Experiment 8: M-ary PSK Modulation and Demodulation

I. OBJECTIVES

Upon completion of the M-ary PSK experiment, you should be able to:

1. Construct and test the M-ary PSK system described in Figures 1 and 2.
   a. Use proper cut-off frequencies for reconstruction filters.
   b. Adjust system to obtain signal voltages with the appropriate amplitude and phase.
2. Using an 8.3 kHz bit-rate and a 2048 (2^{11}) PN Sequence as an input signal, obtain time domain displays for 4-PSK (QPSK), 8-PSK, and 16-PSK constellations. Constellations may be displayed on the scope by "i vs. q " from M-Level Encoder. Which constellation is most sensitive to noise? Least sensitive?
3. Using an 8.3 kHz bit-rate, a 2048 PN Sequence, and a 100 kHz Carrier, obtain time and frequency domain (power spectral density) displays for:
   a. The QPSK (4-PSK) Channel.
   b. The output of a demodulating multiplier and its reconstruction filter.
4. Using an 8.3 kHz bit-rate, a 2048 PN Sequence, and a 100 kHz Carrier, compare at least 16 bits of the output PN sequence with the input. Obtain a time domain display that compares the output and the PN sequence, record any delay between these.
5. Replace the 2048 PN Sequence with a digitized audio input. Use an 8.3 kHz bit rate for the PCM Encoder and Decoder. Don't forget input and output filters. In your lab report, describe the output sound quality for 4-PSK, 8-PSK, and 16-PSK, noting any differences between them.

II. PRELAB

1. Read sections 9.1.1 through 9.1.6 in your course textbook [1] (Note: If the 5th edition is being used, sections 8.1.1 through 8.1.11 should be used instead)
2. Sketch an example constellation for M-ary PSK for the cases of:
   a. M = 2 (Binary Phase Shift Keying or BPSK)
   b. M = 4 (Quadrature Phase Shift Keying or QPSK)
   c. M= 8 (8-PSK)
   d. M=16 (16-PSK)

   State any relevant assumptions made for these sketches.

III. INTRODUCTION.

Figures 1 and 2 show the block diagram and connection diagram of the QPSK system to be investigated for this experiment. The system can be used to generate several constellations for M-ary Phase-Shift Key systems as well as generate and demodulate 4-PSK (Quadrature PSK = QPSK) signals. The carrier frequency shown is 100 kHz and the bit-rate is 8.3 kHz.

On the pages following Figure 2, Table 1 and Figures 1, 3 and 7 are from [2] and [3]. These figures give a very quick overview of M-ary PSK.

NOTE: In Figures 1 and 2, below, phased carriers and bit-clock are supplied to the demodulator from the generator.

