# 國立臺北科技大學 100 學年度碩士班招生考試

## 系所組別：2220 電腦與通訊研究所乙組

## 第二節　通訊系統　試題



**注意事項：**

1. 本試題共 6 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. (12%) Consider a signal

$$x(t) = 60\text{sinc}(600t) + 50\text{sinc}^2(500t).$$

(1) Determine the Fourier transform of the signal. (4%)

(2) Specify the Nyquist rate and the Nyquist interval for the signal. (8%)

2. (16%) A pseudo-noise (PN) sequence is generated using a feedback shift register of length $m = 10$. The chip rate is $10^6$ chips per second. Determine the following parameters:

(1) PN sequence length. (4%)

(2) Chip duration of the PN sequence. (4%)

(3) PN sequence period. (4%)

(4) The total number of runs. (4%)

3. (18%) The input to a low-pass filter with impulse response

$$h(t) = 20e^{-5t}u(t)$$

is white Gaussian noise with mean zero and single-sided power spectral density $2\times10^{-2}$ W/Hz.

(1) Determine the power spectral density of the output. (4%)

(2) Determine the autocorrelation function of the output. (4%)

(3) Determine the probability density function of the output. (4%)

(4) Is still a white noise of the output? (3%)

(5) Is still a Gaussian noise of the output? (3%)

4. (20%) An FM modulator is followed by an ideal band-pass filter having a center frequency of 50 kHz and a bandwidth of 28 kHz. The gain of the filter is one in the passband. The unmodulated carrier is given by $20\cos(10^5\pi t)$, and the message signal is $m(t) = 2\cos(8\times10^3\pi t)$. The frequency sensitivity factor of the modulator is 10 kHz/v.

(1) Determine the peak frequency deviation in hertz. (3%)

(2) Determine the peak phase deviation in radians. (4%)

(3) Determine the modulation index. (3%)

(4) Determine the power at the filter input and the filter output. (10%)

Table 1: Bessel Functions

| $n$ | $\beta=0.05$ | $\beta=0.1$ | $\beta=0.2$ | $\beta=0.3$ | $\beta=0.5$ | $\beta=0.7$ | $\beta=1.0$ | $\beta=2.0$ | $\beta=3.0$ | $\beta=5.0$ | $\beta=7.0$ | $\beta=8.0$ | $\beta=10.0$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.999 | 0.998 | 0.990 | 0.978 | 0.938 | 0.881 | 0.765 | 0.224 | −0.260 | −0.178 | 0.300 | 0.172 | −0.246 |
| 1 | 0.025 | 0.050 | 0.100 | 0.148 | 0.242 | 0.329 | 0.440 | 0.577 | 0.339 | −0.328 | −0.005 | 0.235 | 0.043 |
| 2 | | 0.001 | 0.005 | 0.011 | 0.031 | 0.059 | 0.115 | 0.353 | 0.486 | 0.047 | −0.301 | −0.113 | 0.255 |
| 3 | | | | 0.001 | 0.003 | 0.007 | 0.020 | 0.129 | 0.309 | 0.365 | −0.168 | −0.291 | 0.058 |
| 4 | | | | | | 0.001 | 0.002 | 0.034 | 0.132 | 0.391 | 0.158 | −0.105 | −0.220 |
| 5 | | | | | | | | 0.007 | 0.043 | 0.261 | 0.348 | 0.186 | −0.234 |
| 6 | | | | | | | | 0.001 | 0.011 | 0.131 | 0.339 | 0.338 | −0.014 |
| 7 | | | | | | | | | 0.003 | 0.053 | 0.234 | 0.321 | 0.217 |
| 8 | | | | | | | | | | 0.018 | 0.128 | 0.223 | 0.318 |
| 9 | | | | | | | | | | 0.006 | 0.059 | 0.126 | 0.292 |
| 10 | | | | | | | | | | 0.001 | 0.024 | 0.061 | 0.207 |

5. (18%) A binary FSK signal is given by

$$\begin{cases} s_1(t) = \cos(6000\pi t) & 0 \le t \le 0.002\ s \\ s_2(t) = \cos(5000\pi t) & 0 \le t \le 0.002\ s. \end{cases}$$

Assume that the single-sided AWGN power spectral density is 0.0001 W/Hz.

(1) Determine the basis functions $\phi_1(t)$ and $\phi_2(t)$, and draw the signal-space diagram for the FSK system. (10%)

(2) Determine the bit error probability for the coherent binary FSK system. (8%)

6. (16%) For a BPSK system, the received signals, $s_1(t) = 0.5\cos(2\pi f_c t)$ and $s_2(t) = -0.5\cos(2\pi f_c t)$, are coherently detected with a correlator.

Assume that the single-sided AWGN power spectral density is $2\times10^{-7}$ W /Hz.

(1) Plot the block diagram for the coherent BPSK receiver and determine the bit error probability for the system with a bit rate of 100 kbps. (12%)

(2) In part (1), what is the minimum transmission bandwidth required? (4%)

**Note: If necessary, express your answer in terms of the complementary error function defined by** $erfc(x) = \frac{2}{\sqrt{\pi}}\int_x^\infty \exp(-z^2)dz$.