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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	ELECTRONIC COMMUNICATION SYSTEMS
COURSE CODE	:	BEJ 30103
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY / AUGUST 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 **TWELVE (12)** PAGES

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Q1 (a) Basic communication systems consist of **THREE (3)** components; transmitters, channels and receivers. Draw the block diagram to illustrate the relationship between the components and describe them in relation to the information signals.
(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 transmitter system operates in $22\ ^{\circ}C$ of environment temperature with a bandwidth of 2 MHz. The system incorporates an amplifier that has a gain of 28 dB and contributes an additional 3.84 pW of noise. The input delivers a signal power of 10 nW to the amplifier. 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 $27\ ^{\circ}C$ of environment temperature. The receiver received a signal, S_i with a bandwidth of 40 kHz and produce an output signal-noise-ratio (SNR_o) of 150dB. Given the antenna resistance as 50Ω, calculate the received signal power, S_i in decibel units (dBW).
(7 marks)

Q2 (a) Define the term "modulation" in electronic communication systems. Then, list **TWO (2)** advantages of modulation.
(4 marks)

(b) Explain the operation of Phase Locked Loop (PLL) with the aid of a suitable diagram.
(7 marks)

(c) **Figure Q2(c)** shows the Narrowband FM Phase Modulator block diagram. Given the carrier signal, $v_c(t) = 50\cos(190\pi \times 10^5 t)$, the modulating signal, $v_m(t) = 10\cos(20\pi \times 10^3 t)$ and frequency deviation sensitivity $K_f = {}^{0.7kHz}/_{V}$.

(i) Determine the frequency deviation, Δf and the modulation index, β_f.
(2 marks)

(ii) Produce the FM signal equation at point "A".
(7 marks)

(iii) Draw and label the frequency spectrum at point "A". (3 marks)

(iv) Calculate the total power at point "A", given R = 50Ω. (2 marks)

Q3 (a) Analog-to-digital conversion (ADC) and digital-to-analog conversion (DAC) are processes that allow computers to interact with analog signals. There are three processes involved in converting analog signal to digital signal. Briefly explain each process.

(3 marks)

(b) A television signal (audio and video) has a bandwidth of 4.5 MHz. The signal is then sampled, quantized and encoded to obtain a series of Pulse Code Modulation (PCM) sequence.

(i) Determine the sampling rate if the signal is to be sampled at a rate of 30% above the Nyquist rate.

(3 marks)

(ii) If the samples are quantized into 2048 levels, determine the number of bits required to encode each sample.

(2 marks)

(iii) Determine the binary pulse rate (bits per second) of binary coded signal.

(2 marks)

(c) The energy bit per noise density (E_b/N_0) is given as 8.405. Determine the probability of bit error for optimum coherent detection of:

(i) frequency shift keying (FSK)

(2 marks)

(ii) phase shift keying (PSK)

(2 marks)

(d) **Figure Q3(d)** shows a demodulator block diagram of digital modulation.

(i) Name the digital modulation type.

(1 mark)

(ii) Sketch an appropriate modulator block diagram based on your answer in **Q3(d)(i)**.

(3 marks)

(iii) Derive the output signal of low-pass filter (LPF) for the input signal of $\sin(\omega_c t)$ and $-\sin(\omega_c t)$.

(3 marks)

(iv) Formulate the output signal of LPF if there is a phase error introduces by coherent carrier recovery (CCR) circuit. Assume the same input signal in **Q3(d)(iii)** and the CCR output is $\sin(\omega_c t + \theta)$ where θ is phase error value.

(4 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.

(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) A transmitting antenna has a radiation resistance, R_{rad} of 80 Ω; an effective resistance, R_e of 8 Ω; a directive gain, G_d of 25; and an input power, P_{in} of 90 W.

(i) From the information given, draw the equivalent circuit of the antenna by incorporating all the values in the circuit.

(3 marks)

Then, calculate the followings:

(ii) Antenna efficiency, η_r in percentage;

(1 mark)

(iii) Antenna power gain, G_p; and

(1 mark)

(iv) Effective Isotropic Radiated Power, EIRP in Watt and dBm.