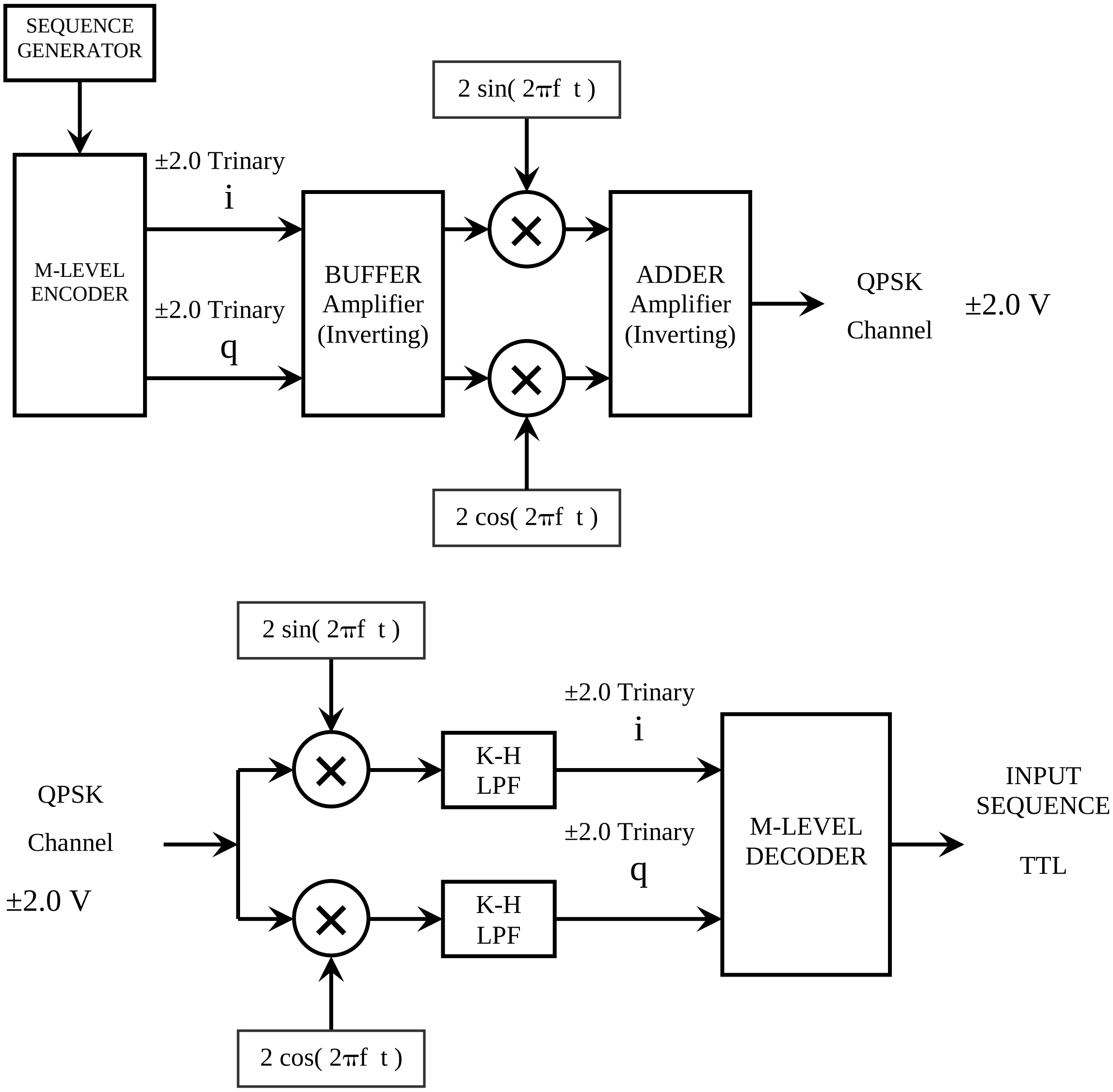


Fig.1. Block Diagram for QPSK System.

