Principles of Communication Systems Lab

Lab 3, 4th September 2019

Pratyush Nandi (IMT2017518)

Answer to Q1

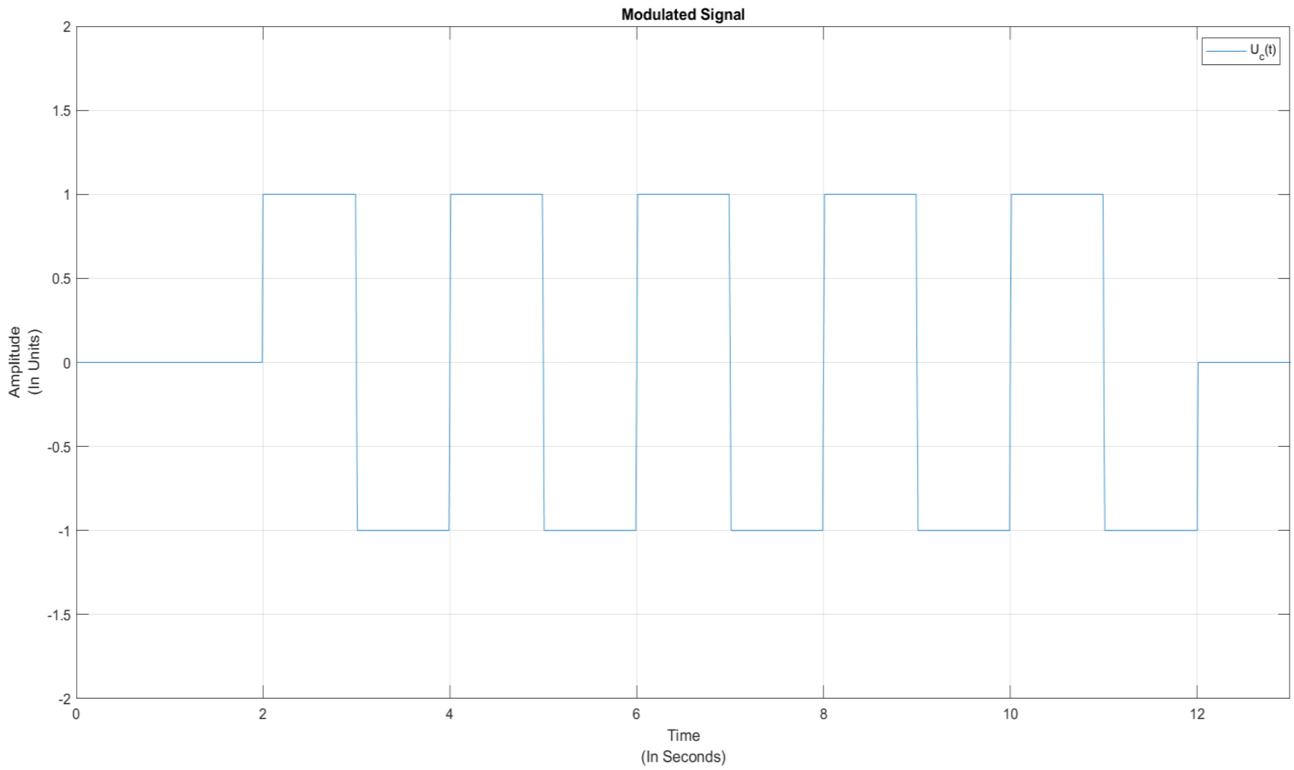
Note: For question 1

uc(t) = Σn=1N bc[n]p(t−n), us(t) = Σn=1N bs[n]p(t−n),

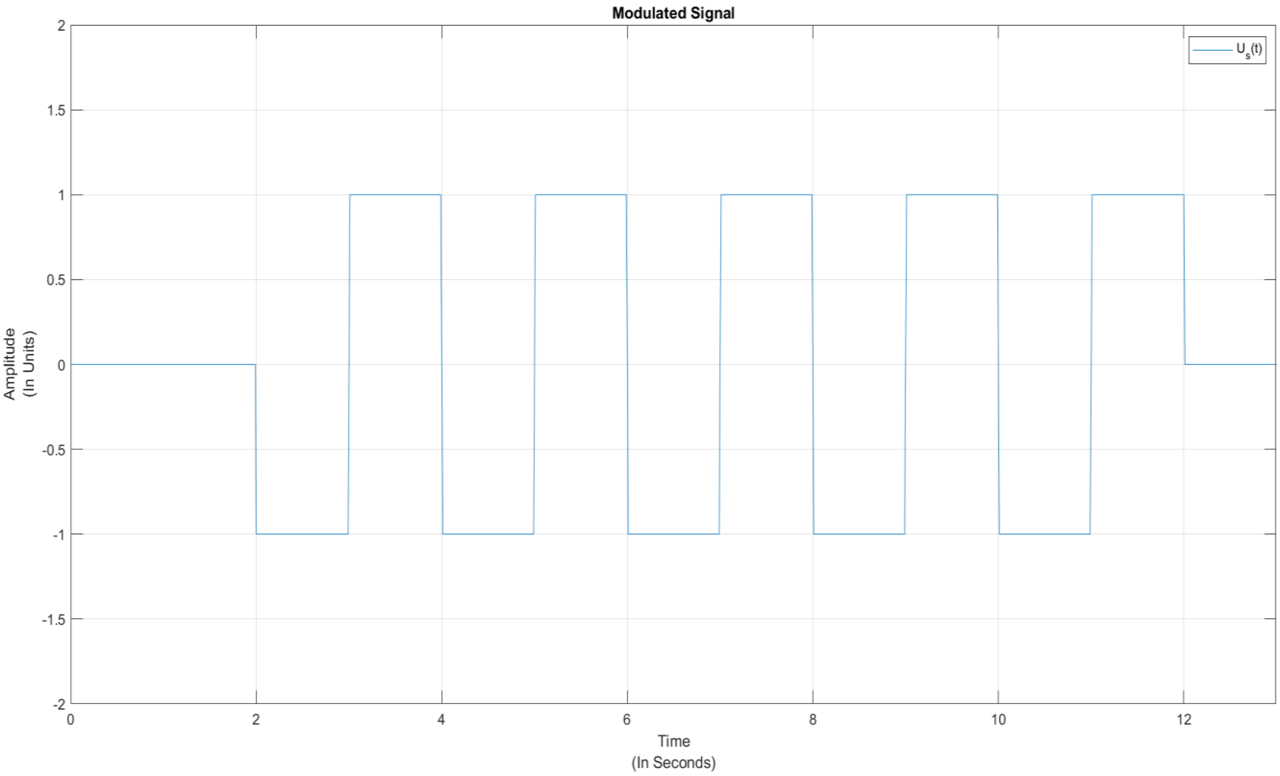
where p(t) = I[0,1](t), m = 100, N = 100,

bc = [1,-1,1,-1,1,-1,1,-1,1,-1],
bs = [-1,1,-1,1,-1,1,-1,1,-1,1],
up,1(t) = uc(t)cos40πt,
up(t) = uc(t)cos40πt – us(t) sin40πt
Unit time is in seconds and sampled at 1KHz frequency.

1.1.1:

