AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH

Faculty of Engineering

Laboratory Report Cover Sheet

Title: Study of Digital to Digital Conversion (Line Coding) Using MATLAB

Experiment Number: 04	Course Title: Data Communication
Course Code: COE3103	Course Instructor: Nowshin Alam
Semester: Spring 2023-2024	Section: E Date of Submission: 19-03-2024

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	Total Marks	

Category	Proficient [6]	Good [5-4]	Acceptable [3-2]	Unacceptable [1]	Secured Marks
Introduction and/or Theory	• Explains all necessary and relevant theoretical background information, measures, and variables.	• Explains the important parts of theoretical background information, may be partially irrelevant or need more details.	• Explains some theoretical background information, but some information may be missing, irrelevant or inaccurate.	• A lot of information is missing, out of context and/or inaccurate.	
Experimental procedure/Code	• Working procedure or code is clearly presented and is supported by proper comments. • Simulation program file is provided which runs properly and shows the expected result. • Methods are clearly written, including all steps in sufficient detail for the experiment to be repeated.	• Working procedure or code is given for the experiment to be sufficient. • Simulation program file is provided which runs properly but the output does not perfectly align with expected result. • Methods are correct but the steps may be lacking in detail, making the experiment hard to be repeated.	• Working procedure or code is missing some steps and/or contains some mistakes. • Simulation program file is provided which runs properly but the output has many problems.	• Working procedure or code is absent or missing major steps and/or contains mistakes. • Simulation program file is not provided/is completely wrong.	
Block Diagrams and Graphical Results	• Clear, accurate diagrams and graphs are labeled neatly and accurately with excellent detail. • Simulated result meets all criteria; outcomes are described clearly and accurately.	• Diagrams and plots are included and are correctly labeled in brief, but there may be some lack of clarity. • Most criteria are met, but there may be some lack of clarity and/or incorrect information.	• Diagrams and plots are included and are labeled, minor mistakes may be present. • Results do not match exactly with the theoretical values and/or analysis is unclear.	• Needed plots/ diagrams are missing or are missing important labels. • Experimental results are missing or completely incorrect.	
Data Interpretation and analysis	• Interpretation and analysis of related outcomes (consequences and implications) are logical and reflect student's informed evaluation and ability to place evidence. • Any report questions are properly answered with detailed justification or calculations.	• Analysis is logically tied to information (because information is chosen to fit the desired conclusion); some related outcomes are not clear. • Report questions are answered correctly but may be lacking detail or contain minor logical error.	• Analysis is inconsistently tied to some of the information discussed; related outcomes (consequences and implications) are oversimplified. • Report questions are answered but contain wrong information or major logical error.	• Only the data was reported, there is no analysis. • Report questions are missing or are completely wrong.	
Overall writing quality	• Demonstrates thorough and sophisticated understanding. Conclusions drawn are appropriate for analyses; • Writing is strong and easy to understand; ideas are fully elaborated and connected; effective transitions between sentences; no typographic, spelling, or grammatical errors.	• Hypotheses are clearly stated, but some concluding statements not supported by data or data not well integrated. • Writing is clear and ideas are connected; effective transitions between sentences; minor typographic, spelling, or grammatical errors.	• Some hypotheses missing or misstated; conclusions not supported by data. • Writing lacks clarity, noticeable amount of typographic, spelling, or grammatical errors are present.	• Conclusions do not match hypotheses, not supported by data; no integration of data from different sources. • Very unclear language, many grammatical and spelling errors.	
Comments:				Total Marks (Out of 30):	

Introduction :

In the domain of digital communication systems, Line coding plays a crucial role in converting data into digital signals for transmission and reception. This process is essential for ensuring accurate and efficient communication between devices. This experiment delves into the study of Digital to Digital Conversion (Line Coding) using MATLAB and helps understanding the principles and practical application of Line Coding in communication engineering.

