EE5193: Wireless Communication Lab

Lab sheet. No: 02

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Consider a pair of independently pulse-modulated signals

uc(t) = $\sum_{n=1}^{N} \mathbf{bc}[\mathbf{n}]\mathbf{p}(\mathbf{t} - \mathbf{nT})$ **and us(t)=** $\sum_{n=1}^{N} \mathbf{bs}[\mathbf{n}]\mathbf{p}(\mathbf{t} - \mathbf{nT})$

where the symbols bc[n] and bs[n] are chosen with equal probability to be +1 or −1, and p(t) = I[0,T](t) is a rectangular pulse. Let N = 100.

Q1. Use Matlab to plot a typical realization of uc(t) and us(t) over 10 symbols. Make sure you sample fast enough for the plot to look reasonably nice.

AIM: To generate and plot the bit stream of +1,-1 with equal probability over 10 symbols.

Short Theory:

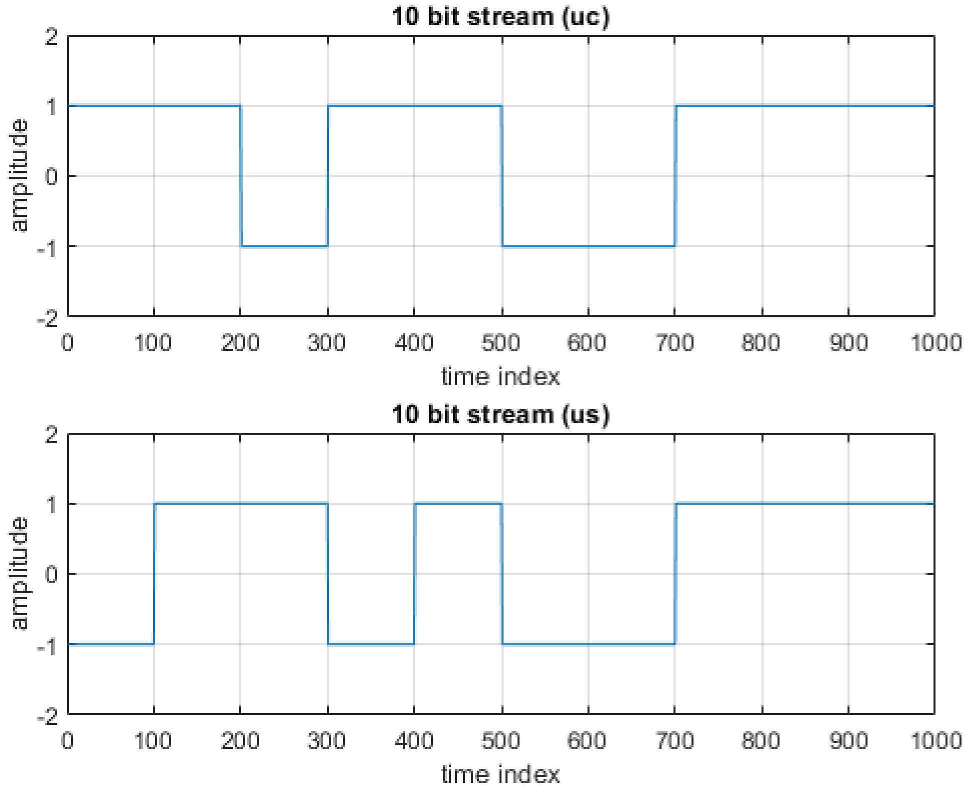
To generate random bit stream with equal probability, first we generate uniformly distributed random variables and we assign +1 and -1 to those uniformly generated random variables with equal probability. In MATLAB we use rand command to generate uniformly distributed random variables.

Key Commands:

rand % it generates the uniform distributed random numbers.

Conv %it convolves the 2 sequences

Plots:



Inferences/comments:

1) we can also use the 'stairs' command to plot the rectangular pulses(bit stream).

2)by using plot command we can not draw the rectangular pulses of bit stream directly, if we want rectangular pulse for one sample so we need to represent the one sample in more samples with same amplitude in the pulse period.

Q2. Up-convert the baseband waveform uc(t) to get

up,1(t) = uc(t)cos40πt --------------(1)

This is so-called binary phase shift keyed (BPSK) signal, since the phase changes whenever the sign of the transmitted symbol switches. Plot the passband signal up,1(t) over four symbols (you will need to sample at a multiple of the carrier frequency for the plot to look nice, which means you might have to go back and increase the sampling rate beyond what was required for the baseband plots to look nice).

AIM: To generate and plot the binary phase shift keyed (BPSK) signal over 4 symbols.