(2 marks)

(c) One mobile operator company in Malaysia has finally decided to upscale their base stations to improve the coverage area. The distance between the two stations is measured to be 300 km with line of sight (LOS) 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 is 1800 MHz;
- The transmitter produces 9 W of power which is fed to the transmit antenna via a 60 meter transmission line with a characteristic impedance of 50 Ω; and
- The transmission line attenuates 8 dB radio frequency (RF) signal at 1800 MHz/100 meter.

Based on the information given, solve 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 are involved. (3 marks)

– END OF QUESTIONS –

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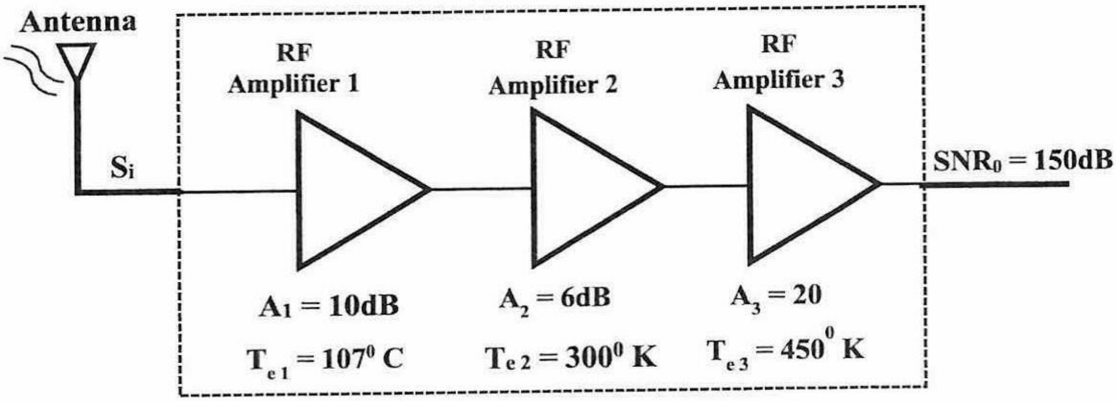

FigureQ1(d)

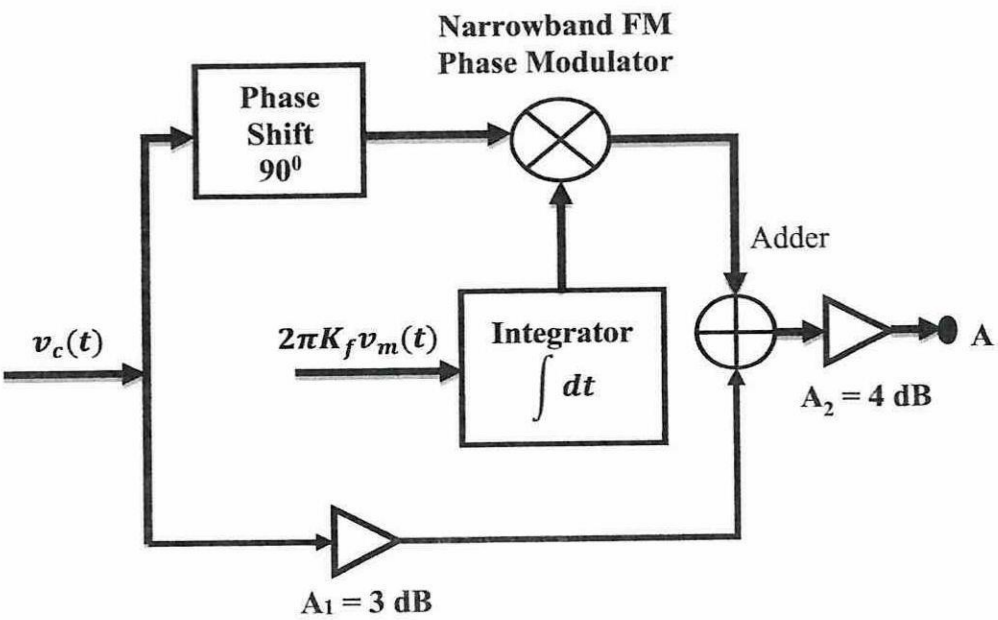

Figure Q2(c)

