EE4513 Analog and Digital Communications Laboratory

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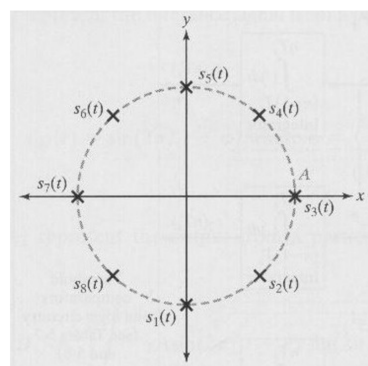
M-ary Phase Shift Keying (M-ary PSK)

In this Laboratory you will investigate the bit error rate (BER) performance for an M-ary PSK digital communication system with M = 8 symbols or 8-PSK. The *Simulink* simulation of a QPSK (M = 4) digital communication system is described on pages 117-123 of the text *Digital Communication Systems Using MATLAB and Simulink*. However, 8-PSK is not discussed in the text and your Laboratory task is to develop such a digital communication system in the *Simulink* simulation.

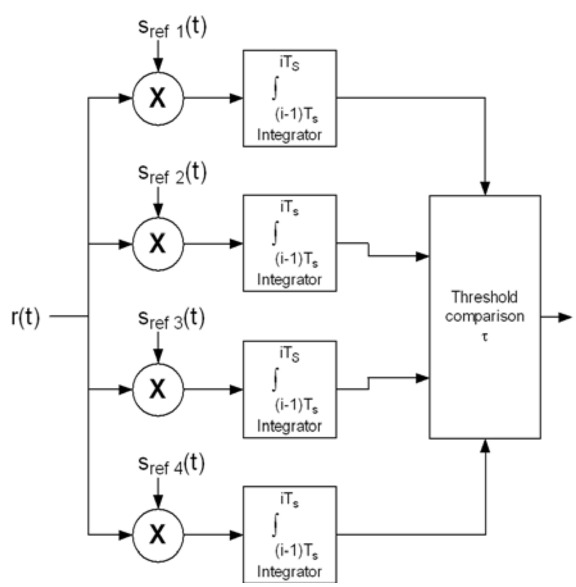
The protocol for 8-PSK is described in the course text and the Gray-coded tri-bit data protocol, analytical expression and the constellation plot is given below.

$b_{i-2}b_{i-1}b_i$ = 000 $A_C \sin(2\pi f_c t + 0°)$
$b_{i-2}b_{i-1}b_i$ = 001 $A_C \sin(2\pi f_c t + 45°)$
$b_{i-2}b_{i-1}b_i$ = 011 $A_C \sin(2\pi f_c t + 90°)$
$b_{i-2}b_{i-1}b_i$ = 010 $A_C \sin(2\pi f_c t + 135°)$
$b_{i-2}b_{i-1}b_i$ = 110 $A_C \sin(2\pi f_c t + 180°)$
$b_{i-2}b_{i-1}b_i$ = 111 $A_C \sin(2\pi f_c t + 225°)$
$b_{i-2}b_{i-1}b_i$ = 101 $A_C \sin(2\pi f_c t + 270°)$
$b_{i-2}b_{i-1}b_i$ = 100 $A_C \sin(2\pi f_c t + 315°)$



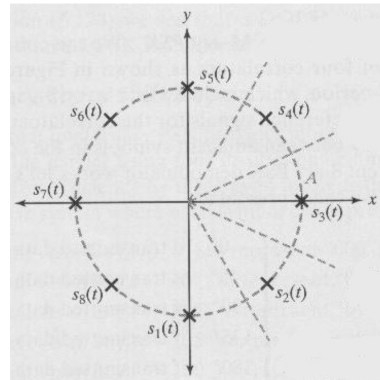
A four-channel correlation receiver from the course text is to be used, as shown, with the four references signals defined as:

$s_{ref\ n}(t) = \sin(2\pi f_c t + \varphi_n)$
$s_{ref\ n}(t) = \sin(2\pi f_c t + n\ 45° + 22.5°)$
n = 0, 1, 2, 3
φ = 22.5°, 67.5°, 112.5°, 157.5°



The decision regions for detection on the constellation plot are shown below:

For reference, the QPSK *Simulink* model is shown in Figure 3.22. The 4-level Gray coded bit-to-symbol and symbol-to-bit blocks for di-bits must be modified for 8-level symbols with tri-bits as described in Figure 2.37 (p 50) and Figure 2.41 (p 55) of the text.