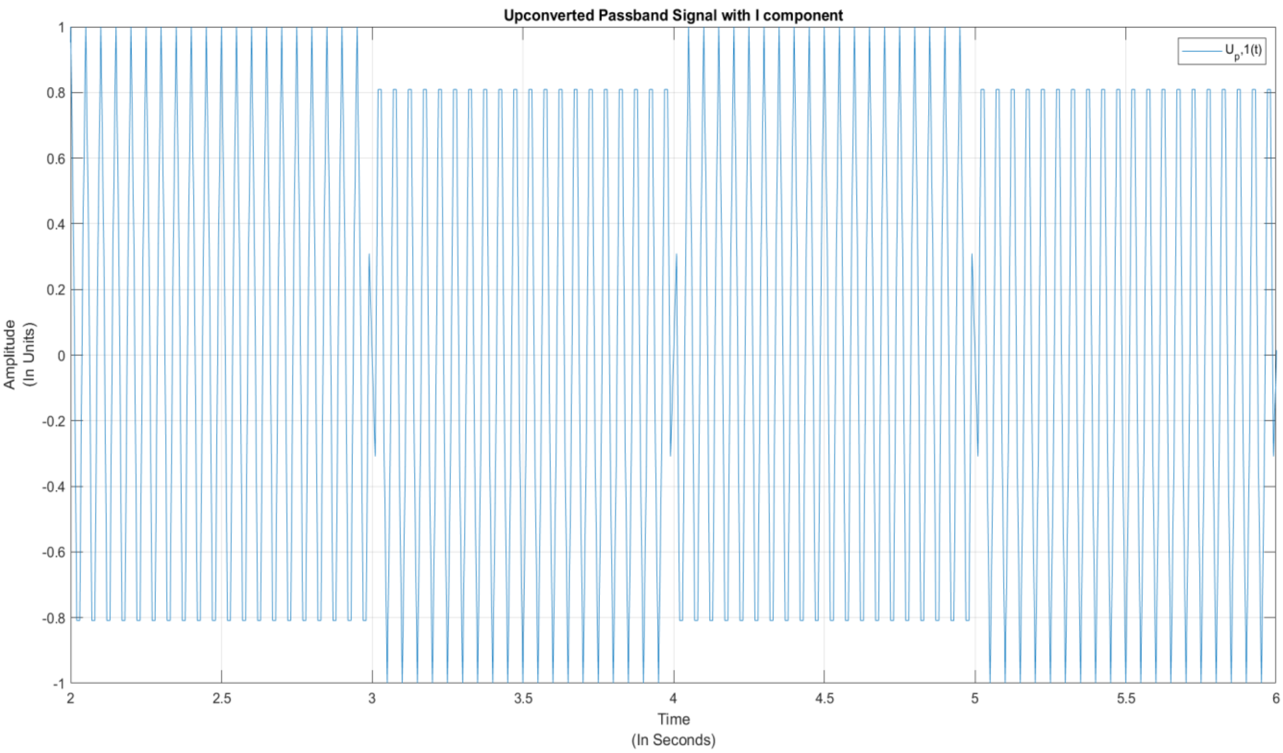


1.1.2:



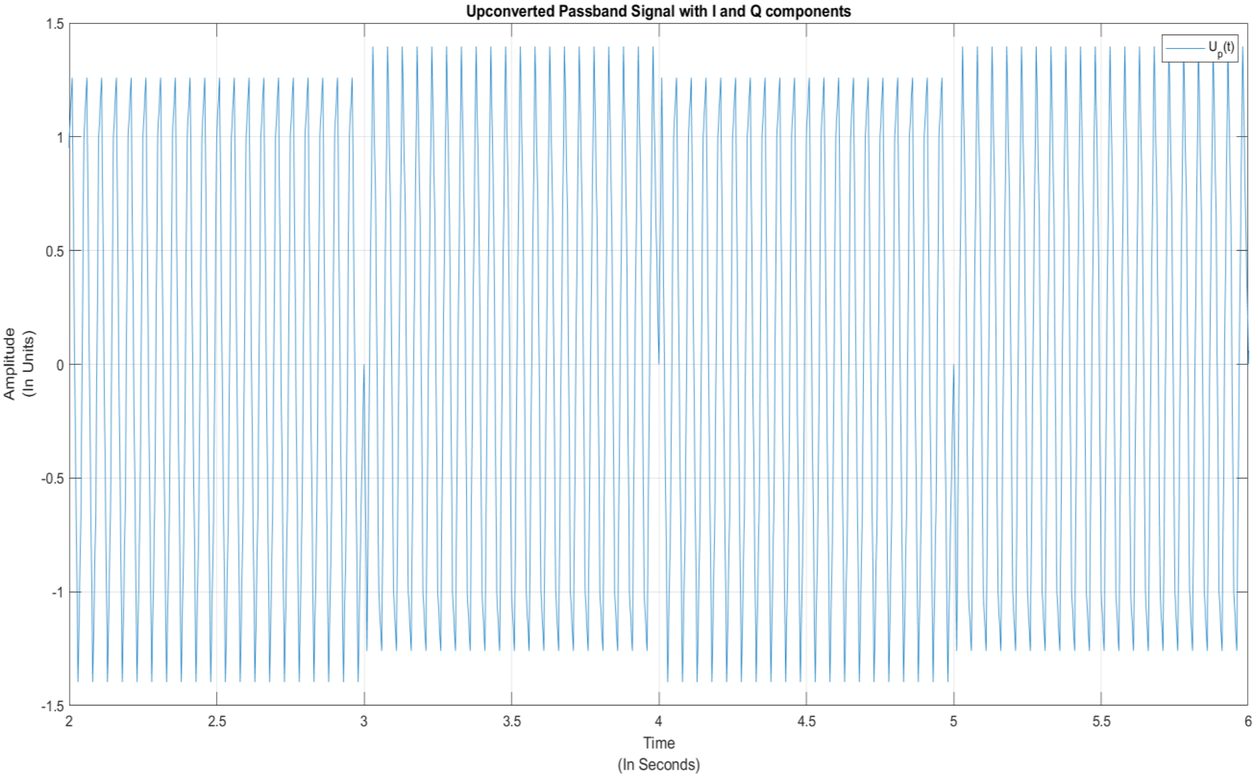
Modulated Signal
U_s(t)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
Amplitude
(In Units)
0
2
4
6
8
10
12
Time
(In Seconds)

1.2:

