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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	ELECTRONIC COMMUNICATION SYSTEM
COURSE CODE	:	BEB 31803
PROGRAMME CODE	:	BEJ/BEV
EXAMINATION DATE	:	DECEMBER 2019/ JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	SECTION A: ANSWER **ALL** QUESTIONS SECTION B: ANSWER **THREE (3)** QUESTIONS ONLY

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

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SECTION A: ANSWER ALL QUESTIONS (40 MARKS)

Q1 (a) Explain **THREE (3)** transmission impairments in electronic communication systems.

(6 marks)

(b) Determine the overall noise factor and noise figure for three cascaded amplifiers with the following parameters:

Power Gain, $A_1 = 3$ dB	Noise Figure $NF_1 = 10$ dB,
Power Gain, $A_2 = 13$ dB	Noise Figure $NF_2 = 6$ dB,
Power Gain, $A_3 = 10$ dB	Noise Figure $NF_3 = 10$ dB,

(4 marks)

Q2 (a) Define the meaning of modulation.

(2 marks)

(b) Double Sideband Full Carrier (DSBFC) and Single Sideband (SSB) are the types of Amplitude Modulation (AM) in electronic communication system. Explain the differences between DSBFC and SSB techniques using the suitable diagram.

(5 marks)

(c) For an FM modulator with a modulation index of 1, modulating signal $v_m(t) = V_m \sin(2\pi 1000t)$, an unmodulated carrier $v_c(t) = 10\sin(2\pi 500kt)$, and a load resistor of 50Ω, determine:

(i) the unmodulated carrier power;

(2 marks)

(ii) the total power in the angle-modulated wave; and

(4 marks)

(iii) the bandwidth

(2 marks)

Q3 (a) Identify **TWO (2)** factors that influence the performance of a M-ary Frequency Shift Keying (MFSK) system.

(2 marks)

(b) Draw the modulated signals of the following digital modulation schemes if the data bits represented by a bipolar Non-Return to Zero waveform is given as 101001.

(i) Amplitude Shift Keying (ASK)

(2 marks)

(ii) Frequency Shift Keying (FSK)

(2 marks)

(iii) Phase Shift Keying (PSK)

(2 marks)

(c) 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)

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

Q4 **Figure Q4** shows the amplitude modulation (AM) Single Sideband (SSB) transmitter and a superheterodyne receiver. The carrier and modulating signals are given by $v_c(t) = 6sin(1800\pi \times 10^3)t$ and $v_m(t) = 5sin(20\pi \times 10^3)t$ respectively. The modulation process of both signals produces single sideband signal, $v_{SSB}(t)$ at point "**C**". Then, the amplifier amplifies $v_{SSB}(t)$ by 7dB before transmission to the receiver.
At the receiver side, the preselector is tuned to the RF center frequency of $v_{SSB}(t)$ with a bandwidth of 10 kHz.

(a) Produce the full equation of $v_{SSB}(t)$ at point "**D**".
(6 marks)

(b) Draw the amplitude spectrum of $v_{SSB}(t)$ at point "**D**". Label the designated frequency and amplitude in your answer.
(3 marks)

(c) Determine the resulted bandwidth of $v_{SSB}(t)$.
(2 marks)

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

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

(f) The mixer/converter at the receiver converts RF-to-IF signal frequency. The local oscillator has the frequency, f_{LO} = 1345 kHz. Determine the IF frequency for the received $v_{SSB}(t)$ signal.
(2 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) Given FM and PM modulators with the following parameters:

FM modulator:
$k_f = 1.5$ kHz/V
$f_c = 500$ kHz
$v_m(t) = 2 \sin(2\pi\, 2kt)$

PM modulator:
$k_p = 0.75$ rad/V
$f_c = 500$ kHz
$v_m(t) = 2 \sin(2\pi\, 2kt)$

(i) Determine the modulation indices and sketch the output spectrums for both modulators.

(6 marks)

(ii) Change the modulating signal frequency for both modulators to 1 kHz and repeat step **(i)**.

(8 marks)

(iii) Based on your answers, analyse the effect of changing the modulating signal frequency to the PM and FM modulators.

(6 marks)

Q6 (a) Define Pulse Code Modulation (PCM).

(2 marks)

(b) **Figure Q6(b)** shows an analog signal, *x(t)*, together with the natural sample value (in voltage) of that analog signal. Explain the process of getting the PCM sequence.

(8 marks)

(c) By using the common voice communication as an example, discuss the advantages of non-uniform quantization over uniform quantization.

(4 marks)

(d) Given a pulse waveform in the format of Nonreturn to Zero-Level (NRZ-L) as shown in **Figure Q6(d)**. Construct the waveform in the format of:

(i) Unipolar Return to Zero (Unipolar RZ)

(2 marks)

(iii) Bipolar Return to Zero (Bipolar RZ)

(2 marks)

(iv) Return to Zero Alternate Mark Inversion (RZ-AMI)

(2 marks)

Q7 (a) 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)

