Sirindhorn International Institute of Technology

Thammasat University at Rangsit

School of Information, Computer and Communication Technology

ECS 455: Problem Set 4

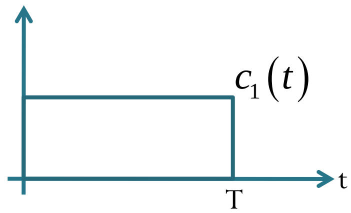
Semester/Year: **2/2012**
Course Title: Mobile Communications
Instructor: Dr. Prapun Suksompong (prapun@siit.tu.ac.th)
Course Web Site: http://www2.siit.tu.ac.th/prapun/ecs455/

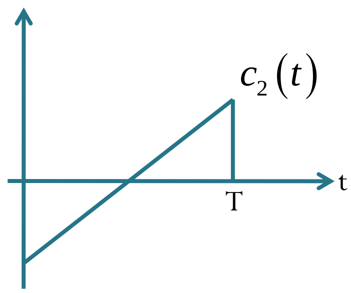
Due date: Feb 4, 2013 (Monday), 8:50AM

Instructions

1. ONE sub-question will be graded (5 pt). Of course, you do not know which part will be selected; so you should work carefully on all of them.
2. It is important that you try to solve all problems. (5 pt)
3. Late submission will be heavily penalized.
4. ***Write down all the steps*** that you have done to obtain your answers. You may not get full credit even when your answer is correct without showing how you get your answer.

1. Consider Global System for Mobile (GSM), which is a TDMA/FDD system that uses 25 MHz for the forward link, which is broken into radio channels of 200 kHz. If 8 speech channels are supported on a single radio channel, and if no guard band is assumed, find the number of simultaneous users that can be accommodated in GSM.
2. Draw the complete state diagrams for linear feedback shift registers (LFSRs) using the following polynomials. Does either LFSR generate an m-sequence?
   a. $1+x^2+x^5$
   b. $1+x+x^2+x^5$
   c. $1+x+x^2+x^4+x^5$
3. Use any resource, find <u>all</u> primitive polynomials of degree 6 over GF(2). Indicate your reference.
4. We have seen in class that the following waveforms are orthogonal.





Suppose we want to have four orthogonal waveforms on [0,T]. Find two more nonzero waveforms, $c_3(t)$ and $c_4(t)$, that are time-limited to [0,T]. Make sure that all four waveforms are mutually orthogonal.

5. In CDMA, each bit time is subdivided into *m* short intervals called **chips**. We will use 8 chips/bit for simplicity. Each station is assigned a unique 8-bit code called a **chip-sequence**. To transmit a 1 bit, a station sends its chip sequence. To transmit a 0 bit, it sends the one's complement[1] of its chip sequence.

   Here are the binary chip sequences for four stations:

   A: 0 0 0 1 1 0 1 1
   B: 0 0 1 0 1 1 1 0
   C: 0 1 0 1 1 1 0 0
   D: 0 1 0 0 0 0 1 0

   For pedagogical purposes, we will use a bipolar notation **with binary 0 being -1 and binary 1 being +1**. In which case, during each bit time, a station can transmit a 1 by sending its chip sequence, it can transmit a 0 by sending the negative of its chip sequence, or it can be silent and transmit nothing. We assume that all stations are synchronized in time, so all chip sequences begin at the same instant.

   When two or more stations transmit simultaneously, their bipolar signals add linearly.

   a. Suppose that A, B, and C are simultaneously transmitting 0 bits. What is the resulting (combined) bipolar chip sequence?
   b. Suppose the receiver gets the following chips: (-1 +1 -3 +1 -1 -3 +1 +1).
      Which stations transmitted, and which bits did each one send?
   c. One of your friends wants to work on part (a) and (b) using MATLAB. Here is his code with two incomplete lines.

[1] You should have seen the "one's complement" operation in your "digital circuits" class.

```
%Chip sequences
C = [0 0 0 1 1 0 1 1; 0 0 1 0 1 1 1 0; 0 1 0 1 1 1 0 0; 0 1 0 0 0 0 1 0];
C = 2*C-1; %Change to bipolar form

% Part a
m = [-1 -1 -1 0] %message to transmit
x = %%%%%%%%%HELP ME%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Part b
r = [-1 1 -3 1 -1 -3 1 1] ;
m_decoded = 1/8* %%%%%%%%%HELP ME%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%This gives [mA mB mC mD]' in bipolar form;
%The value is 1 if 1 was transmitted. The value is 0 if nothing was
%transmitted. The value is -1 if 0 was transmitted.
```

Help him find the expression for “x” and “m_decoded” in the code above. Note that the expression for x should be in terms of C and m. The expression for m_decoded should be in terms of C and r.

