BAPATLA ENGINEERING COLLEGE

DIGITAL SIGNAL PROCESSING LAB

EC-453

PREPARED BY

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1. Simulation of AM

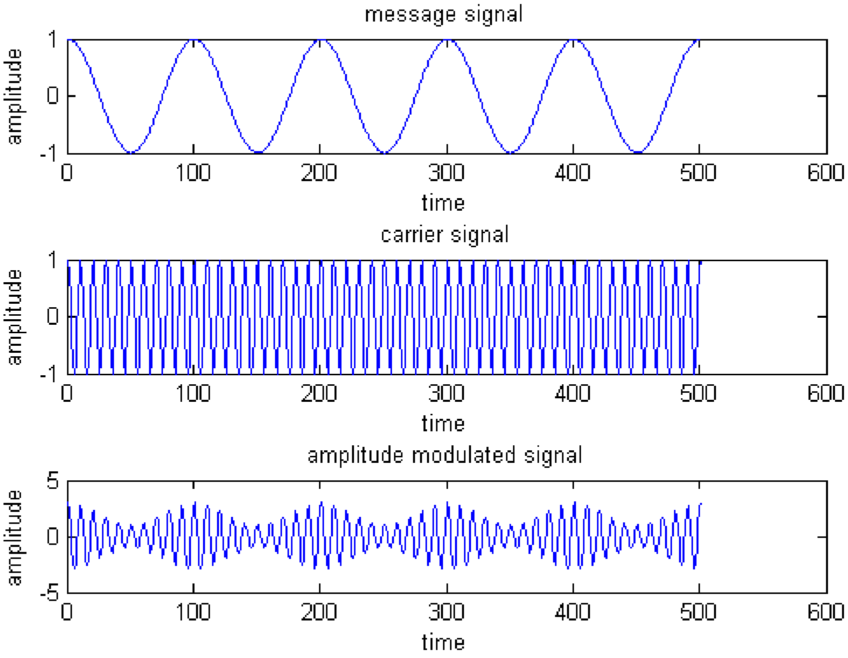
Aim: To simulate amplitude modulation and demodulation.

Program:

```
AM=input('enter message signal amplitude');
Ac=input('enter carrier signal amplitude');
fm=input('enter message signal frequency');
fc=input('enter carrier signal frequency');
n=input('enter no of cycles');
T=1/fm;
t=0:T/100:n*T;
m=AM*cos(2*pi*fm*t);
c=Ac*cos(2*pi*fc*t);
subplot(311);
plot(m);
xlabel('time');
ylabel('amplitude');
title('message signal');
subplot(312);
plot(c);
xlabel('time');
ylabel('amplitude');
title('carrier signal');
ka=AM/Ac;
s=c+c.*(1+ka*m);
subplot(313);
plot(s);
```

```
xlabel('time');
ylabel('amplitude');
title('amplitude modulated signal');
```

Output:



2. Simulation of frequency modulation

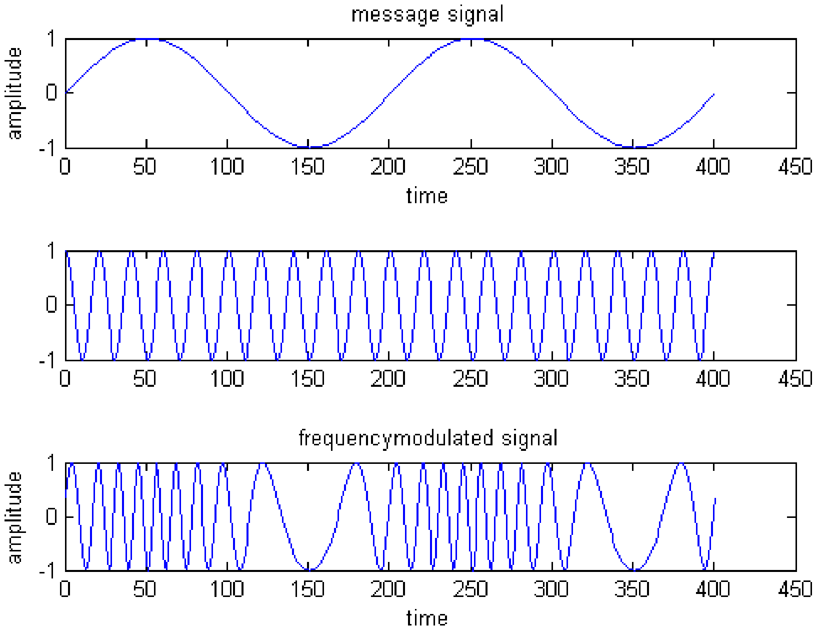
Aim: To simulate frequency modulation and demodulation.