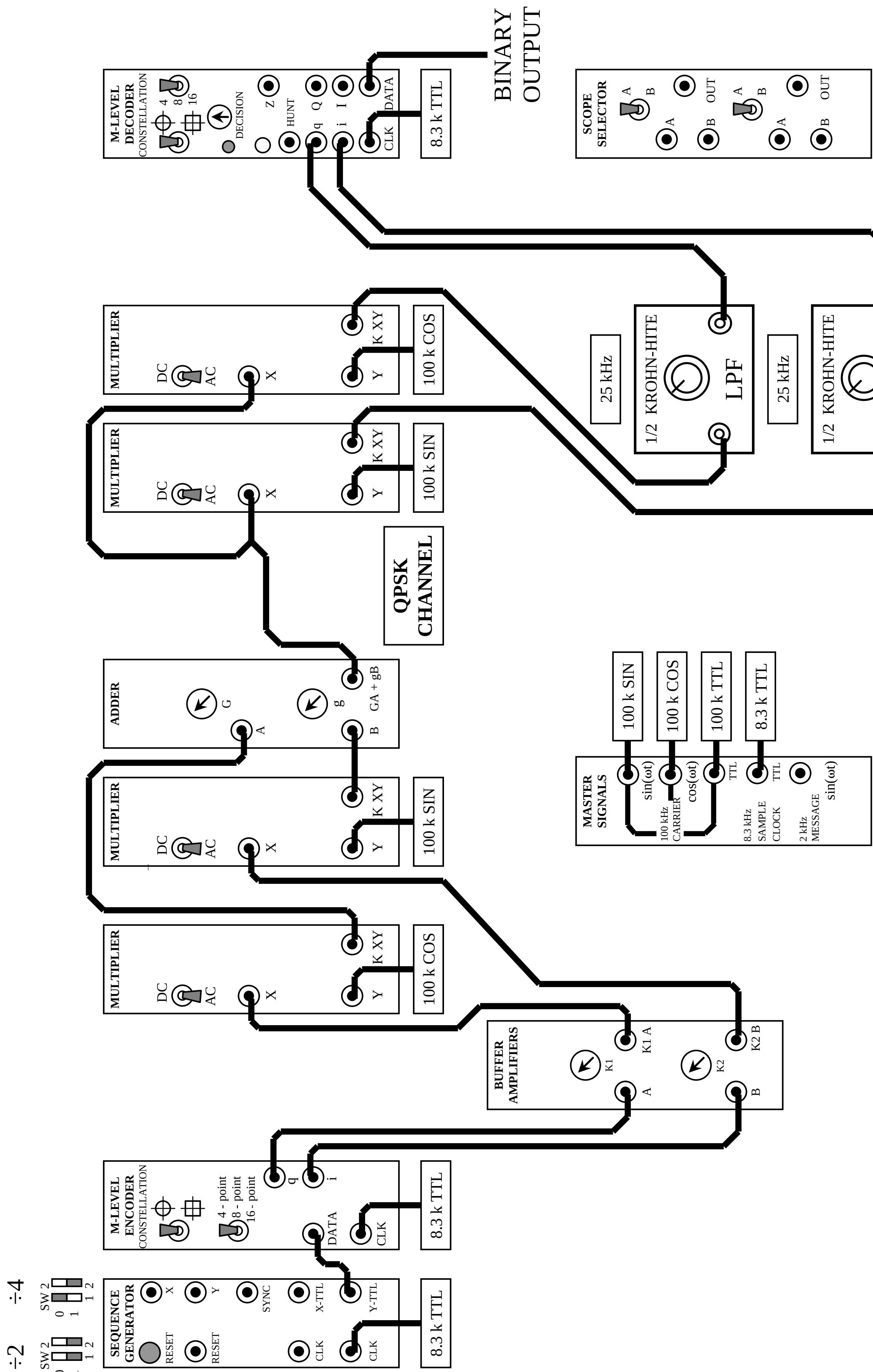
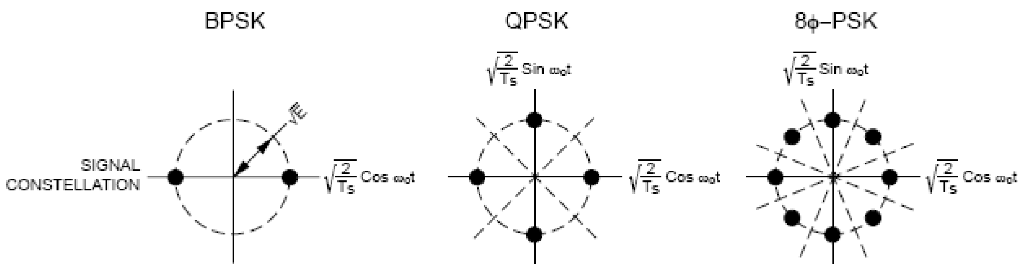


