range is limited from -5.0 V to +5.0 V. The conversion system is designed to achieve dynamic range, DR > 20dB with least numbers of bits is used.

(i) Determine the time interval between each sample of message signal.

(3 marks)

(ii) Find the resolution of quantization scheme.

(4 marks)

(iii) With an aid of a table, relate the PCM folded binary code with quantization range.

(7 marks)

(iv) Predict the transmitted PCM code for 100^{th} and $10{,}000^{th}$ samples.

(6 marks)

Q4 (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.

(3 marks)

(b) An antenna with dimension of 50 cm radiates a RF signal with an operating frequency of 1080 MHz. The antenna is connected by coaxial cable with inductance, $L = 0.2$ μH/m and capacitance, $C = 1.5$ nF/m .Its radiation pattern is measured in the far field region.

(i) Distinguish between near field and far field region for antenna's radiation.
(4 marks)

(ii) Calculate the minimum distance of far field region.
(2 marks)

(iii) Determine the dielectric constant of coaxial cable.
(3 marks)

(c) **Figure Q4(c)** illustrates the wireless communication system between Station A and Station B with operating frequency of 1.2 GHz. The RF signal propagates within line of sight. Both stations use identical parabolic antenna with 1.2 m diameter and 95% efficiency. The length of transmission line at both stations are 10 m respectively.

(i) Identify **TWO (2)** elements that contribute to the loss factor in this wireless communication system.
(2 marks)

(ii) Determine the free space loss in dB at Station B's antenna.
(2 marks)

(iii) Analyze the total loss factor in dB in this communication system.
(2 marks)

(iv) Determine the power density at half of the distance from Station A to Station B.
(2 marks)

(v) Calculate the received power at the receiver in dBW.
(3 marks)

– END OF QUESTIONS –

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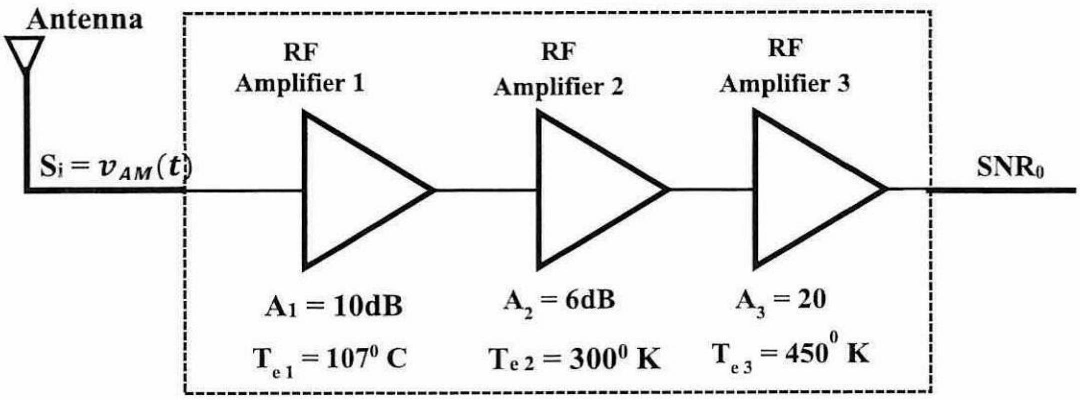

Figure Q1(d)

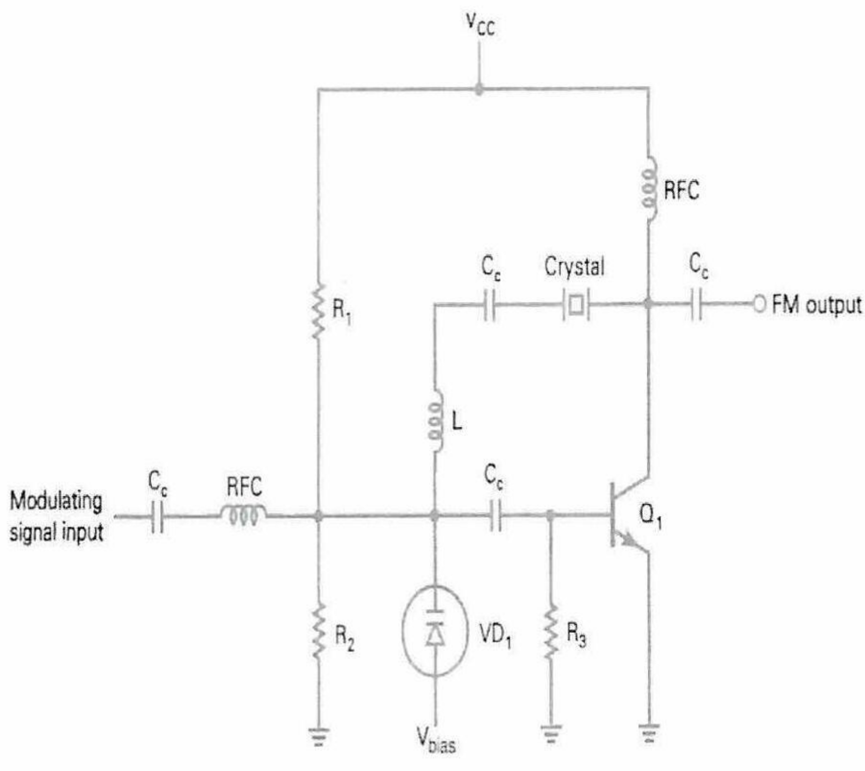

Figure Q2(a)