Theory :

(i) Line Coding -

Line Coding serves as the essential process of transforming digital data into digital signals for communication purposes. In this process, various for of data such as text, numbers, images, audio or video are stored in computer memory as sequences of bits. Line Coding then converts these bit sequences into digital signals. At the sender's end, digital data undergo encoding to form a digital signal, which is later decoded at the reciever's end to recreate the original digital data. This bidirectional conversion ensures the accurate transmission and reception of data.

(ii) Signal elements & Data elements :-

One of the primary objective in data communication is to transmit data elements, which are the smallest units capable of representing information - detoned as bits. When it comes to digital data communications, signal elements play the role of carrying these data elements. A signal element stands as the shortest unit, in terms of time, within a digital signal. Essentially, data elements represent the information we aim to transmit it, when signal elements are the units that facilitate this transmission.

$$S = c * N * \left(\frac{1}{r}\right) \quad \left[S = \text{Signal rate},\ c = \text{case factor},\ N = \text{Data Rate},\ r = \frac{\text{No. of data elements}}{\text{No. of signal elements}} \right]$$

(iii) Bandwidth:

We know that a digital signal carrying information is nonperiodic. The bandwidth of a non-periodic signal is continuous with an infinite range but in ~~the~~ real life bandwidth of most digital signals are finite. So, theorically infinite but components with small amplitude gets ignored. As a result, the effective bandwidth or digital signal bandwidth is finite.

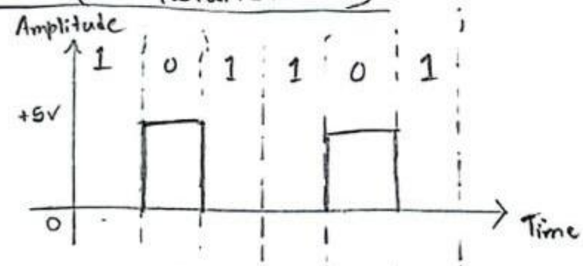
(iv) Line Coding Scheme:

Line Coding ——
- → Unipolar → NRZ
- → Polar → NRZ, RZ & Biphase (Manchester, Diff. Manchester)
- → Bi Polar → AMI & ~~Pseudoternary~~ Pseudoternary
- → Multilevel → 2B/1Q, 8B/6T and 4D-PAM5
- → Multi transition → MLT-3

Suppose, Bit stream: 101101

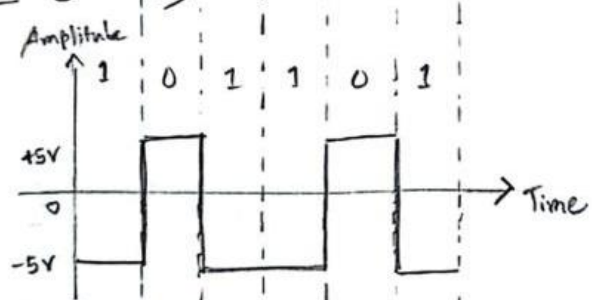
Unipolar:

NRZ (Non Return to Zero):



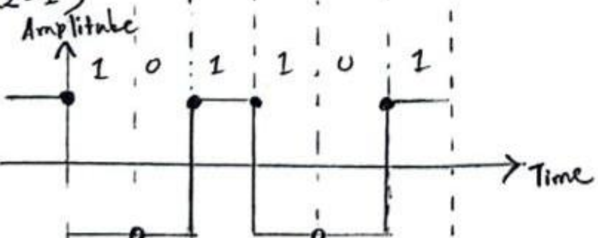
0 → +ve
1 → -ve

Polar: (NRZ-L)

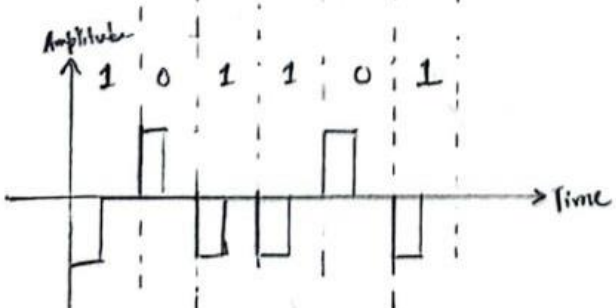


0 → +ve
1 → -ve

(NRZ-I)