Fig. 2. Connection Diagram for QPSK System



	BPSK	QPSK	8φ–PSK
ENCODING EFFICIENCY	MAPS ONE BIT INTO ONE OF TWO SYMBOLS (1 bit/sym)	MAPS TWO CONSECUTIVE BITS INTO ONE OF FOUR SYMBOLS (2 bits/sym)	MAPS THREE CONSECUTIVE BITS INTO ONE OF EIGHT SYMBOLS (3 bits/sym)
$M = 2^N$	$2 = 2^1$	$4 = 2^2$	$8 = 2^3$
CODING EXAMPLE	1 0 1 1 0 1 THIS SEQUENCE REQUIRES SIX SYMBOLS TO BE TRANSMITTED AT SYMBOL RATE = BIT RATE = R	1 0 1 1 0 1 THIS SEQUENCE REQUIRES THREE SYMBOLS TO BE TRANSMITTED ALLOWS SYMBOL RATE $\frac{R}{2}$ WITH BIT RATE R OR SYMBOL RATE R WITH BIT RATE 2R	1 0 1 1 0 1 THIS SEQUENCE REQUIRES TWO SYMBOLS TO BE TRANSMITTED ALLOWS SYMBOL RATE $\frac{R}{3}$ WITH BIT RATE R OR SYMBOL RATE R WITH BIT RATE 3R

Table 1. Three common versions of phase-shift keying (BPSK, QPSK and 8φ-PSK).

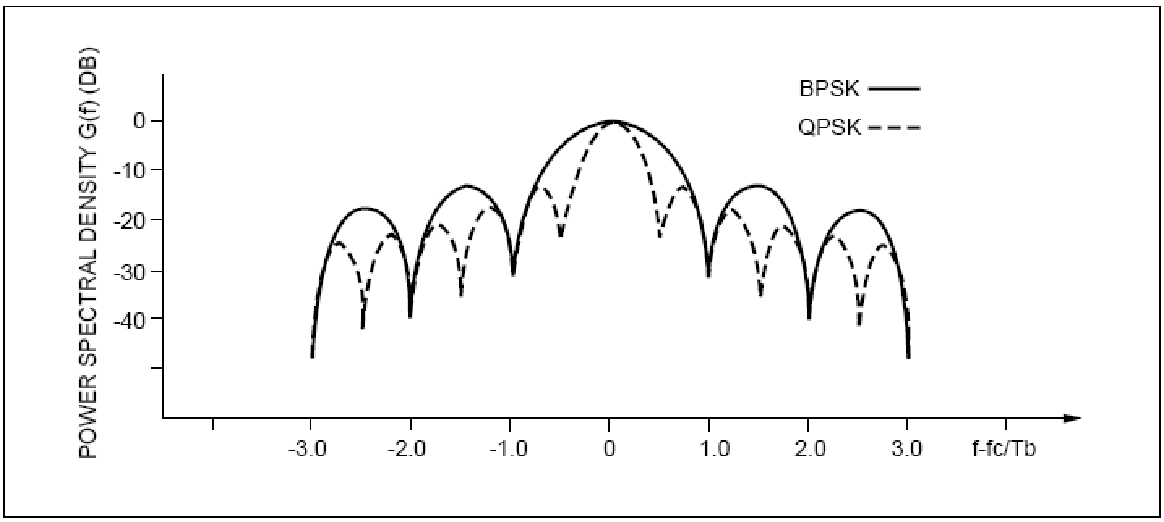


Figure 1. BPSK and QPSK spectra.