Program:

```
AM=input('enter message signal amplitude');
Ac=input('enter carrier signal amplitude');
fm=input('enter message signal frequency');
fc=input('enter carrier signal frequency');
kf=input('enter frequency sensitivity');
T=1/fm;
t=0:T/200:2*T;
m=AM*sin(2*pi*fm*t);
c=Ac*cos(2*pi*fc*t);
subplot(311);
plot(m);
xlabel('time');
ylabel('amplitude');
title('message signal');
subplot(312);
plot(c);
fi=kf*AM;
b=fi/fm;
s=Ac*cos(2*pi*fc*t-(b*cos(2*pi*fm*t)));
subplot(313);
plot(s);
xlabel('time');
ylabel('amplitude');
```

```
title('frequencymodulated signal');
```

Output:



3. (i) Simulation of Lowpass filter

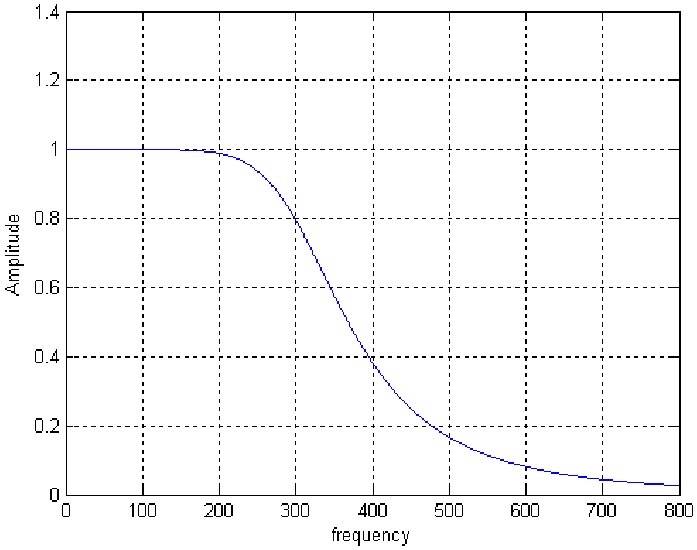
Aim: To simulate frequency response of Lowpass filter

Program:

```
function []=LPF (AP,AS,wp,ws)
b=(10^(0.1*AS)-1)/(10^(0.1*AP)-1);
c=log10(b^0.5);
d=log10(ws/wp);
n=(c/d);
t=ceil(n);
w=0:0.5:800;
m=(10^(0.1*AP)-1)^(1/(2*t));
wc=wp/m;
s=j*w/wc;
switch t
    case 1
        h=1./(s+1);
    case 2
        h=1./((s.^2)+1.414*s+1);
    case 3
        h=1./((s+1).*(s.^2+s+1));
    case 4
h=1./(((s.^2)+0.76537*s+1).*((s.^2)+1.8477*s+1));
    otherwise
        disp('order exceeded');
end;
plot(w,abs(h));
```

```
xlabel('frequency')
ylabel('Amplitude')
grid on
```

Output:



3 (b). Simulation of Highpass Filter

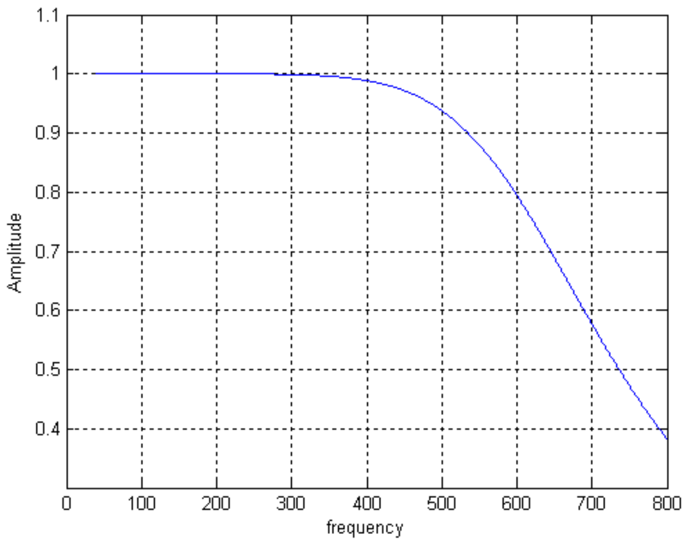
Aim: To simulate frequency response of high pass filter.

Program:

```
function []=HPF (AP,AS,wp,ws)
b=(10^(0.1*AS)-1)/(10^(0.1*AP)-1);
c=log10(b^0.5);
d=log10(wp/ws);
n=(c/d);
t=ceil(n);
w=40:0.4:800;
m=(10^(0.1*AP)-1)^(1/(2*t));
wc=wp/m;
s=-j*wc/w;
switch t
    case 1
        h=1./(s+1);
    case 2
        h=1./((s.^2)+1.414*s+1);
    case 3
        h=1./((s+1).*(s.^2+s+1));
    case 4
h=1./(((s.^2)+0.76537*s+1).*((s.^2)+1.8477*s+1));
    otherwise
        disp('order exceeded');
end;
plot(w,abs(h));
```

```
xlabel('frequency')
ylabel('Amplitude')
grid on
```

Output:



4. Simulation of DFT and IDFT

Aim: To simulate DFT and IDFT.

Program:

```
x=input('enter sequence');
N=length(x);
s=zeros(1,N);

for k=1:N
    for n=1:N
        s(k)=s(k)+x(n)*exp(-j*2*pi*(k-1)*(n-1)/N);
    end
end
disp(s);
% INVERSE DISCRETE FOURIER TRANSFORM.
m=input('enter sequence');  %m=s;
N=length(m);
G=zeros(1,N);
for n=1:N
    for k=1:N
        G(n)=G(n)+m(k)*exp(j*2*pi*(k-1)*(n-1)/N);
    end;
end;
disp(G/N);
```

Output:

```
 enter sequence[1 2 3 4 5]
 Columns 1 through 4
   15.0000            -2.5000 + 3.4410i  -2.5000
+ 0.8123i  -2.5000 - 0.8123i
   Column 5
   -2.5000 - 3.4410i
 enter sequence s
   Columns 1 through 4
    1.0000 - 0.0000i   2.0000 - 0.0000i   3.0000
4.0000 + 0.0000i
   Column 5
    5.0000 + 0.0000i
```