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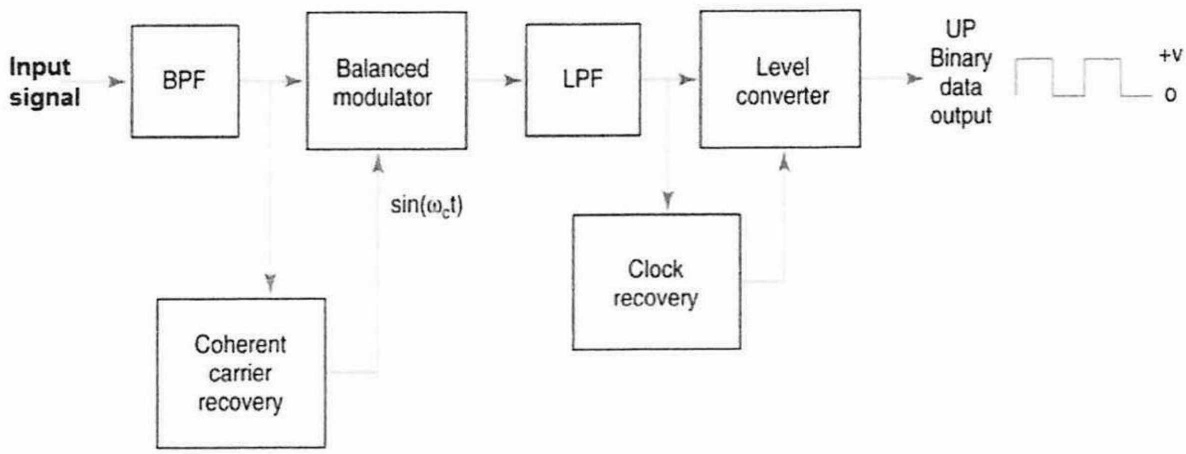

Figure Q3(d)

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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 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		
$A_v = \frac{V_o}{V_i}$	$A_p = \frac{P_o}{P_i}$	
$A_T = A_1 \times A_2 \times A_3 \times \cdots \times A_n$	$\lambda = \frac{c}{f}$	
$T = \frac{1}{f}$	$P(dBm) = 10\log\left(\frac{P}{1\times10^{-3}}\right)$	
$SNR(dB) = 10\log\left(\frac{P_1}{P_2}\right)$	$SNR(dB) = 20\log\left(\frac{V_1}{V_2}\right)$	
$F_T = F_1 + \frac{F_2-1}{A_1} + \frac{F_3-1}{A_1A_2} + \cdots + \frac{F_n-1}{A_1A_2\cdots A_{n-1}}$	$T_e = T(F-1)$	
$A = \frac{R_2}{R_1+R_2}$	$P_N=kTB$ $V_N = \sqrt{4RkTB}$	
$\frac{S_{out}}{N_{out}} = \frac{A_pS_i}{A_pN_i + N_d}$	$F = \frac{SNR_{in}}{SNR_{out}}$	
Amplitude Modulation Equations		
$v_m(t) = V_m \sin 2\pi f_m t$ $v_c(t) = V_c \sin 2\pi f_c t$	$V_c = \frac{V_{max}+V_{min}}{2}$	
$V_m = \frac{V_{max}-V_{min}}{2}$	$m = \frac{V_m}{V_c}$	
$V_{AM}(t) = V_c \sin 2\pi f_c t + \frac{V_m}{2}\cos 2\pi(f_c - f_m)t - \frac{V_m}{2}\cos 2\pi(f_c+f_m)t$		
$P_c = \frac{V_c^2}{2R}$	$P_T = P_c\left(1+\frac{m^2}{2}\right)$	
$P_{USB} = P_{LSB} = \frac{V_m^2}{8R}$	$I_T = I_c\sqrt{\left(1+\frac{m^2}{2}\right)}$	

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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	$DR = \frac{\Delta f_{\max}}{f_{m(\max)}}$
$P_t = P_0 + 2(P_1 + P_2 + P_3 + ... + P_n)$ 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	
$Q_e = \lvert \text{Sampled value} - \text{Quantized value} \rvert$ $SQR = \frac{V}{Q_n}$ $DR = \frac{V_{\max}}{V_{\min}} = \frac{V_{\max}}{\text{Resolution}}$ $DR = 2^n - 1$	$y = y_{\max} \frac{\ln[1 + \mu(\frac{\lvert x \rvert}{x_{\max}})]}{\ln(1 + \mu)} \operatorname{sgn} x$ $\operatorname{sgn} x = \begin{cases} +1 & x \geq 0 \\ -1 & x < 0 \end{cases}$

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Miscellaneous Equations (3)

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

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