Short Theory:

Binary Phase-shift keying (BPSK) is a digital modulation scheme that conveys data by changing, or modulating, two different phase s of a reference signal . If the bit sample value is +1 then it up sampled by cos(wt) else up sampled by cos(wt+180)

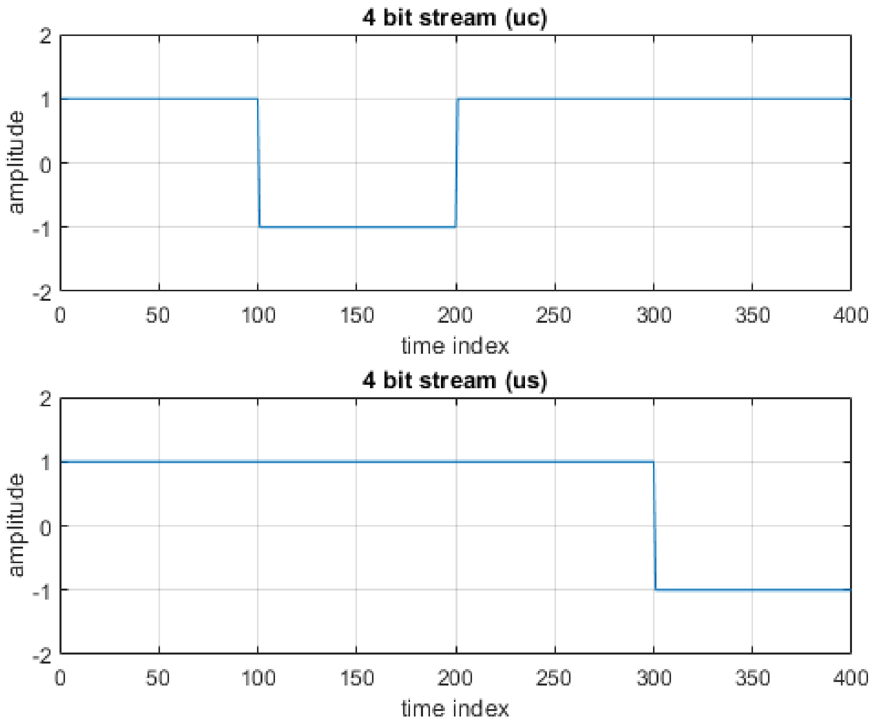
Key Commands:

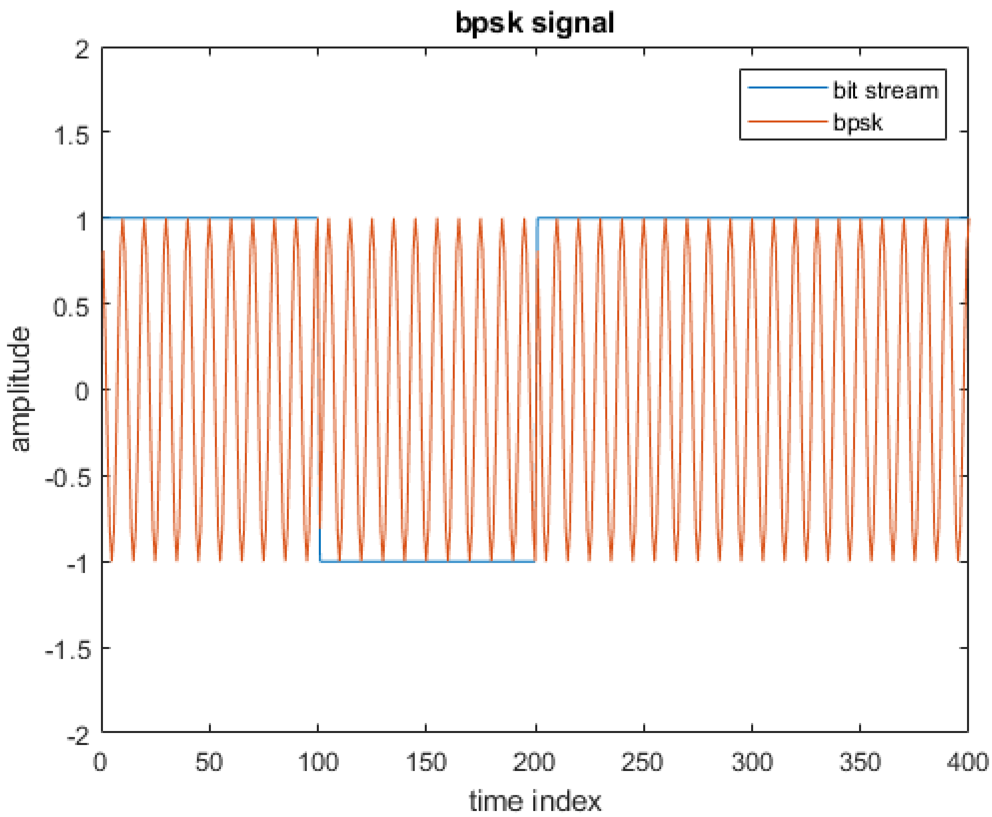
rand % it generates the uniform distributed random numbers.

Conv %it convolves the 2 sequences

cos(x) % this command gives the values of cos(x)

Plots:





Inferences/comments:

if a successive bit amplitude changes We can observe phase (change)error in the plot.

Q3. Now, add in the Q component to obtain the passband signal

$u_p(t) = u_c(t)\sqrt{2}\cos(40\pi t) - u_s(t)\sqrt{2}\sin(40\pi t)$ ----------------------(2)

Plot the resulting Quadrature Phase Shift Keyed (QPSK) signal up(t) over four symbols.