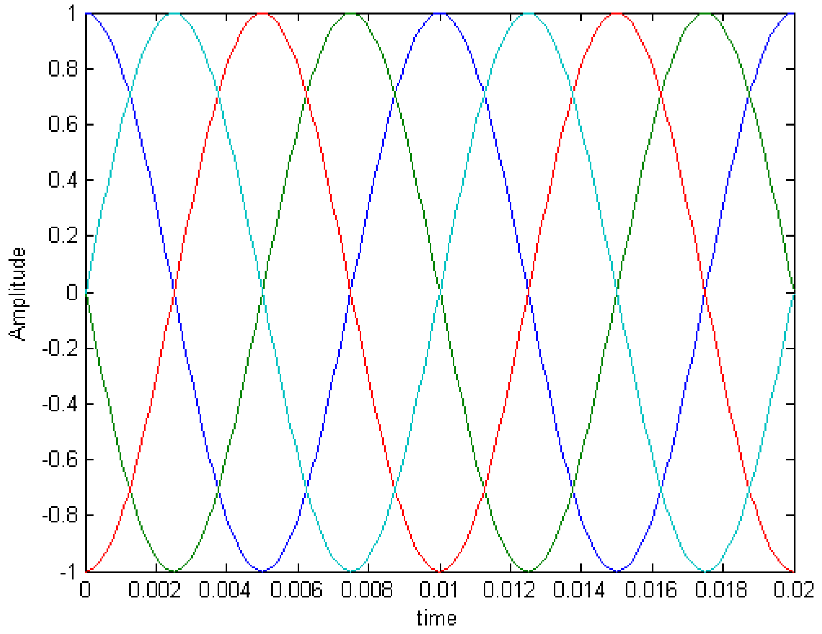
5. Simulation of M- ARY PHASE SHIFT KEYING

Aim: To simulate M-ary PSK.

Program:

```
N=input('enter the no of combinations');
fc=input('enter frequency of the carrier');
ac=input('enter amplitude value');
T=1/fc;
t=0:T/100:2*T;
for n=0:N-1
    s=cos(2*pi*fc*t+2*pi*n/N);
    plot(t,s);
    hold all;
end
xlabel('time');
ylabel('Amplitude');
```

Output:



6. Simulation of DPCM

```
close all
clear
% signal sampling
fs=1/2000;
tn=0:fs:1/25;
%SELECT A SIGNAL ****************************
s=.5*sin(2*pi*50*tn);
%[s,fs]=wavread('bye441');  %read .wav file
 %lpc and encoder-decoder parameters
lpclen=20;
bitsize=input('bitsize=');
fprintf('\nPlease wait... data length is
%i\n',length(s))
%LPF parameters
tap=100;
cf=.15;
 % DPCM with predictor
[Q,b, ai] = dpcm_enco_lpc(s, lpclen, bitsize);
[st]=dpcm_deco_lpc(b, ai, bitsize);
Sa=LPF(tap,cf,st);
%[xa,ya]=stairs(tn,Sa);
figure
subplot(3,1,1):plot(s,'r');
ylabel('amplitude');
title('DPCM with predictor (red:input,
green:decoder output, blue: LPF output)');
subplot(3,1,2):plot(st,'g');
```

```
ylabel('amplitude');
subplot(3,1,3):plot(Sa,'b');
ylabel('amplitude');
xlabel('index, n');
grid
```

Sub Functions:

Dpcm encoding

```
function [Q,b,ai] = dpcm_enco_lpc(s, lpclen,
bitsize)
%function [Q,b, ai] = dpcm_enco_lpc(s, lpclen,
bitsize)
% s : input signal
% bitsize : encoder bit size
% Q : qunatizer output
% b : encoder output
% e = s(i+1) - s(i)
%s = 2^(-1)*s/max(abs(s));
slen = length(s);
e(1) = s(1);
[Q(1),b(1,:)] = pcm_quan_enco(e(1), bitsize);
st(1) = Q(1);
for i=2:slen
   if i<=lpclen
      e(i) = s(i)-st(i-1);
      [Q(i),b(i,:)] = pcm_quan_enco(e(i),
bitsize);
      st(i) = st(i-1) + Q(i);
   else
      m=0;
      [a,G]=lpc(s(i-lpclen:i-1),lpclen);
      a = a*G;
      m = 1:lpclen;
      j=2:lpclen + 1;
      sth = sum(a(j).*st(i-m));
      ai(i,:)=a;
      e(i) = s(i)-sth;
      [Q(i),b(i,:)] = pcm_quan_enco(e(i),
bitsize);
      st(i) = sth + Q(i);
   end
end
b=b';
b=b(:)';
```

