FIT9137 Workshop Week-7

Topics

- Physical layer: Digital and Analogue Modulation
  - FM, AM, and PM encoding & Constellation diagrams
  - Unipolar, NRZ-I, Manchester encoding

Covered Learning Outcomes:

- Analyze and formulate the functions and architectures of (wireless) local area networks, wide area networks and the Internet.
- Examine networks using the underlying fundamental theories, models and protocols for data transmission.
- In this week, you will learn about the network circuits and media. You will also learn how data is transmitted through a medium either digitally or analogy. We also learn how errors can be detected/corrected in such data transmissions.

Instructions:

- One of the main purposes of an applied session is to build the learning community, create connections and include the learners. The other goal is to give and receive feedback from your peers and or your tutors.
- Form groups of 2 students (peers) to work through the exercises. If met a problem, try to solve it by asking direct questions to your peer.
- If you still have a question? jump into one of many consultation hours and ask any of the tutors to help you. Please visit the "Teaching Team and Unit Resources" tile in the FIT9137 Moodle site.

Activity A: Encoding

A.1 Analogue Modulation

Assume a data stream is **`01001110`**. For each of the following schemes, design an encoding, give the encoding rules/table, draw the constellation diagram and plot the analogue signal (waveform). Assume a carrier frequency of 1 Hz, so that each time unit contains a single wave cycle.

a) FM (no need for constellation diagram)

An encoding table is a table that for each *symbol* shows the parameters of the modulation signal.

Symbol	Frequency
0	1hz
1	2hz

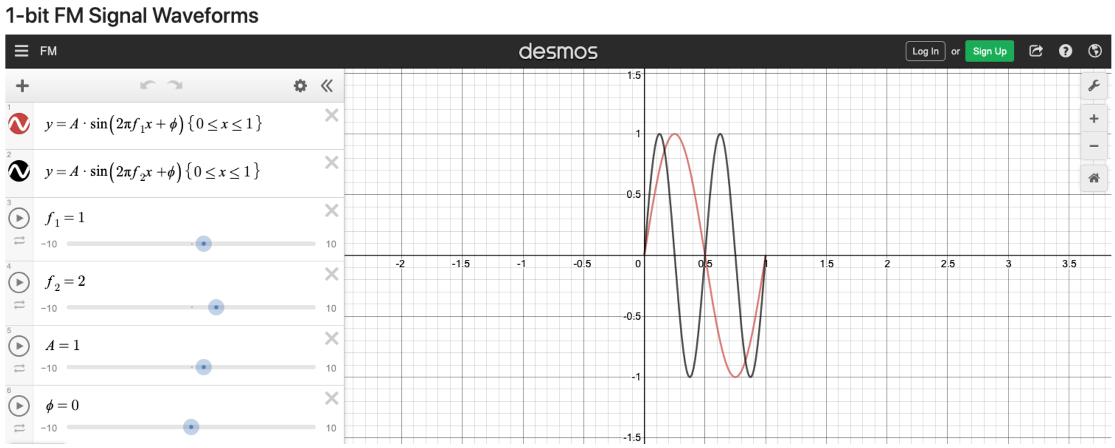


Figure 1: 1-bit FM Signal Waveform

https://www.desmos.com/calculator/5f9obcr1ff

Note: The amplitude and phase will not change for either of the symbols hence it is not included in the encoding table, we can assume $A = 1$ and $\phi = 0$ (these values will be decided for the signal and will be fixed).

- for the first symbol: 0 we will have the signal $y = A \cdot sin(2\pi f_1 x + \phi)$
- for the second symbol: 1 we will have the signal $y = A \cdot sin(2\pi f_2 x + \phi)$
- for the third symbol: 0 we will have the signal $y = A \cdot sin(2\pi f_1 x + \phi)$
- and so on

