國立高雄第一科技大學 106 學年度 碩士班 招生考試 試題紙

系 所 別：電腦與通訊工程系　　組 別：通訊組

考科代碼：2211　　考 科：通訊原理

注意事項：
1、各考科一律可使用本校提供之電子計算器，考生不得使用自備計算器，違者該科不予計分。
2、請於答案卷上規定之範圍作答，違者該題不予計分。

[Signal, Noise, Random Process, Fourier Transform, Power Spectrum] (信號、雜訊、隨機過程、傅立葉轉換、功率頻譜)

1. (15%) Given a signal $x(t) = 2\sin(400\pi t)\cos(1600\pi t)$ where t is in seconds. (已知信號 $x(t) = 2\sin(400\pi t)\cos(1600\pi t)$ 其中 t 的單位是秒。)

   (a) (5%) Decompose $x(t)$ into a linear combination of sinusoidal functions, and find the amplitude, frequency, and phase of each component. (將 $x(t)$ 拆解成正弦波函式的線性組合，並找出每一正弦波成分的振幅、頻率與相位。)

   (b) (5%) Determine the Fourier transform $X(f)$ of $x(t)$. (對 $x(t)$ 求出其傅立葉轉換 $X(f)$。)

   (c) (5%) Determine the Nyquist sampling rate for $x(t)$. (決定 $x(t)$ 的奈奎氏取樣率。)

2. (10%) Consider a random process $x(t) = A\cos(2\pi f_c t + \theta)$, where A is a constant and θ is a uniformly distributed random variable over the interval $[-\pi, \pi]$. Determine: (考慮一隨機過程 $x(t) = A\cos(2\pi f_c t + \theta)$，其中 A 是常數且 θ 是在 $[-\pi, \pi]$ 區間中均勻分佈的隨機變數。請求出：)

   (a) (5%) The autocorrelation function $R_x(\tau)$ of $x(t)$. ($x(t)$ 的自相關函式 $R_x(\tau)$。)

   (b) (2%) The power $E[x^2(t)]$ of $x(t)$. ($x(t)$ 的功率 $E[x^2(t)]$。)

   (c) (3%) The power spectral density $S_x(f)$ of $x(t)$. ($x(t)$ 的功率頻譜密度 $S_x(f)$。)

3. (5%) A telephone line is known to have a loss of 30 dB. The input signal power is measured as 200 mW, and the output noise level is measured as 2.0 μW. Using this information, calculate the output signal-to-noise ratio (SNR) in dB. (Note: $\log_{10} 2 \approx 0.3$.) (已知一電話線具有損耗 30 dB。其輸入信號功率量測為 200 mW，且其輸出雜訊位準量測為 2.0 μW。使用這些資訊，計算輸出端的訊雜比 (SNR) 並以 dB 表示。(注意：$\log_{10} 2 \approx 0.3$。))

[Data Encoding, Symbol Mapping, Channel Coding] (資料編碼、符元映射、通道編碼)

4. (5%) Please design a constellation for a QPSK mapper using the Gray code (i.e., only

one bit changes in going from a symbol to an adjacent symbol). (請使用格雷碼設計一個 QPSK 映射器的星座圖（即相鄰符元間只有一個位元的差異）。)

5. (5%) The waveform in Fig. 1 belongs to a Manchester encoded binary data stream with "bit one" represented by a high-to-low transition. Determine the original binary data sequence. (圖 1 是對應一個曼徹斯特編碼後的二元資料流的波形，其中高-對-低轉換用於表示 "位元 1"。請決定原始的二元資料序列。)

Fig. 1

6. (5%) For a certain binary non-symmetric channel shown in Fig. 2, it is given that $P_{y|x}(0|1)=0.2$ and $P_{y|x}(0|0)=0.9$, where X is the transmitted digit and Y is the received digit. If $P_x(0)=0.4$, determine (圖 2 為一個二元非對稱通道，已知 $P_{y|x}(0|1)=0.2$ 與 $P_{y|x}(0|0)=0.9$，其中 X 是被傳輸的位元而 Y 則是接收到的位元。假設 $P_x(0)=0.4$，請決定)

   (a) (2%) $P_y(1)$

   (b) (3%) The average error probability of the channel. (此通道的平均錯誤率。)

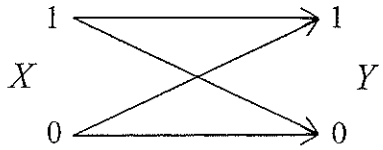

Fig. 2

7. (10%) The Hamming distance $d(\mathbf{v}_1,\mathbf{v}_2)$ between two n-bit binary sequences $\mathbf{v}_1$ and $\mathbf{v}_2$ is the number of bits in which $\mathbf{v}_1$ and $\mathbf{v}_2$ disagree. For example, d(011011, 110001) = 3. The minimum distance $d_{\min}$ of a code is defined as the minimum Hamming distance between any two distinct codewords in this code. Please prove the following assertion: (兩個 n-位元 二元序列 $\mathbf{v}_1$ 與 $\mathbf{v}_2$ 間的漢明距離 $d(\mathbf{v}_1,\mathbf{v}_2)$ 被定義為 $\mathbf{v}_1$ 與 $\mathbf{v}_2$ 間相異的位元數。舉例，d(011011, 110001) = 3。一編碼的最小距離 $d_{\min}$ 被定義為該編碼中任兩不同碼字間的最小漢明距離。請證明下列主張：)

