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COSC 3213 Midterm
8 April 2009

Tips:

- Read the entire midterm **before** starting it.
- There's a reference sheet at the back of the midterm. Read it too.
- Answer easy questions first, no matter what order they're in.
- There aren't many part-marks. Answers are mostly either right or wrong.
- If you're not sure about a question's wording, **ask me**.
- If the question isn't something I can answer, **write down your assumptions**.

Make sure your name and student number are on every page.

Marking scheme

Part A:	/10
Part B:	/11
Part C:	/6
Part D:	/7
Total:	**/34**

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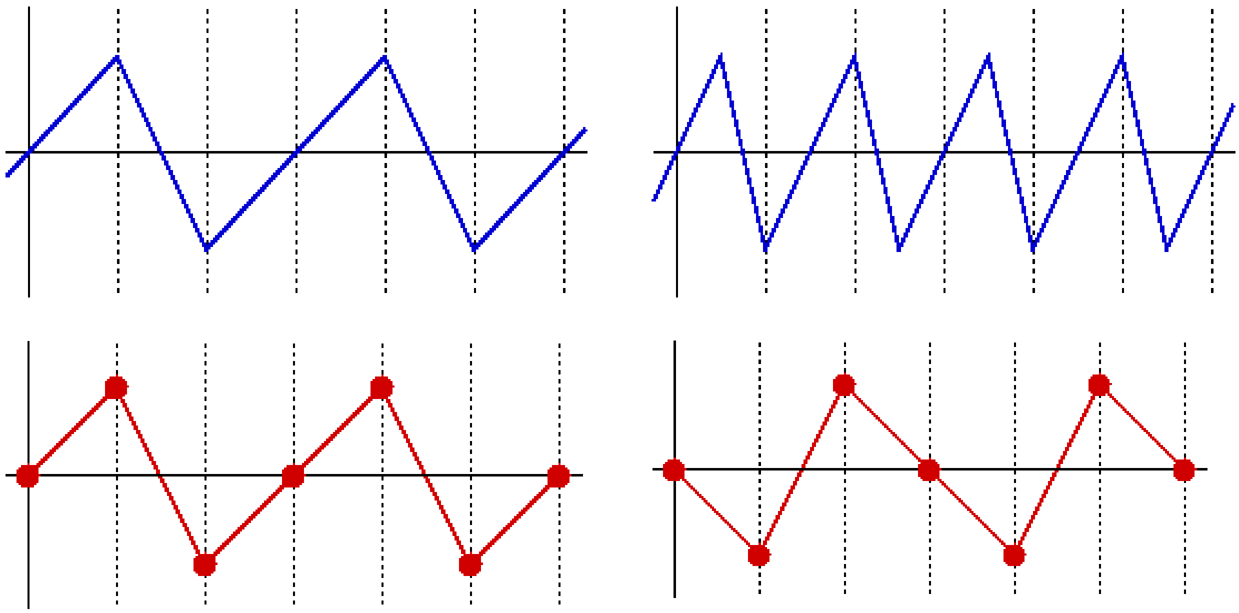
Part A: Digitization

1. Sample these signals at the points indicated, and show the reconstructed signals. [2]



a) b)

