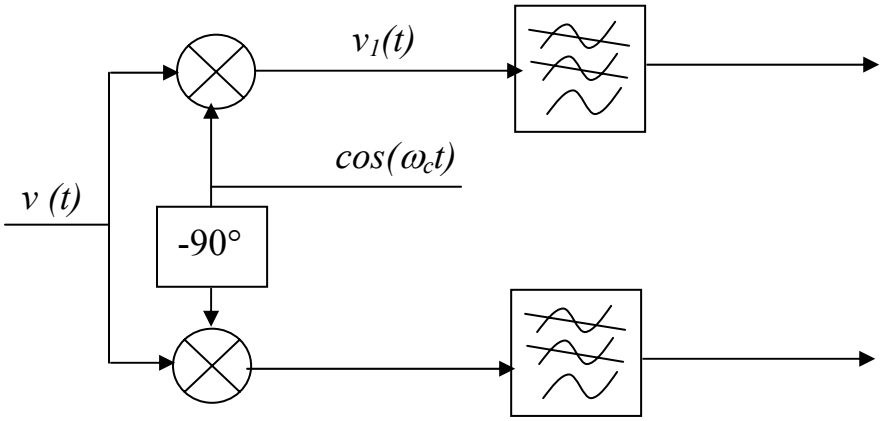
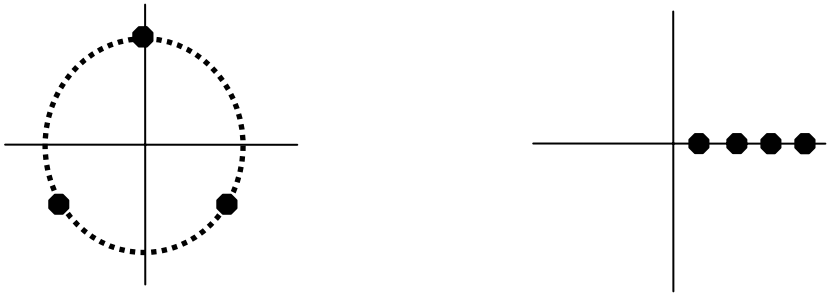
EEE 317 Tutorial answers –M-Ary signalling.

1)

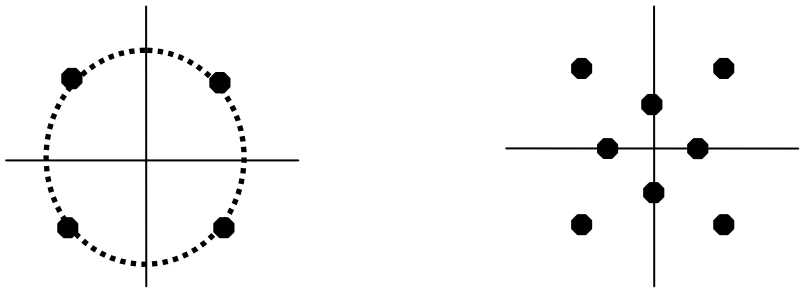


2) QAM modulated signals give better control over the points in the constellation diagram than PSK. The result is that the same bit error probability can be achieved for a lower transmitted power, or alternatively a much lower bit error probability can be achieved for the same transmitted power. This assumes that the QAM signal has been optimised.

3)



(a) (b)



(c) (d)

4) $BWE = \frac{1}{2}\log_2(M)$ from the notes, so,

a) 2-PSK (BPSK), $BWE = \frac{1}{2}\log_2(2) = 0.5$ bps/Hz

b) 3-PSK, $BWE = \frac{1}{2}\log_2(3) = 0.79$ bps/Hz

c) 8-PSK, $BWE = \frac{1}{2}\log_2(8) = 1.5$ bps/Hz

5) Both 8-PSK and 8-QAM can be described generally by the following formula,

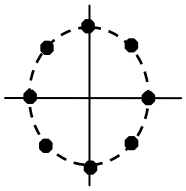
$$s_i(t) = x_i \cos(\omega_c t) + y_i \sin(\omega_c t)$$

In both systems the information is contained in the values of x_i and y_i (which, remember, describe the x,y co-ordinates on the constellation diagram), and both systems have 8 possible combinations of these co-ordinates, hence the amount of information contained in each constellation combination is the same for both systems. Furthermore, both systems use two carriers at the same frequency, albeit out of phase with one another, hence both systems occupy the same bandwidth.

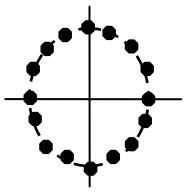
Since both the information contained and the bandwidth occupied by each symbol in 8-PSK and 8-QAM is the same, then the bandwidth efficiency is also the same.

The only difference in 8-PSK and 8-QAM is that in PSK $\sqrt{x_i^2 + y_i^2} = r$, where r is a constant equal to the radius of the circle on which the constellation points lie on, and in QAM there is no such restriction.

6) Take for example 8-PSK, the constellation diagram looks like this,



If we were to increase M to 16 PSK, we would obtain the following



It is relatively simple to see that the distance between adjacent codewords is reduced, thus making it easier for noise signals to 'push' one valid signal into the space for an adjacent signal, confusing the receiver into thinking a message other than that intended was sent. The way to remedy this without changing M, or modulation scheme is to increase the carrier power, which increases the radius of the circle on our diagram.