   ``For a given positive integer t, if a code satisfies $d_{\min} \geq (2t+1)$, then the code can correct all bit errors up to and including errors of t bits." ("給予一正整數 t，如果一編碼滿足 $d_{\min} \geq (2t+1)$，則該編碼最多能更正 t 個位元的錯誤。")

[Matched Filter and Binary Optimum Receiver] (匹配濾波器與二元最佳接收機)

8. (25%) Binary data is transmitted over an AWGN channel by using a pulse $s_1(t)$, $0 \leq t \leq T$ for '1' and a pulse $s_2(t)$, $0 \leq t \leq T$ for '0' as given in Fig. 3, where T is the symbol duration. Assume that the two pulses are transmitted equally likely, and the noise has a power spectrum density $S_n(f)=N_0/2$. (二元資料以圖 3 中的脈波 $s_1(t)$, $0 \leq t \leq T$ 代表 '1' 以及脈波 $s_2(t)$, $0 \leq t \leq T$ 代表 '0' 在 AWGN 通道中傳送，其中 T 是符元期間。假設兩個脈波傳送的機率是相等的，且雜訊的功率頻譜密度為 $S_n(f)=N_0/2$。)

   (a) (2%) Compute the average energy per bit E_b. (計算每一位元平均能量 E_b。)

(b) (3%) Show that $s_1(t)$ and $s_2(t)$ are orthogonal to each other. (證明 $s_1(t)$ 與 $s_2(t)$ 彼此正交。)

(c) (10%) Design an optimum receiver using a matched filter with impulse response $h(t)$ and a detector. Sketch a block diagram for the receiver and find $h(t)$. (使用一個匹配濾波器具有脈衝響應 $h(t)$ 搭配一個檢測器設計一最佳接收機。請描繪出該接收機的方塊圖並找出 $h(t)$。)

(d) (5%) Determine the error probability of the optimum receiver in terms of E_b, N_0 and the Q-function defined as $Q(v)=\frac{1}{\sqrt{2\pi}}\int_v^\infty \exp\left(-\frac{x^2}{2}\right)dx$. (決定並以 E_b、N_0 與 Q-函式定義為 $Q(v)=\frac{1}{\sqrt{2\pi}}\int_v^\infty \exp\left(-\frac{x^2}{2}\right)dx$ 表示出該最佳接收機的錯誤率。)

(e) (5%) How to improve the error probability by modifying the pulse $s_2(t)$? (如何修改脈波 $s_2(t)$ 以便改善錯誤率？)

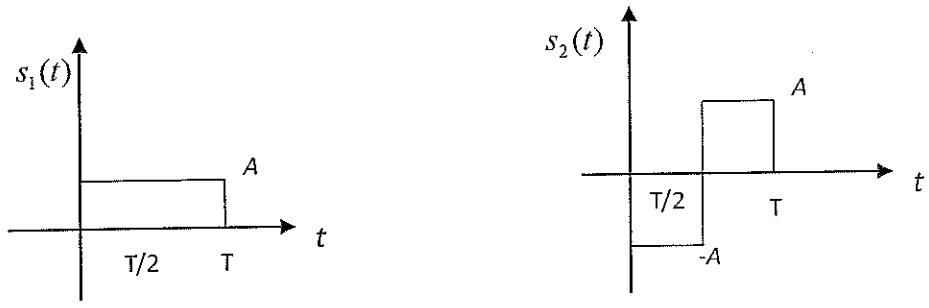

Fig. 3

[Orthogonal Frequency Division Multiplexing (OFDM)] (正交分頻多工)

9. (10%) Consider the design of an OFDM transmission system under the conditions that (考慮在下列條件下設計一個 OFDM 傳輸系統)
   (i) the maximum delay spread of channel τ_{MAX} = 1.60 μs, (通道最大時延擴展 τ_{MAX} = 1.60 μs，)
   (ii) the bandwidth W ≤ 10 MHz, (頻寬 W ≤ 10 MHz，)
   (iii) cyclic prefix is used as the guard interval and the signal power loss in using guard interval ≤ 1 dB, and (使用循環前輟作為保護區間且因使用保護區間造成的訊號功率損耗 ≤ 1 dB，以及)
   (iv) the 16-QAM constellation adopted for data mapping. (採用 16-QAM 星座圖於資料映射。)

   Please determine the following parameters for the OFDM system: (請決定下列 OFDM 系統的參數)
   (a) (2%) Guard interval T_g (保護區間 T_g)
   (b) (2%) Useful symbol time T_{FFT} (有效符元時間 T_{FFT})
   (c) (2%) Subcarrier spacing Δf (子載波間隔 Δf)

(d) (2%) Total number of subcarriers N (子載波總數 N)

(e) (2%) Data transmission rate R (bits per second; bps) if only N-1 subcarriers are data subcarriers (i.e., the DC subcarrier is not used for carrying data.) (假設只有 N-1 個子載波作為資料子載波(即 DC 子載波未被用於載送資料。)時的資料傳輸率(每秒位元數; bps))

10. (10%) Explain the following terminologies associated with OFDM. (解釋下列與 OFDM 相關的專有名詞)

(a) (2%) Guard Interval (GI)

(b) (2%) Cyclic Prefix (CP)

(c) (2%) Subcarrier Spacing

(d) (2%) Peak-to-Average Power Ratio (PAPR)

(e) (2%) Inter Carrier Interference (ICI)