Communication Lab II

(ELC3940)

Experiment No.: 02

Object:

Using rectangular pulse shaping, represent the first 20 bits obtained in Exp. 1 into a waveform with
(a). Polar NRZ signaling.
(b). Bipolar signaling.
(c). Manchester coding

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Program:

Line Coding:

```
info = audioinfo('C:\Users\Maha Khan\Downloads\Hello5.wav');
[signal , fs] = audioread('C:\Users\Maha Khan\Downloads\Hello5.wav'); % Voice signal with
                                                                      % dual channel
                                   % and fs as the sampling frequency
[X ,Rb] = PcmEncoder(signal,info);     % Calling Function to psm encode
                                   % the signal


A = 1;       % Voltage level
Ns = 20;     % Number of samples
n = 0:0.1:20-0.1;

c = 1;
%Polar NRZ
polar = [];
for i = 1:Ns % Encoding signal to polar NRZ format
    if X(i) == 0
    polar(c:c+9)= [1 1 1 1 1 1 1 1 1 1]*(-A);
    else
        polar(c:c+9) =[1 1 1 1 1 1 1 1 1 1]*(A);
    end
    c = c+10;
end

figure('NumberTitle', 'off', 'Name', 'Line Encoding Binary Sequence');

subplot(4,1,2);
stairs(n,polar,'LineWidth',2);
hold on
stem(n,polar,'Marker','.');
yline(0,':');
% axis([0 23 -1.5 1.5]);
title('Polar NRZ Signaling');
% xlabel('Samples n');
ylabel('Amplitude in volts');
avg = mean(polar);  % Calculating Avg Dc value
avg = round(avg,2);
yline(avg,'--');
txt = ['Average DC value: ' num2str(avg) ' units'];
text(20.2,avg+0.2,txt,'FontSize',8)
axis([0 23 -1.5 1.5]);

%bi-polar
bipolar = [];
C = A;
c = 1;
for i = 1:Ns
    if X(i)==1
        bipolar(c:c+9) = C;
        C = -C;
    else
        bipolar(c:c+9) = 0;
    end
```

```
    c = c+10;
end


subplot(4,1,3);
stairs(n,bipolar,'LineWidth',2);
hold on;
stem(n,bipolar,'Marker','.','color','red');
yline(0,':');

avg = mean(bipolar);
avg = round(avg,2);
yline(avg,'--');
txt = ['Average DC value: ' num2str(avg) ' units'];
text(20.2,avg+0.2,txt,'FontSize',8)
axis([0 23 -1.5 1.5]);

title('Bi-polar Signaling');
ylabel('Amplitude in volts');

%Manchester
manchester = [];
c = 1;
for i = 1:Ns
    if X(i)==1
        manchester(c:c+4) = [1 1 1 1 1]*A;
        manchester(c+5:c+9) = [1 1 1 1 1]*(-A);
    else
        manchester(c:c+4) = [1 1 1 1 1]*(-A);
        manchester(c+5:c+9) = [1 1 1 1 1]*A;
    end
    c = c+10;
end

subplot(4,1,4);
stairs(n,manchester,'LineWidth',2);
hold on
stem(n,manchester,'Marker','.');
yline(0,':');
% axis([0 23 -1.5 1.5]);
title('Manchester Encoding');
% xlabel('Samples n');
ylabel('Amplitude in volts');

avg = mean(manchester);
avg = round(avg,2);
yline(avg,'--');
txt = ['Average DC value: ' num2str(avg) ' units'];
text(20.2,avg+0.2,txt,'FontSize',8)
axis([0 23 -1.5 1.5]);


%Data-bit Sequence
subplot(4,1,1);
```

```
stairs(0:20,X(1:21),'LineWidth',2);
yline(0,':');

avg = mean(X(1:20));
avg = round(avg,2);
yline(avg,'--');
txt = ['Average DC value: ' num2str(avg) ' units'];
text(20.2,avg+0.2,txt,'FontSize',8);
txt2 = ['\leftarrow',' Tb ','\rightarrow'];
text(8,-2.3,txt2,'FontSize',10,'FontWeight','bold');
txt3 = ['Time in Tb (1/Rb) ','\rightarrow'];
text(10,-15.5,txt3,'FontSize',18,'FontWeight','bold')
axis([0 23 -1.5 1.5]);

set(gca,'Clipping','Off');

for i = 1:20*2
h = line([0.5*i 0.5*i],[1.5 -14.4],'Color','red','LineStyle',':');
end
title('Data-bit Sequence');
% xlabel('Bit-rate (in Tb)');
ylabel('Magnitude');

%Now we can draw the PSD spectrum of Line-codes using Welch PSD
% estimation method
figure('NumberTitle', 'off', 'Name', 'PSD of Line-Coded Signals');
pxx = pwelch(polar);
plot(0:1/length(pxx):1-1/length(pxx),10*log10(pxx),'LineWidth',2.0,'Color','b');
hold on
pxx = pwelch(bipolar);
plot(0:1/length(pxx):1-1/length(pxx),10*log10(pxx),'LineWidth',2.0,'Color','r');
hold on
pxx = pwelch(manchester);
plot(0:1/length(pxx):1-1/length(pxx),10*log10(pxx),'LineWidth',2.0,'Color','m');

xlabel('Normalized Frequency (x\pi rad/sample)');
ylabel('Power/frequency (dB/(rad/sample))');
title('Welch Power Spectral Density Estimate');
legend('Polar NRZ','Bipolar NRZ','Manchester');
```

