注意事項：

1. 計算過程不清楚，會被扣分。
2. 本試題不需使用計算機；計算準確度請取至小數第二位。
3. 作答請註明題號。

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1. An angle-modulated signal with carrier frequency $\omega_c = 2\pi \times 10^5$ is described by the equation

$$\varphi_{EM}(t) = 10\cos(\omega_c t + 5\sin 3000t + 10\sin 2000\pi t)$$

(a) Find the power of the modulated signal. (3%)

(b) Find the frequency deviation Δf. (3%)

(c) Find the deviation ratio β. (3%)

(d) Find the phase deviation $\Delta\phi$. (3%)

(e) Estimate the bandwidth of $\varphi_{EM}(t)$. (3%)

2. Consider the binary digital communication system in which the transmitted signals corresponding to the two hypotheses (假定) H_0 and H_1 are +1 and −1, respectively. We thus have $Z = Y + V$, where Y is transmitted random variable, Z is a received random variable, and V is zero mean Gaussian with variance σ_v^2.

(a) We are required to estimate the value of the signal y corresponding to Y based on a single signal observation z corresponding to Z. What is the MAP (maximum a posteriori) estimate $\hat{y}_{MAP}$ for y if we assume the prior probabilities for the two hypotheses to be the same? (10%)

(b) If we have multiple independent observations, $z_i, i = 1,\ldots,N$, What is the MAP estimate $\hat{y}_{MAP}$ based on $z_i, i = 1,\ldots,N$? (5%)

3. Frequency shift keying (FSK) is an important class of orthogonal modulation where different information symbol is keyed on different frequency. The simplest case is binary FSK where two frequencies are used to transmit 0 or 1. The signal constellation for binary

FSK is shown in the following figure.

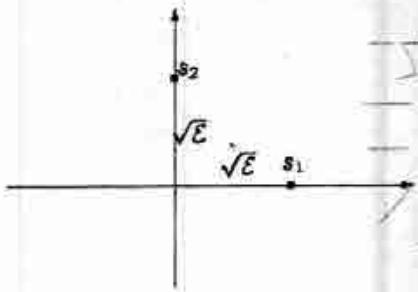

Fig.1 BFSK signal constellation.

Assume that $s_1=[\sqrt{\varepsilon} \quad 0]$ and $s_2=[0 \quad \sqrt{\varepsilon}]$ are equally likely symbols. If the received signal $\mathbf{r}=[r_1 \quad r_2]$ is defined as

$$\mathbf{r}=\begin{cases}\alpha\times s_1+[n_1 \quad n_2], \text{if } s_1 \text{ is sent}\\ \alpha\times s_2+[n_1 \quad n_2], \text{if } s_2 \text{ is sent}\end{cases}$$

where n_1 and n_2 are independent Gaussian random variables with variance $N_0/2$ and zero-mean.

(a) The probability of error in AWGN channels can be viewed as a conditional error probability, where the condition is that α is fixed. What is the probability of error for the optimal receiver in AWGN channels if $\alpha=1$? (Note $Q(\lambda)=\int_{\lambda}^{\infty}\frac{1}{\sqrt{2\pi}}e^{-t^2/2}dt$)(10%)

(b) For a fading channel, α is a random variable. Assume that α is distributed as $f(\alpha)=2\alpha e^{-\alpha^2}, \alpha\geq 0$. What is the probability of error for the optimal receiver in this fading channel? (10%)

4. Consider a baseband transmission system as shown in Fig.2. Where b_k is a binary random sequence; A Bipolar encoder is used as the baseband modulator. Suppose the channel's impulse response $h(t) = \delta(t) + 0.2\delta(t-T)$, where T is the symbol time.

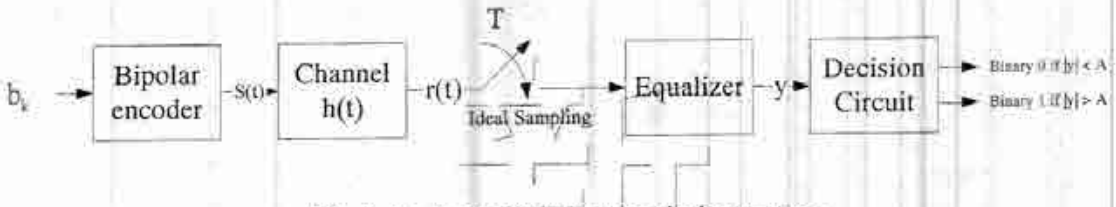

Fig.2 A binary digital transmission system

(a) Please sketch (畫出) the encoded waveform $S(t)$ if b_k = {1 0 0 1 0 0 0 1 1 0 1 1 1 1 0 1 0}. (Hint: The Bipolar encoder sends out positive rectangular pulse or negative rectangular pulse for binary 1, and sends out zero signal for binary 0. Bipolar code is also called as Alternate Mark Inversion (AMI) code.) (5%)

(b) Please sketch the "Eye pattern" of waveform $r(t)$. Then, explain why we need to see the eye pattern in a digital transmission system. (10%)

(c) Please design a three-tap zero-forcing equalizer for the system. (10%)

(d) Explain what is 'intersymbol interference (ISI)", and why need an equalizer in a digital transmission system. (Hint: you still can answer this question even you fail to find the solution of (c)) (5%)

(e) Please determine the threshold level A of the decision circuit shown in Fig.2. (Hint: You first need to know the amplitude levels of S(t))(5%)

5. A wideband frequency modulation (WBFM) generation circuit is shown in Fig.3. Please find the modulation index, frequency deviation, and possible carrier frequency of the WBFM signal. (15%)

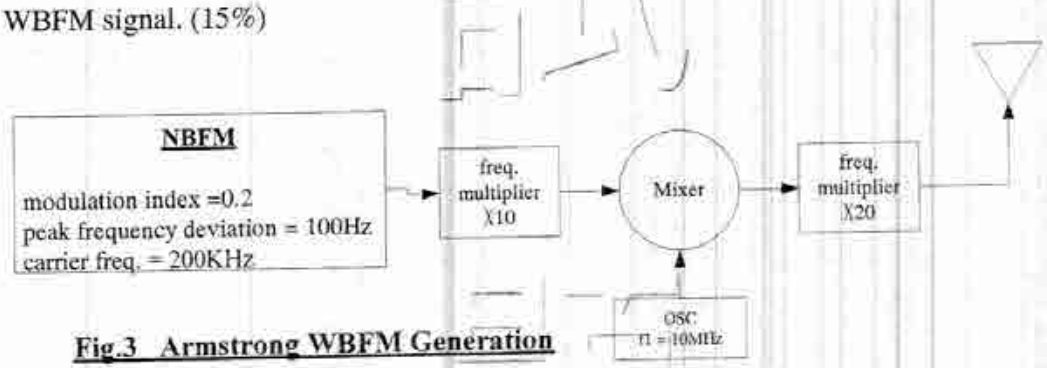

Fig.3 Armstrong WBFM Generation