AIM: To generate and plot the Quadrature Phase Shift Keyed (QPSK) signal up(t) over four symbols.

Short Theory:

Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees).

Qpsk has 4 symbols, each symbol is represented by 2 bits, and it is up sampled by Cos(wt+(m-1)pi/2),where m=1,2,3,4.

Key Commands:

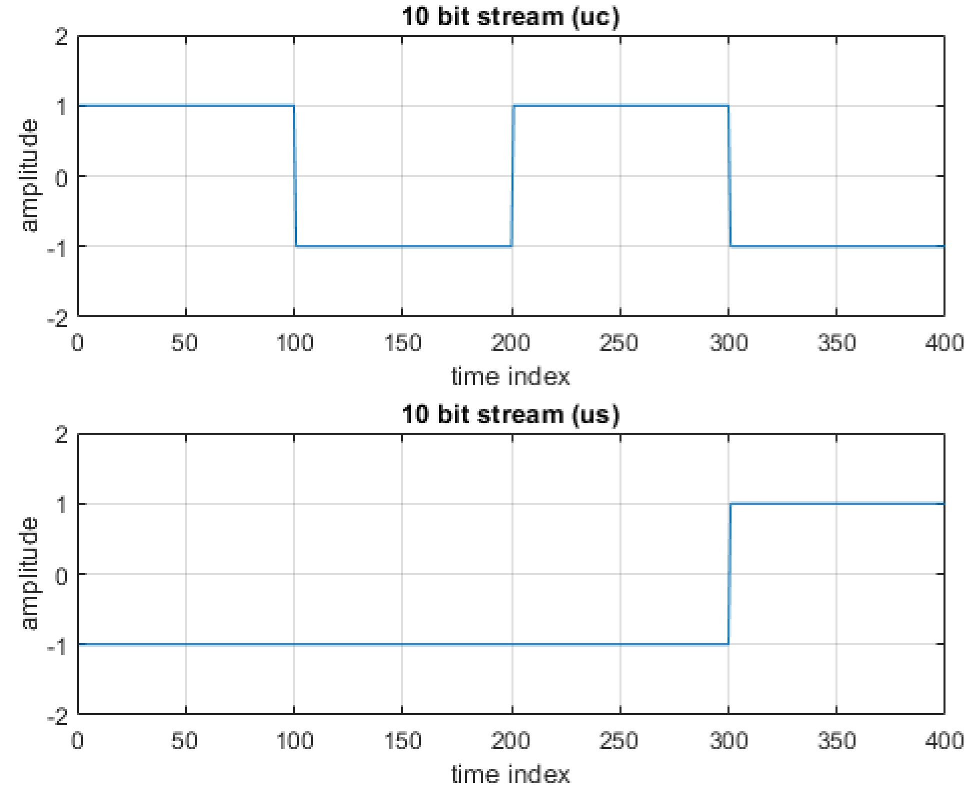
rand % it generates the uniform distributed random numbers.

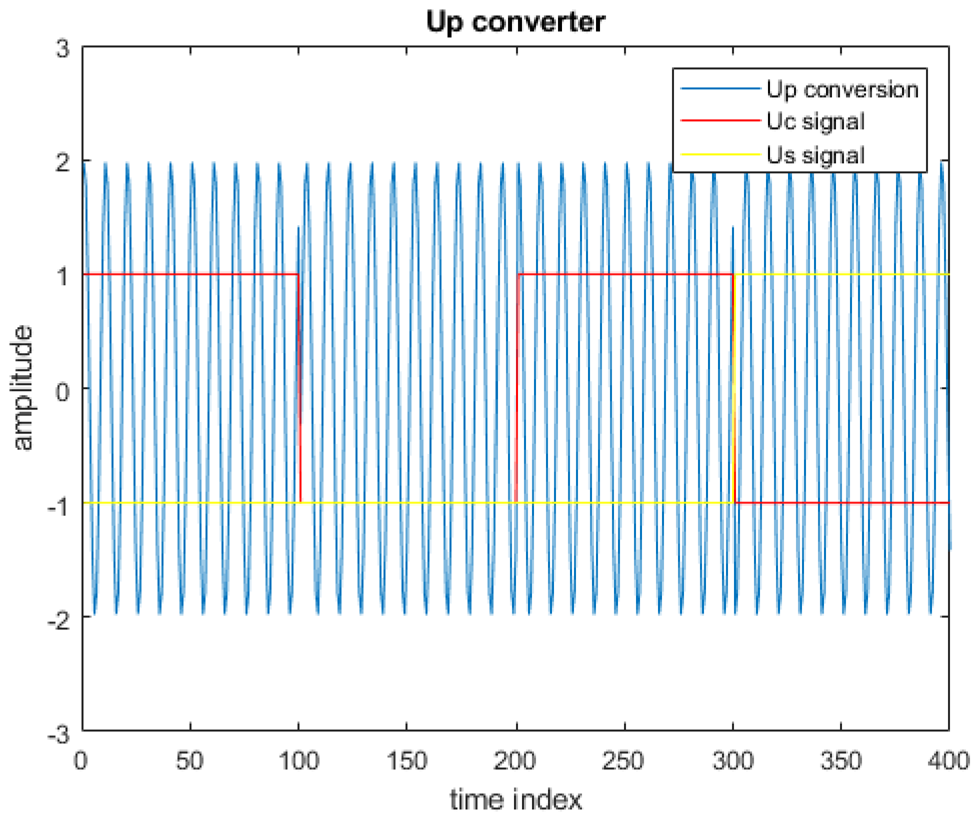
Conv %it convolves the 2 sequences

cos(x) % this command gives the values of cos(x)

Sin(x) %this command gives the values of sin(x)

Plots:





Inferences/comments:

if a bit amplitude changes We can observe phase (change)error in the plot.

