國立臺灣科技大學 104 學年度碩士班招生試題

系所組別：電子工程系碩士班乙一組

科　　目：通訊系統

1. This problem is concerned with the sampling of continuous-time signals. Let us consider two baseband signals x(t) and y(t). The signal x(t) is band-limited to 23 KHz, and the signal y(t) is band-limited to 40 KHz.
   (a).(5%) Is sampling a linear operation ?
   (b).(5%) Find the Nyquist sampling rate for x(3t)+y(t).
   (c).(5%) Find the Nyquist sampling rate for x(t)y(t).

2. Let $u(t)$ denote the unit-step function, which is defined by
$$u(t) = \begin{cases} 1, \text{if } t \geq 0, \\ 0, \text{if } t < 0. \end{cases}$$
   Then, $p(t) = A(u(t) - u(t-T))$, where A is a positive constant, is a pulse of magnitude A and width T (located in $0 < t < T$). Consider a non-return-to-zero (NRZ) waveform
$$x(t) = \sum_{n=-\infty}^{\infty} d_n \times p(t - nT),$$
   where d_n is a binary random variable whose probability distribution is
$$\text{Prob}(d_n = 1) = \text{Prob}(d_n = -1) = \frac{1}{2}.$$
   (a).(5%) Find the autocorrelation function of $x(t)$.
   (b).(5%) Find the power spectral density of $x(t)$.

3. Let $\text{Prob}(E)$ denote the probability of an event E. The Q function is defined to be $Q(x) = \text{Prob}(Z > x)$, where Z is the standard Gaussian random variable (i.e. a Gaussian random variable with a mean of 0, and a variance of 1).
   (a).(5%) Let $Q'(x)$ denote the derivative of $Q(x)$. Then, $Q'(-1) = ?$
   (b).(5%) Let X be a Gaussian random variable with a mean of μ, and a of variance of σ^2. It can be shown that $\text{Prob}(X > t) = Q(\alpha t + \beta)$. Then, $\alpha = ?$, and $\beta = ?$ (Please express your answer in terms of μ and σ.)
   (c).(5%) The erfc function is defined by
$$\text{erfc}(x) = \frac{2}{\sqrt{\pi}} \int_x^{\infty} e^{-u^2} du.$$
   It can be shown that $Q(x)$ and $\text{erfc}(x)$ are related to each other by
$$Q(x) = A \times \text{erfc}(Bx + C).$$
   Then, $A = ?$, $B = ?$, and $C = ?$

4. In BPSK (binary phase shift keying) signal transmission, data bit 0 and data bit 1 are, respectively, mapped into waveforms $s_0(t) = A\cos(2\pi f_c t)$ and $s_1(t) = A\cos(2\pi f_c t + \pi)$, for $0 < t < T$. Notice that one data

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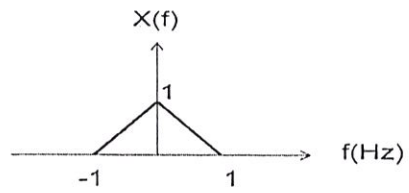
bit occupies a time duration of T.

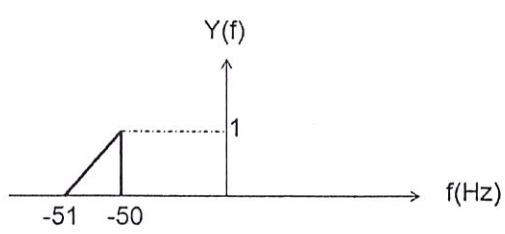
(a).(5%) What is the null-to-null bandwidth, which is equal to the width of the main lobe of the signal power spectrum, consumed by this BPSK transmission? Please express your answer in terms of T.

(b).(5%) Can BPSK be demodulated non-coherently? Please also explain the difference between non-coherent demodulation and coherent demodulation.

5. (10%)Suppose $x(t)$ has the Fourier transform



Find $y(t)$ in terms of $x(t)$ if $y(t)$ has the Fourier transform



6. For a amplifier, the relation of the input signal $u(t)$ and output signal $w(t)$ is given by $w(t)=10u(t)+5u^3(t)$. If we use this amplifier to amplify a frequency modulation (FM) signal $u(t)$, please answer following questions.
   (a) (5%) Compute the distortion signal in $w(t)$.
   (b) (5%) How to remove the distortion signal in $w(t)$?

7. (10%) Suppose that the pulse amplitude modulation (PAM) signal $s(t)=\sum_{n=1}^{N} a_n g(t-nT)$ passes through the multipath channels with the impulse response $h(t)=\delta(t)+0.5\delta(t-2T)$. Please compute the matched filter which can maximize the ratio of the signal power to noise power at the receiver.

8. (5%) Suppose that a communication system uses 5MHz bandwidth to transmit data through the additive white Gaussian noise (AWGN) channel. If 256-QAM modulation is used, please find the maximum transmission rate (bits/sec) if there is no intersymbol interference.

9. If X and Y are independently and identically Gaussian distributed with mean 0 and variance σ, please answer following questions.
   (a) (5%) Compute the probability density function of the random variable $Z=X^2+Y^2$
   (b) (10%) Prove the random variable $Z=aX+bY$ is Gaussian distributed if both a and b are constants.