



## 12 Pages

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, for the invigilator to see, and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either read your answers in legible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

SURNAME: KRISTIANSEN

FORENAME(S): THORBJØRN  
RAVNAAS

|   |                                  |                                    |
|---|----------------------------------|------------------------------------|
| 1 | Student Number                   | P151226                            |
| 2 | Title of Examination Paper       | DIGITAL SIGNAL PROCESSING AND COMM |
| 3 | Module Code                      | M2X8518                            |
| 4 | Date and Time of Examination     | 18/01/18<br>15:00                  |
| 5 | Examination Venue                | TOWNHILL GYM                       |
| 6 | Seat Number                      | G006                               |
| 7 | Number of Answer Books handed in | 1                                  |

| List the numbers of the questions you have attempted | Office Use      |
|------------------------------------------------------|-----------------|
| 1                                                    | 10              |
| 2                                                    | <del>12</del>   |
| 3                                                    | 2               |
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| Total                                                | 24 / 60<br>40 % |

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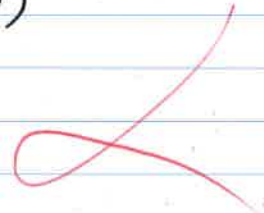
1a)

b) a-000000 : Can Detect 4, correct 1.

 $d_{min} =$ 

The Hamming distance depends on the length of the message and the code word.

Hamming can correct 1 error (7,4)



1b)

$$H = \begin{pmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{pmatrix}$$

$$G = \begin{pmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T_{u_1} = \overline{u_1} \times G$$

$$\begin{aligned} (0101) / \begin{pmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 1 \end{pmatrix} &= (0 \oplus 0 \oplus 0 \oplus 0 \oplus 1) = 1 \\ &= (0 \oplus 1 \oplus 0 \oplus 0 \oplus 1) = 0 \\ &= (0 \oplus 1 \oplus 0 \oplus 0 \oplus 1) = 0 \end{aligned}$$

$$\underline{T_{u_1} = 0101100}$$

$$T_{u_2} = \overline{u_2} \times G$$

$$\begin{aligned} (1101) / \begin{pmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 1 \end{pmatrix} &= (1 \oplus 0 \oplus 0 \oplus 0 \oplus 1) = 0 \\ &= (1 \oplus 1 \oplus 0 \oplus 0 \oplus 1) = 1 \\ &= (0 \oplus 1 \oplus 0 \oplus 0 \oplus 1) = 0 \end{aligned}$$

$$\underline{T_{u_2} = 1101010}$$

$$1b) T_{u3} = \overline{u_3} \times \overline{G}$$

$$(1010) \begin{pmatrix} 110 & 1000 \\ 011 & 0100 \\ 101 & 0010 \\ 111 & 0001 \end{pmatrix} = (1 \oplus 0 \oplus 1 \oplus 0) = 0$$