2. Did aliasing occur for either of these signals? If so, which one aliased (or did both alias)? [1]

   b) aliased

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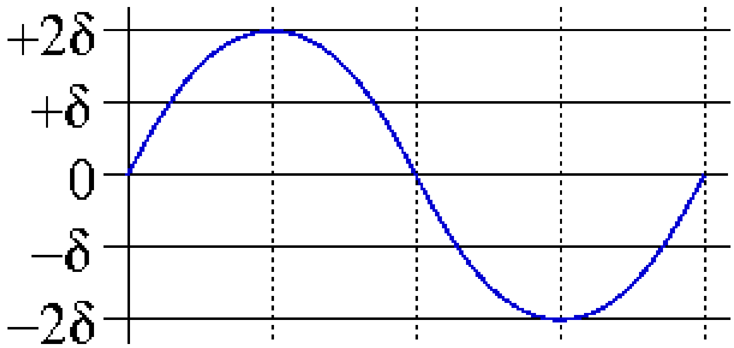
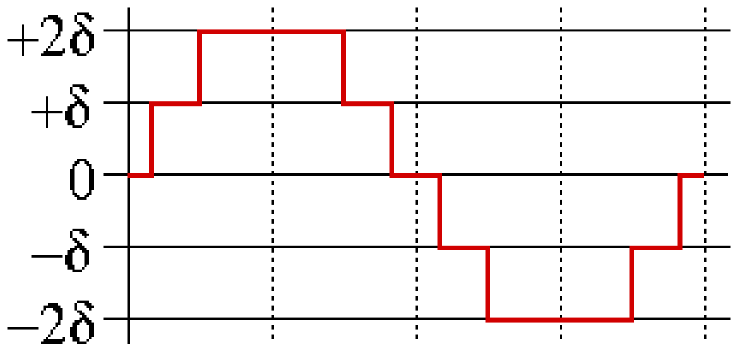
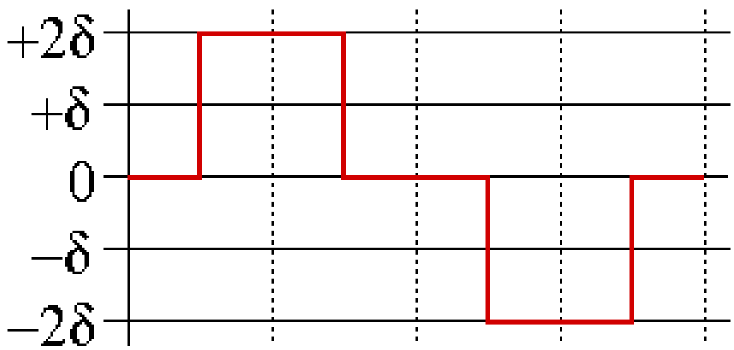
Quantize this signal to the levels shown: [1]





or



3. What is the maximum quantization error (difference between quantized and original signals)? [1]

$\delta/2$

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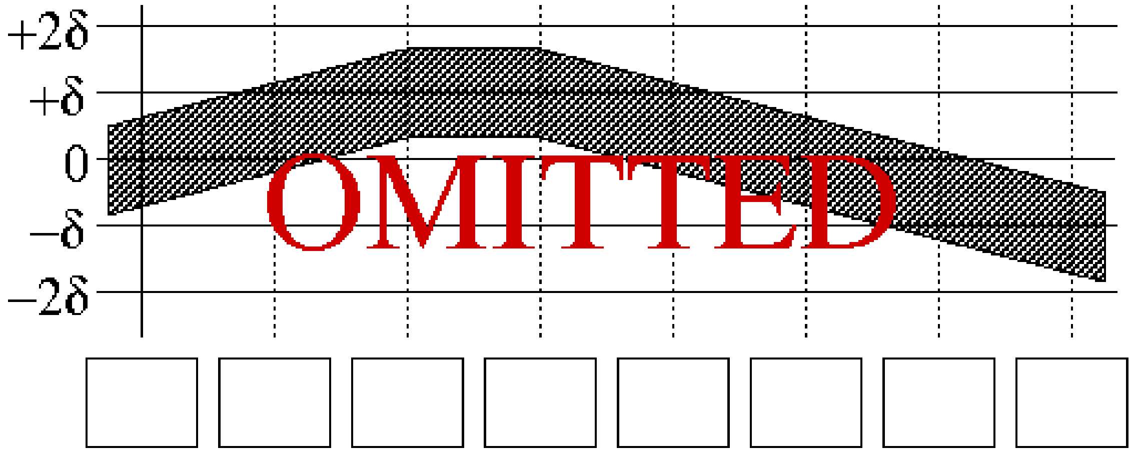
Sample and quantize this signal (taking the quantized values at the sampling times indicated). The signal has "signal noise", which may interfere with quantization. Write the quantized signal levels in the boxes provided, or "?" if the quantizer might get more than one level from the signal at that sampling point. [1]