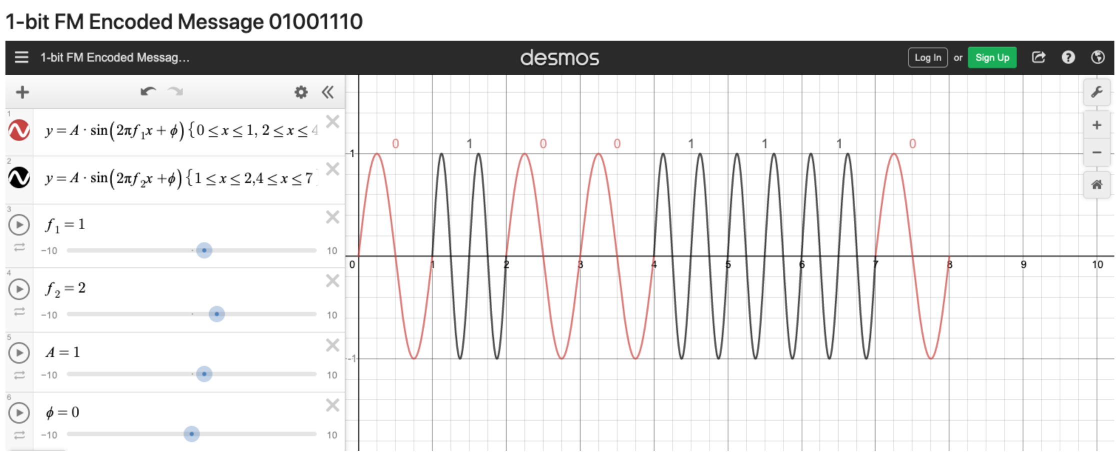


Figure 2: 1-bit FM Encoded Message `01001110`

https://www.desmos.com/calculator/d4vhhb7rat

b) PM

Encoding Table

Symbol	Phase
0	$45° = \frac{\pi}{4}$
1	$225° = \frac{5\pi}{4}$

1-bit PM Signal Waveform

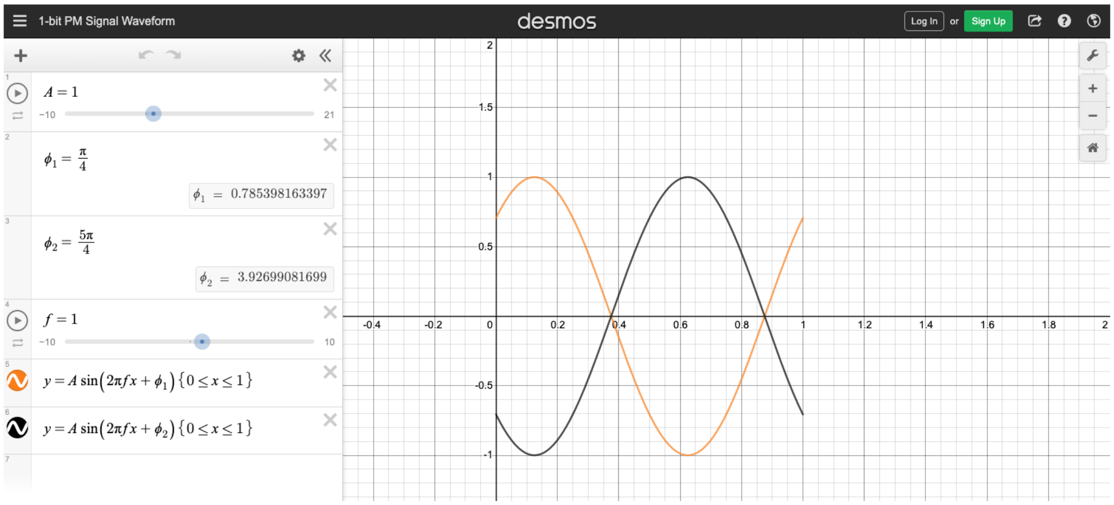


Figure 3: 1-bit PM Signal Waveform

https://www.desmos.com/calculator/q9vqwdkcdk

Constellation Diagram Another form of representation of the signal parameters. We can only use the Constellation diagram to represent *pahse* and *amplitude* for each symbol.

Trigonometry formula for right-angle triangle:

$sin(\theta) = \frac{Opposite}{Hypotenuse}$ and $cos(\theta) = \frac{Adjacent}{Hypotenuse}$ Hence, to calculate the x and y coordinate of each symbol using the characteristics of the waveform:

- Symbol 0 x-coordinate= $Adjacent = Hypotenuse \cdot cos(\phi_1) = A \cdot cos(\phi_1)$
- Symbol 0 y-coordinate= $Opposite = Hypotenuse \cdot sin(\phi_1) = A \cdot sin(\phi_1)$
- Symbol 1 x-coordinate= $Adjacent = Hypotenuse \cdot cos(\phi_2) = A \cdot cos(\phi_2)$
- Symbol 1 y-coordinate= $Opposite = Hypotenuse \cdot sin(\phi_2) = A \cdot sin(\phi_2)$