LPF for DPCM

```
function Sa=lpf(tap, cf, Sn)
%LPF lowpass filter
%function Sa=LPF(tap,cf,Sn)
%
%tap: filter order.
%cf: cut-off frequency.
%Quantized reconstructed signal.
%Sa: decoder output.
b=fir1(tap,cf);
Sa = conv2(Sn,b,'same');
```

PCM Quantization Encoding:

```
function [Q,B] = pcm_quan_enco(e,bitsize)
%function [Q,b] = pcm_quan_enco(e,bitsize)
% e : input to quantizer
% bitsize : encoder bit size
% Q : qunatazer output
% B : encoder output
 if bitsize<4
  slen = length(e);
  D = 2^(-bitsize);
  switch bitsize
  case 3,
      for i=1:slen
         if e(i) < -3*D
             Q(i) = -(7/2)*D;
          b(i,:) = [ 0 0 0 ];
        elseif e(i) >= -3*D & e(i) < -2*D
            Q(i) = -(5/2)*D;
            b(i,:) = [ 0 0 1 ];
        elseif e(i) >= -2*D & e(i) < -D
            Q(i) = -(3/2)*D;
             b(i,:) = [ 0 1 0 ];
            elseif e(i) >= -D & e(i) < 0
           Q(i) = -(1/2)*D;
             b(i,:) = [ 0 1 1 ];
       elseif e(i) >= 0 & e(i) < D
           Q(i) = (1/2)*D;
            b(i,:) = [ 1 0 0 ];
          elseif e(i) >= D & e(i) < 2*D
          Q(i) = (3/2)*D;
           b(i,:) = [ 1 0 1 ];
            elseif e(i) >= 2*D & e(i) < 3*D
          Q(i) = (5/2)*D;
           b(i,:) = [ 1 1 0 ];
          elseif e(i) >= 3*D
          Q(i) = (7/2)*D;
           b(i,:) = [ 1 1 1 ];
         end
      end
   case 2,
      for i=1:slen
         if e(i) < -D
            Q(i) = -(3/2)*D;
             b(i,:) = [ 0 0 ];
            elseif e(i) >= -D & e(i) < 0
           Q(i) = -(1/2)*D;
            b(i,:) = [ 0 1 ];
         elseif e(i) >= 0 & e(i) < D
            Q(i) = (1/2)*D;
             b(i,:) = [ 1 0 ];
            elseif e(i) >= D
           Q(i) = (3/2)*D;
             b(i,:) = [ 1 1 ];
         end
      end
   case 1,
      for i=1:slen
```

```
         if e(i) < 0
            Q(i) = -(1/2)*D;
             b(i,:) = [ 0 ];
            elseif e(i) >= 0
           Q(i) = (1/2)*D;
            b(i,:) = [ 1 ];
         end
      end
   otherwise
      fprintf('choose a bit size 1,2 or 3.\n');
   end
   b=b';
   B=b(:)';
else
  [b0, b, bb] = dbc(e, bitsize);
  [Q] = bdc(b0,b);
  B = [b0 b];
end
```

Decimal to Binary:

```
function [b0,b,bb]=dbc(x,B);
% [b0,b,bb]=dbc(x,B)
% Decimal-to-Binary conversion using B+1 bit
precision
% x  : a constant in decimal
% B  : number of the precision bit
% b0 : sign bit ( 0 represent + sign, and 1
represents - sign)
% b  : binary bits after the binary point
% bb : (B+1)st bit
B = B-1;
if x>1, error(' x is not normilized.'); end
if x>=0
    b0=0;       % + sign is assigned.
    z=x;
else
    b0=1;       % - sign is assigned.
    z=-x;
end
if z >= 0
    for i=1:B,
    a=2*z;
     if a>=1
    b(i)=1;
    z=a-1;
     else
        b(i)=0;
        z=a;
     end
    end
    a=2*z;
     if a>=1
    bb=1;
      else
        bb=0;
     end
end
```

