

Instructions for Examination

- This is a closed book exam.
- Standard type calculator may be used.
- Cellular phones are not allowed.
- Show all the intermediate steps of your solution.
- Make reasonable assumptions if necessary.
- You may only write on the provided answer booklet.
- You may not separate any sheet from formula sheet or answer booklet.

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- Exam is worth 12.5% of your overall course grade.
 - There are 3 questions and each has two parts.
 - Part “a” or part “b” of each question is worth 2.5%.
 - If you solve 5 parts (a or b), you may receive a grade of up to 12.5%.
 - If you solve 6 parts, all of them will be marked and you may receive a bonus mark of up to 2.5%.
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Amplitude Modulator (with carrier):

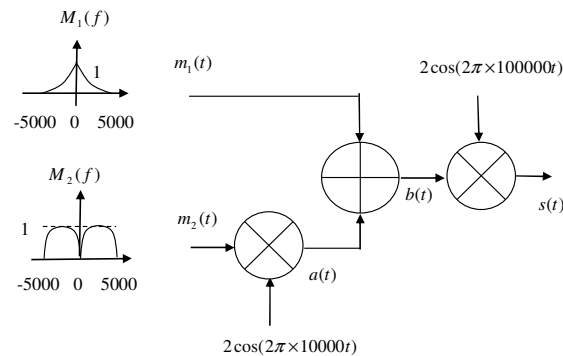
$$\varphi_{AM}(t) = [A + m(t)] \cos 2\pi f_c t \qquad \mu = \frac{m_p}{A}$$

Signal-to-Noise Ratio considering quantization error:

Linear Quantizer: $\frac{S_o}{N_o} = 3L^2 \frac{\overline{m^2(t)}}{m_p^2}$

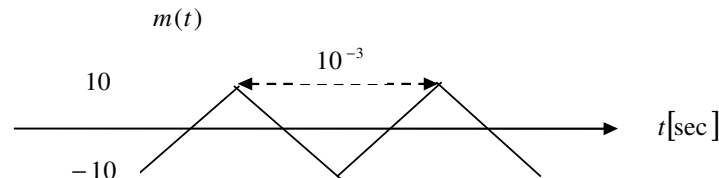
Non-Linear Quantizer (μ – Law): $\frac{S_o}{N_o} = \frac{3L^2}{[\ln(1 + \mu)]^2} \qquad \mu^2 \gg \frac{m_p^2}{\overline{m^2(t)}}$

Question 1: Two signals $m_1(t)$ and $m_2(t)$ band-limited to 5000 Hz are to be transmitted simultaneously over a wireless channel by the frequency multiplexing scheme shown in the figure. The signal $s(t)$ is transmitted to the channel using an antenna.



- (2.5 marks) Sketch the frequency spectrum of $a(t)$, $b(t)$ and $s(t)$. What is the bandwidth of the transmitted signal $s(t)$?
- (2.5 marks) Assume there is no noise in the channel and the signal $s(t)$ is received by the receiver antenna. Design the receiver to recover the signals $m_1(t)$ and $m_2(t)$. Show all receiver blocks with exact parameters.

Question 2: Consider an amplitude modulation with carrier having a modulation index of 0.5. The message signal $m(t)$ is a periodic signal as shown in the figure.



- (2.5 marks) Sketch the modulator structure. If the carrier frequency is 5kHz , sketch the modulated signal which is transmitted (in time domain).
- (2.5 marks) Sketch the circuitry for the demodulator and briefly explain how it works.

Question 3: Analog signal $m(t)$ varies between -1 volt and +1 volt and is band-limited to 5000 Hz. This signal is to be transmitted on a wireless link using digital modulation. The power of $m(t)$ do not exceed 20 mWatts. To transmit this signal first it is sampled by a sampling frequency of twice the Nyquist rate. The output of sampler is applied to a μ – law compander with $\mu = 50$ and then to a linear quantizer. The SQNR of this system should be better than 48 dB. Then, quantizer output is transferred to a bit stream and modulated using Binary-Phase-Shift-Keying modulation scheme with carrier frequency of 5 MHz.

- (2.5 marks) What is the bandwidth of the signal in the wireless link? Justify your answer.
- (2.5 marks) Draw the detailed block diagram of the receiver for the transmitter explained in part “a” and identify each block. Show all receiver blocks with exact parameters.