1-bit PM Constellation Diagram

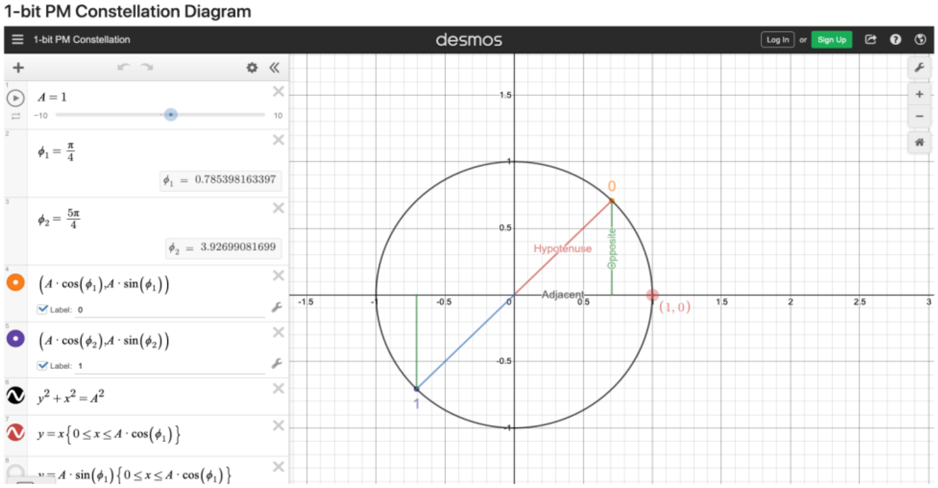


Figure 4: 1-bit PM Constellation Diagram

https://www.desmos.com/calculator/qarynysczv

Encoded Message

Note: The amplitude and frequency will not change for either of the symbols hence it is not included in the encoding table, we can assume $A = 1$ and $f = 1$ (these values will be decided for the signal and will be fixed).

- for the first symbol: 0 we will have the signal $y = A \cdot sin(2\pi f x + \phi_1)$
- for the second symbol: 1 we will have the signal $y = A \cdot sin(2\pi f x + \phi_2)$
- for the third symbol: 0 we will have the signal $y = A \cdot sin(2\pi f x + \phi_1)$
- and so on