6. Consider the list of Walsh sequence of order 64 provided in [Lee and Miller, 1998, Table 5.2].

Table 5.2 Walsh functions of order 64 (indexed by zero crossings)

W_{0}	0000000000000000	0000000000000000	0000000000000000	0000000000000000
W_{1}	0000000000000000	0000000000000000	1111111111111111	1111111111111111
W_{2}	0000000000000000	1111111111111111	1111111111111111	0000000000000000
W_{3}	0000000000000000	1111111111111111	0000000000000000	1111111111111111
W_{4}	0000000011111111	1111111100000000	0000000011111111	1111111100000000
W_{5}	0000000011111111	1111111100000000	1111111100000000	0000000011111111
W_{6}	0000000011111111	0000000011111111	1111111100000000	1111111100000000
W_{7}	0000000011111111	0000000011111111	0000000011111111	0000000011111111
W_{8}	0000111111110000	0000111111110000	0000111111110000	0000111111110000
W_{9}	0000111111110000	0000111111110000	1111000000001111	1111000000001111
W_{10}	0000111111110000	1111000000001111	1111000000001111	0000111111110000
W_{11}	0000111111110000	1111000000001111	0000111111110000	1111000000001111
W_{12}	0000111100001111	1111000011110000	0000111100001111	1111000011110000
W_{13}	0000111100001111	1111000011110000	1111000011110000	0000111100001111
W_{14}	0000111100001111	0000111100001111	1111000011110000	1111000011110000
W_{15}	0000111100001111	0000111100001111	0000111100001111	0000111100001111
W_{16}	0011110000111100	0011110000111100	0011110000111100	0011110000111100
W_{17}	0011110000111100	0011110000111100	1100001111000011	1100001111000011
W_{18}	0011110000111100	1100001111000011	1100001111000011	0011110000111100
W_{19}	0011110000111100	1100001111000011	0011110000111100	1100001111000011
W_{20}	0011110011000011	1100001100111100	0011110011000011	1100001100111100
W_{21}	0011110011000011	1100001100111100	1100001100111100	0011110011000011
W_{22}	0011110011000011	0011110011000011	1100001100111100	1100001100111100
W_{23}	0011110011000011	0011110011000011	0011110011000011	0011110011000011
W_{24}	0011001111001100	0011001111001100	0011001111001100	0011001111001100
W_{25}	0011001111001100	0011001111001100	1100110000110011	1100110000110011
W_{26}	0011001111001100	1100110000110011	1100110000110011	0011001111001100
W_{27}	0011001111001100	1100110000110011	0011001111001100	1100110000110011
W_{28}	0011001100110011	1100110011001100	0011001100110011	1100110011001100
W_{29}	0011001100110011	1100110011001100	1100110011001100	0011001100110011
W_{30}	0011001100110011	0011001100110011	1100110011001100	1100110011001100
W_{31}	0011001100110011	0011001100110011	0011001100110011	0011001100110011
W_{32}	0110011001100110	0110011001100110	0110011001100110	0110011001100110
W_{33}	0110011001100110	0110011001100110	1001100110011001	1001100110011001
W_{34}	0110011001100110	1001100110011001	1001100110011001	0110011001100110
W_{35}	0110011001100110	1001100110011001	0110011001100110	1001100110011001
W_{36}	0110011010011001	1001100101100110	0110011010011001	1001100101100110
W_{37}	0110011010011001	1001100101100110	1001100101100110	0110011010011001
W_{38}	0110011010011001	0110011010011001	1001100101100110	1001100101100110
W_{39}	0110011010011001	0110011010011001	0110011010011001	0110011010011001
W_{40}	0110100110010110	0110100110010110	0110100110010110	0110100110010110
W_{41}	0110100110010110	0110100110010110	1001011001101001	1001011001101001
W_{43}	0110100110010110	1001011001101001	0110100110010110	1001011001101001
W_{44}	0110100101101001	1001011010010110	0110100101101001	1001011010010110
W_{45}	0110100101101001	1001011010010110	1001011010010110	0110100101101001
W_{46}	0110100101101001	0110100101101001	1001011010010110	1001011010010110
W_{47}	0110100101101001	0110100101101001	0110100101101001	0110100101101001
W_{48}	0101101001011010	0101101001011010	0101101001011010	0101101001011010
W_{49}	0101101001011010	0101101001011010	1010010110100101	1010010110100101
W_{50}	0101101001011010	1010010110100101	1010010110100101	0101101001011010
W_{51}	0101101001011010	1010010110100101	0101101001011010	1010010110100101
W_{52}	0101101010100101	1010010101011010	0101101010100101	1010010101011010
W_{53}	0101101010100101	1010010101011010	1010010101011010	0101101010100101
W_{54}	0101101010100101	0101101010100101	1010010101011010	1010010101011010
W_{55}	0101101010100101	0101101010100101	0101101010100101	0101101010100101
W_{56}	0101010110101010	0101010110101010	0101010110101010	0101010110101010
W_{57}	0101010110101010	0101010110101010	1010101001010101	1010101001010101
W_{58}	0101010110101010	1010101001010101	1010101001010101	0101010110101010
W_{59}	0101010110101010	1010101001010101	0101010110101010	1010101001010101
W_{60}	0101010101010101	1010101010101010	0101010101010101	1010101010101010
W_{61}	0101010101010101	1010101010101010	1010101010101010	0101010101010101
W_{62}	0101010101010101	0101010101010101	1010101010101010	1010101010101010
W_{63}	0101010101010101	0101010101010101	0101010101010101	0101010101010101

In class, we observed that one of the sequenced is missing. Find the content of that sequence.
Hint: Use MATLAB.