

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。

(Fourier Transform and Inverse Transform、Spectrum and Bandwidth) (傅立葉轉換、反轉換、頻譜與頻寬)

(1) (10 %) Find the inverse Fourier transform and sketch the waveform for the spectrum given below. (對以下的頻譜求其反傅立葉轉換並描繪其波形。)

$$(a) \quad (5 \%) \quad X(f) = \begin{cases} 1 & -1/2 \leq f \leq 1/2 \\ 0 & \text{elsewhere} \end{cases}$$

$$(b) \quad (5 \%) \quad X(f) = \frac{1}{2} \delta(f + 2000) + \frac{1}{2} \delta(f - 2000).$$

(2) (10 %) Determine and sketch the Fourier transform for the signal given below. (對以下訊號求出與描繪其傅立葉轉換。)

$$(a) \quad (5 \%) \quad x(t) = \frac{\sin(\pi t)}{(\pi t)} \equiv \text{sinc}(t).$$

$$(b) \quad (5 \%) \quad x(t) = \begin{cases} -1 & -1 \leq t < 1 \\ 0 & \text{elsewhere} \end{cases}$$

(Nyquist Sampling Theory) (奈奎氏取樣定理)

(3) (10 %) Determine the Nyquist sampling rate for the following signal. (請決定每個訊號的奈奎氏取樣率。)

$$(a) \quad (5 \%) \quad x(t) = 5 \cos(2\pi 60t).$$

$$(b) \quad (5 \%) \quad x(t) = \text{sinc}\left(\frac{t}{1000}\right)$$

(Line Code) (線碼)

(4) (12 %) A digital signal is generated by the following modulator shown in Fig. 1(a), where the mapper converts the digital data to signal symbols in the way given below: (圖 1(a)所示之調變器產生一種數位訊號，其中之映射器以下列方式將數位資料轉成訊號符元：)

digital data d_k (位元資料 d_k)	→	symbol a_k (符元訊號 a_k)
1	→	+1
0	→	0

Following the mapper is the pulse-shaping filter is shown in Fig. 1(b). (在映射器後面的是脈波整形濾波器，如圖 1(b)所示。)

- (a) (4 %) For the input data 10100101, sketch the output waveform $x(t)$. (當輸入資料為 10110100 時，描繪輸出訊號 $x(t)$ 的波形。)
- (b) (4 %) What is the data rate (bit rate) at the input of the modulator? (調變器輸入端的位元速率是多少?)
- (c) (4 %) What is the symbol rate (baud rate) of the output digital signal? (調變器輸出數位訊號的符元速率是多少?)

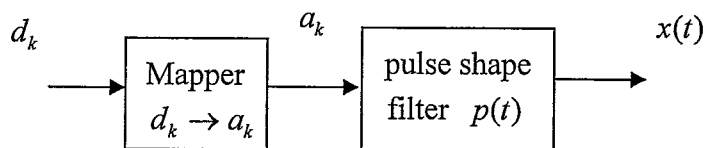


Fig. 1(a)

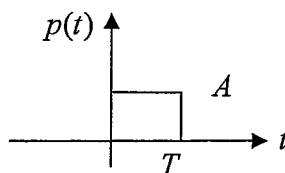


Fig. 1(b)

(Analog Modulations) (類比調變)

- (5) (12 %) For the message signal $m(t) = \cos(2\pi 100t)$ and the carrier signal $5\cos(2\pi 1000t)$, we have the double-side band (DSB) modulated signals: $\phi_{DSB}(t) = 5\cos(2\pi 100t)\cos(2\pi 1000t)$ (已知訊息訊號 $m(t) = \cos(2\pi 100t)$ 與載波訊號 $5\cos(2\pi 1000t)$ ，我們構成了雙旁波柱調變訊號： $\phi_{DSB}(t) = 5\cos(2\pi 100t)\cos(2\pi 1000t)$)

Answer the following questions: (請回答下列問題：)

- (a) (4 %) Sketch the double-side band waveform? (描繪此 DSB 訊號的波形)
- (b) (4 %) Find and sketch the spectrum. (求出與描繪訊號的頻譜)
- (c) (4 %) Find the power of the DSB signal. (求出 DSB 訊號的功率)

