3. An ideal sampling system is shown below where $x(t) = \sin(c200t)$, and $p(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT_s)$. (Note: $\sin(c\lambda) = \sin(\frac{c\lambda}{\lambda})$)
(a) Determine the required minimum value of $f_s$ (sampling frequency). (3%)
(b) Sketch Fourier transform of the sampled signal $x_s(t)$ if $f_s = 150$ Hz. (6%)
(c) What phenomenon happened in (b)? How to overcome such a problem in practice? (4%)

4. A white Gaussian noise with zero mean and PSD of $N_0/2$ is applied to the BPF shown below where $f_s \gg 2B$
(a) Find $\bar{m}(f)$ (average value of $m(t)$). (3%)
(b) Find the average power of $m(t)$ delivered to a $1 - \Omega$ resistor. (4%)
(c) Find the average power of $n(t)$ (in phase component of $n(t)$) to a $1 - \Omega$ resistor. (5%)

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1. (18%, each 3%) Answer the following questions.
(a) What is the capture effect? What cause(s) may result in such an effect?
(b) What benefits can FM system obtain when pre-emphasis and de-emphasis are applied?
(c) What modulation scheme is employed in the GSM system? What advantages does this scheme have?
(d) What is the function of repeater in a PCM system?
(e) Which of the following modulation schemes: PSK, FSK, ASK and QAM, do you prefer to use in the case of passband data transmission over nonlinear channel? Describe your reason(s).
(f) Why the nonuniform $\mu$-law (or A-law) quantization is commonly used in the PCM-based telephone network?

2. An FM modulation system has $k_f = 10^7$ Hz/volt and carrier wave $c(t) = \cos 2\pi 10^4t$.
Assume that the input signal is $m(t) = \cos 2\pi 10^4t$ volt
(a) Write down the equation of the resulting FM signal $s(t)$ in terms of modulation index $\beta$, $f_c$, and $f_m$. Is $s(t)$ a wideband FM (WBFM) signal? Why? (5%)
(b) Calculate the maximum and minimum instantaneous frequencies of $s(t)$. Please illustrate your result with unit of MHz. (4%)
(c) Find $s_{1}(t) = s(t) + ji(t)$, and $s_{2}(t) = s(t) + ji_2(t)$. (8%)
(d) Estimate bandwidth of $s(t)$ using the Carson's rule. (4%)

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注意：第面尚有試題
5. An analog signal is sampled, quantized, and encoded into a binary PCM wave. The number of representation levels used is 128. A synchronizing pulse is added at the end of each code word representing a sample of the analog signal. The resulting PCM wave is transmitted over a channel of bandwidth 10 kHz using a M-ary PAM system with raised-cosine spectrum. The rolloff factor \( \alpha = 1 \).

(a) Find the symbol rate and bit rate of the information transmitted through the channel when \( M = 2 \) and \( M = 16 \). (6%)  
(b) For the case of \( M = 16 \), find the rate at which the analog signal is sampled. What is the maximum possible value for the highest frequency component of the analog signal? (6%)

6. A pair of sinusoidal waves of a coherent BFSK system is represented by

\[
s_i(t) = \begin{cases} 
\frac{2E_s}{T_s} \cos(2\pi f_i t), & 0 \leq t \leq T_s \\
0, & \text{elsewhere}
\end{cases}
\]

where \( f_i = \frac{n_i}{T_s} + \frac{i}{T_s} \) for some fixed integer \( n_i, i = 1, 2 \), \( s_1(t) \) for symbol 1 and \( s_2(t) \) for symbol 0) and \( E_s \) is the transmitted signal energy per bit.

(a) Plot their signal constellation and decision regions for optimum detection in the signal space. Simply describe your decision rule. (6%)  
(b) Plot block diagrams of transmitter and receiver of this system. (6%)  
(c) Show that for the case of equiprobable symbols, the bit error rate for coherent BFSK over AWGN channel with PSD of \( \frac{N_0}{2} \) is \( p_e = \frac{1}{2} \text{erfc}(\sqrt{\frac{E_s}{2N_0}}) \). (8%)  
(d) Describe advantage(s) and disadvantage(s) of this system. (4%)

Note: \( \text{erfc}(x) = \frac{2}{\sqrt{\pi}} \int_x^{\infty} e^{-t^2} dt = 1 - \text{erf}(x) = 2Q(\sqrt{2x}) \)