4. A signal with signal noise is being quantized. The spacing between quantization levels is δ, and the signal noise has a Gaussian distribution with standard deviation σ. What **symbol error rate (SER)** would you expect for each of the following situations: [3]

   a. $\sigma \ll \delta/2$: 0

   b. $\sigma \gg \delta/2$: 1

   c. $\sigma = \delta/2$: about 0.30

5. A signal's amplitude has a standard deviation of $\sigma = 1$ volt. The signal also has noise. The noise's amplitude has a standard deviation of $\sigma_{noise} = 0.01$ volt. What is the **signal to noise ratio (SNR)**? [1]

$$SNR = \sigma^2 / \sigma_{noise}^2$$

SNR = 10000

6. A different signal has a signal to noise ratio of about 4000. It's transmitted through a channel with a bandwidth of 7 kHz. What is the **maximum data capacity** of this channel? [1]

$$C = W \times \log_2(1 + SNR)$$
$$C = 7000 \times \log_2(4001)$$
$$C = 7000 \times 12$$

C = 84 kbit/sec

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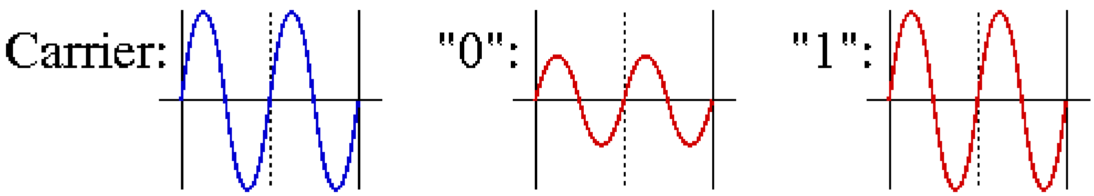
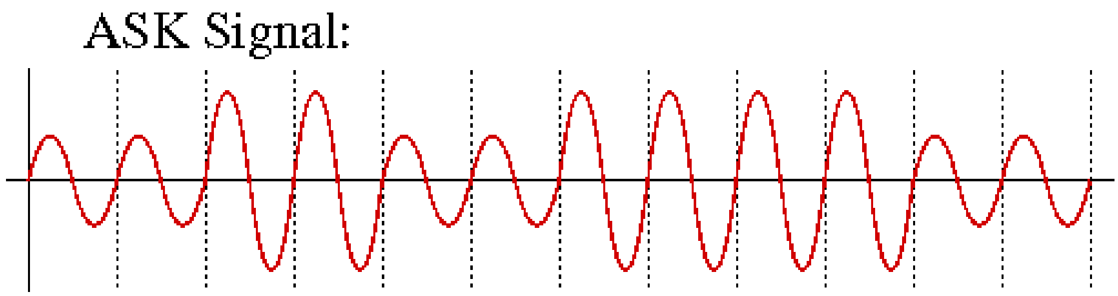
Part B: Modulation

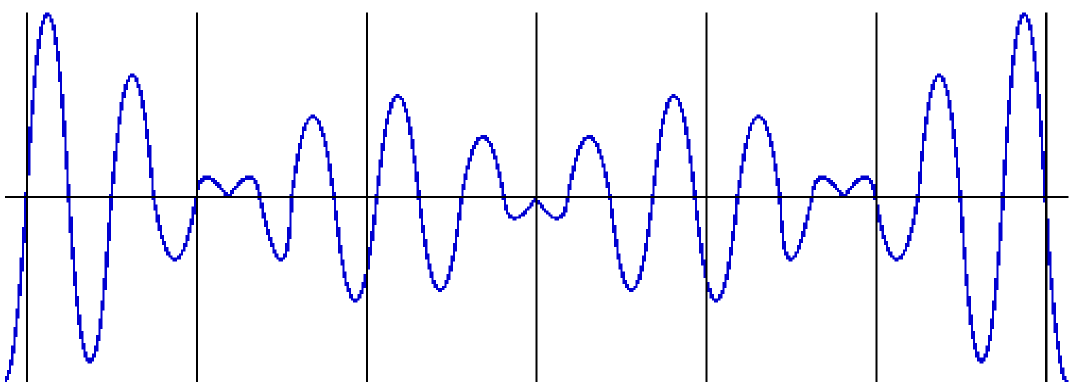
1. Modulate **010110** on to the supplied carrier, using amplitude shift keying. Show the symbol encodings (“tiles”) you used. [1]