Q4. Down-convert up(t) by passing up(t)√2cos(40πt + θ) and up(t)(−√2)sin(40πt + θ) through crude lowpass filters with impulse response h(t)= I[0,0.25](t). Denote the resulting I and Q components by vc(t) and vs(t), respectively. Plot vc and vs for θ = 0 over 10 symbols. How do they compare to uc and us ? Can you read off the corresponding bits bc[n] and bs[n] from eyeballing the plots for vc and vs?

AIM: To Down covert Up(t) by passing through low pass filter with impulse response h(t)= I[0,0.25](t).

Short Theory:

The up converted signal is down converted by multiplyng the same signal used in the up convertion and passing resultant signal through low pass filter , we can retrive the original bit stream signal.

Key Commands:

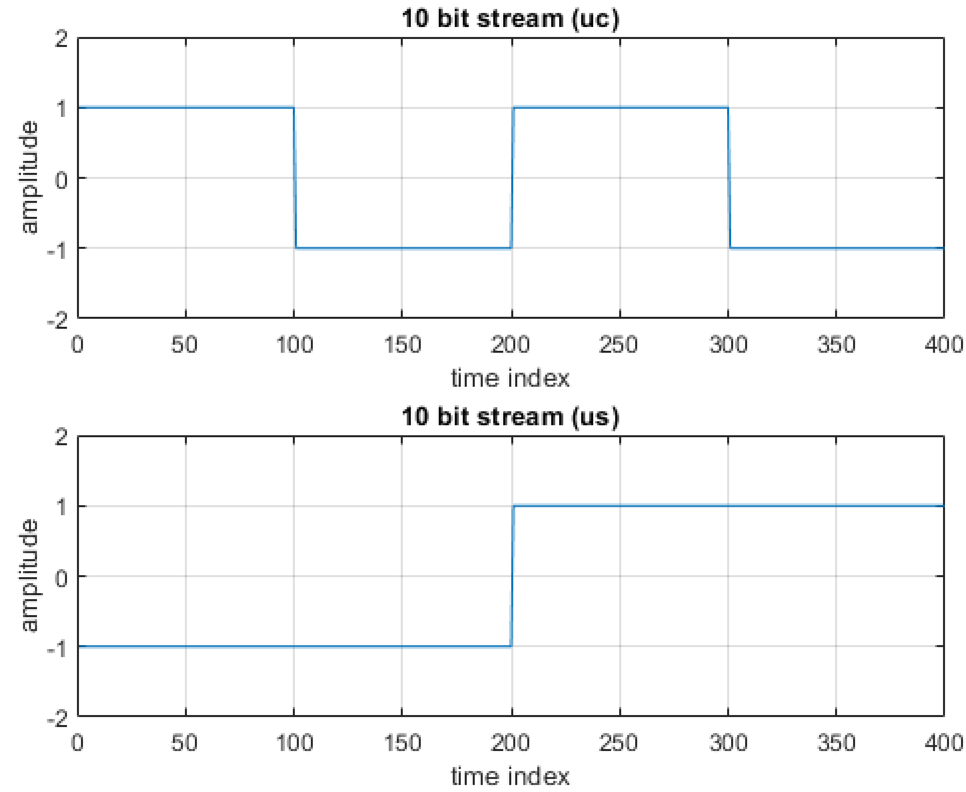
rand % it generates the uniform distributed random numbers.