(b) 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 -

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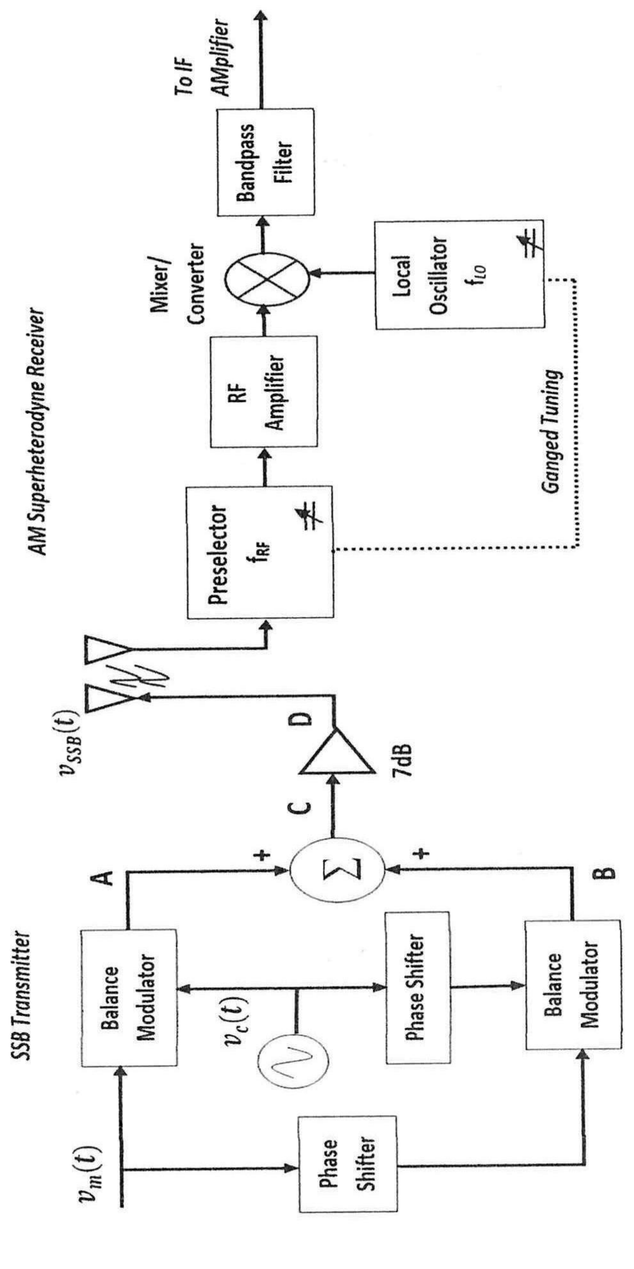

Figure Q4

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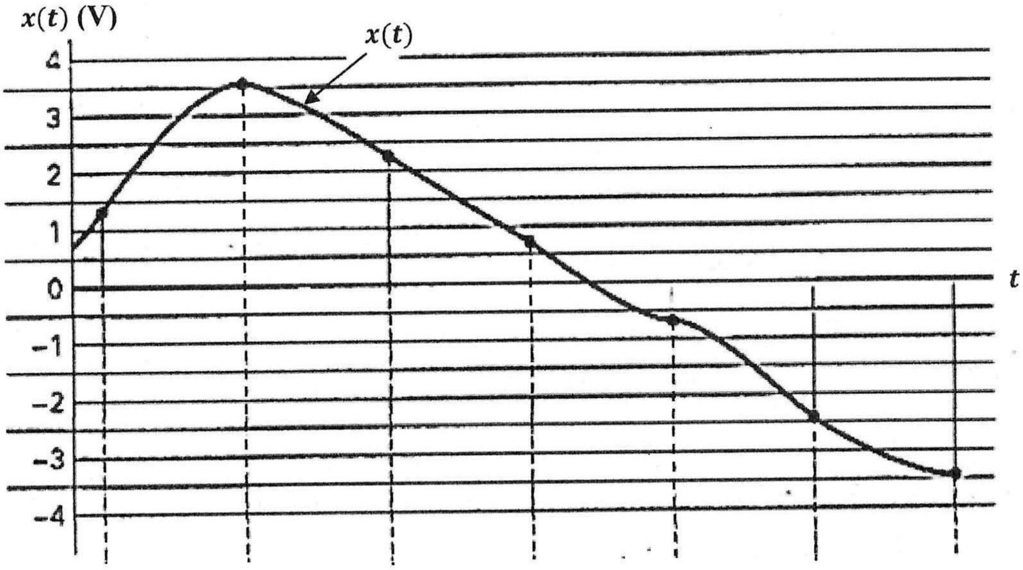

Figure Q6(b)

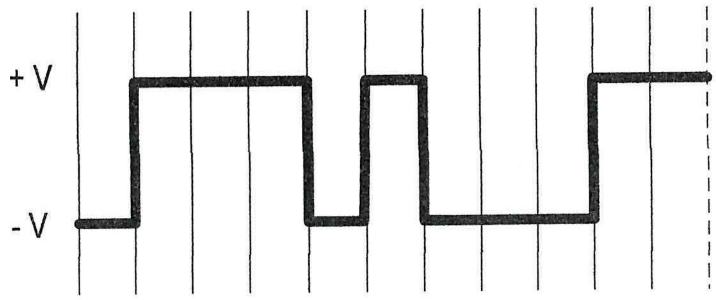

Figure Q6(d)

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

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

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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	
$P_R = \left(\dfrac{P_T G_T G_R}{\left(\dfrac{4\pi d}{\lambda}\right)^2} \right) \times \dfrac{1}{L_t L_r} \quad W$	$P_d = \dfrac{EIRP}{4\pi d^2} \quad \dfrac{W}{m^2}$
$\Gamma = \dfrac{VSWR-1}{VSWR+1}$	$Z_0 = \sqrt{\dfrac{L}{C}} \quad \Omega$
$Z_{in} = Z_0 \dfrac{Z_L \cos \beta l + jZ_0 \tan \beta l}{Z_0 \cos \beta l + jZ_L \tan \beta l} \quad \Omega$	$\gamma = \alpha + j\beta = \sqrt{(R + j\omega L)(G + j\omega C)} \quad \dfrac{Np}{m} \text{ or } \dfrac{rad}{m}$