MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal)

FIFTH SEMESTER BTECH. (E & C) DEGREE END SEMESTER EXAMINATION MARCH 2021 SUBJECT: ANALOG AND DIGITAL COMMUNICATION (ECE -3151)

TIME: 3 HOURS

MAX. MARKS: 50

Instructions to candidates

- Answer **ALL** questions.
- Missing data may be suitably assumed.
- Use erfc table if required

1A. Power spectral density of a signal g(t) is given by $S_g(f) = \begin{cases} f+1, f < 0 \\ 1-f, f \ge 0 \end{cases}$

Determine a) the autocorrelation function b) Average power of the signal g(t).

- 1B. A signal with frequency ranging from 1KHz to 3KHz is applied as an input to a two stage SSB modulator. The carrier frequencies are 100KHz and 10MHz for stage 1 and 2 respectively. Determine
 - i. The spectrum of the outputs after each block.
 - ii. Define the pass band and guard band of the filters required so as to get SSB output in the highest possible band.

(5+5)

- 2A. A device has an input-output relation, $x = ai + bi^2$ where *i* is input and *x* is output. Obtain an expression for an AM signal using this device. Draw the block diagram for the same by giving proper frequency and amplitude specifications for each block.
- 2B. Explain the need of multipliers and a mixer in an FM transmitter using indirect method. The output FM is expected to have a carrier frequency, fc=150MHz and frequency deviation=100KHz. If the oscillator frequencies are 10MHz and 1MHz, find the multiplication factors of the multipliers. Write down the output frequency and frequency deviation after each block. Input signal has a frequency of 200Hz and modulation index for the narrowband FM is 0.2.

(5+5)

3A. For the signal shown below:

$$s_1(t) = \begin{cases} a, \ 0 \le t \le T \\ 0, \ otherwise \end{cases} \qquad s_2(t) = \begin{cases} a, \ \frac{T}{2} \le t \le T \\ 0, \ otherwise \end{cases} \qquad s_3(t) = \begin{cases} a, \ 0 \le t \le \frac{T}{2} \\ -a, \ \frac{T}{2} \le t \le T \end{cases}$$

Using Gram Schmidt orthoganalization procedure

- i. Find the orthonormal basis functions
- ii. Draw the signal space.
- iii. Represent the signal as vectors.

3B. Design a matched filter for the following signals

$$s_1(t) = \begin{cases} 1, \ 0 \le t \le T \\ 0. \ otherwise \end{cases} \qquad s_2(t) = \begin{cases} -1, \ 0 \le t \le T \\ 0. \ otherwise \end{cases}$$

Assuming a noise free channel sketch the estimated output signals $y_1(t)$ and $y_2(t)$ of the matched filter receiver for each of the following case

i. If the transmitted signal is $s_1(t)$ ii. If the transmitted signal is $s_2(t)$

(5+5)

- 4A. A sinusoidal signal, $x(t) = cos(\pi t)$ is sampled at 5 samples per second and quantized using memoryless mid-tread quantizer of step size 0.2V.
 - i. Draw the transfer characteristic of the quantizer properly indicating peak to peak excursion and overload voltage level values.
 - ii. Tabulate the output of the sampler and the quantizer for one cycle of the input.
 - iii.What is the average information content of this quantizer output if only given x(t) is the permanent input signal.
 - iv. What will be the maximum average information content of this quantizer output if any message signal ranging from -1V to +1V, as input the sampler?
- 4B. A computer puts out binary data at the rate of 56Kbits/sec. The computer output is transmitted using a baseband binary PAM system that is designed to have a raised cosine spectrum. Determine the transmission bandwidth required the following roll off factors:

i.
$$\alpha = 0.25$$
 ii. $\alpha = 0.75$

(7+3)

- 5A. Binary data are transmitted over a bandpass channel at the rate of 10^6 bits per second and the power spectral density of the noise at the receiver input is 10^{-10} watts/hertz. Find the average carrier power required to maintain the average probability of error $P_e \leq 10^{-4}$ for coherent binary (i) FSK and (ii) BPSK. Compute the required channel bandwidth.
- 5B. A discrete memoryless source has an alphabet of 8 symbols in which one of the symbols is emitted with the probability 0.3 and rest of the symbols are equiprobable. Construct a minimum variance Huffman Code and Compute its efficiency and redundancy.