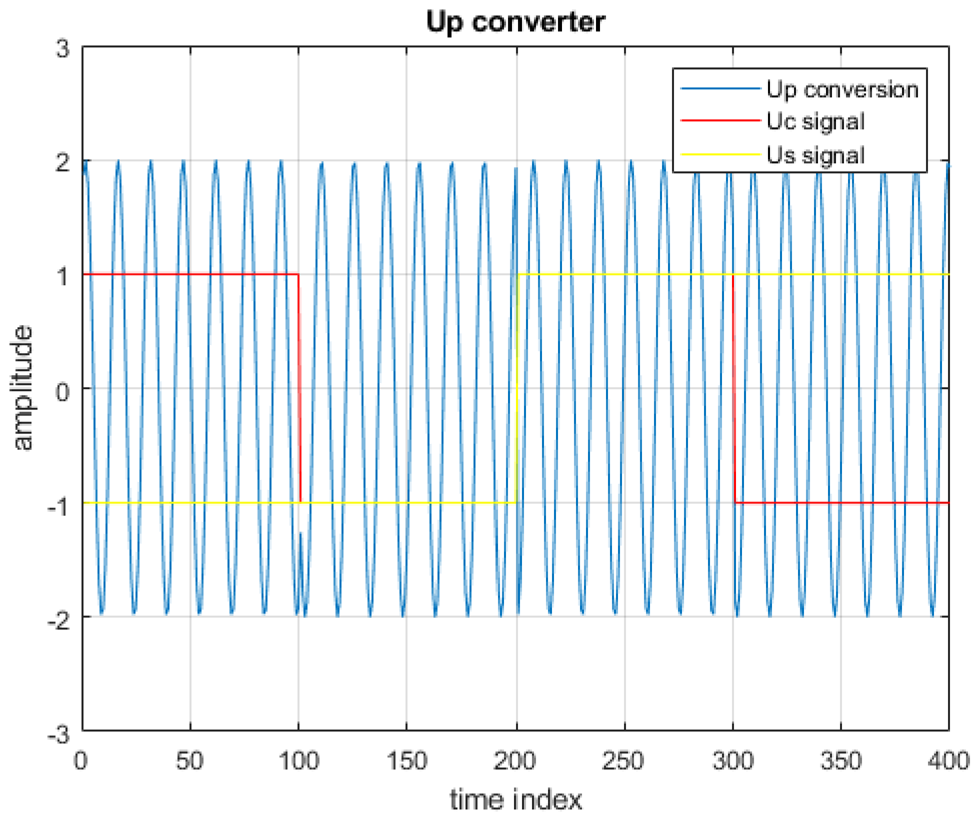
Conv %it convolves the 2 sequences

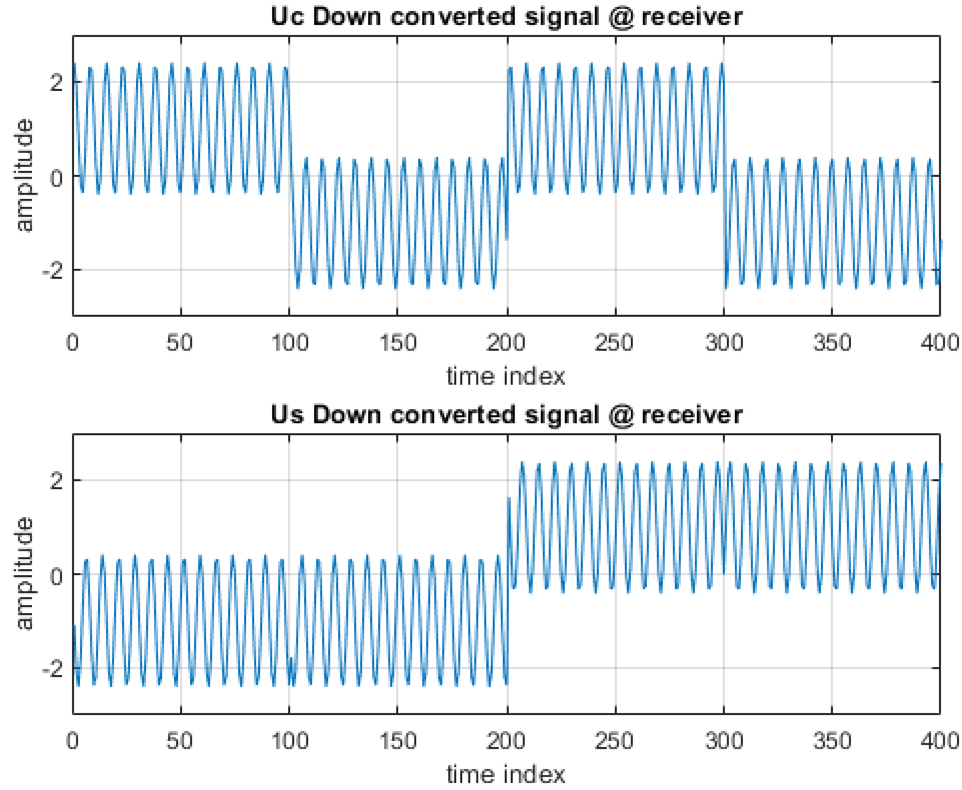
cos(x) % this command gives the values of cos(x)

