元智大學 九十七 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　

●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!!

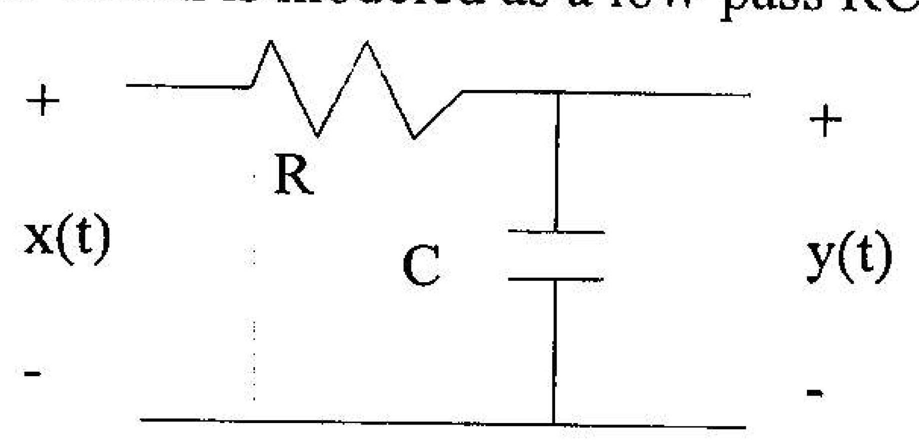
一、本試卷共五大題，務要依題號順序(1,2,3,4,5)做答於答案卷上。

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、每題均分(a), (b)兩小題，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. Consider a communication channel which is modeled as a low-pass RC filter shown below:



where R=10^3 Ohms and C=100 μF.

(a) Sketch the **two output waveforms $y_1(t)$ and $y_2(t)$** for the 2-impulse input $x_1(t)=\delta(t)-\delta(t-1)$ and square-wave input $x_2(t)=2\times\text{rect}(t-1.5)$, respectively. (10%)

(b) Find **the average power of the output y(t)** for the DC-plus-sinusoid input $x(t)=2+\cos(10t)$. (10%)

2. Consider a passband signal $x(t)=\cos(2\pi\times 11t)+\cos(2\pi\times 15t)+\text{sinc}(t)\times\cos(2\pi\times 13t)$ which is to be down-converted to baseband I/Q signals. Assume the I/Q down-converter multiplies x(t) by two orthogonal LO carriers $\{2\times\cos(2\pi\times 12t), 2\times\sin(2\pi\times 12t)\}$, and the cutoff frequency of the output ideal LPF is $f_o=2.5$ Hz

(a) Find the output **I component** $y_I(t)$ from the I/Q down-converter. (10%)

(b) If the input to the specified down-converter is only AWGN with PSD $N_o/2=10^{-1}$ W/Hz, find the **first-order PDF** $f_R(r)$ of the corresponding output envelope $R(t)=\sqrt{y_I^2(t)+y_Q^2(t)}$. (10%)

3. An analog bipolar message signal m(t) is transmitted using a QPSK system with the following specifications:

- The message bandwidth is W=5 kHz.
- Uniform quantization is used, and the quantization error should be less than 0.1% of max{m(t)}.
- The system bit rate is R_b= 200 kbps
- The transmitter uses a square-root raised cosine baseband pulse shaping with a rolloff factor of α=0.5.
- The carrier frequency is f_c = 10 MHz.
- The passband QPSK signal s(t) has a transmitted power of 1W.

(a) Find the **oversampling ratio** OSR =$f_s/f_{Nyquist}$ at which the message signal m(t) is sampled, where f_s is the sampling frequency, and f_{Nyqist} is the Nyquist rate. (10%)

(b) Find and sketch the **power spectrum density** (PSD) S(f) of the QPSK signal. You should accurately mark all important values for S(f) on the two axes. (10%)

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4. Consider an 8-ary signaling scheme. The signaling waveform in a symbol duration $T = 1$ sec can be expressed as

$$s(t) = \sqrt{\frac{1}{3}} \sum_{k=1}^{3} a_k \phi_k(t) \quad 0 \le t \le T$$

where $\mathbf{a}=[a_1\ a_2\ a_3] = [\pm 1\ \pm 1\ \pm 1]$ denotes the 8-ary symbol, and the set $\{\phi_1(t), \phi_2(t), \phi_3(t)\}$ forms the orthonormal basis in $0 \le t \le 1$. Assume the waveform *s(t)* is passing through an AWGN channel with noise PSD $N_0/2 = 10^{-1}$ W/Hz, and the channel output is denoted as x(t).

(a) Sketch the **signal constellation** and define the **decision region** for the particular symbol $\mathbf{a}_0 = [1\ 1\ 1]$. (10%)

(b) Assume equally likely symbols and gray coding, find the **bit error rate** P_b of the optimum receiver. (10%)

5. A quaternary symbol sequence $x_n \in \{-3, -1, 1, 3\}$ is passing through a cascade of three LTI filters, including the transmit (TX) pulse shaping filter with frequency response $G(f)=\Im\{g(t)\}=0.1\times \text{rect}(0.01f)$, then the physical channel with impulse response $c(t)=\delta(t)+\delta(t-0.01)$ plus an AWGN noise w(t) with PSD $N_0/2=10^{-4}$ W/Hz, finally the receive (RX) filter with impulse response h(t) matched to g(t), i.e., h(t)=g(-t). The transmit signal at the TX filter output can be expressed as $s(t)=\sum_{n=-\infty}^{\infty} x_n g(t-0.01n)$, and the RX filter output is expressed as $y(t)=s(t)\otimes c(t)\otimes h(t)+n(t)$, where $\otimes$ denotes convolution integral, and $n(t)=w(t)\otimes h(t)$ is the output noise. Let $y_n=y(nT_s)$ denote the sampled signal of y(t) at the sampling rate $f_s=1/T_s=100$Hz.

(a) Assume equally likely symbols, find the **signal-to-noise ratio** (SNR) in dB at the RX filter output. (10%)

(b) Under noise-free situation, find the discrete-time relation between x_n and y_n, and devise a **receiver structure** to recover y_n from x_n. Discuss the major advantage and disadvantage of your receiver. (10%)