Dpcm Decoding

```
function [st]=dpcm_deco_lpc(b, ai, bitsize)
%function [st]=dpcm_deco_lpc(b, ai, bitsize)
% b : input to decoder from communication channel
% bitsize : encoder bit size
% st : s_tilda (decoder output to lpf)
[jj,size_ai] = size(ai);
[Q] = pcm_deco_quan(b, bitsize);
st=cumsum(Q(1:size_ai-1));
slen=length(Q);

m=1:size_ai-1;
j=2:size_ai;
for i=size_ai:slen
   sth = sum(ai(i,j).*st(i-m));
   st(i) = Q(i) + sth ;
end
```

Binary-to-Decimal:

```
function [x]=bdc(b0,b);
%  [X]=BDC(b0,b)
%  Binary-to-Decimal  conversion
% b0 : sign bit ( 0 represent + sign, and 1
represents - sign)
% y  : binary bits after the binary point
% x  : a constant in decimal
N=length(b);      % finds the bit precision, B
y=0;
for i=1:N,
y=y+b(i)*2^(-i);  % for  x >0, converts from
binary to decimal
end
x=-b0+y;
if x < 0
[b0,b,bb]=dbc(x,N+1); %+1 bit is for sign
y=0;
  for i=1:N,
  y=y+b(i)*2^(-i);    end
end
x=-b0+y;
```

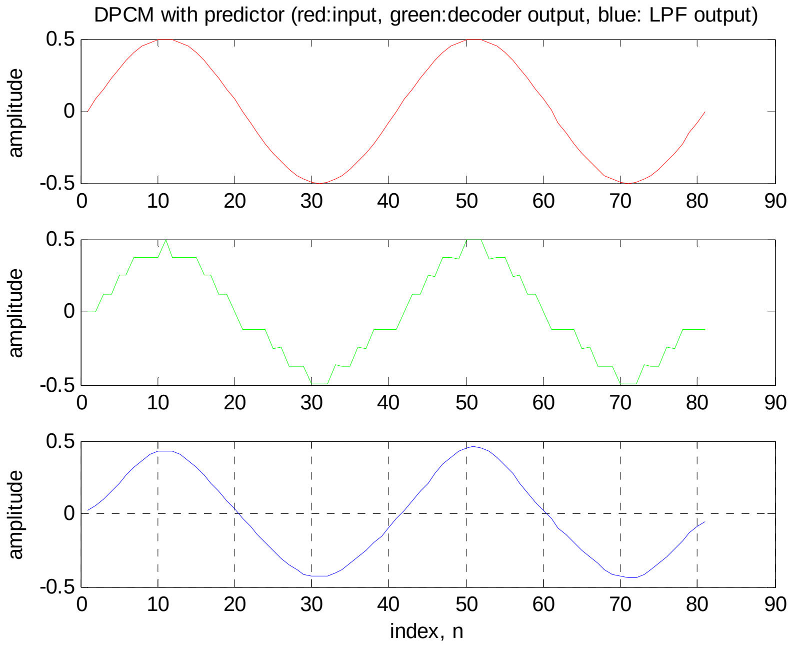
PCM Quantization Decoding:

```
function [Q] = pcm_deco_quan(B,bitsize)
% function [Q,b] = pcm_deco_quan(b,bitsize)
% pcm decoder and quantizer
% bitsize : encoder bit size
% B : input to decoder from encoder ouput
% Q : qunatazer output
if bitsize<4
  b=B;
  slen = length(b);
  D = 2^(-bitsize);
  i = 0;
  for j=1:bitsize:slen
   mask=j:j+bitsize-1;
   i = i+1;
   switch bitsize
      case 3,
         if b(mask) == [ 0 0 0 ]
             Q(i) = -(7/2)*D;
        elseif b(mask) == [ 0 0 1 ]
            Q(i) = -(5/2)*D;
         elseif b(mask) == [ 0 1 0 ]
            Q(i) = -(3/2)*D;
            elseif b(mask) == [ 0 1 1 ]
           Q(i) = -(1/2)*D;
       elseif b(mask) == [ 1 0 0 ]
           Q(i) = (1/2)*D;
          elseif b(mask) == [ 1 0 1 ]
          Q(i) = (3/2)*D;
```

```
            elseif b(mask) == [ 1 1 0 ]
          Q(i) = (5/2)*D;
          elseif b(mask) == [ 1 1 1 ]
          Q(i) = (7/2)*D;
         end
      case 2,
         if b(mask) == [ 0 0 ]
            Q(i) = -(3/2)*D;
            elseif b(mask) == [ 0 1 ]
           Q(i) = -(1/2)*D;
         elseif b(mask) == [ 1 0 ]
            Q(i) = (1/2)*D;
            elseif b(mask) == [ 1 1 ]
           Q(i) = (3/2)*D;
       end
      case 1,
         if b(mask) == [ 0 ]
            Q(i) = -(1/2)*D;
            elseif b(mask) == [ 1 ]
           Q(i) = (1/2)*D;
         end
      otherwise
         fprintf('choose a bit size 1,2 or
3.\n');
      end
   end
else
  slen=length(B)
  i = 0;
  for j=1:bitsize:slen
     i = i + 1;
   mask=j:j+bitsize-1;
     bb = B(mask);
     b0 = bb(1);
     b = bb(2:bitsize);
     Q(i)=bdc(b0,b);
  end
end
```