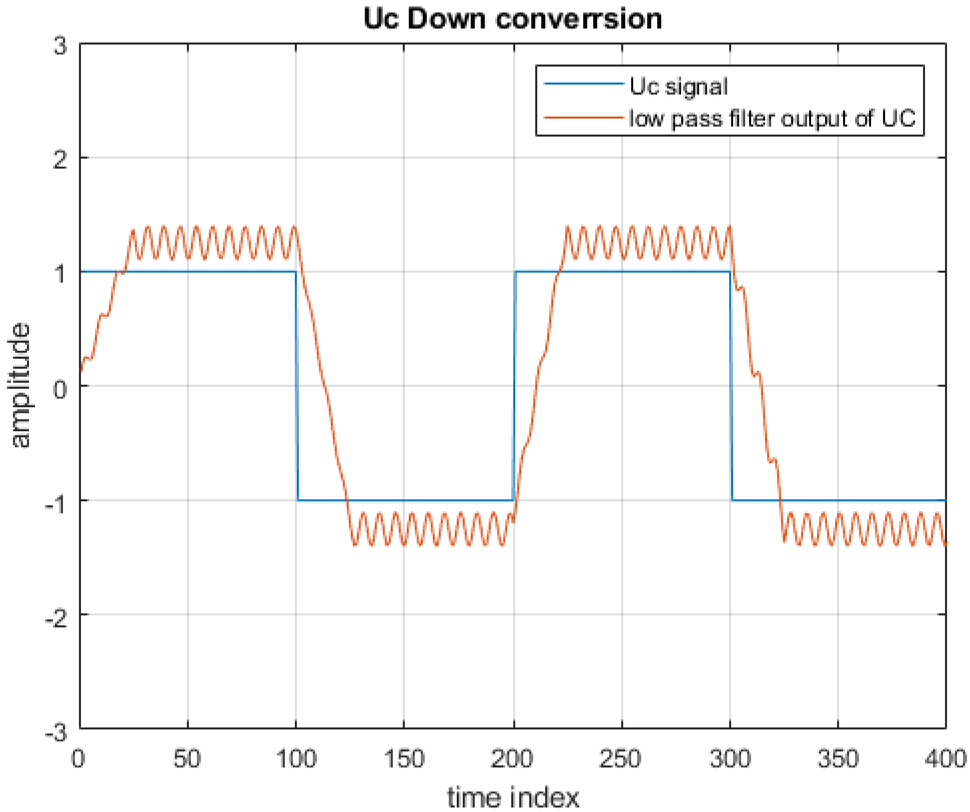
Sin(x) %this command gives the values of sin(x)

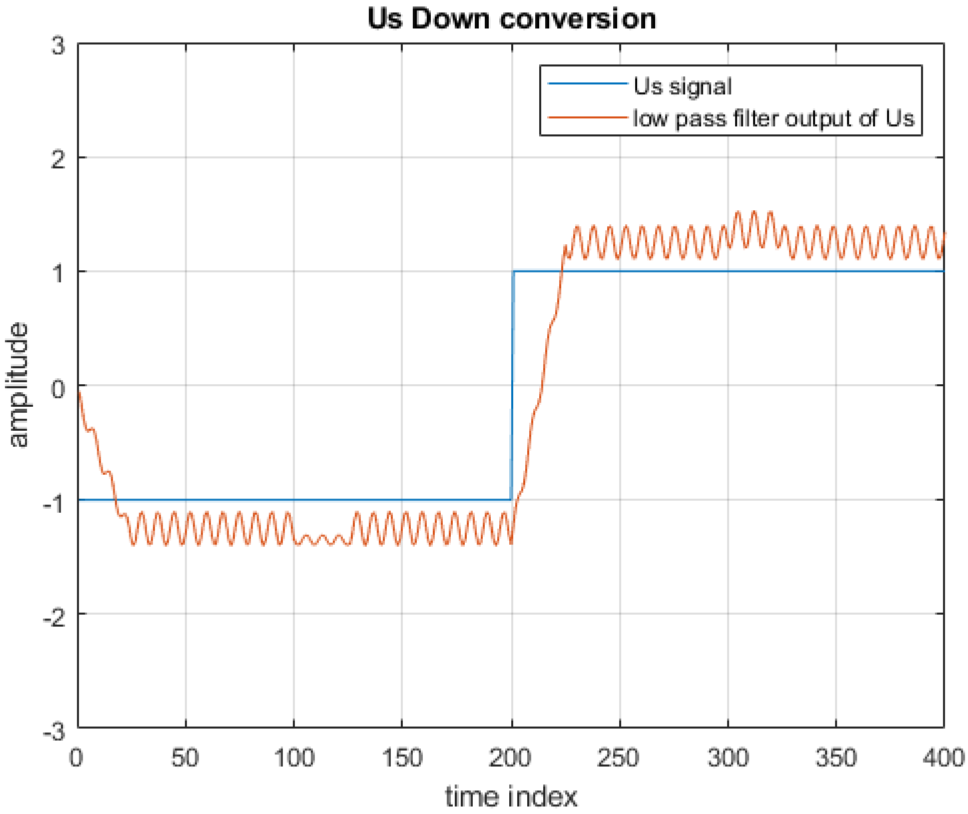
Plots:


10 bit stream (uc)
amplitude
time index
10 bit stream (us)
amplitude
time index


Up converter
Up conversion
Uc signal
Us signal
amplitude
time index


Uc Down converted signal @ receiver
amplitude
2
0
-2
0
50
100
150
200
250
300
350
400
time index
Us Down converted signal @ receiver
amplitude
2
0
-2
0
50
100
150
200
250
300
350
400
time index


Uc Down converrsion
Uc signal
low pass filter output of UC
amplitude
3
2
1
0
-1
-2
-3
0
50
100
150
200
250
300
350
400
time index



Inferences/comments:

1)Vc and Vs are same as Uc and Us but with some tolerance amplitude error.

2) Yes, we Can read off the corresponding bits bc[n] and bs[n] from eyeballing the plots

3) We can recover the bit stream by down converting with the same signal used in the up converting.