0 → no inversion
1 → inversion
Initial: +ve

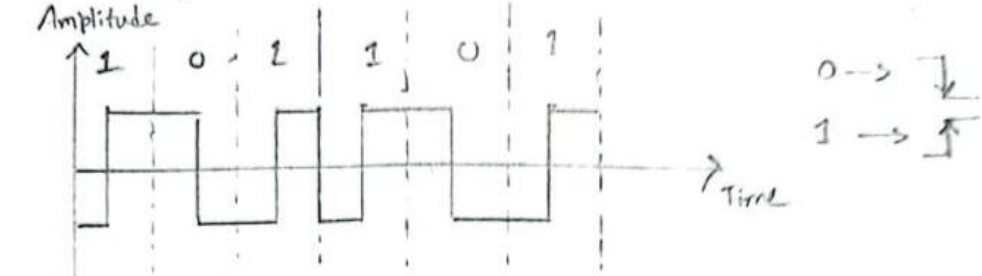


0 → +ve
1 → -ve

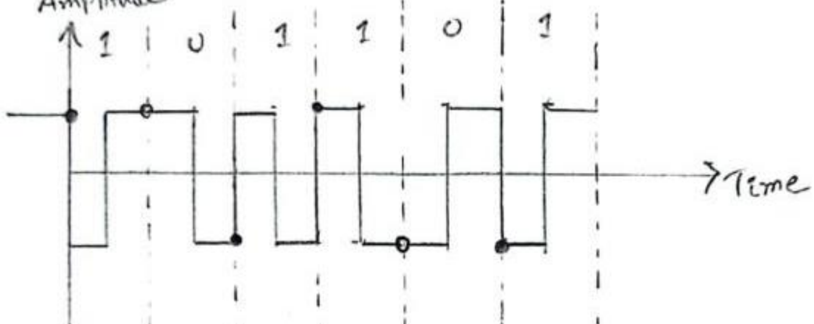
(RZ) Return to Zero

Polar Biphase:

(Manchester)

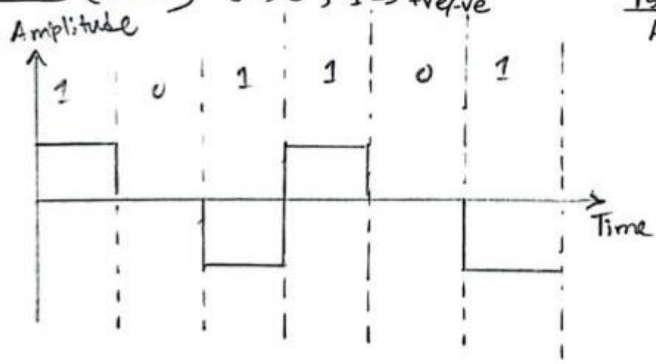


(Differential Manchester)