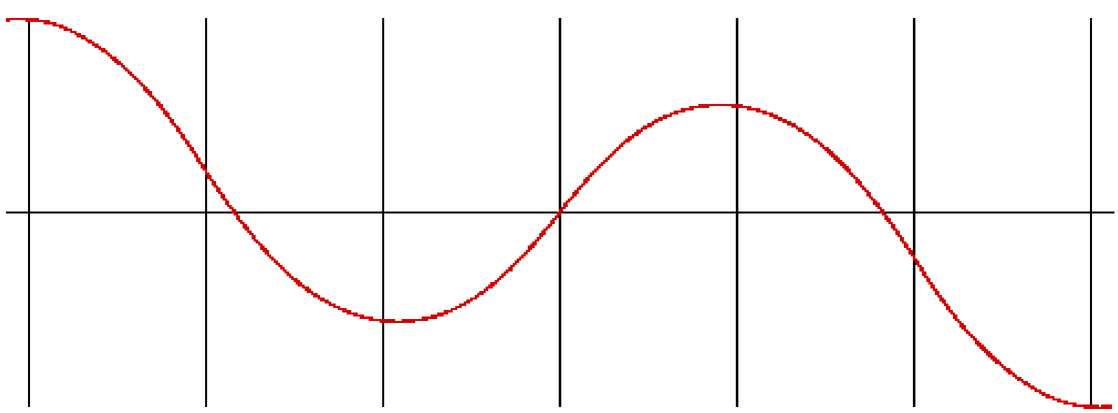




Using a DC level, or the same wave flipped vertically, was also ok.

2. Show the original input for this amplitude-modulated signal: [2]





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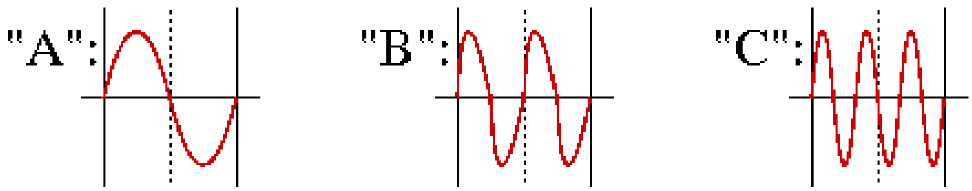
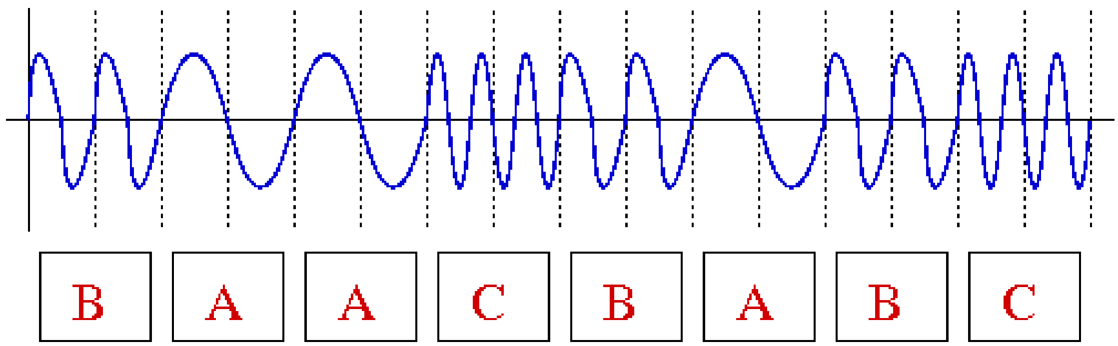
3. Demodulate this FSK signal. Show the symbol encodings (“tiles”) you used for this. [1]

