# 國立臺北科技大學九十七學年度碩士班招生考試

## 系所組別：2140 電機工程系碩士班丁組

## 第一節　通訊原理　試題

填准考證號碼　　　　　　　　　　第一頁　共二頁

**注意事項：**

1. 本試題共六題，配分共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1. White Gaussian noise of zero-mean and power spectral density of $N_0/2$ is applied to the filtering scheme shown in Figure 1(a). The frequency response of these two filters are shown in Figure 1(b). The noise at the low pass output is denoted by $n(t)$.
   (a) (5%) Find the power spectral density of $n(t)$.
   (b) (5%) Find the autocorrelation function of $n(t)$.
   (c) (5%) Find the mean and variance of of $n(t)$.

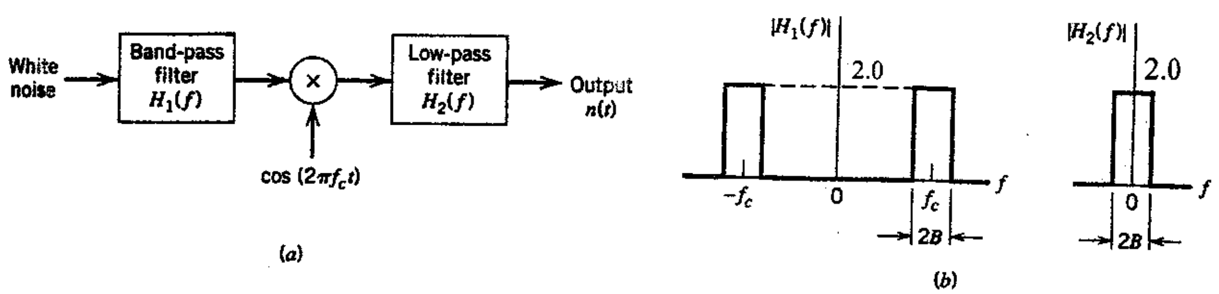


Figure 1

2. A frequency synthesizer to control the output frequency of a stable oscillator is shown in the Figure 2 where $f_c$=100kHz.
   (a) (5%) What is the output frequency when $N_1$=4, $N_2$=2.
   (b) (10%) Determine the frequency range and the minimum frequency increment of the synthesizer if the integer value of $N_1$ is selectable between 1 and 5 , and the integer value of $N_2$ is selectable between 1 and 10.

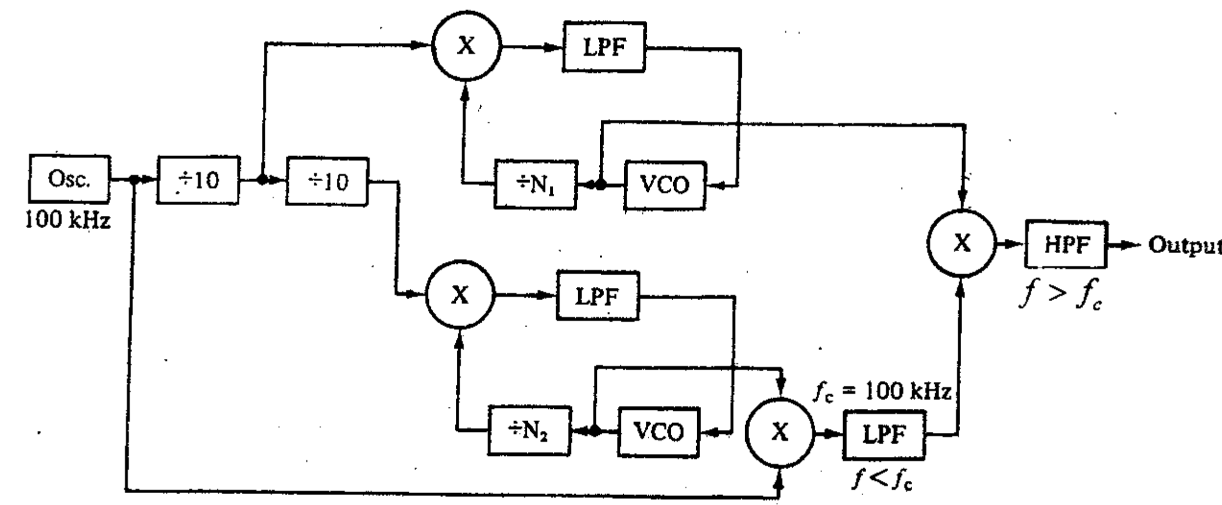


Figure 2

3. The sinusoidal signal $f(t) = a\cos(2\pi f_m t)$ is applied to the input of a FM system. The corresponding modulated signal output (in Volts) with $a = 1$ V, $f_m = 1kHz$ , is $\phi(t) = 100\cos(2\pi \times 10^7 t + 4\sin(2000\pi t))$ across a 50-ohm resistive load.
   (a) (4%) What is the peak frequency deviation from carrier?
   (b) (4%) What is the total average power developed by $\phi(t)$?
   (c) (4%) What the percentage of average power is at 10MHz?
   (d) (4%) What is the approximate bandwidth, using Carson's rule?
   (e) (4%) Repeated parts (a)-(d), if $a = 0.75$, $f_m = 2kHz$ ; assume all other factors remain unchanged.