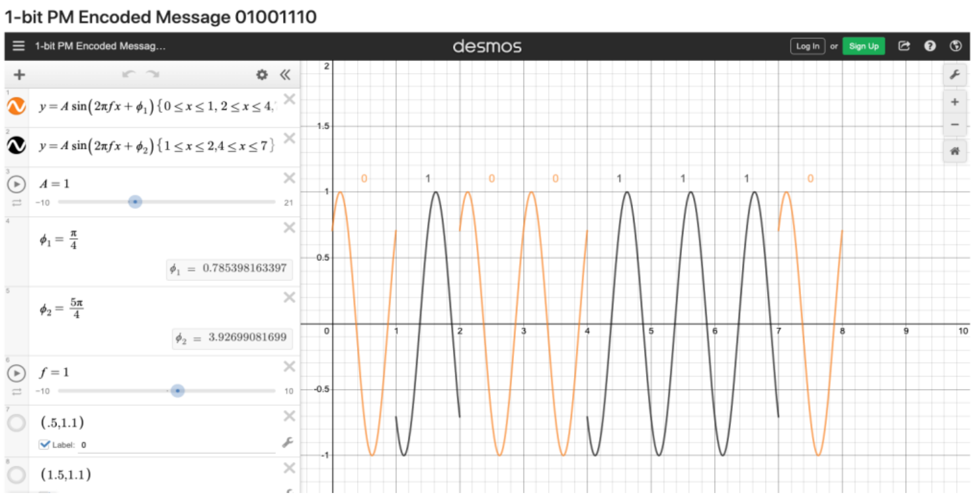


Figure 5: 1-bit PM Encoded Message ***01001110***

https://www.desmos.com/calculator/t4jyybb1uf

c) AM

Encoding Table

Symbol	Amplitude
0	1
1	.7

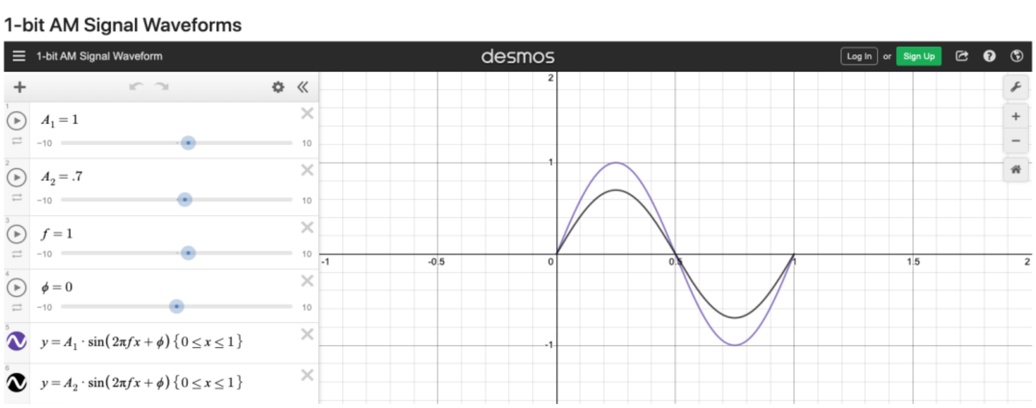


Figure 6: 1-bit AM Signal Waveforms

https://www.desmos.com/calculator/mid7gmtkty

1-bit AM Constellation Diagram

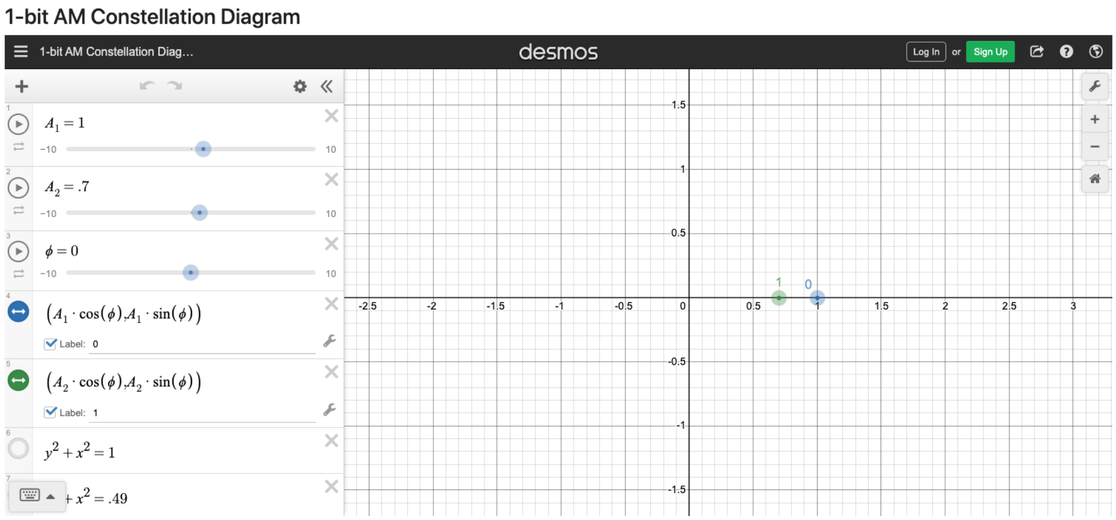


Figure 7: 1-bit AM Constellation Diagram

https://www.desmos.com/calculator/9dmvlz2ai1

1-bit AM Encoded Message `01001110`

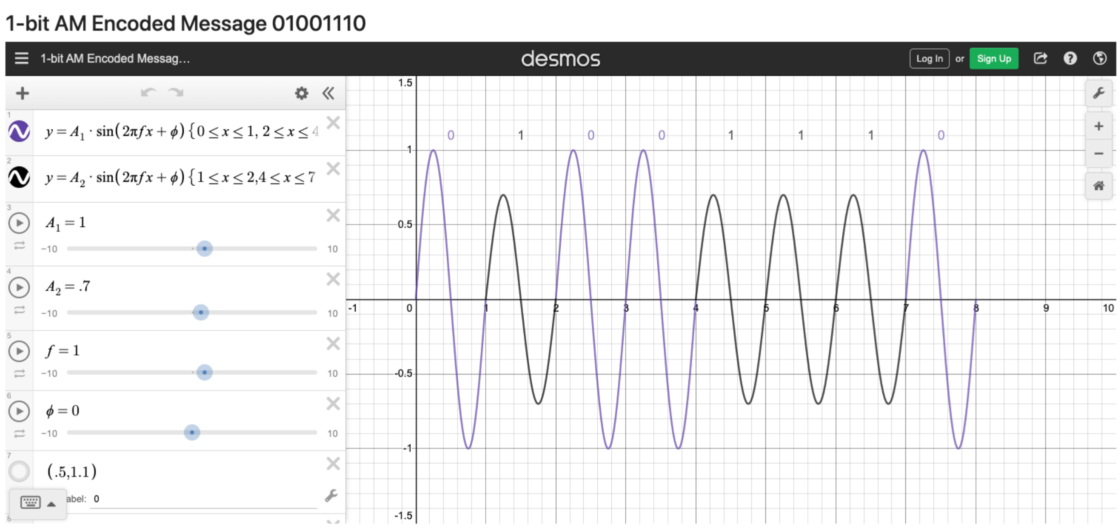


Figure 8: 1-bit AM Encoded Message `01001110`

https://www.desmos.com/calculator/raonyrrfst

d) 2-bit-per-symbol PM

2-bit PM

Here each symbol represents 2 bits, that is the waveform in the unit of time (1 second) carries 2 bits instead of a single bit shown in all previous examples. One or more signal parameters can be used in multi-bit per symbol modulation. Here only phase is used henec frequency and amplitude are unchanged for all of the symbols (we assume $A = 1$ and $f = 1\text{Hz}$).

