

Worksheet:

Introduction to Digital Modulation

1. Explain the basic operation of the following digital modulation techniques with reference to a generalized modulation equation, $x(t) = A(t) \cos(2\pi f(t) + \phi(t))$ using one sentence and one diagram for each:

(a) ASK

(b) FSK

(c) PSK

(d) QAM

2. Sketch a binary FSK receiver and mathematically describe the output of each stage if a carrier modulated to communicate a logic 0 is received.

Helpful hints:

- (a) Derive an equation to describe the result of the upper product operation.

- (b) Derive an equation to describe the result of the lower product operation.

- (c) Describe the operation and result of the upper and lower integrate and dumps and what happens to the signal following.

3. A QAM system is designed with 16 states:

- (a) Draw a constellation diagram for 16QAM and label each state with appropriately selected binary codes.

(b) Derive the equation for relative bandwidth B_{rel} and then calculate B_{rel} for this 16QAM system.

(c) How many bits is it capable of communicating simultaneously? Why?

(d) Calculate the amplitude for each of the states.

(e) Find the RMS amplitude for this 16-QAM system.

4. An equation that can be used to compare modulation schemes in terms of relative power for the same symbol error rate is:

$$P \propto B_{\text{rel}} \times \left(\frac{A}{d}\right)^2.$$

where d is minimum distance between states which for PSK is given by:

$$d = 2A \sin\left(\frac{\pi}{M}\right).$$

Calculate the right hand side of the above equation for the following modulation schemes:

(a) 4PSK

(b) 4QAM

(c) 16PSK

(d) 16QAM

5. Based on the above calculations:

(a) Is 4PSK better than 4QAM? Why?

(b) Is 16PSK better than 16QAM? Why?

Noise Sensitivity

6. Find the power relative to the power of BPSK for 32QAM and 64QAM schemes as used in DVB-C.

7. What modulation scheme does DVB-S use? Why?

8. Compare the two diagrams below and confirm for each state whether or not AM/AM conversion and AM/PM conversion have taken place.