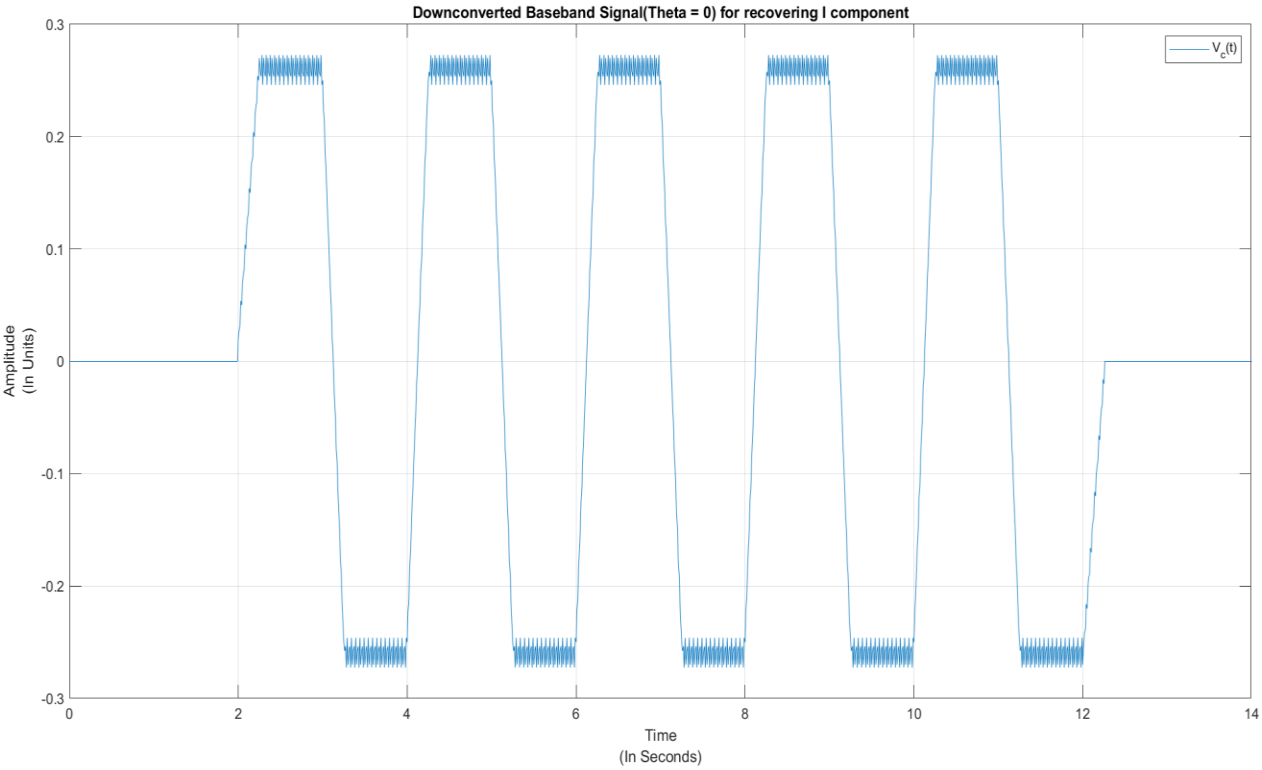


Upconverted Passband Signal with I component
U_p,1(t)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Amplitude
(In Units)
2
2.5
3
3.5
4
4.5
5
5.5
6
Time
(In Seconds)

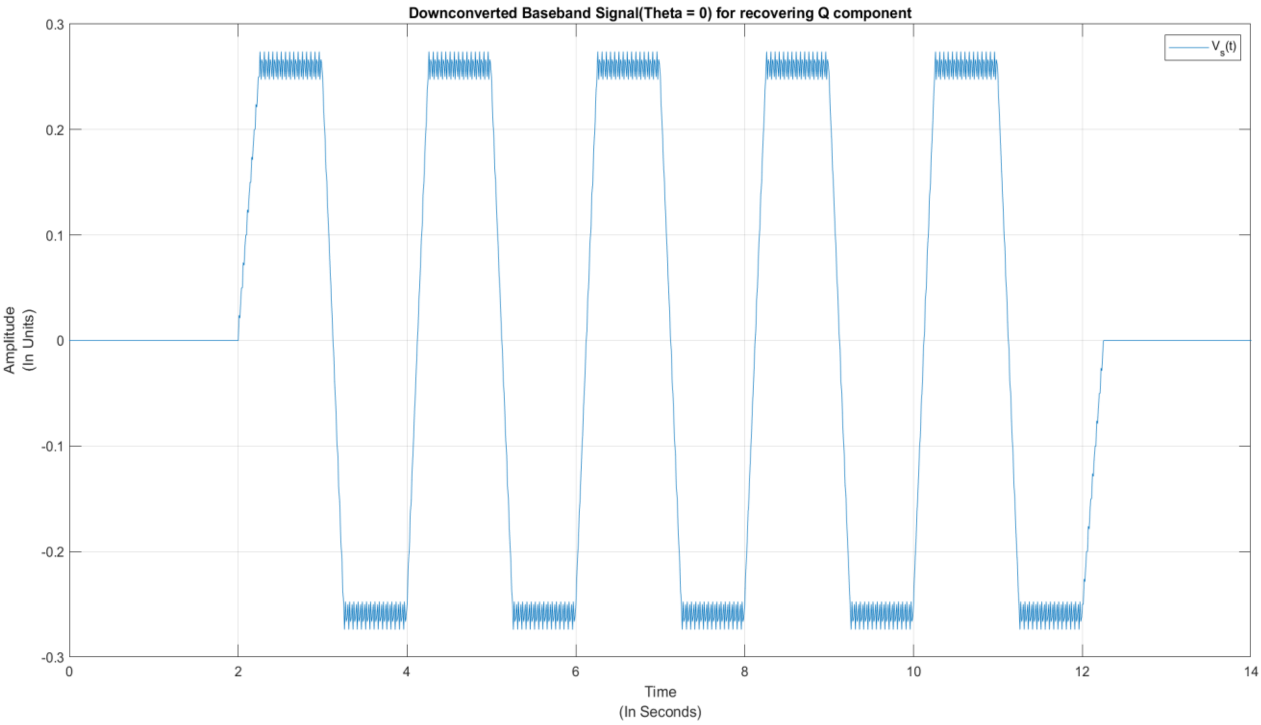
1.3:


Upconverted Passband Signal with I and Q components
$U_p(t)$
Amplitude
(In Units)
Time
(In Seconds)
1.5
1
0.5
0
-0.5
-1
-1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

1.4.1:

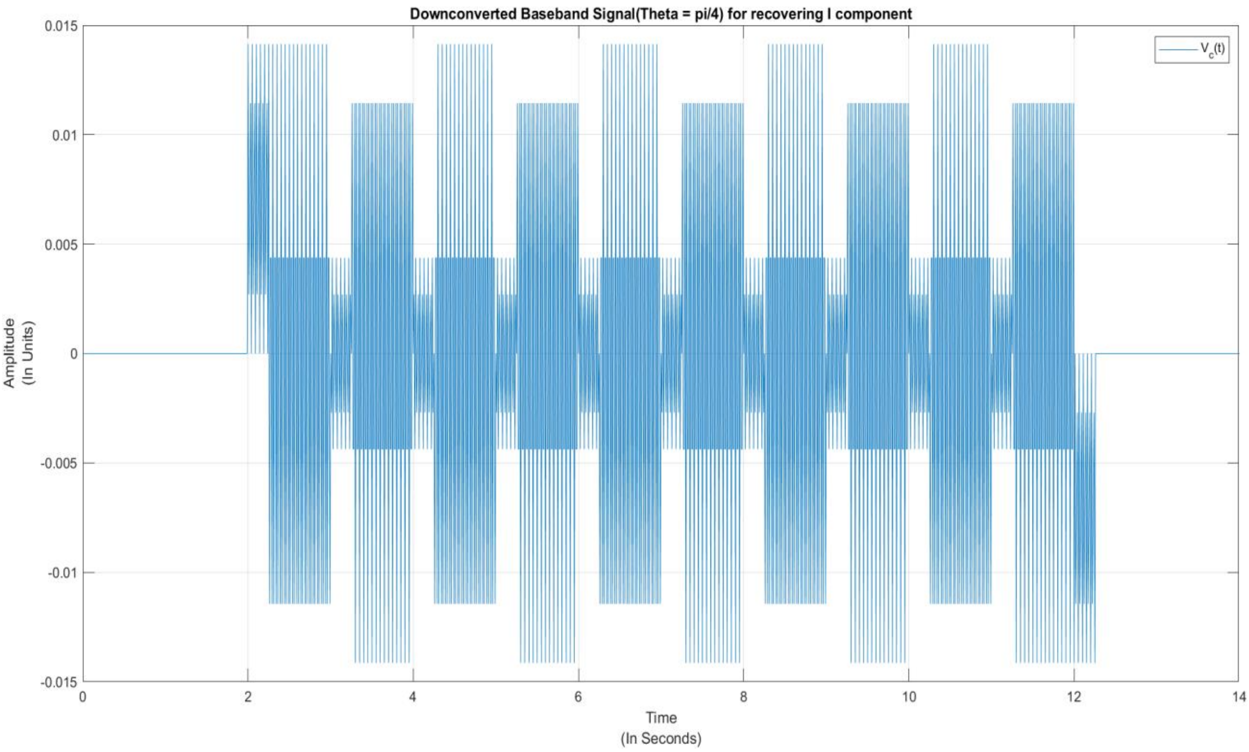

Downconverted Baseband Signal(Theta = 0) for recovering I component
$V_c(t)$
Amplitude
(In Units)
Time
(In Seconds)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
0
2
4
6
8
10
12
14

1.4.2:

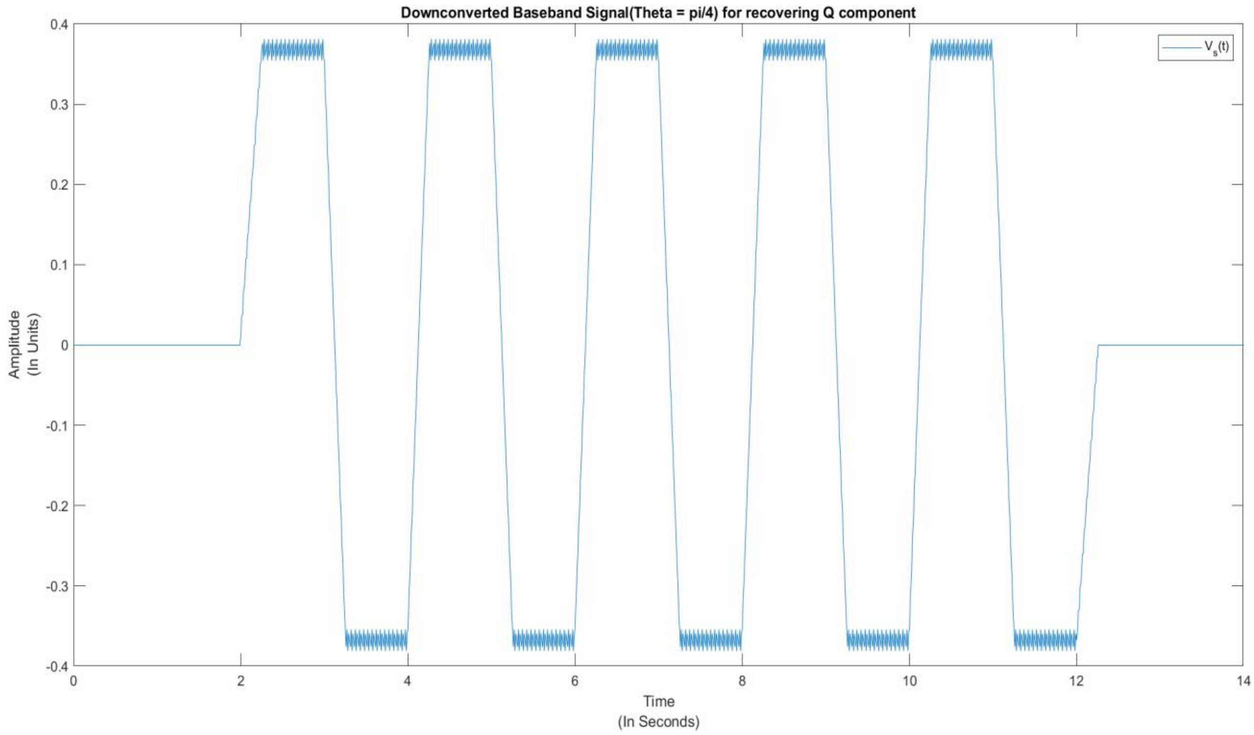


Ans: It is possible to read the graph by eyeballing. The graph shown in 1.4.2 is actually Us*(-cos(0)) and the graph shown in 1.4.1 is actually Uc(cos(0)).

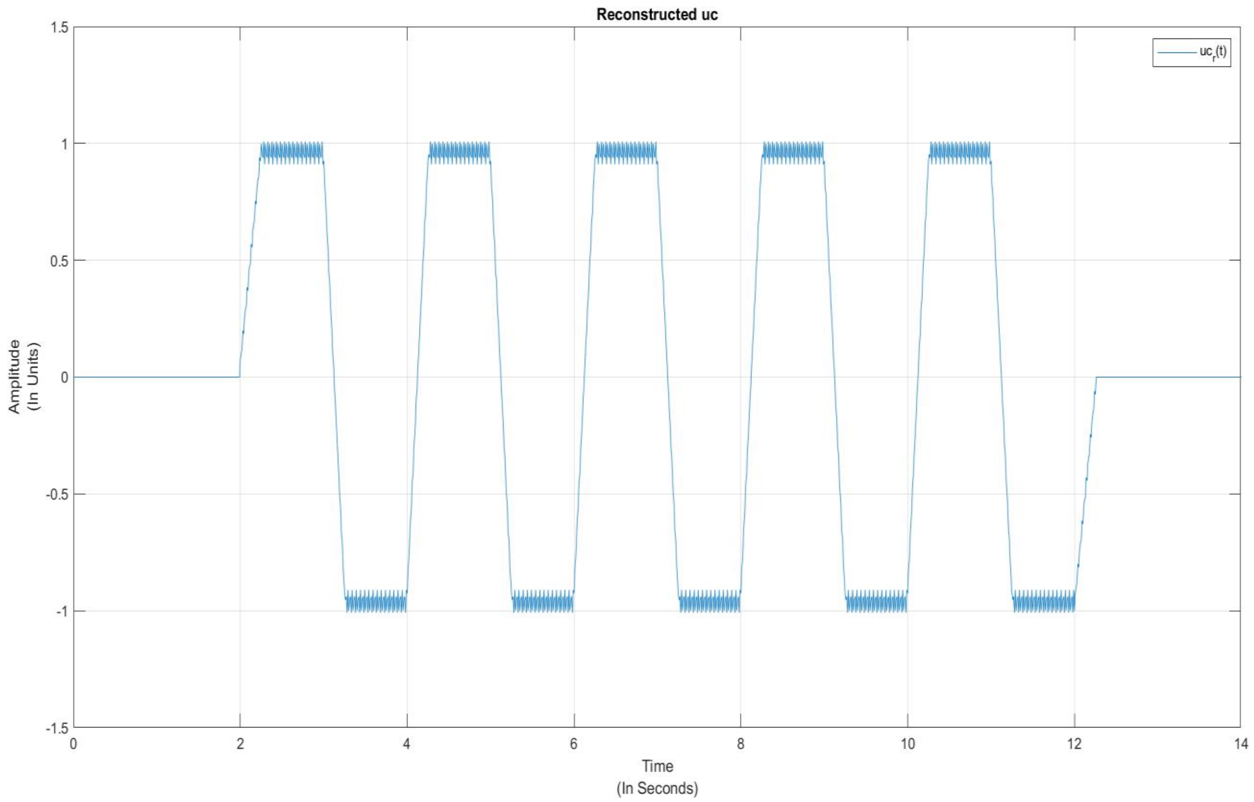
1.5.1:



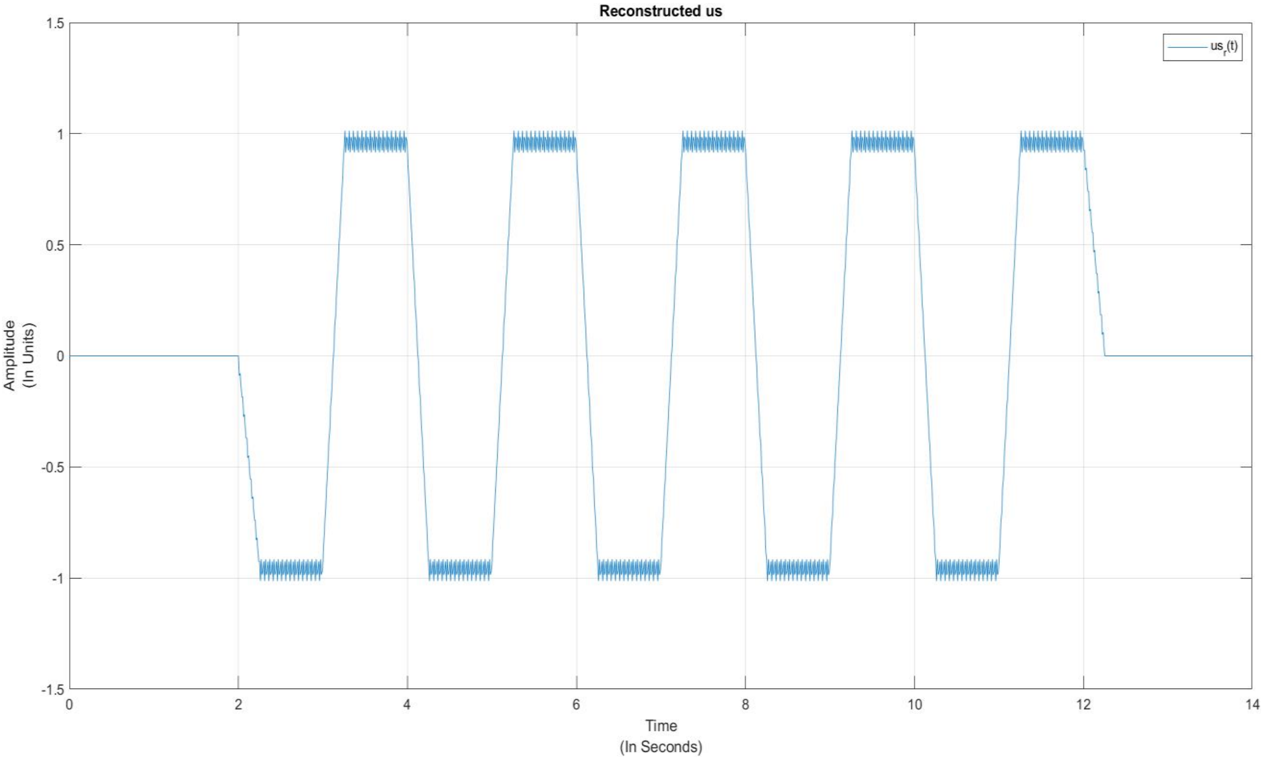
1.5.2:


Downconverted Baseband Signal(Theta = pi/4) for recovering Q component
$V_s(t)$
Amplitude
(In Units)
Time
(In Seconds)

1.6.1:


Reconstructed uc
$uc_r(t)$
Amplitude
(In Units)
Time
(In Seconds)

1.6.2:



Ans: 1.6.1 and 1.6.2 graphs represent the reconstructed version of the original Uc and Us signals.