Symbol	Phase
00	$\phi_1 = 45^\circ = \frac{\pi}{4}$
01	$\phi_1 = 135^\circ = \frac{3\pi}{4}$
10	$\phi_1 = 225^\circ = \frac{5\pi}{4}$
11	$\phi_1 = 315^\circ = \frac{7\pi}{4}$

2-bit PM Symbols Waveforms

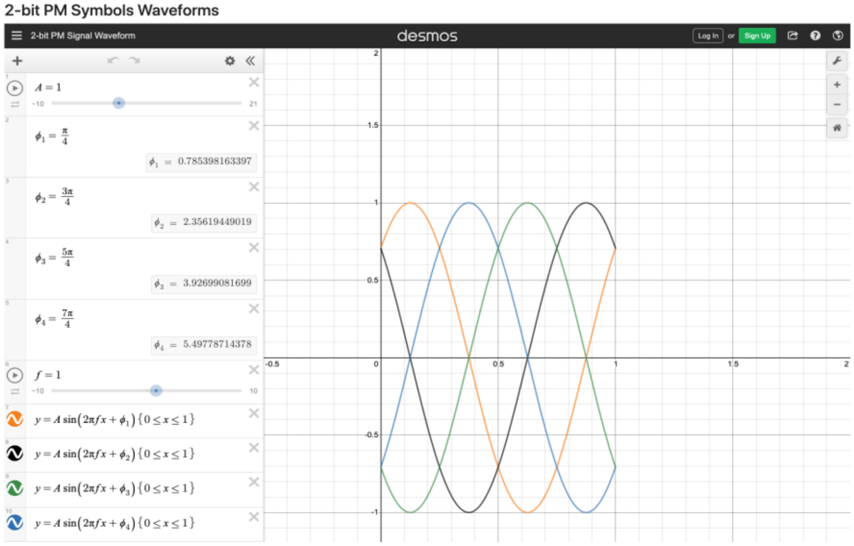


Figure 9: 2-bit PM Symbols Waveforms

https://www.desmos.com/calculator/brovayikjp

2-bit PM Constellation Diagram

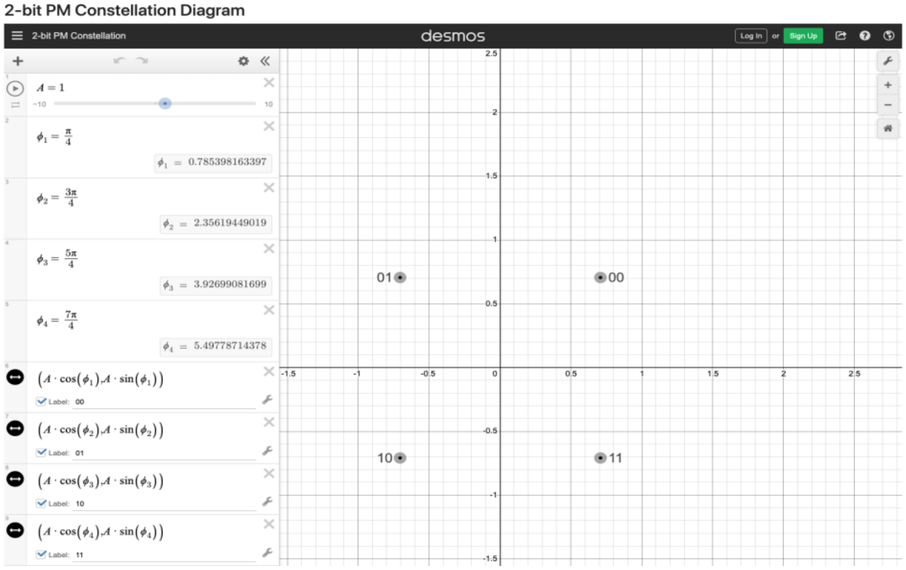


Figure 10: 2-bit PM Constellation Diagram

https://www.desmos.com/calculator/hvmbpw9wwh

e) 2-bit PM Encoded Message 01001110

To encode this message in a waveform we first need to represent it as symbols since each symbol is two bits long and we only need a waveform in unit of time for each 2-bit of the message:

- symbols: 01, 00, 11, 10
- Waveforms: $A \cdot sin(2\pi f x + \phi_2)$, $A \cdot sin(2\pi f x + \phi_1)$, $A \cdot sin(2\pi f x + \phi_4)$, $A \cdot sin(2\pi f x + \phi_3)$