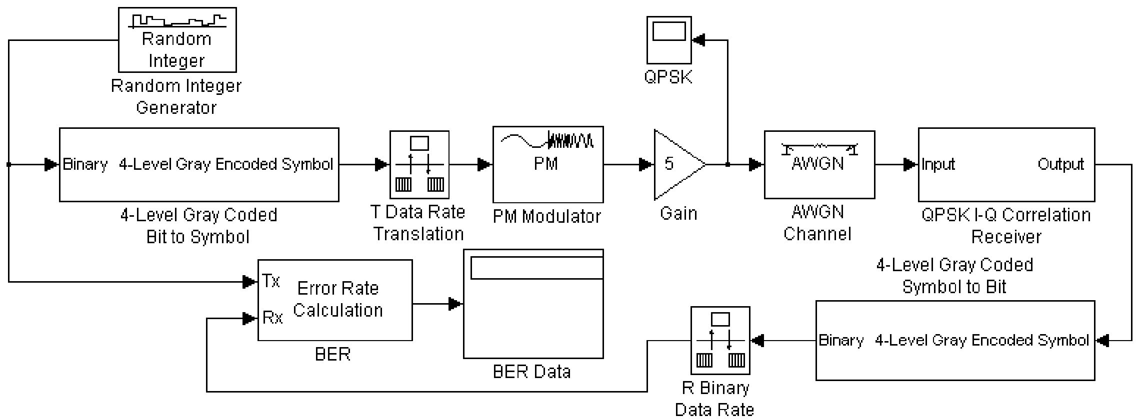
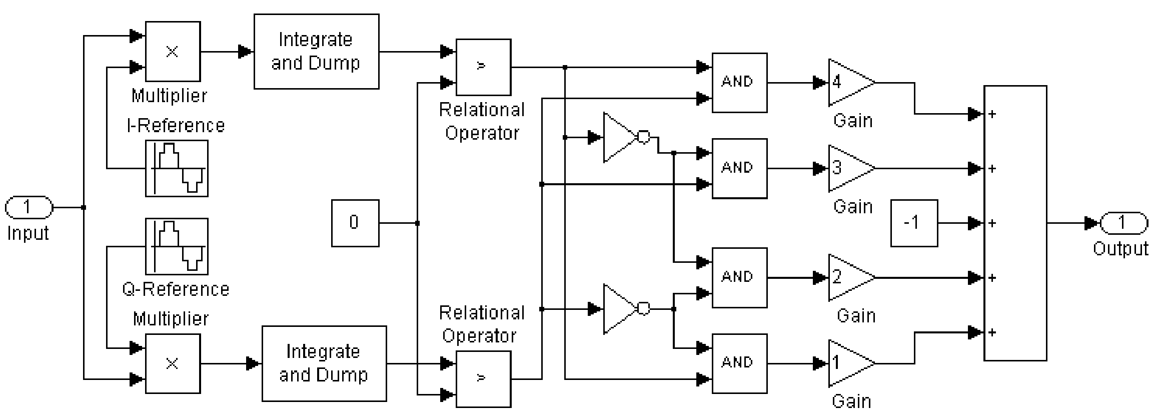


Figure 3.22

The two-channel QPSK I-Q correlation receiver is replaced by the specified four-channel correlation receiver and the threshold detection circuit modified appropriately. Table 5-7 and Table 5-8 (p 290) of the course text describes the decoding scheme. Only *Simulink* blocks can be utilized (*no* M-blocks) and the relational operators and logical components are a reasonable construct for this Laboratory task.



The Random Integer Generator block data source has a rate of r_b b/sec. The carrier amplitude of the 8-PSK transmitter signal is A_C = 5 V at a carrier frequency f_C = 20 kHz. You are to chose a single *random bit time* from T_b = 50 μsec to 500 μsec (r_b = 20 kb/sec to 2 kb/sec) in steps of 50 μsec.

T_b = ______________________ μsec

The Laboratory tasks are as follows:

1. Plot and describe the bandwidth and shape of the PSD of the 8-PSK signal and compared it to that for QPSK with the same data rate r_b.

2. Obtain the observed BER and the upper bound of P_b verses E_b/N_o. This was described for QPSK on pages 121-123 and in Table 3.11 of the text.

3. Based on the 8-PSK *Simulink* simulation, configure a 16-PSK transmitter *only* using the same data rate r_b and carrier amplitude and frequency, A_C = 5 V and f_C = 20 kHz. The 16-PSK signal protocol is as follows:

   $s_n(t) = A_C \sin(2\pi f_c t + \varphi_n)$
   $s_n(t) = A_C \sin(2\pi f_c t + n\, 22.5°)$
   n = 0, 1, 2, 3, …, 13, 14, 15

   Obtain the PSD of the 16-PSK signal, plot and describe its bandwidth and shape and compare it to that of 8-PSK and QPSK with the same data rate r_b.

This is a *three-week* Laboratory for Weeks 11, 12 and 13 (November 9-13, 16-20 and the partial week 23-25) and would be due at the regular Laboratory session in Week 14 (November 30-December 4). It is suggested that you begin the design early to complete the assignment *on-time*.