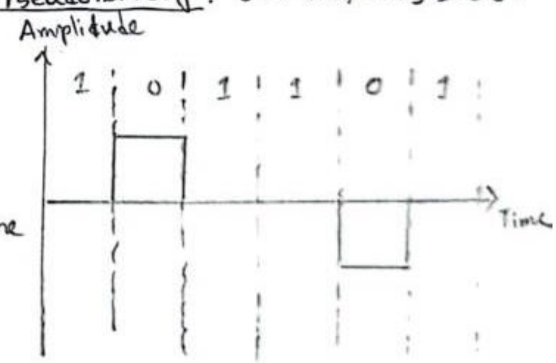


0 → no inversion
1 → inversion
initial → +ve

Bi-Polar (AMI) $0 \rightarrow 0$, $1 \rightarrow$ +ve/-ve



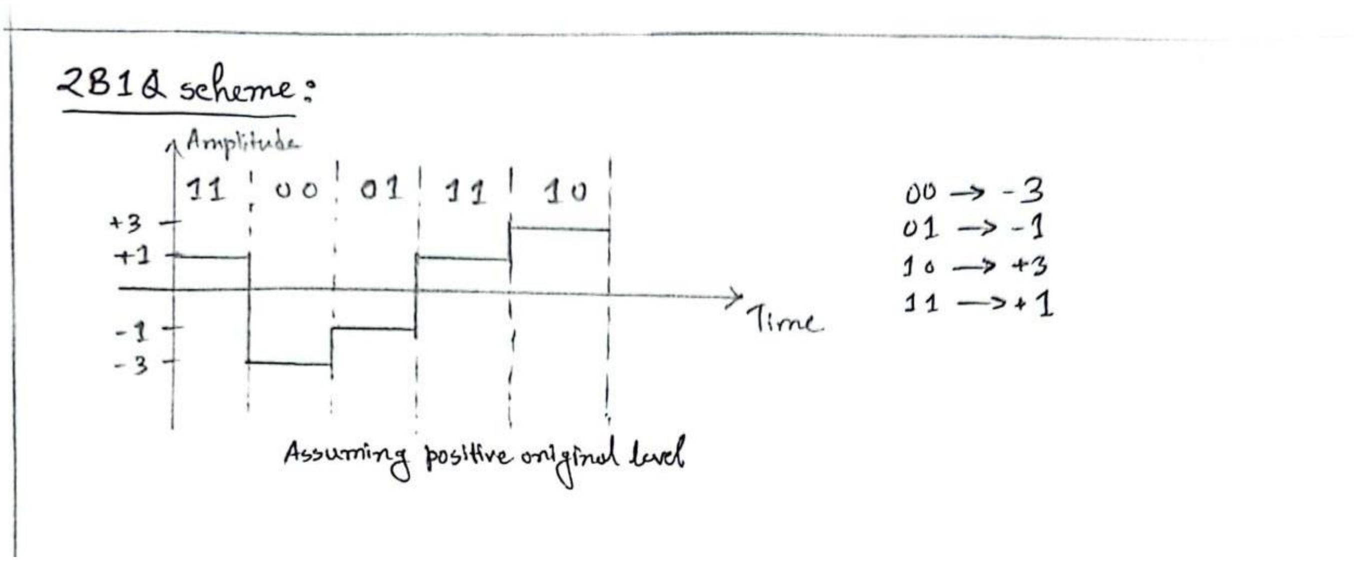
Pseudoternary: $0 \rightarrow$ +ve/-ve, $1 \rightarrow 0$v



v) Multilevel:

The goal is to increase the number of bits per baud by encoding a pattern of m data elements into a pattern of n signal elements. With 2 types of data element (0s & 1s), a group of m data elements can produce combination of 2^m data patterns. If we have L different levels, L^n combinations of signal patterns can be produced.

If, $2^m = L^n$, each data pattern is encoded into 1 signal pattern.
$2^m < L^n$, data patterns occupy only a subset of signal patterns
$2^m > L^n$, data encoding not possible because some data cannot.



Simulated Results:

ID: AB-CDEFG-H
ID: 22-47038-1

(Task 1) Polar NRZ-L assuming bit rate is 4 kbps.

Code-

```
% polar NRZ-L
% 22-47038-1
% AB-CDEFG-H
clc
clear all
close all
bit_stream = [0 0 0 0 0 0 1 1 1 0 0 0];
no_bits = length(bit_stream);
bit_rate = 4000; % 4 kbps
pulse_per_bit = 1; % for polar NRZ-L
pulse_duration = 1/((pulse_per_bit)*(bit_rate));
no_pulses = no_bits*pulse_per_bit;
samples_per_pulse = 500;
fs = (samples_per_pulse)/(pulse_duration); %sampling frequency
% including pulse duration in sampling frequency
% ensures having enough samples in each pulse
t = 0:1/fs:(no_pulses)*(pulse_duration); % sampling interval
% total duration = (no_pulse)*(pulse_duration)
no_samples = length(t); % total number of samples
```

```
dig_sig = zeros(1,no_samples);
max_voltage = 5;
min_voltage = -5;
for i = 1:no_bits
    if bit_stream(i) == 0
        dig_sig(((i-1)*(samples_per_pulse)+1):i*(samples_per_pulse)) =
max_voltage*ones(1,samples_per_pulse);
    else
        dig_sig(((i-1)*(samples_per_pulse)+1):i*(samples_per_pulse)) =
min_voltage*ones(1,samples_per_pulse);
    end
end
plot(t,dig_sig,'linewidth',1.5)
grid on
xlabel('time in seconds')
ylabel('Voltage')
ylim([(min_voltage - (max_voltage)*0.2)
(max_voltage+max_voltage*0.2)])
title(['NRZ - L for ',num2str(bit_stream),''])
```