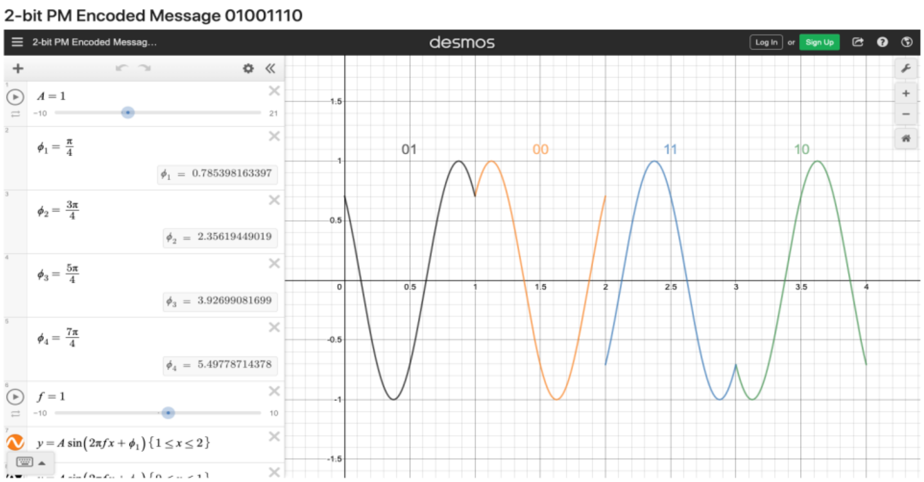


Figure 11: 2-bit PM Encoded Message `01001110`

https://www.desmos.com/calculator/fwehzwvxpj

A.2 Digital Modulation

Assume a data stream is **`000001`**. For each of the following schemes plot the encoded digital signal.

a) Unipolar

where the zero voltage represents logical 1 and positive voltage represents 0

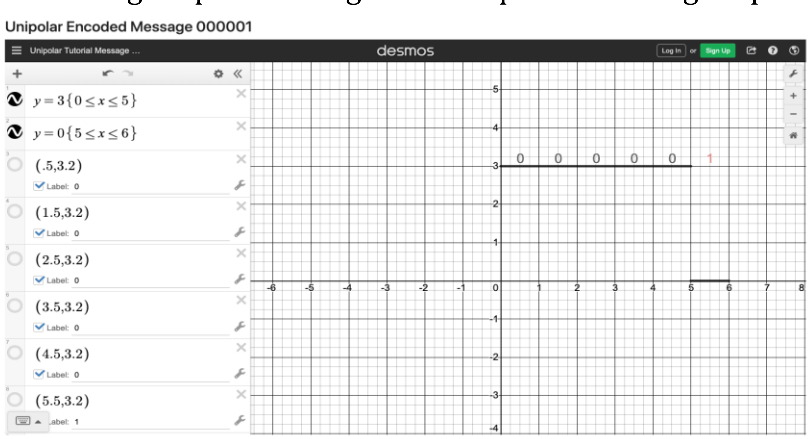


Figure 12: Unipolar Encoded Message `000001`

https://www.desmos.com/calculator/bsu3cdyvnm

There are three issues with Unipolar: i) losing synchronization (interpreting 4 zeros instead of 5 for instance) ii) DC voltage (positive or negative) causes heating problem which increases power consumption (due to imbalanced number of 0s and 1s) iii) burst noise will have a great impact when there are long sequences of 0s and 1s

b) NRZ-I

Non Return to Zero Inverted where *transition* represents 1 and *no transition* represents 0.

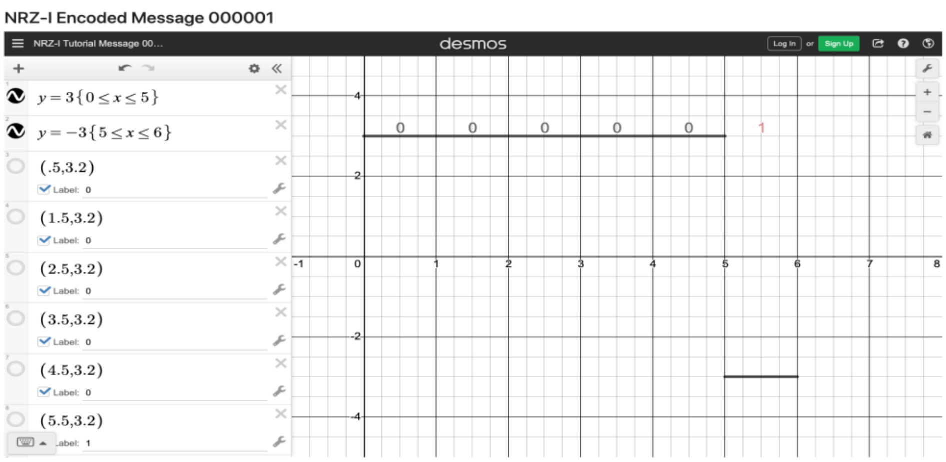


Figure 13: NRZ-I Encoded Message 000001

https://www.desmos.com/calculator/94rinhq8w4

c) Manchester

where a **Low to High transition** represents 1 and a **High to Low transition** represents 0 (in this case there will be a transition in every bit regardless of its value hence long repeated bits will not lose the clock).