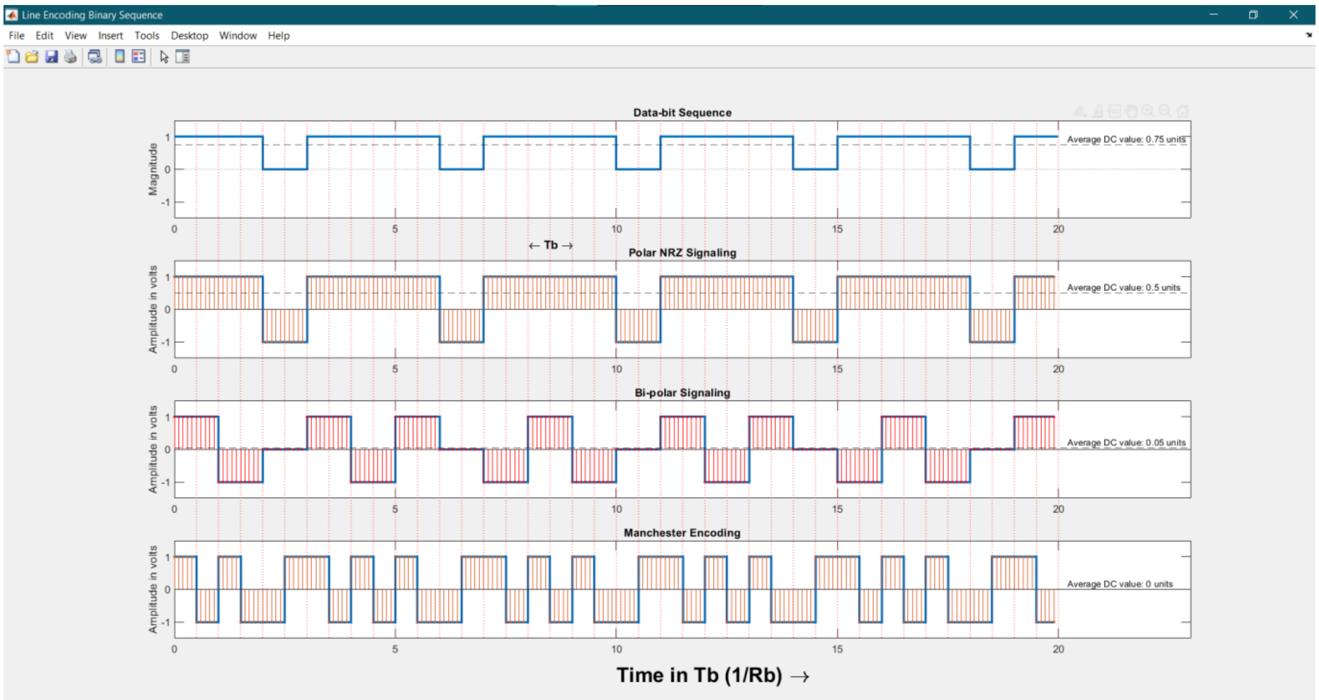
Wave Encoding Using PCM:

```
function [Encoded,Rb] = PcmEncoder(Signal,info)

dur = info.Duration;          % Signal duration in seconds
Ts1 = info.TotalSamples;      % Total no. of samples in time-domain
n1 = linspace(0,dur,Ts1);
y1 = Signal(:,1);                % Channel 1 of the signal sig

% Sampling Signal Waveform
fs = 16000;                   % Sampling frequency given in the Experiment
k = 4;                        % bit-rate for 16 bit quantizer
l = 2^k;                       % 16 level
```