(Digital Modulations) (數位調變)

- (6) (12 %) For the binary orthogonal modulation, a binary data sequence is transmitted by using the pulse $s_1(t)$, $0 \leq t \leq T$ for '1' and the pulse $s_2(t)$, $0 \leq t \leq T$ for '0' as shown in Fig. 2, where A is the signal amplitude and T is the symbol duration. (對二元正交調變，一個二元資料序列是以脈波 $s_1(t)$ $0 \leq t \leq T$ 代表 '1' 以及脈波 $s_2(t)$, $0 \leq t \leq T$ 代表 '0' 來傳送，如圖 2 所示，這裡 A 是訊號的振幅 以及 T 是訊號符元期間。)

- (a) (4 %) For the input data 10100101, sketch the transmitted waveforms. (當輸入資料為 10110100 時，描繪傳送訊號的波形。)
- (b) (4 %) Find the energy for the transmitted signal $s_1(t)$. (找出訊號 $s_1(t)$ 的能量。)
- (c) (4 %) Find a set of basis signals for this modulation scheme, then represent each of these signals $\{s_1(t), s_2(t)\}$ in the form of vectors and draw the constellation diagram. (就此調變方法找到一組基底訊號，然後將 $\{s_1(t), s_2(t)\}$ 的每個訊號用向量表示，繪出星座圖。)

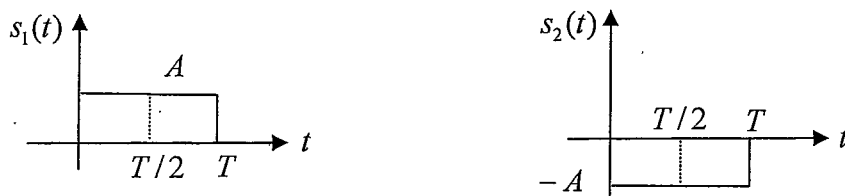


Fig. 2

(Terminologies in Communication Engineering) (通訊工程專有名詞)

- (7) (12 %) Explain the following terminologies: (解釋下列專有名詞)
- (a) (2 %) FM
 - (b) (2 %) MPEG
 - (c) (2 %) Cellular Phone
 - (d) (2 %) 4G LTE
 - (e) (2 %) Internet of Things
 - (f) (2 %) Antenna

(Matched Filter) (匹配濾波器)

- (8) (8 %) A pulse signal $p(t)$ corrupted by an AWGN noise $n(t)$ with the power spectral density $S_N(f) = N_0/2$ was received at the input of a matched filter $h(t)$ shown in Fig. 3. The output signal can be expressed by $r_o(t) = h(t) * (p(t) + n(t)) = p_o(t) + n_o(t)$, and then is sampled at the time T to yield $r_o(T) = p_o(T) + n_o(T)$. (圖 3 所示的匹配濾波器 $h(t)$ ，其輸入端收到一個受到功率譜密度為 $S_N(f) = N_0/2$ AWGN 雜訊 $n(t)$ 影響的數位脈波訊號 $p(t)$ 。輸出訊號可表示為 $r_o(t) = h(t) * (p(t) + n(t)) = p_o(t) + n_o(t)$ ，在時間 T 取樣而得到輸出訊號值為 $r_o(T) = p_o(T) + n_o(T)$ 。)

- (a) (4 %) Determine the impulse response $h(t)$ of the matched filter. (求出匹配濾波器的響應 $h(t)$ 。)
- (b) (4 %) Determine the sampled value $p_o(T)$ of the output signal at the time T . (求出輸出訊號 $p_o(t)$ 於時間 T 的取樣值 $p_o(T)$ 。)

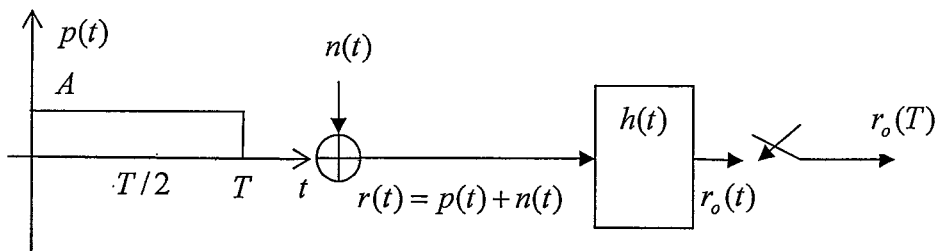


Fig. 3

(Binary Optimum Receiver Design) (二元最佳接收機設計)

