Spring 2010
EE 4601: Assignment 6

- Date Assigned: March 16, 2010.
- Date Due: March 30, 2010.

1. (a) The two signal constellations shown in Figure P5.17 exhibit the same average probability of symbol error. Justify the validity of this statement.
(b) Which of these two constellations has minimum average energy? Justify your answer. You may assume that the symbols pertaining to the message points displayed in Figure P5.17 are equally likely.

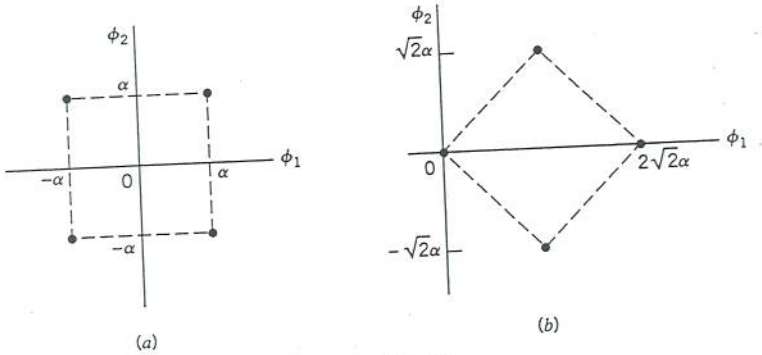

FIGURE P5.17

2. *Simplex (transorthogonal) signals* are equally likely highly-correlated signals with the most negative correlation that can be achieved with a set of M orthogonal signals. That is, the correlation coefficient between any pair of signals in the set is defined by

$$\rho_{ij} = \begin{cases} 1 & \text{for } i = j \\ \dfrac{-1}{M-1} & \text{for } i \neq j \end{cases}$$

One method of constructing simplex signals is to start with a set of M orthogonal signals, each with energy E, and then apply the minimum energy translate.

Consider a set of three equally likely symbols whose signal constellation consists of the vertices of an equilateral triangle. Show that these three symbols constitute a simplex code.

3. Let P_{eI} and P_{eQ} denote the probabilities of symbol error for the in-phase and quadrature channels of a narrowband digital communication system. Show that the average probability of symbol error for the overall system is given by

$$P_e = P_{eI} + P_{eQ} - P_{eI}P_{eQ}$$

4. Figure 6.53 shows a 240-QAM signal constellation, which may be viewed as an extended form of QAM cross constellation.
   (a) Identify the portion of Figure 6.53 that is a QAM square constellation.
   (b) Build on part (a) to identify the portion of Figure 6.53 that is a QAM cross constellation.
   (c) Hence, identify the portion of Figure 6.53 that is an extension to QAM cross constellation.

5. Determine the transmission bandwidth reduction and average signal energy of 256-QAM, compared to 64-QAM.

6. Two passband data transmission systems are to be compared. One system uses 16-PSK, and the other uses 16-QAM. Both systems are required to produce an average probability of symbol error equal to 10^{-3}. Compare the signal-to-noise ratio requirements of these two systems.

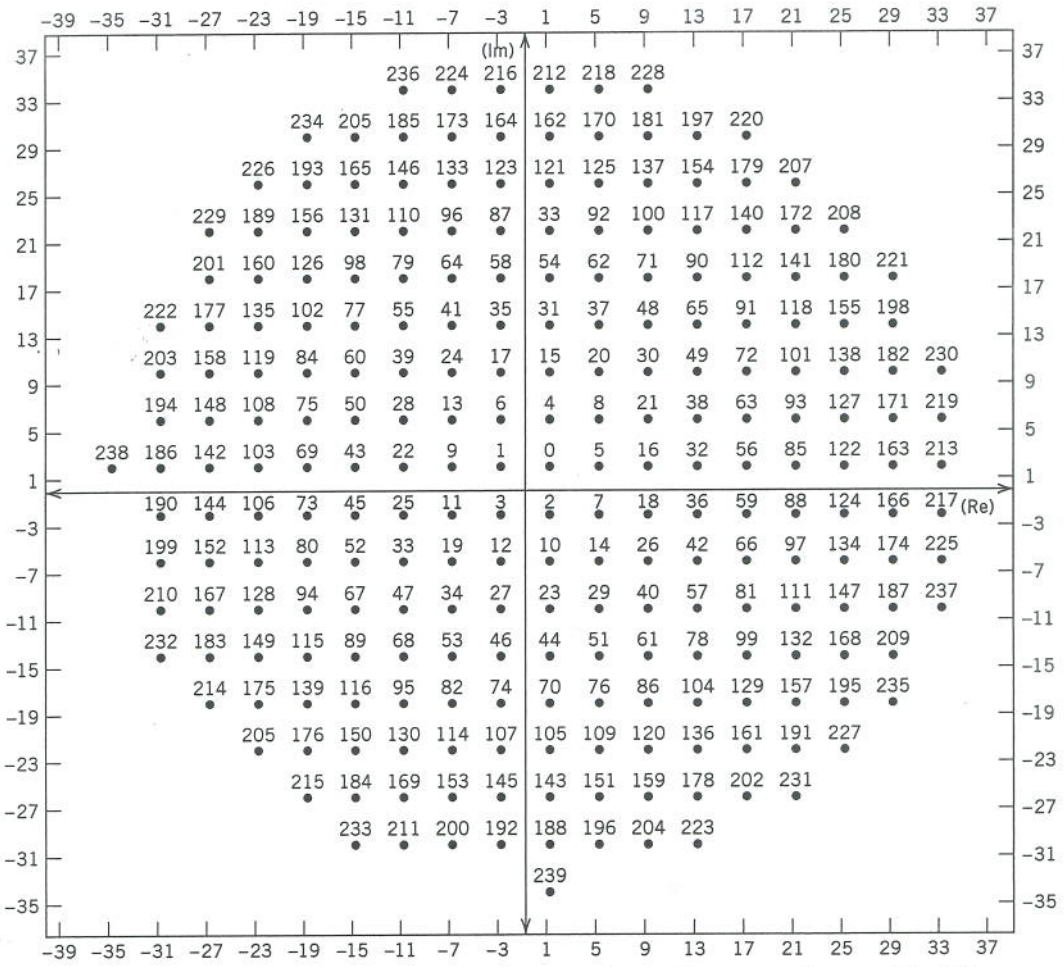

FIGURE 6.53 Quarter-superconstellation of V.34 modem with 240 signal points. The full superconstellation is obtained by combining the rotated versions of these points by 0, 90, 180, and 270 degrees. (Taken from Forney et al., 1996, with permission of the IEEE.)