4) even if you use the different frequency(not same as up conversion) at the down conversion we can not retrieve the bit stream.

Q5. Plot vc and vs for θ = π/4. How do they compare to uc and us? Can you read off the corresponding bits bc[n] and bs[n] from eyeballing the plots for vc and vs?.

AIM: To plot the down converted signal with phase shift of θ = π/4.

Short Theory:

The up converted signal is down converted by multiplying the same signal used in the up conversion and passing resultant signal through low pass filter. If down converted signal has some phase shift with up conversion signal, then there will be an error in the bit stream.

Key Commands:

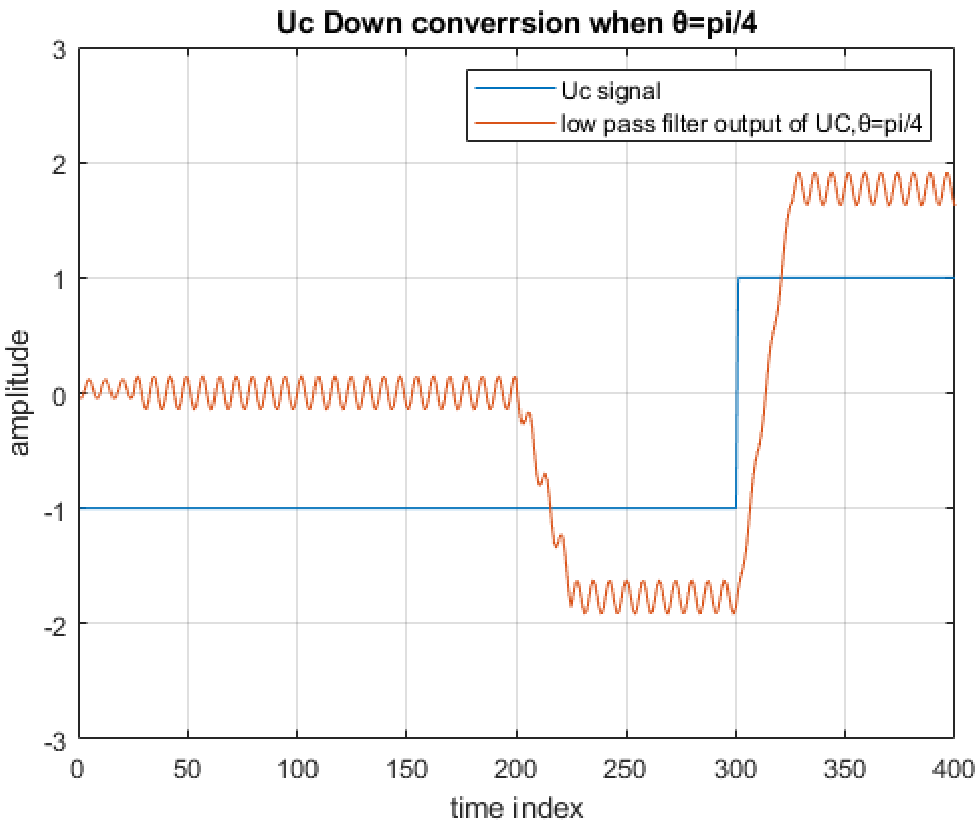
rand % it generates the uniform distributed random numbers.