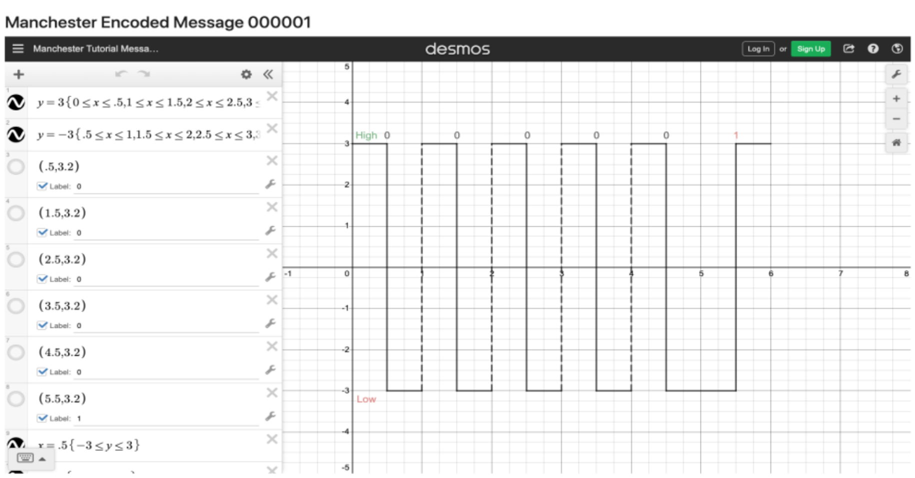
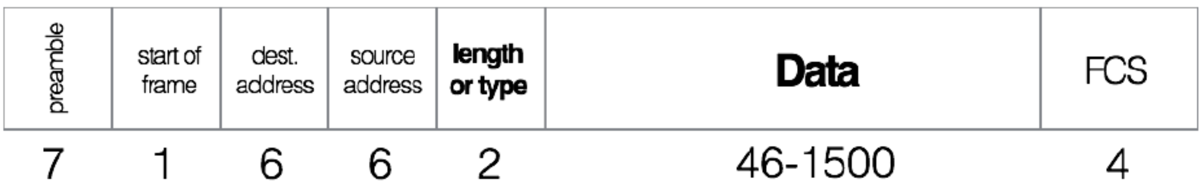


Figure 14: Manchester Encoded Message 000001

https://www.desmos.com/calculator/btqiiliixq

Activity B: Data Link Layer; Analysis using Wireshark

In this activity you will use Wireshark to capture the live network traffic into and out of the VM. Recall from the textbook/lecture notes that Ethernet frames have the following structure:



The description of the fields is as follows:

- Hardware fields, invisible in Wireshark:
  - 7-byte **preamble**: repeating pattern of ones and zeros
  - 1-byte **start of frame** delimiter (SFD): `10101011`
  - 4-byte CRC-32 frame **check sequence**

- Fields visible in Wireshark:
  - 6-byte **destination** and 6-byte **source** MAC addresses
  - 2-byte length or type of frame field. If value is ≤ 1500 (=`0x05DC`) this is the length of the data. If value is ≥ 1536 (=`0x0600`) this is the type of frame. The length is then determined dynamically, by listening for the end of the packet (no signal) and determining the correct FCS. E.g.: a type of `0x0800` means the frame contains an IPv4 packet, `0x86DD` means IPv6, and `0x0806` indicates an ARP frame (we'll learn about these protocols later).

- Variable length **data** field - 46 to 1500 bytes.

1. In the VM open Wireshark. We are going to capture the live network traffic of the VM. From the Wireshark list of available interfaces click on `enp0s3` to select (blue line identifies selected interface) and then click on the blue shark fin on the Wireshark panel to start capturing. Alternatively double click on the interface name to select and start capturing traffic.