(5+5)

	Complementary Error Function Table												
x	erfc(x)	x	erfc(x)	x	erfc(x)	x	erfc(x)	x	erfc(x)	x	erfc(x)	x	erfc(x)
0	1.000000	0.5	0.479500	1	0.157299	1.5	0.033895	2	0.004678	2.5	0.000407	3	0.00002209
0.01	0.988717	0.51	0.470756	1.01	0.153190	1.51	0.032723	2.01	0.004475	2.51	0.000386	3.01	0.00002074
0.02	0.977435	0.52	0.462101	1.02	0.149162	1.52	0.031587	2.02	0.004281	2.52	0.000365	3.02	0.00001947
0.03	0.966159	0.53	0.453536	1.03	0.145216	1.53	0.030484	2.03	0.004094	2.53	0.000346	3.03	0.00001827
0.04	0.954889	0.54	0.445061	1.04	0.141350	1.54	0.029414	2.04	0.003914	2.54	0.000328	3.04	0.00001714
0.05	0.943628	0.55	0.436677	1.05	0.137564	1.55	0.028377	2.05	0.003742	2.55	0.000311	3.05	0.00001608
0.06	0.932378	0.56	0.428384	1.06	0.133856	1.56	0.027372	2.06	0.003577	2.56	0.000294	3.06	0.00001508
0.07	0.921142	0.57	0.420184	1.07	0.130227	1.57	0.026397	2.07	0.003418	2.57	0.000278	3.07	0.00001414
0.08	0.909922	0.58	0.412077	1.08	0.126674	1.58	0.025453	2.08	0.003266	2.58	0.000264	3.08	0.00001326
0.09	0.898719	0.59	0.404064	1.09	0.123197	1.59	0.024538	2.09	0.003120	2.59	0.000249	3.09	0.00001243
0.1	0.887537	0.6	0.396144	1.1	0.119795	1.6	0.023652	2.1	0.002979	2.6	0.000236	3.1	0.00001165
0.11	0.876377	0.61	0.388319	1.11	0.116467	1.61	0.022793	2.11	0.002845	2.61	0.000223	3.11	0.00001092
0.12	0.865242	0.62	0.380589	1.12	0.113212	1.62	0.021962	2.12	0.002716	2.62	0.000211	3.12	0.00001023
0.13	0.854133	0.63	0.372954	1.13	0.110029	1.63	0.021157	2.13	0.002593	2.63	0.000200	3.13	0.00000958
0.14	0.843053	0.64	0.365414	1.14	0.106918	1.64	0.020378	2.14	0.002475	2.64	0.000189	3.14	0.00000897
0.15	0.832004	0.65	0.357971	1.15	0.103876	1.65	0.019624	2.15	0.002361	2.65	0.000178	3.15	0.00000840
0.16	0.820988	0.66	0.350623	1.16	0.100904	1.66	0.018895	2.16	0.002253	2.66	0.000169	3.16	0.00000786
0.17	0.810008	0.67	0.343372	1.17	0.098000	1.67	0.018190	2.17	0.002149	2.67	0.000159	3.17	0.00000736
0.18	0.799064	0.68	0.336218	1.18	0.095163	1.68	0.017507	2.18	0.002049	2.68	0.000151	3.18	0.00000689
0.19	0.788160	0.69	0.329160	1.19	0.092392	1.69	0.016847	2.19	0.001954	2.69	0.000142	3.19	0.00000644
0.2	0.777297	0.7	0.322199	1.2	0.089686	1.7	0.016210	2.2	0.001863	2.7	0.000134	3.2	0.00000603
0.21	0.766478	0.71	0.315335	1.21	0.087045	1.71	0.015593	2.21	0.001776	2.71	0.000127	3.21	0.00000564
0.22	0.755704	0.72	0.308567	1.22	0.084466	1.72	0.014997	2.22	0.001692	2.72	0.000120	3.22	0.00000527
0.23	0.744977	0.73	0.301896	1.23	0.081950	1.73	0.014422	2.23	0.001612	2.73	0.000113	3.23	0.00000493