To recunstruct the signal we use

Uc(bar) = Vc*cos(theta= pi/4) + Vs*sin(theta=pi/4)

Us(bar) = Vc*cos(theta= pi/4) - Vs*sin(theta=pi/4).

Appendix:

```
function upsampling
theta = pi/4;
m =  100;
N = 100;
dt = 1/m;
t = -2:dt:2;
p = signalx(t);
bc = [1,-1,1,-1,1,-1,1,-1,1,-1];
bs = [-1,1,-1,1,-1,1,-1,1,-1,1];
[uc,tc] = upsampler(p,bc,m,10);
[us,ts] = upsampler(p,bs,m,10);
figure(1);
plot(tc,uc);
xlim([0 13]);
ylim([-2 2]);
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Modulated Signal');
```

```
legend('U_c(t)');
grid on;
figure(2);
plot(ts,us);
xlim([0 13]);
ylim([-2 2]);
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Modulated Signal');
legend('U_s(t)');
grid on;
[uc1,tc1] = upsampler(p,bc,m,4);
[us1,ts1] = upsampler(p,bs,m,4);
up1 = uc1.*cos(tc1.*40*pi);
figure(3);
plot(tc1,up1);
xlim([2 6]);
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Upconverted Passband Signal with I component');
legend('U_p,1(t)');
grid on;
up_1 = uc1.*cos(tc1.*40*pi) - us1.*sin(ts1.*40*pi);
up = uc.*cos(tc.*40*pi) - us.*sin(ts.*40*pi);
figure(4);
plot(tc1,up_1);
xlim([2 6]);
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Upconverted Passband Signal with I and Q components');
legend('U_p(t)');
grid on;
h = lowpassfilter(t);
[udc,tdc] =
contconv(double(2*up.*(cos(tc.*40*pi))),double(h),tc(1),t(1),dt);
figure(5);
plot(tdc,udc);
xlim([0 14]);
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Downconverted Baseband Signal(Theta = 0) for recovering I
component');
legend('V_c(t)');
grid on;
[uds,tds] =
contconv(double(2*up.*(sin(ts.*40*pi))),double(h),ts(1),t(1),dt);
figure(6);
plot(tds,uds);
xlim([0 14]);
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Downconverted Baseband Signal(Theta = 0) for recovering Q
component');
legend('V_s(t)');
grid on;
[udco,tdco] =
contconv(double(2*up.*(cos(tc.*40*pi+theta))),double(h),tc(1),t(1),dt);
figure(7);
plot(tdco,udco);
xlim([0 14]);
grid on;
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Downconverted Baseband Signal(Theta = pi/4) for recovering I
component');
legend('V_c(t)');
```

```
[udso,tdso] =
contconv(double(2*up.*(sin(ts.*40*pi+theta))),double(h),ts(1),t(1),dt);
figure(8);
grid on;
plot(tdso,udso);
xlim([0 14]);
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Downconverted Baseband Signal(Theta = pi/4) for recovering Q
component');
legend('V_s(t)');
uc_ = (udco*cos(pi/4) + udso*sin(pi/4))*3.7;
us_ = (udco*sin(pi/4) - udso*sin(pi/4))*3.7;
figure(9);
plot(tdco,uc_);
xlim([0 14]);
grid on;
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Reconstructed uc');
legend('uc_r(t)');
figure(10);
plot(tdso,us_);
grid on;
xlim([0 14]);
xlabel({'Time','(In Seconds)'});ylabel({'Amplitude','(In Units)'});
title('Reconstructed us');
legend('us_r(t)');
end
function [y,t] = contconv(x1,x2,s1,s2,dt)
y = conv(x1,x2)*dt;
s1_2 = s1 + (length(x1)-1)*dt;
s2_2 = s2 + (length(x2)-1)*dt;
t1 = s1+ s2;
t2 = s2_2 + s1_2;
t = t1:dt:t2;
end
function [s,t] = upsampler(p,bc,m,N)
nsymbols = length(bc);
nsymbols_upsampled = 1 + (nsymbols - 1) * m;
symbols_upsampled = zeros(nsymbols_upsampled, 1);
symbols_upsampled(1:m:nsymbols_upsampled) = bc;
s1 = conv(symbols_upsampled,double(p));
s = s1.';
t = 0:1/m:(length(s) - 1)/m;
end
function u = signalx(t)
syms x;
y = piecewise(0 <= x <= 1, 1, 0);
u = subs(y,x,t);
end
function u = lowpassfilter(t)
syms x;
y = piecewise(0 <= x <= 0.25, 1, 0);
u = subs(y,x,t);
end
```