Concordia University
Department of Electrical and Computer Engineering
ELEC691X/ELEC498X: Broadcast Signal Transmission
Midterm Exam
Fall 2015

1) Answer the following questions using less than three sentences:
   a. What is the advantage of using B frames? What is the disadvantage? **1 Mark**
   b. What is the difference between progressive and interlaced scanning? **1 Mark**
   c. Why zig-zag scanning is used? **1 Mark**
   d. A video is compressed at the rate of 3.2 Mbps with 4:2:2 colour representation. What would be the rate if we transform it to 4:2:0 keeping everything else the same? **1 Mark**
   e. What is the advantage of MPSK over M-QAM? What is its disadvantage?**1 Mark**

2) The specifications of a TV program are as follows: 1080p, aspect ratio 16/9, 60 frames per second, 4:2:0, 8 bits per pixel.
   a. Find the bit rate required to transmit this signal as is (uncompressed). **3 Marks**
   b. How many minutes of this program can we store on a DVD disc with a capacity of 50 Gbytes? **2 Marks**
   c. Assume that the frames are divided into GOP as IBPBIBPBI … and compressed. Assume that the compression ratio for I, P and B frames are 1/30, 1/50 and 1/100, respectively. Find the bit rate required to transmit this compressed signal. **3 Marks**
   d. For the compressed signal in part c find how much of the program you can store on the DVD disc of part b. **1 Mark**
   e. Repeat part c if the program was 1080i with other parameters remaining the same. **1 Mark**

3) An 8x8 set of pixels has gone through DCT and then quantized. The result is the following matrix. Excluding the DC coefficient (-26) and zero entries, design a Huffman code to encode the remaining 20 coefficients. Find the total number of bits needed to encode these 20 coefficients with your code. **7 Marks**

$$\begin{bmatrix} -26 & -3 & -6 & 2 & 2 & -1 & 0 & 0 \\ -2 & -2 & -4 & 1 & 1 & 0 & 0 & 0 \\ -3 & 1 & 5 & -1 & -1 & 0 & 0 & 0 \\ -4 & 1 & 2 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

4) Assume that a TV station has 7 MHz. of bandwidth and wishes to transmit two different channels of HDTV each with a bit rate of 15 Mbps. Find the minimum required Signal to Noise ratio at the edge of the coverage (the farthest place the station can be viewed) if M-QAM with roll-off factor $\beta = 0.1$ is used and a bit error rate of $BER \leq 10^{-3}$ is required for reception. **8 Marks**

Bit error rate for BPSK:

$$P_B(BPSK) = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$$

Symbol Error Rates:

$$P_E(MPSK) = 2Q\left(\sqrt{\frac{2E_s}{N_0}}\sin\frac{\pi}{M}\right) \quad \text{for} \quad M \geq 4$$

$$P_E(MQAM) = 4\left(\frac{\sqrt{M}-1}{\sqrt{M}}\right)Q\left(\sqrt{\left(\frac{3}{M-1}\right)\frac{E_s}{N_0}}\right) \quad \text{for} \quad M \geq 4$$

Bit Error Rates:

$$P_B(Gray) = \frac{P_E}{\log_2 M}$$

$$P_B(Non-Gray) = \frac{M/2}{M-1}P_E$$

Bandwidth Occupancy:

BW(MPSK) = BW(MQAM) = $(1+\beta)\frac{1}{T_s} = (1+\beta)R_s$

$$T_S = T_b \log_2 M$$

$$E_S = E_b \log_2 M$$

$$P_r = E_b R_b = E_S R_S$$

TABLE B.1 Complementary Error Function $Q(x) = \int_x^\infty (1/\sqrt{2\pi}) \exp(-u^2/2) du$

x	$Q(x)$ 0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2168	0.2148
0.8	0.2169	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0094	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002

$$\operatorname{erfc}(x) = 2Q(x\sqrt{2}) \qquad \text{(B.20)}$$

$$Q(x) = \frac{1}{2} \operatorname{erfc}\left(\frac{x}{\sqrt{2}}\right) \qquad \text{(B.21)}$$