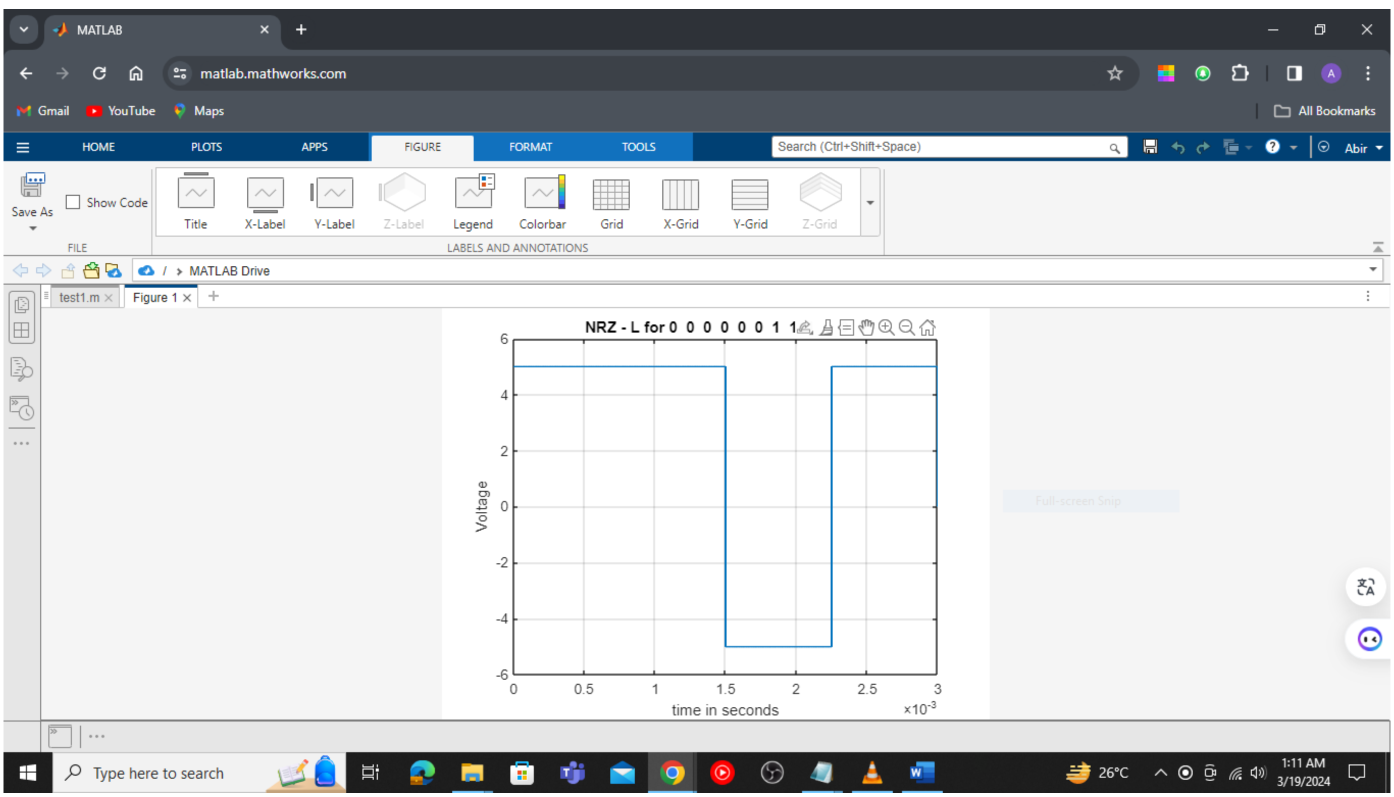


Figure 1- NRZ-L for Bit stream: 0 0 0 0 0 0 1 1 1 0 0 0

(Task 2) Manchester assuming bit rate is 2 kbps.

