國立臺灣科技大學102學年度碩士班招生試題

系所組別：電機工程系碩士班乙一組

科　　目：通訊系統

（總分為100分）

Problem 1: (25 %)

Consider an FM modulator with output

$$x_c(t)=8\cos[2000\pi t+\phi(t)]=8\cos\left[2000\pi t+2\pi f_d\int^t m(\tau)d\tau\right]$$

The modulator operates with frequency sensitivity $f_d=8$ and the input message signal $m(t)=5\cos(16\pi t)$. Note that the nth order Bessel function of the first kind is defined as $J_n(\beta)=\frac{1}{2\pi}\int_0^{2\pi} exp[j(\beta\sin x-nx)]dx$.

(a) (5 %) Write down $\phi(t)$ in the form of $\phi(t)=\beta\sin(2\pi f_m t)$ and determine the modulation index β.

(b) (5 %) Determine the maximum frequency deviation.

(c) (5 %) Determine Carson's bandwidth of the FM signal.

(d) (10 %) Determine the bandwidth of the modulator output with 90% of transmitted power enclosed. You need to sketch the resulting double-sided spectrum and give the corresponding weights along with the frequency components.

TABEL 1: 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

Problem 2: (25 %)

Assuming the message signal is of the form as $\cos(2\pi f_m t)$, an **AM** modulation has the following output

$$x_c(t)=2\cos(290\pi t)+10\cos(300\pi t)+2\cos(310\pi t)$$

(a) (5 %) Determine the modulation index.

(b) (5 %) Determine the power efficiency.

(c) (8 %) Plot the noncoherent demodulation and explain why we need a certain range of modulation index for successful demodulation.

(d) (7 %) Assuming the carrier in (1) is taken off, how can you generate a lower sideband SSB? You also need to draw the resulting spectrum.

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Problem 3: (25 %)

Let $X(t)$ be a real-valued stationary process, and $R_X(\tau)=E\left[X(t+\tau)X(t)\right]$ for all t be the autocorrelation function of $X(t)$. Answer the following questions and **justify your answers:**

(a) (5 %) Is $R_X(\tau)$ an even or odd function?

(b) (5 %) What is the maximum magnitude of $R_X(\tau)$?

(c) (5 %) What is the power spectral density $S_X(f)$ of $X(t)$?

(d) (5 %) Can $S_X(f)$ be negative?

(e) (5 %) Is $S_X(f)$ an even or odd function?

Problem 4: (25 %)

A constellation is shown in Figure 1, where the dots (i.e., $c_1, c_2, \cdots, c_8$) denote symbols. The AWGN channel with power spectral density $\frac{N_0}{2}$ is assumed. Answer the following questions:

(a) (5 %) How many bits can we transmit in each symbol?

(b) (5 %) What is the average symbol energy?

(c) (5 %) Assuming equally likely symbols and applying the optimal detector, what is the decision region for each symbol? Plot these regions.

(d) (5 %) What is the pair-wise error probability $P_e(c_1, c_2)$, i.e., the probability of transmitting c_1 while detecting c_2 ?

(e) (5 %) Derive the union bound for $P(error\,|\,c_1)$.

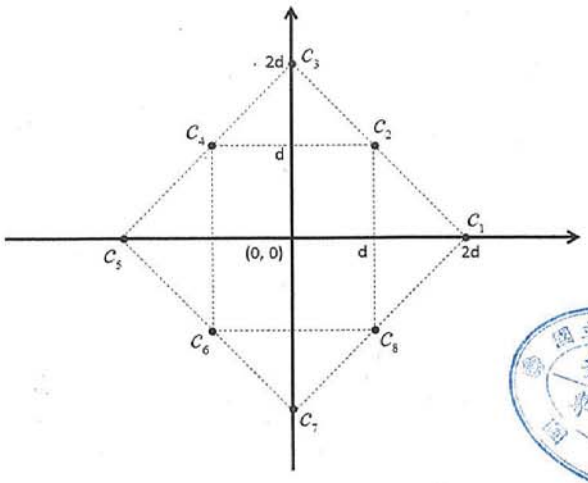

Figure 1. Constellation for problem 4.