0.24	0.734300	0.74	0.295322	1.24	0.079495	1.74	0.013865	2.24	0.001536	2.74	0.000107	3.24	0.00000460
0.25	0.723674	0.75	0.288845	1.25	0.077100	1.75	0.013328	2.25	0.001463	2.75	0.000101	3.25	0.00000430
0.26	0.713100	0.76	0.282463	1.26	0.074764	1.76	0.012810	2.26	0.001393	2.76	0.000095	3.26	0.00000402
0.27	0.702582	0.77	0.276179	1.27	0.072486	1.77	0.012309	2.27	0.001326	2.77	0.000090	3.27	0.00000376
0.28	0.692120	0.78	0.269990	1.28	0.070266	1.78	0.011826	2.28	0.001262	2.78	0.000084	3.28	0.00000351
0.29	0.681717	0.79	0.263897	1.29	0.068101	1.79	0.011359	2.29	0.001201	2.79	0.000080	3.29	0.00000328
0.3	0.671373	0.8	0.257899	1.3	0.065992	1.8	0.010909	2.3	0.001143	2.8	0.000075	3.3	0.00000306
0.31	0.661092	0.81	0.251997	1.31	0.063937	1.81	0.010475	2.31	0.001088	2.81	0.000071	3.31	0.00000285
0.32	0.650874	0.82	0.246189	1.32	0.061935	1.82	0.010057	2.32	0.001034	2.82	0.000067	3.32	0.00000266
0.33	0.640721	0.83	0.240476	1.33	0.059985	1.83	0.009653	2.33	0.000984	2.83	0.000063	3.33	0.00000249
0.34	0.630635	0.84	0.234857	1.34	0.058086	1.84	0.009264	2.34	0.000935	2.84	0.000059	3.34	0.00000232
0.35	0.620618	0.85	0.229332	1.35	0.056238	1.85	0.008889	2.35	0.000889	2.85	0.000056	3.35	0.00000216
0.36	0.610670	0.86	0.223900	1.36	0.054439	1.86	0.008528	2.36	0.000845	2.86	0.000052	3.36	0.00000202
0.37	0.600794	0.87	0.218560	1.37	0.052688	1.87	0.008179	2.37	0.000803	2.87	0.000049	3.37	0.00000188
0.38	0.590991	0.88	0.213313	1.38	0.050984	1.88	0.007844	2.38	0.000763	2.88	0.000046	3.38	0.00000175
0.39	0.581261	0.89	0.208157	1.39	0.049327	1.89	0.007521	2.39	0.000725	2.89	0.000044	3.39	0.00000163
0.4	0.571608	0.9	0.203092	1.4	0.047715	1.9	0.007210	2.4	0.000689	2.9	0.000041	3.4	0.00000152
0.41	0.562031	0.91	0.198117	1.41	0.046148	1.91	0.006910	2.41	0.000654	2.91	0.000039	3.41	0.00000142
0.42	0.552532	0.92	0.193232	1.42	0.044624	1.92	0.006622	2.42	0.000621	2.92	0.000036	3.42	0.00000132
0.43	0.543113	0.93	0.188437	1.43	0.043143	1.93	0.006344	2.43	0.000589	2.93	0.000034	3.43	0.00000123
0.44	0.533775	0.94	0.183729	1.44	0.041703	1.94	0.006077	2.44	0.000559	2.94	0.000032	3.44	0.00000115
0.45	0.524518	0.95	0.179109	1.45	0.040305	1.95	0.005821	2.45	0.000531	2.95	0.000030	3.45	0.00000107
0.46	0.515345	0.96	0.174576	1.46	0.038946	1.96	0.005574	2.46	0.000503	2.96	0.000028	3.46	0.0000099
0.47	0.506255	0.97	0.170130	1.47	0.037627	1.97	0.005336	2.47	0.000477	2.97	0.000027	3.47	0.00000092
0.48	0.497250	0.98	0.165769	1.48	0.036346	1.98	0.005108	2.48	0.000453	2.98	0.000025	3.48	0.0000086
0.49	0.488332	0.99	0.161492	1.49	0.035102	1.99	0.004889	2.49	0.000429	2.99	0.000024	3.49	0.00000080