Output:

```
bitsize=4
data length is 81
slen =324
```



7. (i) DFT USING DIT

```
function b=ditdft(a)
a=bitrevorder(a);
N=length(a);
l=log2(N);
for     m=1:1:l
for t=0:1:((2^(m-1))-1)
    k(t+1)=(N*t)/2^m;
    wn(t+1)=exp((-2*i*pi*k(t+1))/N);
end
for p=1:2^m:(N-2^(m-1))
    r=1;
    x=p;
    for q=x+2^(m-1):1:(x+2^m)-1
        b(p)=a(p)+a(q)*wn(r);
        b(q)=a(p)-a(q)*wn(r);
        p=p+1;
        r=r+1;
    end
end
end
return;
Output:
 a=[1 2 2 2]
 b=ditdft(a)          b=[7    -1    -1    -1]
```

7. (ii)IDFT USING DIT

```
function a =idftdit(a)
a=conj(a);
a=ditdft(a);
a=(a/length(a));
a=conj(a);
return;
 a=[7 -1 -1 -1];
b=idftdit(a)
     b= 1     2     2     2
```

8. (i)FFT USING DIF

```
function a=difdft(a)
N=length(a);
l=log2(N);
for     m=l:-1:1
for t=0:1:((2^(m-1))-1)
    k(t+1)=(N*t)/2^m;
    wn(t+1)=exp((-2*i*pi*k(t+1))/N);
end
for p=1:2^m:(N-2^(m-1))
    r=1;
    x=p;
    for q=x+2^(m-1):1:(x+2^m)-1
        b(p)=a(p)+a(q);
        b(q)=(a(p)-a(q))*wn(r);
        p=p+1;
        r=r+1;
    end
end
a=b;
end
a=bitrevorder(a);
return;
```

<u>Output:</u>

```
a=[1 2 3 4]
X=dftdif(a)
X =  10.0000            -2.0000 + 2.0000i  -
2.0000            -2.0000 - 2.0000i
```

8. (ii)IDFT USING DIF

```
function r =idftdif(a)
a=conj(a);
a=difdft(a);
a=(a/length(a));
r=conj(a);
return;
```

Output:

```
 A =  10.0000            -2.0000 + 2.0000i  -
2.0000            -2.0000 - 2.0000i
r =idftdif(a)
a=[1  2  3  4]
```