Code –

```
% Manchester
% 22-47038-1
% AB-CDEFG-H
clc
clear all
close all
bit_stream = [0 0 0 0 0 0 1 1 1 0 0 0];
no_bits = length(bit_stream);
bit_rate = 2000; % 2 kbps
pulse_per_bit = 2; % for Manchester
pulse_duration = 1/((pulse_per_bit)*(bit_rate));
no_pulses = no_bits*pulse_per_bit;
samples_per_pulse = 500;
fs = (samples_per_pulse)/(pulse_duration); %sampling frequency
% including pulse duration in sampling frequency
% ensures having enough samples in each pulse
t = 0:1/fs:(no_pulses)*(pulse_duration); % sampling interval
% total duration = (no_pulse)*(pulse_duration)
no_samples = length(t); % total number of samples
dig_sig = zeros(1,no_samples);
max_voltage = 5;
min_voltage = -5;
for i = 1:no_bits
   j = (i-1)*2;
   if bit_stream(i) == 1

dig_sig((j*(samples_per_pulse)+1):(j+1)*(samples_per_pulse)) = min_voltage*ones(1,samples_per_pulse);

dig_sig(((j+1)*(samples_per_pulse)+1):(j+2)*(samples_per_pulse)) =
max_voltage*ones(1,samples_per_pulse);
   else

dig_sig((j*(samples_per_pulse)+1):(j+1)*(samples_per_pulse)) = max_voltage*ones(1,samples_per_pulse);

dig_sig(((j+1)*(samples_per_pulse)+1):(j+2)*(samples_per_pulse)) =
min_voltage*ones(1,samples_per_pulse);
   end
end
plot(t,dig_sig,'linewidth',1.5)
grid on
xlabel('time in seconds')

ylabel('Voltage')
ylim([(min_voltage - (max_voltage)*0.2)
(max_voltage+max_voltage*0.2)])
title(['Manchester for ',num2str(bit_stream),''])
```