$$= (1 \oplus 0 \oplus 0 \oplus 0) = 1$$

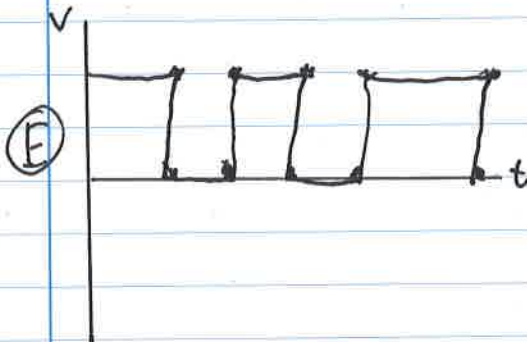
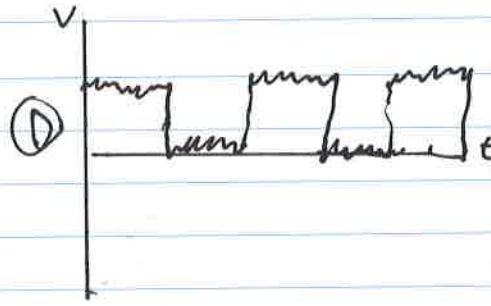
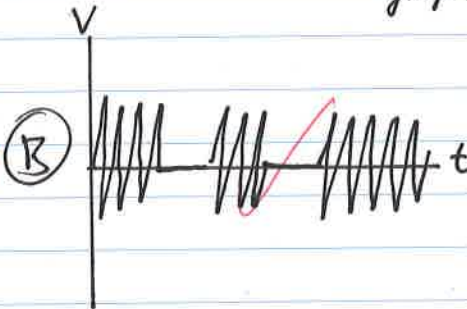
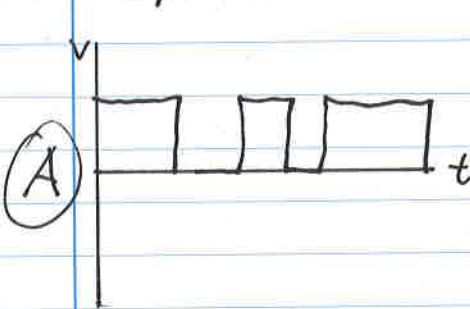
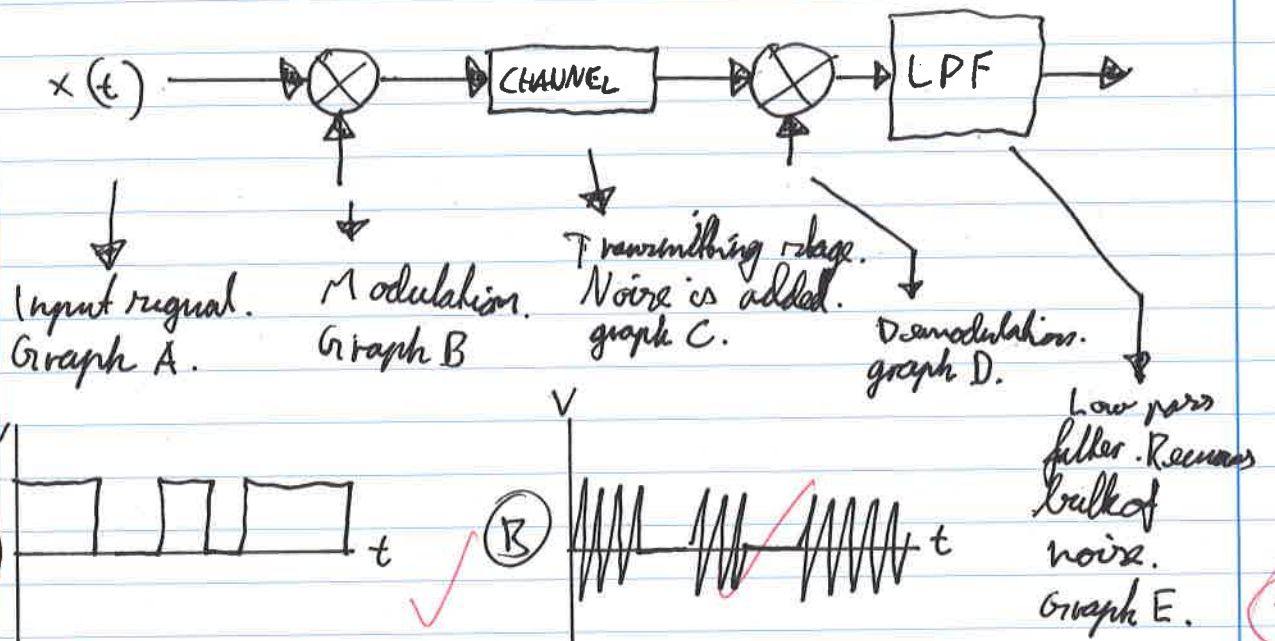
$$= (0 \oplus 0 \oplus 1 \oplus 0) = 1$$

$$T_{u3} = \underline{\underline{1010011}}$$

10

10

2a)



(2)

(2)

2a) For graph A, the input signal is fed into the modulation system. This is raw binary data, shown here as pulses.

For graph B, the carrier wave starts to "pulse" according to the input pulses. This modulates the signal.

In graph C, the signal travels through a channel. This could be through the atmosphere, through a cable, etc. Noise is everywhere, and it affects the signal, hence the need for modulation.

In graph D, we see the signal being demodulated. This happens by injecting a waveform which exposes the binary pulses again.

In graph E, the noise is mostly removed by removing the high-frequency components utilizing a ~~low~~ low-pass filter.

This is a simplified view of the system. To reduce noise to a minimum, more abstraction and complexity is needed.

A spectral domain will have been built

2

$$2b) M(x) = 10001$$

$$G(x) = x^3 + x^2 + 1 = 1101$$

Transfer Error

$$\begin{array}{r}
 1101 \overline{) 10001000} \\
 \underline{1101} \phantom{000} \\
 1011 \phantom{000} \checkmark \\
 \underline{1101} \phantom{000} \checkmark \\
 1100 \phantom{000} \checkmark \\
 \underline{1101} \phantom{000} \checkmark \\
 0010 \phantom{000} \checkmark \\
 \underline{0000} \phantom{000} \checkmark \\
 0100 \phantom{000} \checkmark \\
 \underline{0000} \phantom{000} \checkmark \\
 0000
 \end{array}$$

NO ERRORS

← Not finished

$$M(x) = 10001$$

$$G(x) = 1101$$

ERROR

Transfer Error

$$\begin{array}{r}
 1101 \overline{) 10001000} \\
 \underline{1101} \phantom{000} \\
 1011 \phantom{000} \checkmark \\
 \underline{1101} \phantom{000} \checkmark \\
 1101 \phantom{000} \checkmark \\
 \underline{1101} \phantom{000} \checkmark \\
 0000 \phantom{000} \checkmark \\
 \underline{0000} \phantom{000} \checkmark \\
 0000
 \end{array}$$

Marks for Method