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $x$ | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 |
| $J_0(x)$ | 1.0 | 0.99 | 0.96 | 0.91 | 0.85 | 0.77 | 0.67 | 0.57 | 0.46 | 0.34 | 0.22 | 0.11 |
| $x$ | 2.4 | 2.6 | 2.8 | 3.0 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 |
| $J_0(x)$ | 0.00 | -0.10 | -0.19 | -0.26 | -0.32 | -0.36 | -0.39 | -0.40 | -0.40 | -0.38 | -0.34 | -0.30 |
| $x$ | 4.8 | 5.0 | 5.2 | 5.4 | 5.6 | 5.8 | 6.0 | 6.2 | 6.4 | 6.6 | 6.8 | 7.0 |
| $J_0(x)$ | -0.24 | -0.18 | -0.11 | -0.04 | 0.03 | 0.09 | 0.15 | 0.20 | 0.24 | 0.27 | 0.29 | 0.30 |

Table 1 Table of Bessel function of the first kind $J_0(x)$

注意：背面尚有試題

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4. Consider the baseband binary data transmission system as shown in Figure 3 and let $p(t)=\mu g(t)*h(t)*c(t)$ with $p(0)=1$ and $\mu$ is a constant. The transmitted signal is $s(t)=\sum_k a_k g(t-kT_b)$ where $a_k=\begin{cases}1 & b_k=1\\ -1 & b_k=-1\end{cases}$ and $T_b$ is the bit duration.

   (a) (5%) State the condition for this system without ISI in terms of $p(t)$.

   (b) (5%) State the condition for this system without ISI in terms of $P(f)$ which is the Fourier transform of $p(t)$.

   (c) (5%) Consider the system with $P(f)=\begin{cases}T_b(1-|f|T_b) & |f|\le\frac{1}{2T_b}\\ 0 & \text{else}\end{cases}$. Does this system have ISI effect? Explain your answer.

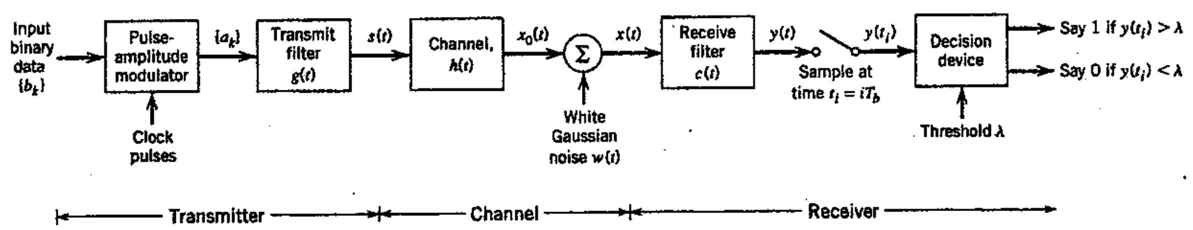


Figure 3

5. Consider a binary transmission system. The probability of sending symbol 1 is 2/3. The received signal is

$$x(t)=\begin{cases}s(t)+w(t) & \text{for sanding symbol 1}\\ -s(t)+w(t) & \text{for sanding symbol 0}\end{cases}\quad 0\le t\le T$$

where $s(t)=\begin{cases}-1 & 0\le t\le T/2\\ 1 & T/2<t\le T\\ 0 & \text{else}\end{cases}$ and $w(t)$ is an additive zero-mean white Gaussian noise with power spectral density $N_0/2$.

   (a) (6%) Using the matched filter with impulse response $h(t)=\frac{1}{\sqrt{T}}s(T-t)$, find the mean and variance of the output $y$ of matched filter at $t=T$ for sending symbol 1 and 0, respectively.

   (b) (8%) Let $\lambda$ be the threshold such that the decision is making by the rule

   $y>\lambda \Rightarrow$ chossing symbol 1

   $y<\lambda \Rightarrow$ chossing symbol 0

   Find the probability of error in terms of erfc function for this system.(Using $\lambda$ and $\text{erfc}(x)=\frac{2}{\sqrt{\pi}}\int_x^\infty e^{-z^2}dz$ ).

   (c) (6%) Find the optimum threshold $\lambda_{opt}$.

6. Consider the M-ary QAM system for M=16. The transmitting symbol can be represented as

$$s_k(t)=\sqrt{\frac{2E_0}{T}}a_k\cos(2\pi f_c t)-\sqrt{\frac{2E_0}{T}}b_k\sin(2\pi f_c t)\qquad 0\le t\le T, k=1,2,\ldots,16$$

where

$$\{a_k,b_k\}=\begin{bmatrix}(-3,3) & (-1,3) & (1,3) & (3,3)\\ (-3,1) & (-1,1) & (1,1) & (3,1)\\ (-3,-1) & (-1,-1) & (1,-1) & (3,-1)\\ (-3,-3) & (-1,-3) & (1,-3) & (3,-3)\end{bmatrix}.$$

Assumed that all symbols are equally likely, transmitting in AWGN channel with noise power spectral density $N_0/2$, and detecting by coherent detectors

   (a) (5%) Find the basis functions of this QAM system and draw the signal space diagram of this system.

   (b) (5%) Derive the probability of correct symbol detection for this system. (You may use $p_2(\bar{s}_i,\bar{s}_k)=P(\text{observation vector } \bar{x} \text{ is closer to } \bar{s}_k \text{ than } \bar{s}_i \,/\, \bar{s}_i \text{ was sent})=\frac{1}{2}\text{erfc}(\frac{d_{ik}}{2\sqrt{N_0}})$ where $d_{ik}$ is the distance between message point $\bar{s}_i,\bar{s}_k$ in signal space.)

   (c) (5%) Find the average symbol energy of this system.