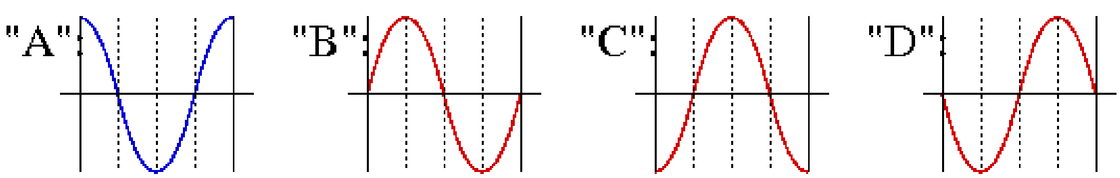


FSK Signal:

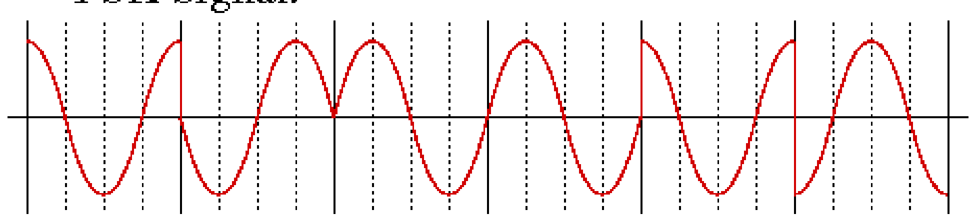


Any consistent letter assignment is correct.

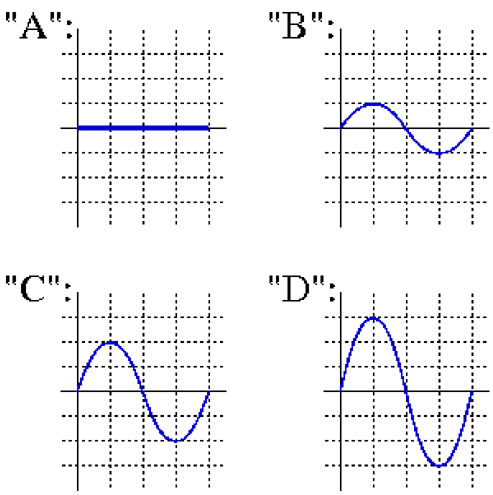
4. Encode **“ADBBAC”** using phase shift keying. Show the symbol encodings (“tiles”) that you used. The encoding for **“A”** is given. [1]

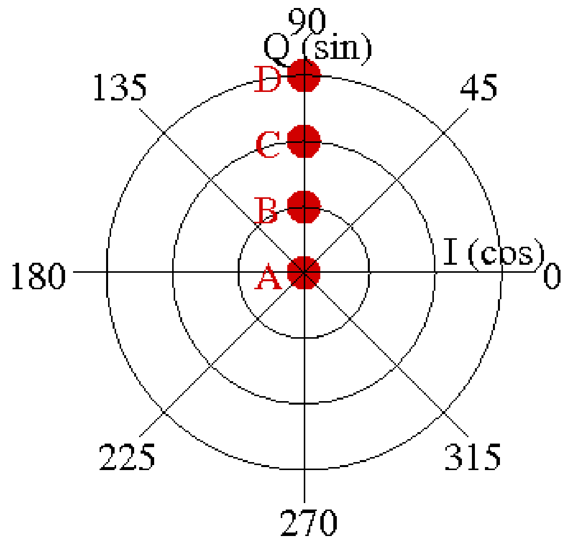


PSK Signal:

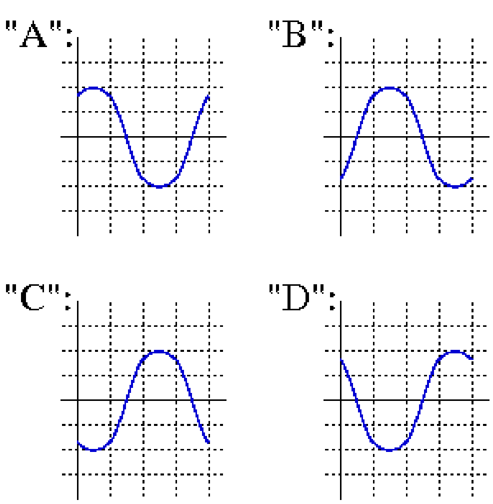


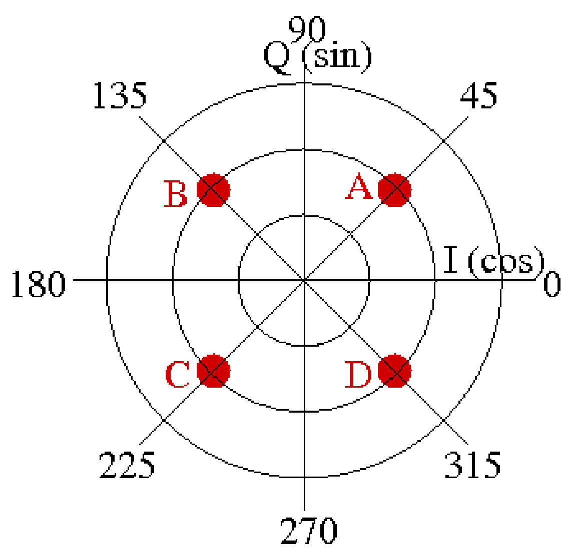
5. Show and label the constellation diagram for this **amplitude shift keying** encoding: [2]





6. Show and label the constellation diagram for this **phase shift keying** encoding: [2]





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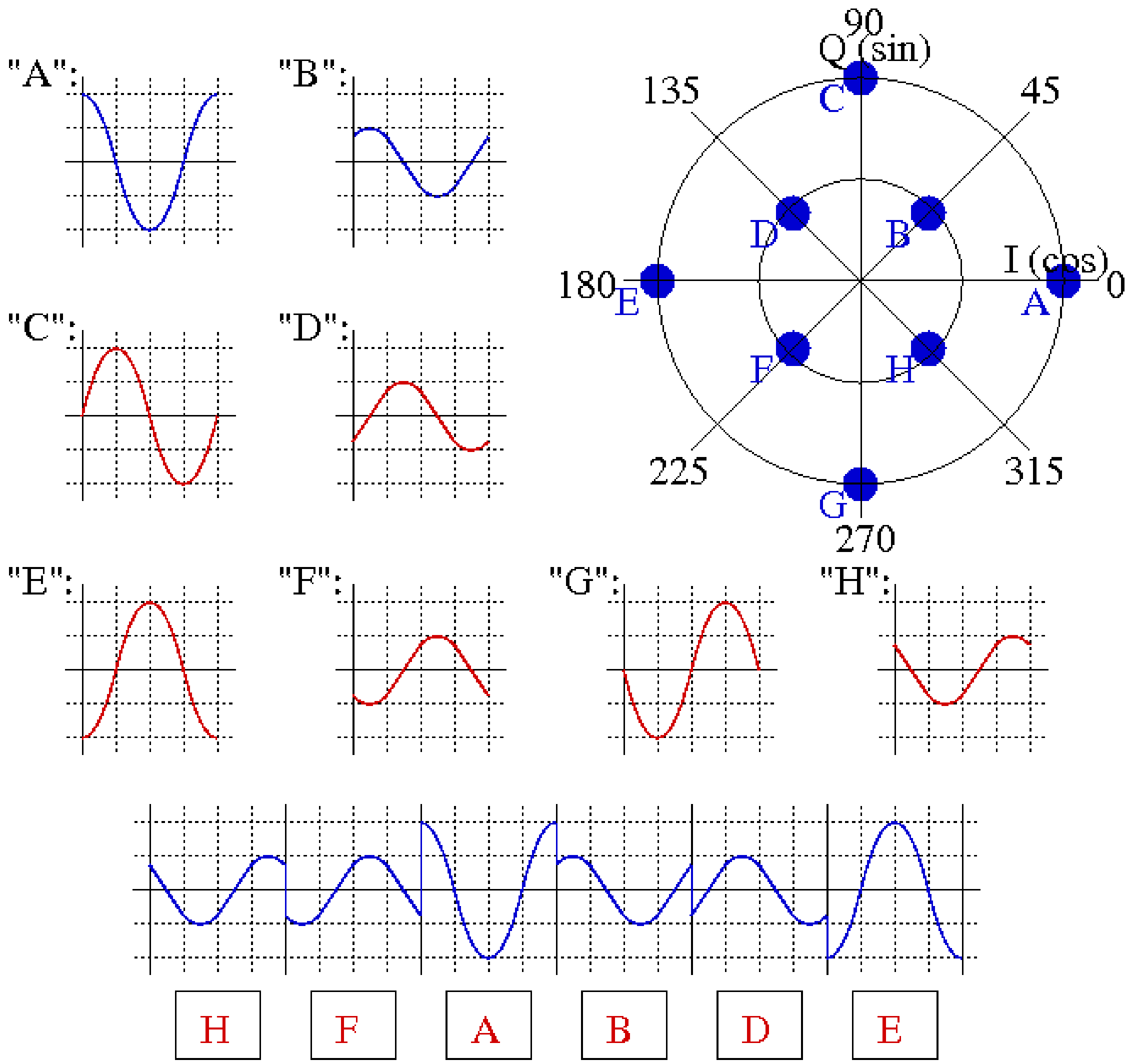
7. Decode the following quadrature amplitude modulated signal. Show all symbol encodings (“tiles”). The first two are given. [2]



