元智大學 102 學年度研究所 碩士班 招生試題卷

系(所)別：通訊工程學系碩士班　組別：通訊組　科目：通訊系統　用紙第 1 頁共 2 頁

●不可使用電子計算機

注意：考生請務必依以下 3 項規定做答，違者不予給分!!

一、本試卷共五大題，務要依題號順序(1,2,3,4,5)做答於答案卷上。

二、每題均要由一空白頁開始作答，不論會不會寫，均要清楚編明題號。

三、每題均有數小題，每小題中有 underline 處表示答題重點，請針對重點作答，並在答案卷上清楚標示所要求的圖形及答案。(答非所問及字跡難以辨認者均不給分)

題目開始

1. Given a **bandpass signal** $x(t) = 4\times\text{sinc}^2(100t)\times\sin(1000\pi t)$. (10%)
   (a) Find the **pre-envelope** $x_+(t)$ and **complex envelope** $\tilde{x}(t)$ of x(t). (5 %)
   (b) Find the **energy** of x(t). (5%)

2. Consider an FM system having the following specifications: (30%)
   Carrier frequency: $f_c = 100$ kHz.
   Carrier amplitude: $A_c = 2$ V.
   Frequency sensitivity: $k_f = 4$ kHz/V
   Assume the input message signal of the transmitter (TX) is $m(t) = 2\times\cos(4000\pi t)$ Volts, resulting in the FM signal s(t) which is then passing through an AWGN channel with PSD $N_0/2 = 10^{-6}$ W/Hz.
   (a) Find the **bandwidth** B_T of the FM signal s(t) using Carson's rule, and sketch its **spectrum S(f)** within the bandwidth B_T. You should correctly mark the frequency axis scale. (10 %)
   (b) At the receiver (RX), find the **joint FDF** $f_{n_I(t),n_Q(t)}(x,y)$ of the I/Q components $\{n_I(t), n_Q(t)\}$ of the received bandpass noise $n(t)$ at the RX BPF output. (10 %)
   (c) Find the **output noise power** and the **output SNR** $(SNR)_{o,FM}$ of the FM receiver. (10%)

3. Consider a **uniform PCM** system having the following specifications: (20%)
   - Message signal (audio signal) bandwidth : W= 10 kHz
   - Sampling rate: f_s=2×(Nyquist rate).
   - No. of quantizer's representation levels : L=8 (uniform quantizer)
   - Quantizer input range : -2 ~ +2 Volts
   - Each representation level is encoded into 3-bit codeword, with '000' for the most negative level,..., and '111' for the most positive level.
   - Line coding : AMI-RZ (Alternate mark inversion, return-to-zero)

   (a) Sketch the **transfer characteristics** of the uniform quantizer. (5 %)
   (b) Find the transmit **bit rate** R_b of the system. (5%)
   (c) If a sequence of three input samples $\{m_1=-0.9, m_2= 1.33, m_3=0.4\}$ is fed to the quantizer, find the resultant **bit sequence** and the corresponding AMI-RZ **waveform**. (5%)
   (d) Assume the message input is $m(t)=2\times\cos(1000\pi t)$ and there is no bit error at the PCM receiver side.

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Find the receiver's **output SNR** in dB. (5%)

4. A **binary PAM baseband transmission system** has the TX signal as (20%)

$$s(t)=\sum_k A_k g(t-kT)$$

where A_k is an i.i.d. ±1 binary sequence with $P(A_k=+1) = 0.5$, and the transmit pulse shape is $g(t)=rect\left(\frac{t-0.5T}{T}\right)$ with T=1 ms. Assume the channel is AWGN with noise PSD $N_0/2 = 10^{-4}$ W/Hz .

(a) Sketch a block diagram of the **optimum receiver** using matched filter. Find the **impulse response** h(t) of the matched filter, and the decision rule. (5%)

(b) Find the **bit error rate** P_e of the optimum receiver in terms of the erfc function. (5%)

(c) For the 5-bit TX sequence "1 0 0 1 0", sketch the **matched filter's output waveform** y(t) and the 5 samples {y(kT), k=T, 2T, …, 5T}, under the noise-free condition. (5%)

(d) Does this system satisfy the **Nyquist zero-ISI criterion**? Why? (5%)

5. Consider a **passband 16-QAM digital modulation system** with bit rate R_b=20 Mbps, and using the **raised cosine pulse shaping** with roll-off factor of α=0.5. (20%)

(a) Sketch the **signal constellation** for 16-QAM scheme with gray-coded bit mapping. (5 %)

(b) Find the required **transmission bandwidth** B_T for the passband 16-QAMsystem. (5%)

(c) Let the minimum distance between the signal points be $d_{min} = 2\times10^{-6}$ and AWGN PSD $N_0/2 = 10^{-7}$ W/Hz, find the **bit error rate** (BER) in terms of the erfc function for the 16-QAM scheme. (10%)