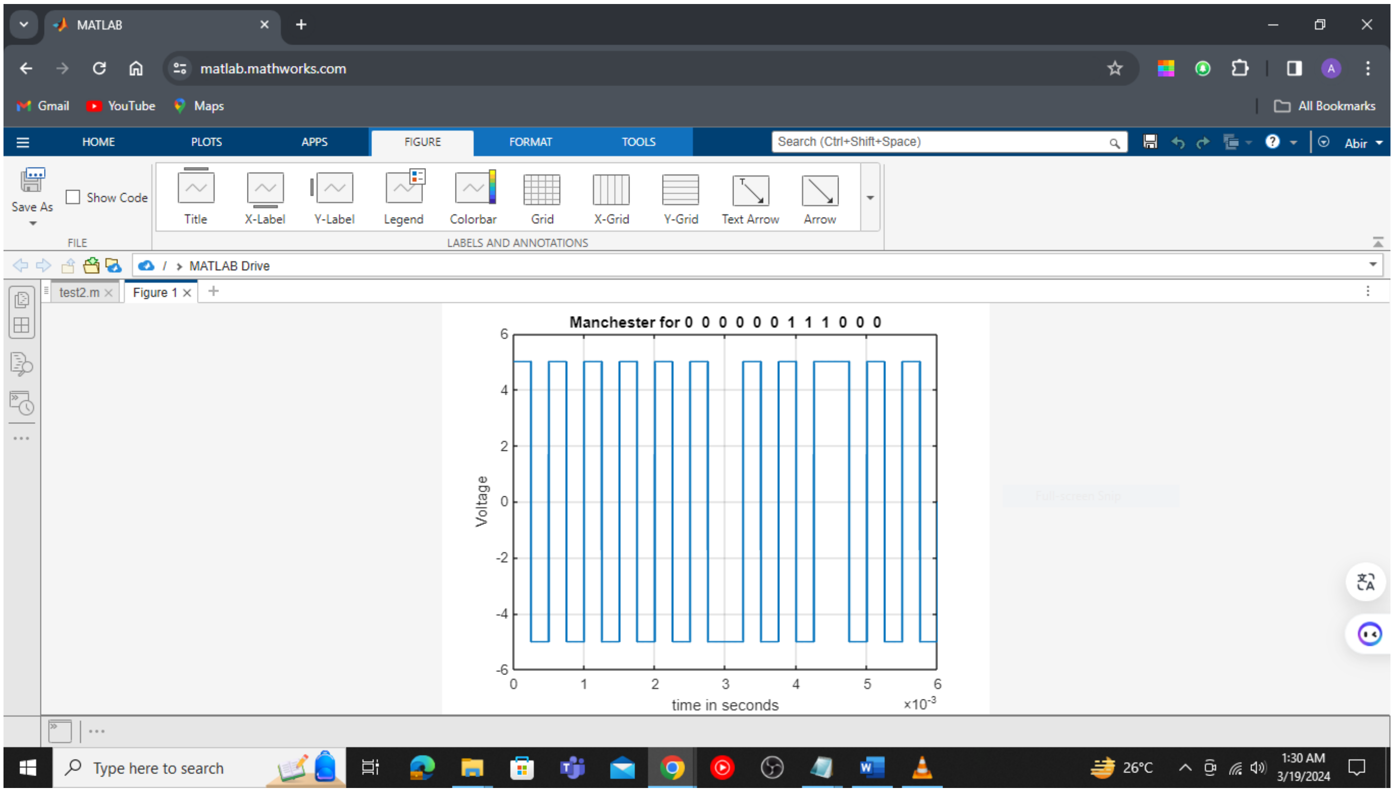


Figure 2- Manchester for Bit stream: 0 0 0 0 0 0 1 1 1 0 0 0

(Task 3) AMI assuming bit rate is 5 kbps

Code –

```
% AMI
% 22-47038-1
% AB-CDEFG-H
clc
clear all
close all
bit_stream = [0 0 0 0 0 0 1 1 1 0 0 0];
no_bits = length(bit_stream);
bit_rate = 5000; % 5 kbps
pulse_per_bit = 1; % for AMI
pulse_duration = 1/((pulse_per_bit)*(bit_rate));
no_pulses = no_bits*pulse_per_bit;
samples_per_pulse = 500;
fs = (samples_per_pulse)/(pulse_duration); %sampling frequency
% including pulse duration in sampling frequency
% ensures having enough samples in each pulse
t = 0:1/fs:(no_pulses)*(pulse_duration); % sampling interval
% total duration = (no_pulse)*(pulse_duration)
no_samples = length(t); % total number of samples
dig_sig = zeros(1,no_samples);
```

```
max_voltage = 5;
min_voltage = 0;
sign = 1;

for i = 1:no_bits
   if bit_stream(i) == 1
      dig_sig(((i-1)*(samples_per_pulse)+1):i*(samples_per_pulse)) =
sign*max_voltage*ones(1,samples_per_pulse);
      sign = (-1)*sign;
   else
      dig_sig(((i-1)*(samples_per_pulse)+1):i*(samples_per_pulse)) =
min_voltage*ones(1,samples_per_pulse);
   end
end

plot(t,dig_sig,'linewidth',1.5)
grid on
xlabel('time in seconds')
ylabel('Voltage')
title(['AMI for ',num2str(bit_stream),''])
```

