國立臺灣科技大學101學年度碩士班招生試題

系所組別： 電機工程系碩士班己一組

科　　目： 通訊系統

（總分為100分）

Problem 1 (10%)

A modulated signal is given by

$$x_c(t) = 3\cos(140\pi t) + 6\cos(200\pi t) + 3\cos(260\pi t) \ .$$

Assuming a carrier frequency of 100 Hz, write this signal in the form of

$$x_c(t) = A(t)\cos(2\pi f_c t + \theta(t)) \ .$$

Give equations for the envelope $A(t)$ and $\theta(t)$.

Problem 2 (15%)

An AM modulator operations with the message signal $m(t) = 3\cos(20\pi t) - 4\cos(60\pi t)$, whose minimum and maximum values are -5.5759 and 5.5759, respectively. The unmodulated carrier is given by $100\cos(200\pi t)$, and the system operates with an amplitude sensitivity of 1/2. Recall that AM's output is

$$x_c(t) = A_c(1 + K_a m_n(t))\cos(2\pi f_c t) \ ,$$

where K_a is the amplitude sensitivity, and $m_n(t)$ is the normalized $m(t)$ with a minimum value of -1.

(a) (5%) What is the period of $m(t)$.

(b) (5%) Determine the efficiency of the modulator.

(c) (5%) Sketch the double-sided spectrum $x_c(t)$, the AM modulator output, giving the weights and frequencies of all component.

Problem 3 (25%)

(a)(10%) Prove that the Fourier transform of $\frac{1}{\pi t}$ is j for $f < 0$ and $-j$ for $f > 0$.

(b)(15%) Express the spectrum $Y(f)$ of

$$y(t) = x(t)\cos(\omega_0 t) - \hat{x}(t)\sin(\omega_0 t) \ ,$$

where $\hat{x}(t) = x(t) * \frac{1}{\pi t}$ is the Hilbert transform of $x(t)$, in terms of the spectrum $X(f)$ of $x(t)$, where $X(f)$ is lowpass with bandwidth $B < \frac{\omega_0}{2\pi}$ and "$*$" is the linear convolution.

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Problem 4 (20%)

An analog baseband signal of bandwidth 10 kHz is sampled at a rate of 24 kHz, quantized into 256 levels, and coded using *M*-ary multiamplitude pulses satisfying the Nyquist criterion with a roll-off factor $\alpha = 0.2$.

(a) (10%) If $M = 16$, determine the transmission baseband bandwidth.

(b) (10%) If a 60 kHz baseband bandwidth is available to transmit the data, determine the smallest acceptable value of *M*.

Problem 5 (16%)

A ternary signaling scheme ($M = 3$) uses three waveforms $s_1(t), s_2(t)$ and $s_3(t)$, where $s_1(t) = 20\sqrt{2}\sin(2\pi f_c t)$, $s_2(t) = 10\sqrt{2}\cos(2\pi f_c t)$ and $s_3(t) = -10\sqrt{2}\cos(2\pi f_c t)$. Each of these signal durations is $0 \le t \le \frac{1}{20}$ and is zero outside this interval.

(a) (12%) Find a set of orthonormal basis functions and represent these signals in a signal space.

(b) (4%) Find the minimum distance of this signal constellation.

Problem 6 (14%)

The received equally probable waveforms $s_1(t) = A\cos(\omega_o t)$ and $s_2(t) = -A\cos(\omega_o t)$ are coherently detected with a matched filter. The value of *A* is $10\sqrt{2}$ mV. Assume that signal power and energy per bit are normalized relative to a $1\ \Omega$ load and that AWGN with two-sided power spectral density $N_0/2$, where $N_0 = 10^{-11}$ W/Hz.

(a) (8%) Find the bit error probability for this BPSK system with a bit rate of 1 Mbits/s. Express the answer in terms of a *Q* function, where $Q(x) = \int_x^\infty \frac{1}{\sqrt{2\pi}} e^{-u^2/2} du$.

(b) (6%) Now suppose $s_1(t)$ is transmitted with probability 0.3 and $s_2(t)$ is transmitted with probability 0.7. Suppose we also change the threshold value in the receiver to be $\sqrt{E_b}/2$, where E_b is energy per bit. Find the bit error probability in terms of a *Q* function.