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TELECOMMUNICATION THEORY

Final exam 02.04.2004

1. Answer briefly but punctually on the following questions; employ diagrams and/or formulas to clarify your answer, if possible (1 p/item):
   a) differential encoding
   b) integrate-and-dumb receiver
   c) matched filter
   d) ISI (intersymbol interference)
   e) equalizer
   f) diversity method

2. Describe the exact moldulator and demodulator structure of the DSB modulation method. Draw the block diagrams of transmitter and receiver. Also, sketch roughly the time signal waveforms and spectrums at the end of modulator, and at the receiver before and after detection (i.e. the figures in the textbook). (6 p).

3. a) Compare SNR performances of the following modulation methods (rank them in increasing or decreasing order): AM (coherent detection), AM (envelobe detection) AM (square-law detection), DSB, SSB, VSB, PM and FM. If some methods possess equal SNR performance value, indicate it clearly. (2 p)

   b) Compare the required bandwidths for all analog modulation methods (assume the bandwidth of a measge signal is equal to W Hz). Which analog modulations have connection (i.e. possible tradeoff) between obtainable SNR performance and required bandwidth? (2 p)

   c) What is the *threshold effect*? Describe, in which cases it appears (i.e. for which modulations and receiver structures it appears)? Clarify your answer with the aid of a simplified signal phasor (vector) presentation. (2 p)

4. a) Describe with the aid diagram and/or flowchart the connection between the mutual information (transinformation) I(X;Y) and the entropies: H(X), H(Y), H(X,Y), H(X | Y), H(Y | X)? (4 p)

   b) Describe the contents of the Shannon's first coding theorem. (2 p)

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5. An FM modulator has the input signal m(t) = 4cos(10πt). The peak frequency deviation is 25 Hz. The modulator is followed by an ideal bandpass filter with a center frequency speficied by the carrier frequency and with a bandwidth of 54 Hz. Determine the power at the filter output assuming that the power of the modulator output is 100 W. Sketch the amplitude spectrum of the filter output. Bessel functions can be found from Table 1. (6 p)

TABLE 3.2 Table of Bessel Functions

n	$\beta = 0.05$	$\beta = 0.1$	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1.0$	$\beta = 2.0$	$\beta = 3.0$	$\beta = 5.0$	$\beta = 7.0$	$\beta = 8.0$	$\beta = 10.0$
0	0.999	0.998	0.990	0.978	0.938	0.881	0.765	0.224	−0.260	−0.178	0.300	0.172	−0.246
1	0.025	0.050	0.100	0.148	0.242	0.329	0.440	0.577	0.339	−0.328	−0.005	0.235	0.043
2		0.001	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047	−0.301	−0.113	0.255
3				0.001	0.003	0.007	0.020	0.129	0.309	0.365	−0.168	−0.291	0.058
4						0.001	0.002	0.034	0.132	0.391	0.158	−0.105	−0.220
5								0.007	0.043	0.261	0.348	0.186	−0.234
6								0.001	0.011	0.131	0.339	0.338	−0.014
7									0.003	0.053	0.234	0.321	0.217
8										0.018	0.128	0.223	0.318
9										0.006	0.059	0.126	0.292
10										0.001	0.024	0.061	0.207
11											0.008	0.026	0.123
12											0.003	0.010	0.063
13											0.001	0.003	0.029
14												0.001	0.012
15													0.005
16													0.002
17													0.001

Table 1

$\beta = k_pA$, $\beta = (f_dA)/f_m$, peak frequency deviation = $f_d\max|m(t)|$

$\sin(u \pm v) = \sin(u)\cos(v) \pm \cos(u)\sin(v)$

$\cos(u \pm v) = \cos(u)\cos(v) \mp \sin(u)\sin(v)$

$\sin(u)\sin(v) = [\cos(u-v) - \cos(u+v)]/2$

$\cos(u)\cos(v) = [\cos(u-v) + \cos(u+v)]/2$

$\sin(u)\cos(v) = [\sin(u-v) + \sin(u+v)]/2$

$\cos^2(u) = [1 + \cos(2u)]/2$

$\sin^2(u) = [1 - \cos(2u)]/2$

$\sin(2u) = 2\sin(u)\cos(u)$

$\cos(2u) = \cos^2(u) - \sin^2(u)$

$\cos(u) = (e^{ju} + e^{-ju})/2$

$\sin(u) = (e^{ju} - e^{-ju})/2j$

$e^{\pm ju} = \cos(u) \pm j\sin(u)$