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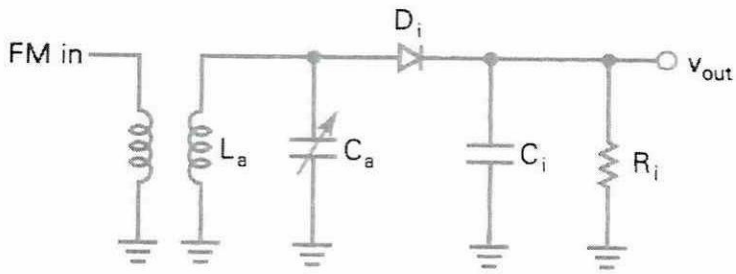

Figure Q2(b)

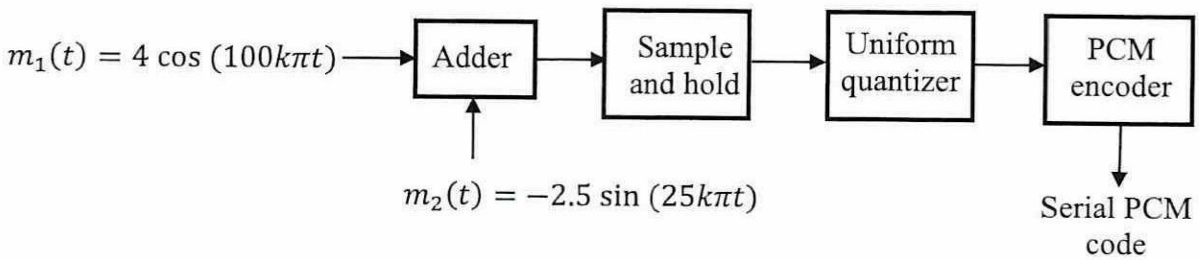

Figure Q3(c)

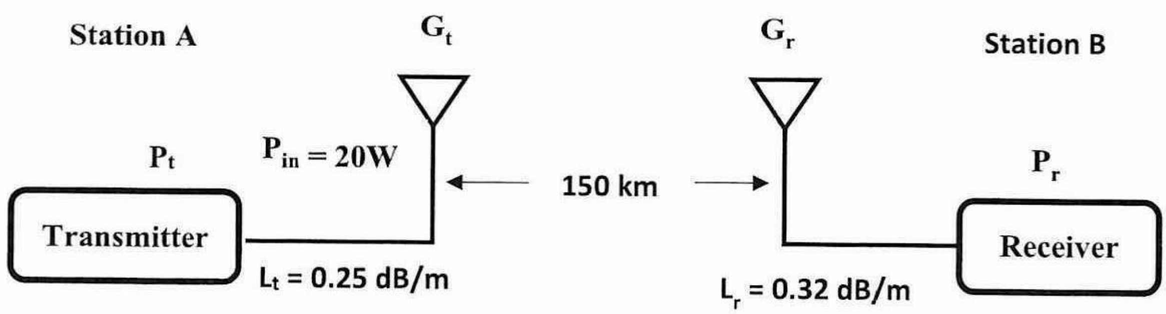

Figure Q4(c)

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Complimentary Error Function Table

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

	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 J_0	Sidebands									
		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	
$sin(A + B) = sinAcosB + cosAsinB$	$sin(A - B) = sinAcosB - cosAsinB$
$cos(A + B) = cosAcosB - sinAsinB$	$cos(A - B) = cosAcosB + sinAsinB$
$sin(2A) = 2\ sinAcosA$	$cos(2A) = cos^2A - sin^2A$
$cos^2A=(1/2)[1+cos2A]$	$sin^2A=(1/2)[1-cos2A]$
$SinAsinB=(1/2)[cos(A-B)-cos(A+B)]$	$cosAcosB=(1/2)[cos(A-B)+cos(A+B)]$

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

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

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	
$SF = \frac{BW_{(-60dB)}}{BW_{(-3dB)}}$	$Q = \frac{f_r}{BW}$
$BI = \frac{B_{RF}}{B_{IF}}$	$Q = \frac{X_L}{R}$
$f_{LO} = f_{RF} \pm f_{IF}$	$f_{image} = f_{LO} + f_{IF}$
$\alpha = \sqrt{1 + Q^2\rho^2}$ $IFRR(dB) = 20 \log \alpha$	$\rho = \frac{f_{image}}{f_{RF}} - \frac{f_{RF}}{f_{image}}$
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
$\%\text{ modulation} = \frac{\Delta f_{actual}}{\Delta f_{max}} \times 100\%$	$BW_{Bessel} = 2\,(n \times f_m)$ Hz
$BW_{Carson} = 2\,(\Delta f + f_m)$ Hz	$DR = \frac{\Delta f_{max}}{f_{m(max)}}$
$P_t = P_0 + 2(P_1 + P_2 + P_3 + \ldots\ldots + P_n)$ 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	
$Q_e = \vert \text{Sampled value} - \text{Quantized value} \vert$ $SQR = \frac{V}{Q_n}$ $DR = \frac{V_{max}}{V_{min}} = \frac{V_{max}}{\text{Resolution}}$ $DR = 2^n - 1$	$y = y_{max} \frac{\ln[1 + \mu(\frac{\vert x \vert}{x_{max}})]}{\ln(1+\mu)} \operatorname{sgn} x$ $\operatorname{sgn} x = \begin{cases} +1 & x \geq 0 \\ -1 & x < 0 \end{cases}$

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Miscellaneous Equations (3)

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