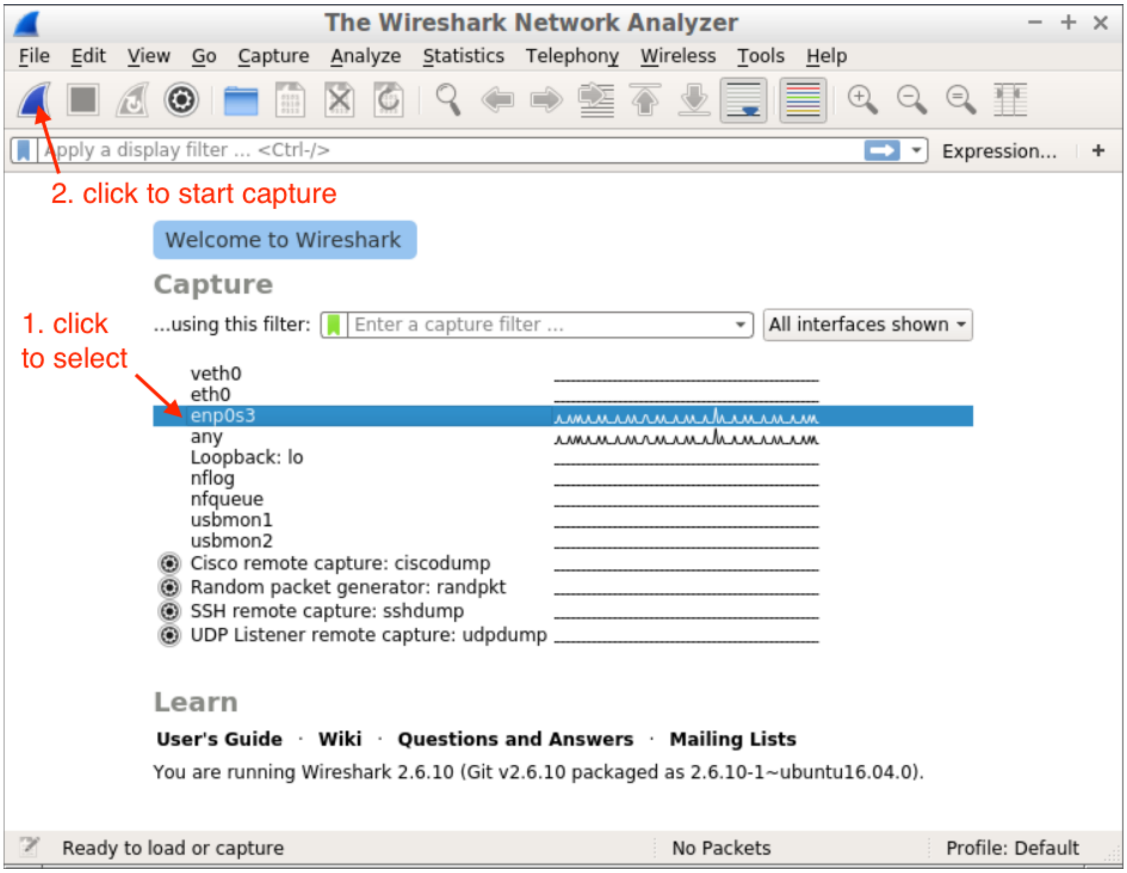


Figure 18: Capturing traffic on `enp0s3` interface

2. After starting the capture in Wireshark, open Firefox and browse to the following page:

   http://shell.cas.usf.edu/mccook/uwy/hyperlinks.html

   The page contains a simple text and an image. As soon as the page has finished loading, you can stop the capturing in Wireshark. Analyse the captured packets to identify the different requests and responses. Select the Ethernet frame containing the `HTTP GET` message.

3. Answer the following questions, based on the contents of the Ethernet frame containing the `HTTP GET` message (`GET /mccook/uwy/hyperlinks.html HTTP/1.1`).

   a) What is the value of the Ethernet source address?

   Most likely the same for everyone unless the option to change the MAC address is selected when importing the VM `2a67e84168b1 or selecting the Machine's O.S, then it will be a different 48 bit hexadecimal number.`

   b) What is the destination address in the Ethernet frame? Is this the Ethernet address of users.monash.edu?

   `525400123502`, No it is the MAC address of VBox playing the role of the default gateway of the VM, again if you are using the Machine's O.S then it will be the Mac address of the modem router.

c) Give the hexadecimal value for the two-byte Frame type field.

`0800` meaning IPv4. (See under the Ethernet II → Source→ Type.

d) How many bytes from the very start of the Ethernet frame does the ASCII "`G`" in `GET` appear in the Ethernet frame

3 rows + 6 bytes = $3 \times 16 + 6 = 54$ (If you click on the GET, you will see the HTTP request method is 3 bytes from byte 54 to 56 bytes.

e) What is the total size of each header for Datalink, Network and Transport layers?

14bytes for Ethernet + 20 bytes for IP and 20 bytes for TCP headers

4. Next, answer the following questions, based on the contents of the Ethernet frame containing the first byte of the HTTP response message (the first `HTTP/1.1 200 OK` after the `GET` request, part of this HTTP stream).

   a) What is the value of the Ethernet source address? Is this the address of your computer (VM), or of http://shell.cas.usf.edu/mccook/uwy/hyperlinks.html ?

   `525400123502`, Neither it is the MAC address of VBox playing the role of the router, the default gateway of the VM.

   b) What is the destination address in the Ethernet frame? Is this the Ethernet address of your computer (VM)?

   `2a67e84168b1`, yes.

   c) Give the hexadecimal value for the two-byte Frame type field.

   `0800` meaning IPv4