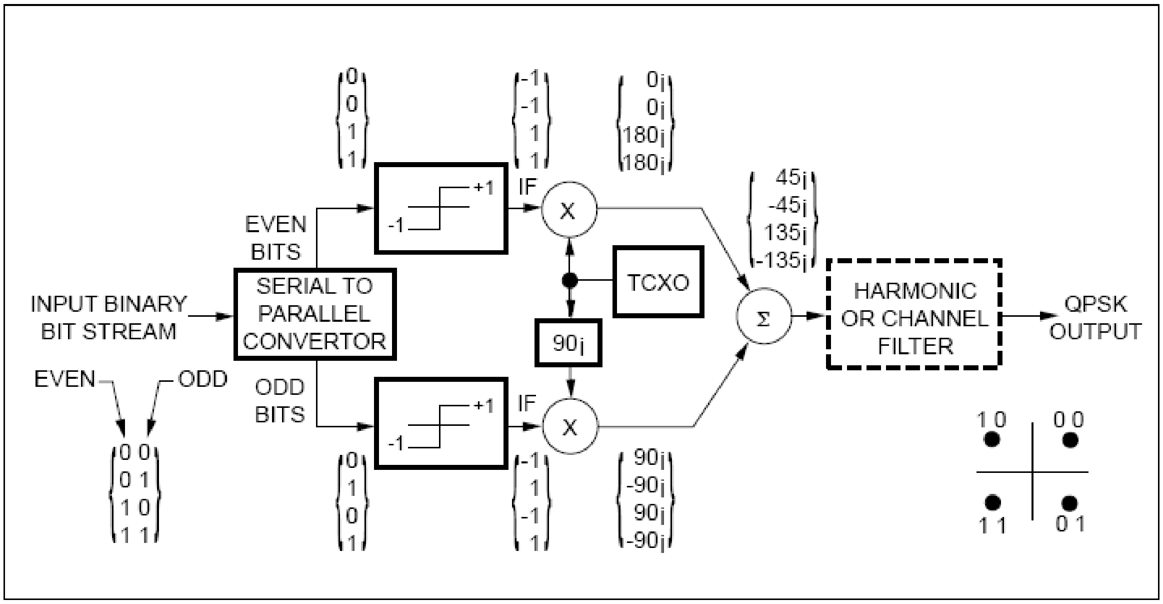


Figure 3. QPSK modulator.

NOTE:

The circuit of Figure 7 demodulates without a carrier from the modulating circuit. The next trick would be to "steal" the bit clock from the data signal.

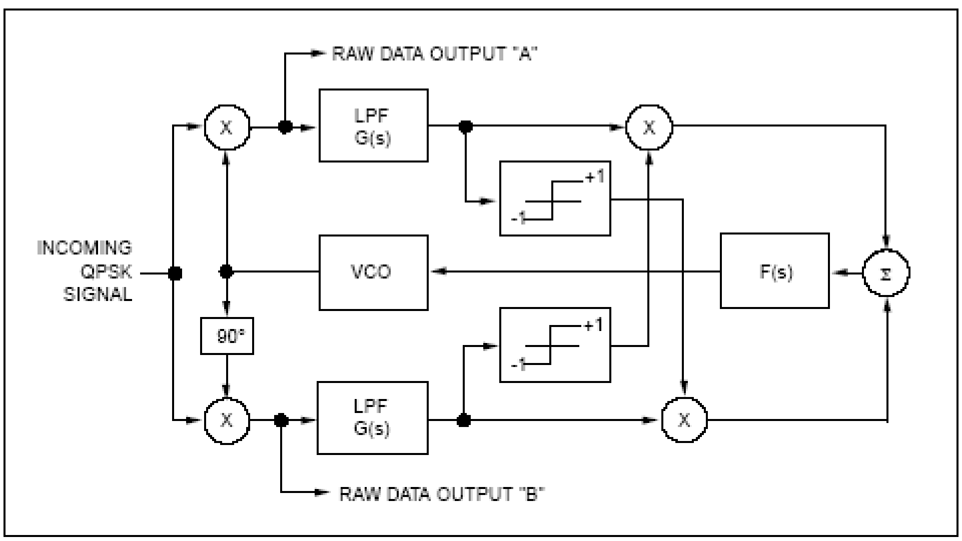


Figure 7. Modified (hard-limited) QPSK Costas loop.

IV. EXPERIMENT.

Perform experiments required to meet the stated objectives.
Record your procedures and results.

REFERENCES

[1] R. E. Ziemer and W. H. Tranter, *Principles of Communications*, 6th ed. Hoboken, NJ: John Wiley, 2002.

[2] Steber, J. Mark, *PSK Demodulation (Part 1).* Online. Available: http://www.triquint.com/products/d/wj-classic-vol11-n2-2001

[3] Steber, J. Mark, *PSK Demodulation (Part 1).* Online. Available: http://www.triquint.com/products/d/wj-classic-vol11-n3-2001