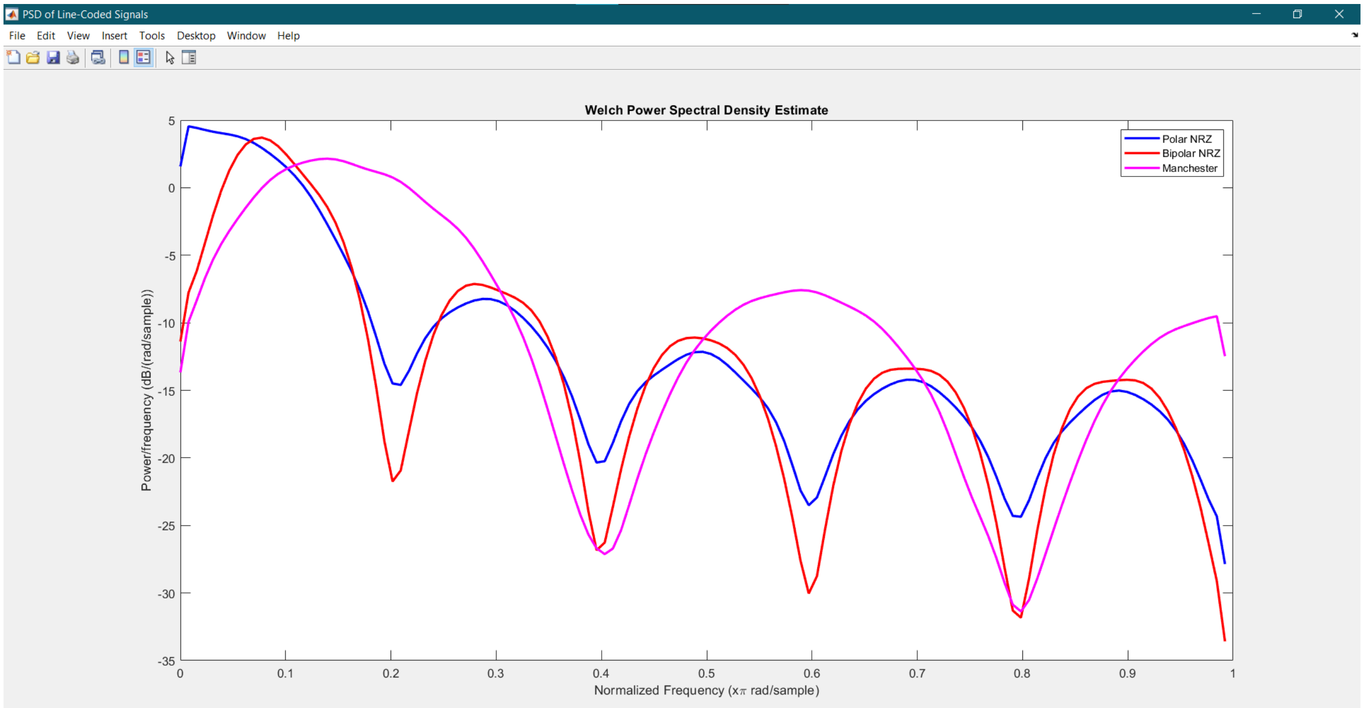
```
n = 0:1/fs:dur;
y = interp1(n1,y1,n);       % Signal Waveform with sampling frequency fs
Ns = length(y);

 ymax = max(y);
 ymin = min(y);


%Quantizing Signal Waveform
partition = linspace(ymin,ymax,l-1);
codebook = linspace(ymin,ymax,l);

[index,quants] = quantiz(y,partition,codebook); %quantizer

coder = [0 0 0 0;       % 4-bit Coder
         0 0 0 1;
         0 0 1 1;
         0 0 1 0;
         0 1 1 0;
         0 1 1 1;
         0 1 0 1;
         0 1 0 0;
         1 1 0 0;
         1 1 0 1;
         1 1 1 1;
         1 1 1 0;
         1 0 1 0;
         1 0 1 1;
         1 0 0 1;
         1 0 0 0];

pcm = linspace(0,0,Ns*k); % Array to store pcm signal
i = 1;
c = 1;
    % Encoding Quantized Signal
     while i <= length(pcm)
         pcm(i:i+3) = coder(index(c)+1,:);
         i = i+4;
         c = c+1;
     end

   Encoded = pcm;
   Rb = k*fs;
end
```

Result:

Waveform Coding:



Power Spectrum:



Discussion:

Polar NRZ:

In Polar NRZ set the output to High (+A) if input bit is 1 and if the input bit is 0 we set the output to low (--A). The avg DC value for Polar NRZ signaling came out to be 0.5 volts. We can observe that Line codes like Polar NRZ require less bandwidth but have demerit of having High DC level and bad synchronization.

Bi-polar:

In Bi-polar, I have set the output to 0 volts when the input is logic zero, else if input is logic 1, there will be two cases: Output will be +A if the previous high bit was –A and output will be –A if previous high bit was +A. The avg DC value for Bipolar signaling came out to be 0.05 volts. We can observe that in Bipolar scheme, the Average DC level has decreased significantly from Polar NRZ Scheme, but requires more bandwidth than the polar scheme.

Manchester:

In Manchester coding scheme, the output signal shows a transition from high (+A) to low (-A) when the input is ‘1’, in the middle of the input bit pulse, else if input is ‘0’, the output transitions from –A to +A. The avg DC value for Manchester signaling came out to be 0.0 volts. As we can see from results Line coding scheme like Manchester have good synchronization but require significantly higher bandwidth than Polar and Bipolar format.