所別：通訊工程學系碩士班 通訊系統與訊號處理組 科目：通訊系統

15% 1. In a communication system, two baseband signals are transmitted simultaneously by generating the RF signal

$$s(t) = m_1(t)\cos(\omega_c t) + m_2(t)\sin\omega_c t.$$

The carrier frequency is 20.25 MHz. The bandwidth of $m_1(t)$ is 20 KHz and the bandwidth of $m_2(t)$ is 10 kHz.

(a) Evaluate the bandwidth of $s(t)$.

(b) Derive an equation for the spectrum of $s(t)$ in terms of $M_1(f)$ and $M_2(f)$, where $M_1(f)$ and $M_2(f)$ are spectra of $m_1(t)$ and $m_2(t)$, respectively.

20% 2. Let $X(t)$ and $Y(t)$ be statistically independent Gaussian random processes, each with zero mean and unit variance at any time instant. Define the process:

$$Z(t) = X(t)\cos(2\pi t + \theta) + Y(t)\sin(2\pi t + \theta)$$

(a) If θ is a deterministic constant, determine the joint probability density function of the random variable $Z(t_1)$ and $Z(t_2)$ obtained by observing $Z(t)$ at time instants t_1 and t_2, respectively.

(b) If θ is a deterministic constant, is the process $Z(t)$ stationary? Please explain for your answer.

15% 3. A phase modulation (PM) system uses a pair of pre-emphasis and de-emphasis filters defined by the transfer functions

$$H_{pe}(f) = 1 + j\frac{f}{f_0} \quad \text{and} \quad H_{de}(f) = \frac{1}{(1 + j\frac{f}{f_0})}.$$

The power spectral density of the noise at the phase discriminator output is assumed to be constant and bandlimited ($|f| \le W$) in the absence of pre-emphasis and de-emphasis for the PM system. Show that the improvement in output signal-to-noise ratio produced by using this pair of filters is

$$G = \frac{W / f_0}{\tan^{-1}(W / f_0)}$$

where W is the message bandwidth. ($\int \frac{\partial u}{a^2+u^2} = \frac{1}{a}\tan^{-1}(\frac{u}{a}) + C$)

注意：背面有試題

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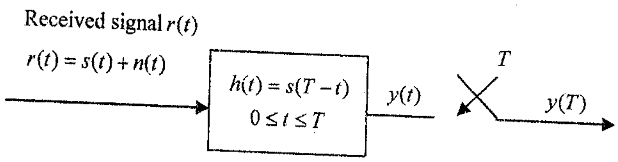
10% 4. Please plot a correlator implementation of the following matched-filter receiver and show the output $y(T)$ of the correlator receiver is equivalent to that of the matched-filter receiver.



20% 5. Consider the following set of three finite-energy signals

$S_0(t) = 1 \quad 0 \le t \le T$

$S_1(t) = \cos 2wt \quad 0 \le t \le T, w = \frac{2\pi}{T}$.

$S_2(t) = \sin^2 wt \quad 0 \le t \le T$

Please use the Gram-Schmidt procedure to obtain an orthonormal basis for the space spanned by these three signals.

20% 6. Consider a discrete memoryless channel (DMC) with input, output and transition probabilities given by $p(x), p(y)$ and $p(y|x)$ respectively, where $x \in \{x_1, x_2, \cdots x_N\}$ and $y \in \{y_1, y_2, \cdots y_M\}$. The entropy functions for the DMC channel are defined as

$$H(X) \equiv -\sum_{i=1}^{N} p(x_i) \log_2 p(x_i) \qquad H(Y) \equiv -\sum_{j=1}^{M} p(y_j) \log_2 p(y_j)$$

$$H(Y|X) \equiv -\sum_{i=1}^{N} \sum_{j=1}^{M} p(x_i, y_j) \log_2 p(y_j | x_i)$$

(i) Please show that $H(X) \le \log_2 N$ and $H(Y) \le \log_2 M$.

(ii) Please show that $H(Y|X) \le H(Y)$.