9. DESIGN OF BUTTERWORTH FILTER USING IMPULSEINVARIENT METHOD

```
function [b,a] =butteriit(wp,ws,ap,as,t);
p=(10^(0.1*ap)-1)^0.5;
s=(10^(.1*as)-1)^0.5;
n=ceil(log(p/s)/log(wp/ws));
wc=wp/(p^(1/n)*t);
[u,v]=butter(n,wc,'s');
[r,p,k]=residue(u,v);
p=exp(p*t);
[b,a]=residue(r,p,k)
```

Output:

```
[b,a] =butteriit(.2*pi,.3*pi,7,16,1)
  a =
     1.0000   -2.0233    1.4675   -0.3690
  b =
          0    0.0438    0.0314
```

10.DESIGN OF LPF USING HAMMING WINDOW

```
function []=hamm(wp,ws)
T=ws-wp;
wc=ws-wp;
wc=(ws+wp)/2;
M=ceil(6.6*pi/t)+1;
hd=ideal-lp(wc,M);
function hd=ideal-lp(wc,M)
x=(M-1)/2;
n=[0:M-1];
m=n-x+eps;
hd=sine(wc*m)./(pi*m);
for i=1:m
w-ham(1)=0.54-.46*cos(2*pi*()i-1)/M;
end
M=hd.*w-ham;
subplot(2,2,1);stem(h,hd);titll('Ideal Imp
Responce');
axis([0 M-1-.1 0.4]);Xlable('n');Ylble('hd(n));
subplot(2,2,2);steam(n,w-ham);
title('Hamming window')
axis([0 M-1 0 1.1);Xlable('n');Ylable('hd(n));
subplot(2,2,3);stem(n,H);title('Actual Imp
Responce')
axis([0 N-1 .1 .4]);Xlable('n');
Y lable('H(n)');
```

11. (i) LINEAR CONVOLUTION

```
x=input ('Enter first sequence;')
h=input ('Enter Second sequence;')
m=length(x);
n=length (h);
l=m+n-1;
for i=1:l
    r(i)=0;
end
for k=1:l
    for j=max(1,k+1-n):min(k, m)
        r(k)=r(k)+x(j)*h(k+1-j);
    end
end
```

```
Enter first sequence; [1 2 3]
Enter Second sequence; [1 2 3 4]
r = [ 1     4    10    16    17    12]
```

11. (ii) CIRCULAR CONVOLUTION

```
a=input('Enter first sequence:');
b=input('Enter Second sequence:');
x=length(a);
y=length(b);
z=max(x,y);
if x>y
    for i=y+1:x
        b(i)=0;
    end
elseif x<y
    for j=x+1:y
    a(j)=0
        end
end
for i=1:z
     c(i)=0;
    for k=1:z
    j=(i-k)+1;
    if (j<=0)
        j=z+j;
    end
    c(i)=c(i)+(a(k)*b(j));
    end
end
```

Enter 1st sequence: [1 2 2 2]

Enter 2nd sequence: [1 2 3]

```
          c =[   11    10     9    12]
```

12. (i) AUTO-CORRELATION

```
a=input('Enter the sequence:');
n1=length (a);
 n=2*n1-1;
b=zeros(1,n);
c=zeros(1,n);
d=zeros(1,n);
n2=n-n1;
 for i=1:n1
b(i)=a(i);
end
 for i=n2:n-1
c(i+1)=a(i+1-n2);
end
for i=1:n
d(i)=sum(b.*c);
for j=n:-1:2
b(j)=b(j-1);
end
b(i)=0;
end
Enter first sequence: [1 2 3 4]
Ans = [4  11  20  30  20  11  4]
```

12. (ii) CROSS-CORRELATION

```
x=input('Enter first sequence:');
h1=input('Enter Second sequence:');
m=length(x);
n=length(h1);
h(n:-1:1)=h1(1:n);
l=m+n-1;
for i=1:l
    r(i)=0;
end
for k=1:l
    for j=max(1,k+1-n):min(k,m)
        r(k)=r(k)+x(j)*h(k+1-j);
    end
end

Enter first sequence:[1 2 2 2]
Enter Second sequence:[2 2 3]
ans: r =[  3     8    12    14     8     4]
```