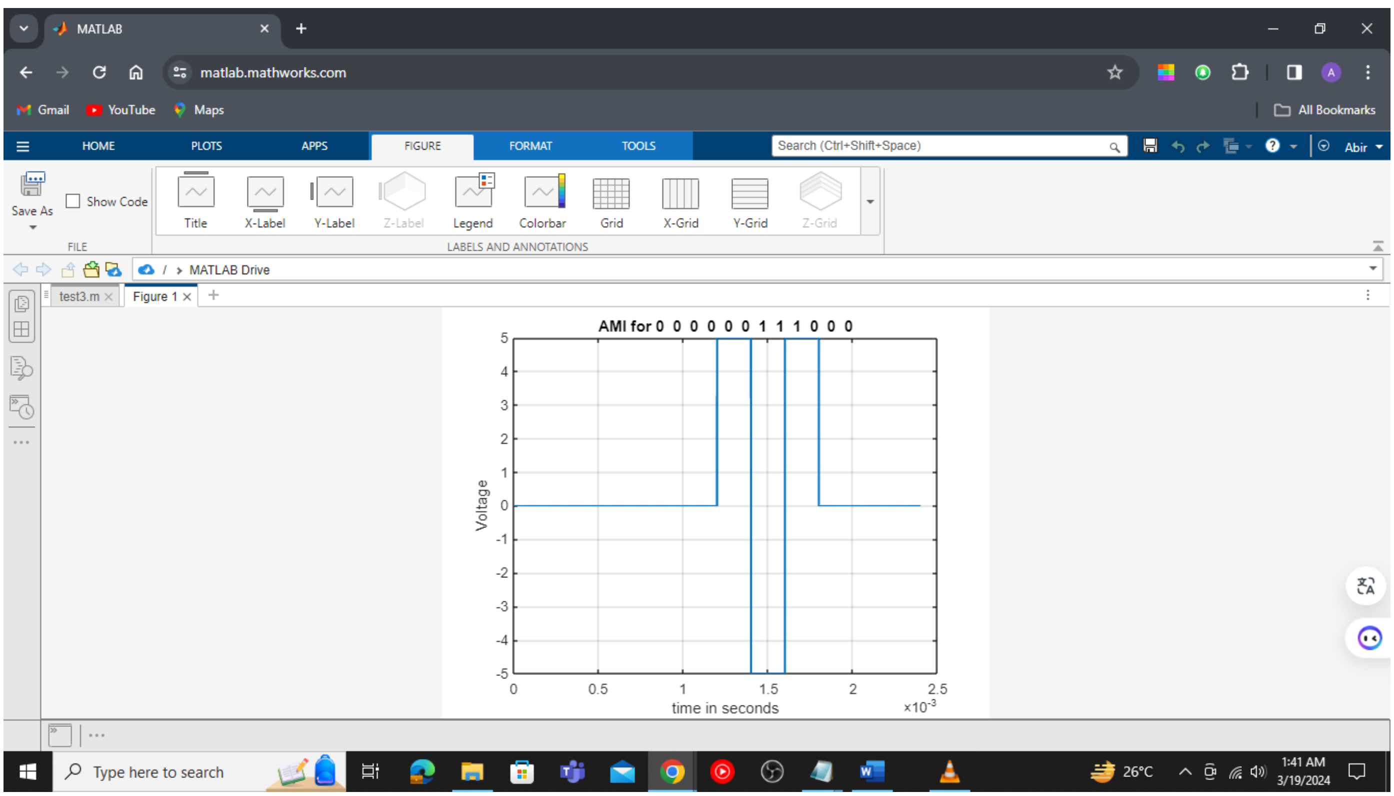


Figure 3- AMI for Bit stream: 0 0 0 0 0 0 1 1 1 0 0 0

Conclusion:

From this experiment, we have gained valuable insights into the world of Line Coding and its application in digital communication system. By utilizing MATLAB, we have gained experience in implementing various Line Coding schemes like Unipolar NRZ, RZ, Differential Manchester Polar NRZ, AMI, Manchester Understanding these encoding techniques ~~are~~ essential for engineers and researchers working in the field of communication engineering to design efficient and reliable data transmission system.