※ 考生請注意：本試題可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (35%) Consider the following system:

$$y(n) = \frac{1}{3}x(n) + \frac{1}{3}x(n-1) + \frac{1}{3}x(n-2)$$

where $x(n)$ and $y(n)$ represent the input and output of the system, respectively. Note that we assume that the condition of initial rest is satisfied. Therefore, the system is a linear time-invariant system.

(a) (10%) Plot the magnitude and phase responses of the system. [頻率(ω)軸請畫出-2π~2π 的範圍。]

(b) (5%) Is the frequency response periodic in frequency? Briefly explain your answer (i.e., why so or why not).

(c) (10%) Let us assume that $x(n)$ is independent and identically distributed. At each time instant n, $x(n)$ is of zero mean and a variance of σ^2, and is Gaussian distributed. Find the probability density function of $y(n)$.

(d) (10%) Are $y(n)$ and $y(n-1)$ independent? Justify your answer.

2. 簡答題 (15%)

(a) (5%) Modulator output 經過 nonlinear power amplifier 後，其 nonlinear distortion 現象對通訊系統造成哪些影響? 簡述之。(請用完整句子回答。最少需寫 2 個面向。)

(b) (5%) Nonlinear distortion 和 linear distortion 對訊號頻譜造成之影響有何不同? 簡述之。(請用完整句子回答。最少需寫 2 個面向。)

(c) (5%) 簡述類比調變技術和數位調變技術基本的差異。(請用完整句子回答。最少需寫 2 個面向。)

3. (a) (14%) Consider the representation of a signal x(t) by a so-called ideal instaneous sampled waveform of the form

$$x_\delta(t) = \sum_{-\infty}^{\infty} x(nT_s)\delta(t - nT_s)$$

where T_s is the sampling interval; and the signal spectra of the low-pass signal x(t) is shown in Fig. 1. Please explain the sampling theory that the sampling frequency f_s should comply with $f_s > 2W$. Also, please draw the spectra of $x_\delta(t)$, which can be helpful to your explanation. It should be noticed that some mathematical derivations are required.

(b) (6%) If a signal has a spectrum of bandwidth W Hz and upper frequency limit f_u (as shown in Fig. 2), then a rate f_s at which the signal can be sampled is $2f_u/m$, where m is an integer. How can you decide m? Note that Fig. 2 is just an example. That means you should write down the general rule of deciding m rather than using the specific values of $f_u = 3$ Hz and $w = 2.1$ Hz.

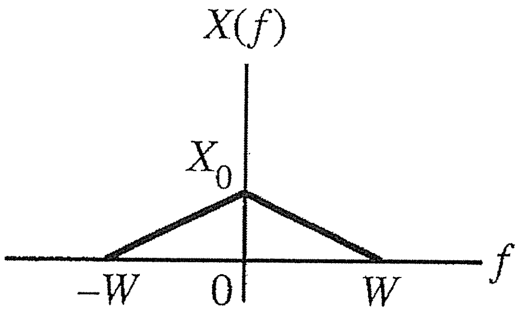

Fig. 1 Signal spectra of the low-pass signal x(t).

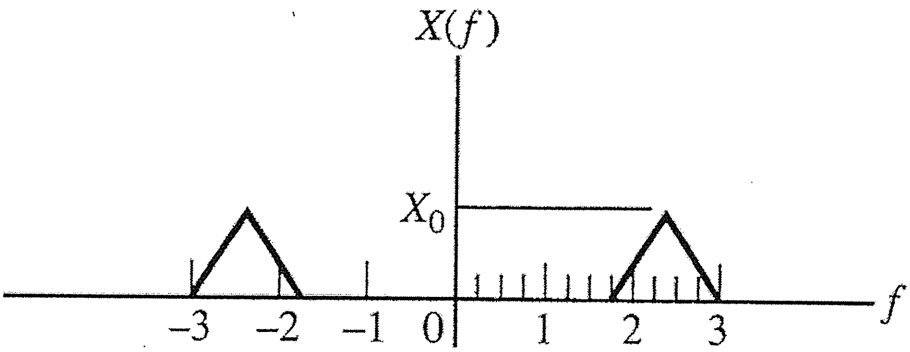

Fig. 2 Signal spectra of the band-pass signal x(t), where $f_u = 3$ Hz and $w = 1.25$ Hz herein.

4. (15%) Consider the system of Fig. 3, where the transmitted signal is

$$\mathrm{x(t)} = \sum_{k=-\infty}^{\infty} a_k \delta(t-kT) * h_T(t)$$
$$= \sum_{k=-\infty}^{\infty} a_k h_T(t-kT)$$

where $a_k = \pm 1$ with equal probability; and $h_T(t)$ is the impulse response of the transmitter filter that has the lowpass frequency-response function $H_T(f) = \mathcal{F}[h_T(t)]$. This signal passes through a bandlimited channel filter, after which Gaussian noise with power spectrum density $G_n(f)$ is added to give the received signal

$$\mathrm{y(t)} = \mathrm{x(t)} * \mathrm{h_C}(t) + n(t)$$

where $h_C(t) = \mathcal{F}^{-1}[H_C(f)]$ is the impulse response of the channel. Detection at the receiver is accomplished by passing y(t) through a filter with impulse response $h_R(t)$ and sampling its output at intervals of T, where t_d is the delay imposed by the channel and receiver filters; and it can be ignored.

Now, please decide the proper transmitter and receiver filters such that the zero-ISI received signal

$$\mathrm{V} = Aa_0 + N$$

can minimize the probability of error, where A is a constant and N denotes AWGN. Mathematical derivations are required.

5. (15%) An MSK system has a carrier frequency of 10 MHz and transmits data at a rate of 50 Kbps.
   (a) For the data sequence 1010101010..., what is the instantaneous frequency?
   (b) For the data sequence 1000000000..., what is the instantaneous frequency?

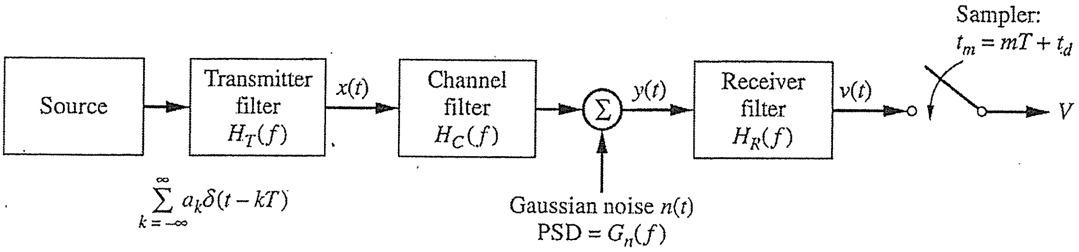

Fig. 3 Baseband system for signaling through a bandlimited channel.