**ENGR 4323/5323: Digital and Analog Communication**

**Answer Keys of HW 6_Ch6**

**1)** A binary data sequence 01001010110… is transmitted by means of the line codes listed below where the bit duration $T_b$ is 1 microsecond. Sketch the transmitted waveform for the following line codes. Use a rectangular pulse for the pulse waveform.

a) On-Off (RZ)
b) Polar (RZ)
c) Bipolar (RZ)
d) On-Off (NRZ)
e) Polar (NRZ)
f) Manchester

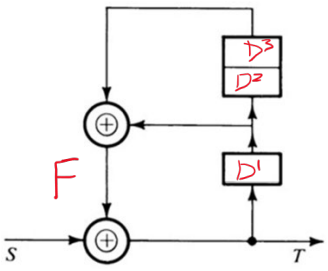
**2)** List the main advantage and disadvantage of each of the following line codes:

a) On-Off (RZ)
b) Polar (RZ)
c) Bipolar (RZ)
d) On-Off (NRZ)
e) Polar (NRZ)
f) Manchester

**3)** What are the major criteria of an ideal pulse shape for bit transmission?

**4)** Indicate the advantage and disadvantage of the following pulse shapes $p_1(t) = \Delta(t/T_b)$ and $p_2(t) = \Pi(t/T_b)$

**5)** Consider the scrambler below




$F = D^1 \oplus D^3$

$T = S \oplus (D^1 \oplus D^3)T$

a) If a sequence $S$ = 1001011001110101… is applied to the input of this scrambler, determine the output sequence $T$.

$T = 1\,1\,1\,1\,0\,0\,0\,0\,1\,0\,1\,0\,1\,0\,1$

b) Design a corresponding descrambler.

$R = T \oplus (D^1 \oplus D^3)T$

**6)** If the input to a binary differential *PSK* modulation system is 1011001011… , derive and tabulate the following results:

a) differential encoder output

$I_k =$ 1011001011---

$q_k =$ 1001000110 1---

b) modulated phase value $\theta_k$

$2\pi = 0$ & Initial Phase $= 0$

$q_k =$ 1 0 0 1 0 0 0 1 1---

$a_k =$ 1 −1 −1 1 −1 −1 −1 1 1---

$\theta_k =$ 0 π π 0 π π π 0 0---

c) modulated phase difference $\theta_k - \theta_{k-1}$

$\theta_k =$ 0 π π 0 π π π 0 0 — --

$\theta_k - \theta_{k-1} =$ π 0 π π 0 0 π 0 - - -

d) decision rule of the detector

If the phase of the two consecutive received signals are different then 1 is sent otherwise a zero is sent

**7)** Consider an *M*-ary *FSK* carrier modulated signal for which the data rate is 2.4 Mbit/s, and the carrier frequency is $f_c = 900$ MHz.

a) Find the minimum frequency separation for this *FSK* and design the specific frequencies for this *FSK* modulator centered at carrier frequency of $f_c = 900$ MHz.

b) Determine the estimated bandwidth of this *M-FSK* carrier modulation for $M = 4$.

a) $\delta f = \frac{1}{2T_s} = \frac{R_b}{2\log_2 M} = \frac{2.4 \times 10^6}{2\log_2 M} = \frac{1.2}{\log_2 M} \times 10^6$

$\Delta f = \frac{f_M - f_1}{2} = \frac{M\delta f - \delta f}{2} = \frac{M-1}{\log_2 M} \times 6 \times 10^5$ Hz

b) $BW = 2(\Delta f + B)$ $\quad \Delta f = \frac{4-1}{\log_2 4} \times 6 \times 10^5 = 9 \times 10^5$

for $M = 4$, two bits will be sent by a pulse of width $T_p = \frac{1}{(2.4/2) \times 10^6} = 0.83\,\mu sec$

$B = 1/T_p = \frac{1}{0.83 \times 10^{-6}} = 1.2 \times 10^6$ MHz

$BW = 2(9 \times 10^5 + 1.2 \times 10^6) = 4.2$ MHz