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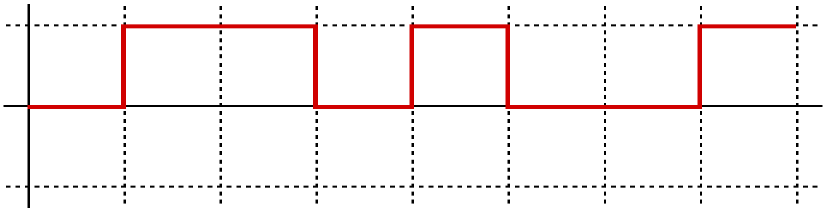
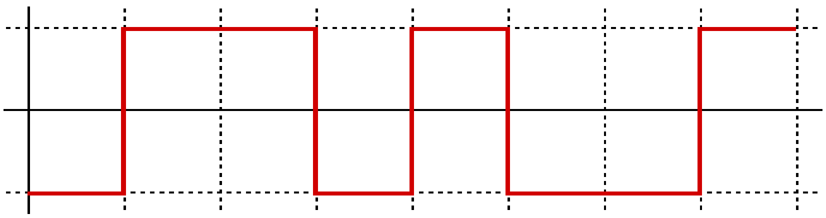
Part C: Line Coding

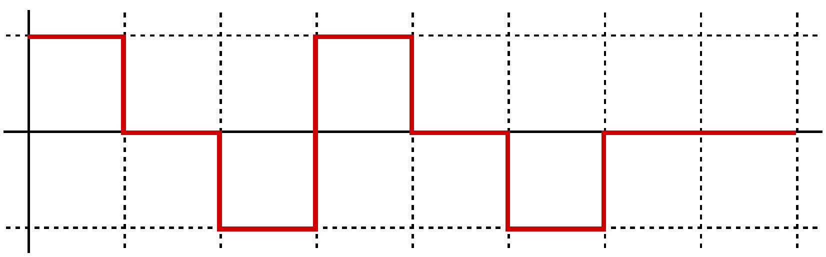
1. Encode 01101001 using **NRZ encoding**: [1]



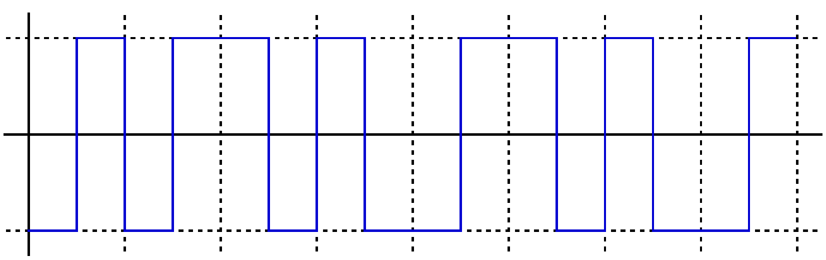
or



2. Encode 10110100 using **bipolar encoding**: [1]



3. Decode the following **Manchester-encoded** signal: [1]



00110110

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4. A line coding has no DC component (is **zero-average**) if it guarantees that the same number of "0" bits and "1" bits are transmitted, for **any** input. A line coding is **self-clocking** if it guarantees at least one change from 0 to 1 or from 1 to 0 within **all** codes.

