1. (15%) An amplitude modulation (AM) signal is defined by

$$x_c(t) \;=\; [A + m(t)] \cos 2000\pi t$$

where the message signal $m(t) = \cos 2\pi t$.

(a) (5%) Draw the envelope detection circuit that can be used to demodulate the AM signal.

(b) (5%) If $A = 0.5$, draw the waveform of $x_c(t)$.

(c) (5%) Dtermine the output of the envelope detection circuit for the case in (b).

2. (20%) Consider the 16-QAM modulation.

(a) (5%) Draw the block diagram of the 16-QAM modulator.

(b) (5%) Plot the signal constellation (i.e., signal space representation) of the 16-QAM.

(c) (5%) Draw the decision boundaries of the 16-QAM on the signal constellation diagram.

(d) (5%) Design Gray codes for the 16-QAM signal points.

3. (15%) The carrier synchronization is important to the success of a BPSK system.

(a) (5%) What would happen to the BPSK demodulation result if the carriers between the transmitter and the receiver are not synchronized?

(b) (5%) Name one method to achieve the carrier synchronization for the BPSK. Plot the block diagram of your method.

(c) (5%) Explain the phase ambiguity problem in achieving the carrier synchronization for the BPSK.

4 現有基帶信號功率 $S = 5$ dBm，雜訊功率密度(two-side) $N_0 = 2$ dBm/MHz，請問在高斯白雜訊頻道下(AWGN)傳輸頻寬 1MHz 時，利用 Shannon Capacity 定理計算二次元(binary)通道容量 (channel capacity)？ (20%)

5 在無線通訊技術，分集式接收 (Diversity Reception)用來改善通訊品質，尤其在多路徑衰弱通道 (multipath fading channel)。 假設現有 二組特性一致之接收天線設定同時接收信號場強低於特定臨界值(失敗)的機率爲 4% (i.e. join probability). 若同條件下, 請問每組獨立天線 (無分集接收功能時)個別接收到低於此特定臨界值(失敗的機率)(Join Probability)爲何? 若增爲三組接收天線，其同時失敗的機率應爲何? (15%)

6 一階式無線電超外差接收機 (Superheterodyde Receiver), 載波頻率 25.5MHz (desired signal)， 本地震盪頻率(local oscillator frequency)使用中頻輸出在 1.25MHz，其影像干擾信號源(image interference)可能發生於何處,試繪出其頻率響應?
若採用二階式超外差接收機設計有何優點 ? 其第一中頻與第二中頻應如何選擇爲佳 ? (15%)