- (9) (14 %) A binary data sequence is transmitted over an AWGN channel by using the pulse $s_1(t)$, $0 \leq t \leq T$ for '1' and the pulse $s_2(t)$, $0 \leq t \leq T$ for '0', where T is the symbol duration. The AWGN noise $n(t)$ is with the power spectral density $S_n(f) = N_0/2$, and the received signals at the receiver end (Fig. 4) can be expressed as $r(t) = s_i(t) + n(t)$, $0 \leq t \leq T, i = 1, 2$. The correlator of the receiver is supplied with a locally generated coherent reference signal $c(t)$. Assume that the two pulse signals are transmitted equally likely. (一個二元資料序列以脈波 $s_1(t)$ $0 \leq t \leq T$ 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，這裡 T 是訊號符元期間。此 AWGN 雜訊 $n(t)$ 的功率譜密度為 $S_N(f) = N_0/2$ ，圖 4 所示的接收機端接收到的訊號可以表示為 $r(t) = s_i(t) + n(t)$, $0 \leq t \leq T, i = 1, 2$ 。本地產生的同調參考訊號 $c(t)$ 提供給接收機的相關器使用。我們假設兩個脈波訊號傳送的機率是相等的。)

- (a) (6 %) Determine the optimum threshold value V_{th} for the detector. (求出偵測器的最佳門檻值 V_{th} 。)
- (b) (6 %) Determine the error probability of the receiver. (求出此接收機的錯誤機率。)
- (c) (2 %) Is this an optimum receiver? Give your reason. (這是最佳接收機嗎？說明你的判定理由。)

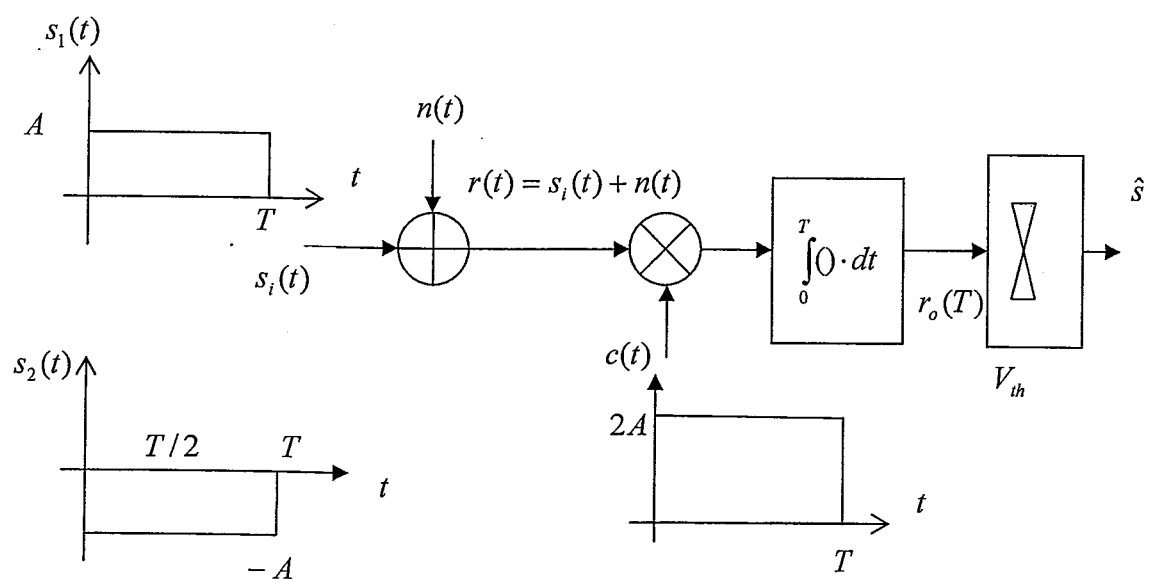


Fig. 4