   Consider the following 2b4b code:

Symbol	Encoding
"00"	"0011"
"01"	"0110"
"10"	"1100"
"11"	"1001"

   a. Is this code zero-average? [1] Yes

   b. Is this code self-clocking? [1] Yes

5. Decode the following encoded stream, using the 2b4b code from Question 4: [1]

   0110/0011/1100/0011

   "01" "00" "10" "00"

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Part D: Error Detection and Correction

1. The following codewords contain 8 bits of data and a single parity bit, bringing the codewords to even parity. Circle codewords with parity errors. [1]

010010001 011001010 011011000 011011001 011011111

2. Calculate the 4-bit checksum value needed to make this data stream sum to 0 (keeping only the last 4 bits):

1101 + 0110 + 1010 + 0110 + [1101] = 0

1101 + 0110 + 1010 + 0110 = 0011

two's complement negative of 0011 is 1101.

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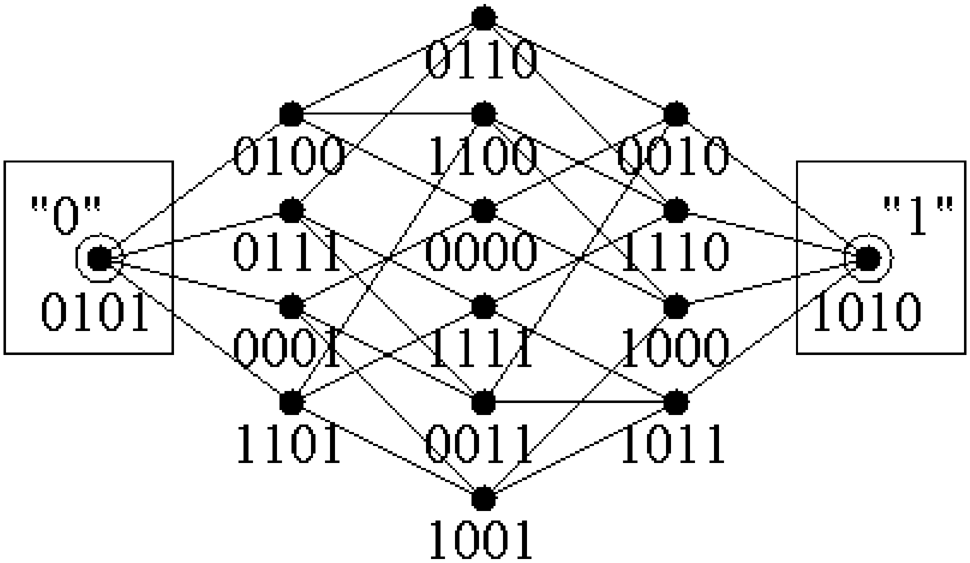
3. Consider a code that maps "0" to "0101" and "1" to "1010". This code is zero-average, self-clocking, and error-correcting.



a. What is the Hamming distance h between the code for "0" and the code for "1"? [1]

4

b. If we want to detect errors with up to 3 bits changed, how many changed bits can we repair? [1]

0

c. If we want to repair single-bit errors, how many changed bits can we detect? [1]

2

4. Use the code from Question 3, and assume that we're fixing single-bit errors. Write the symbol stream corresponding to the following codeword stream. Symbols should be "0", "1", or (for unfixable errors) "X".

0010	1010	0110	1110	0101	1011
"1"	"1"	"X"	"1"	"0"	"1"

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Reference Section:

n	$\log_2 n$
2	1
4	2
8	3
16	4
32	5
64	6
128	7
256	8
512	9
1024	10
2048	11
4096	12
8192	13
16384	14
32768	15
65536	16