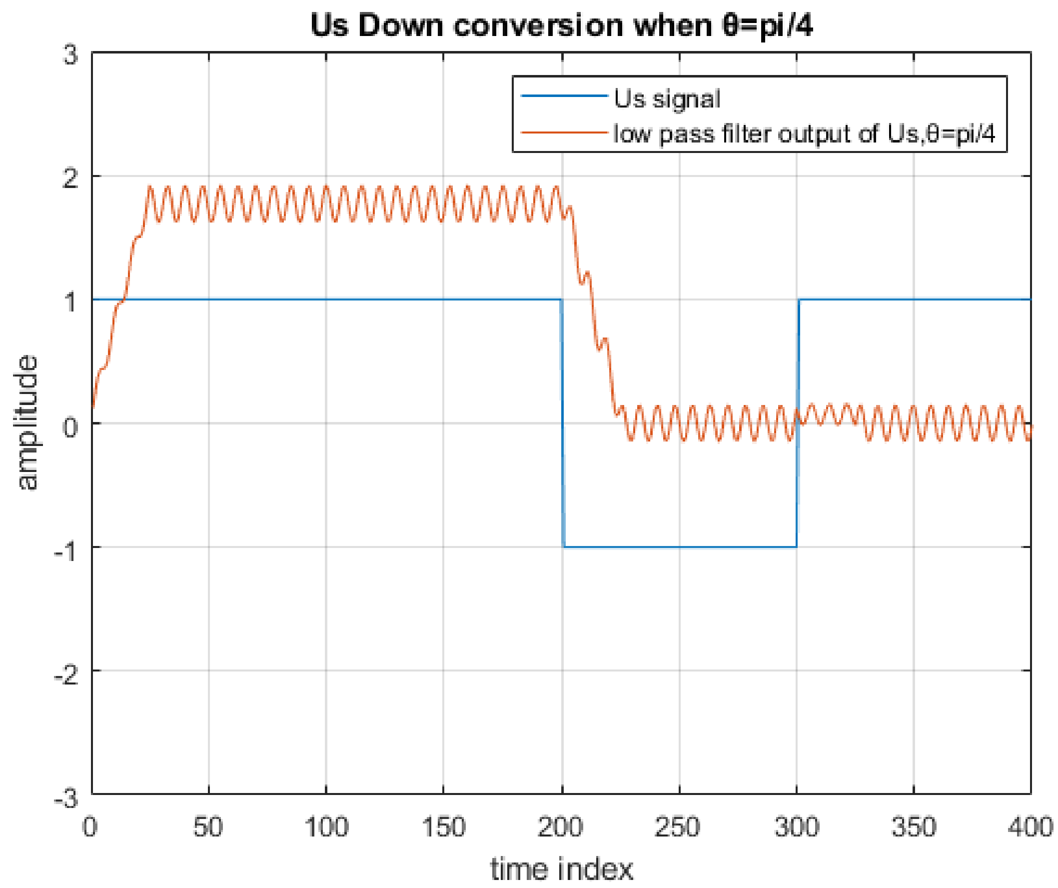
Conv %it convolves the 2 sequences

cos(x) % this command gives the values of cos(x)

Sin(x) %this command gives the values of sin(x)

Plots:





Inferences/comments:

1) Vc and Vs are not same as Uc and Us .
2) If down converted signal has some phase shift with up conversion signal, then there will be a errors in the bit stream.
3)No, we can not read off the corresponding bits bc[n] and bs[n] from eyeballing the plots

Q6. Figure out how to recover uc and us from vc and vs if a genie tells you the value of θ (we are looking for an approximate reconstruction since the LPFs used in down conversion are non-ideal, and the original waveforms are not exactly bandlimited). Check whether your method for undoing the phase offset works for θ = π/4, the scenario in (5). Plot the resulting reconstructions˜uc(t) and˜us(t) and compare them with the original I and Q components uc(t) and us(t). Can you read off the corresponding bits bc[n] and bs[n] from eyeballing the plots of˜uc(t) and˜us(t)?

AIM: To recover and plot the phase shifted θ = π/4 signal by apply the appropriate phase correction.

Short Theory:

If down converted signal has some phase shift with up conversion signal, then there will be an errors in the bit stream . if we the θ value, we can retrieve the original bit stream using the correction faction as given bellow

Uc=Vc* cos θ-Vs*sin θ

Us= Vs* cos θ+Vc*sin θ

Key Commands:

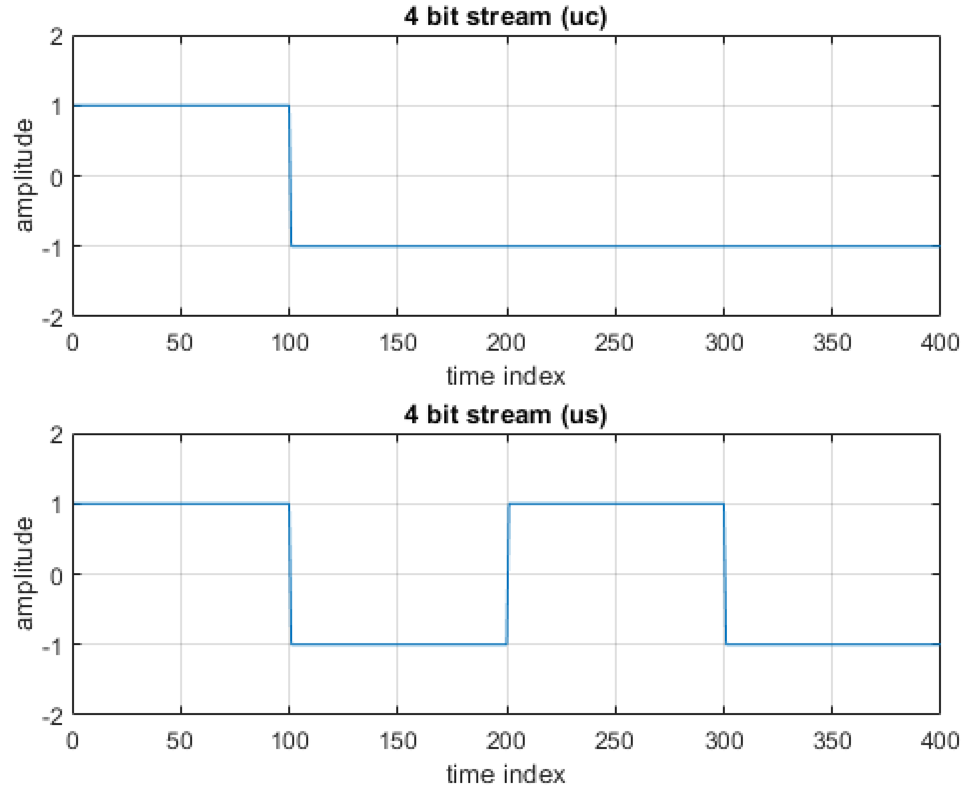
rand % it generates the uniform distributed random numbers.

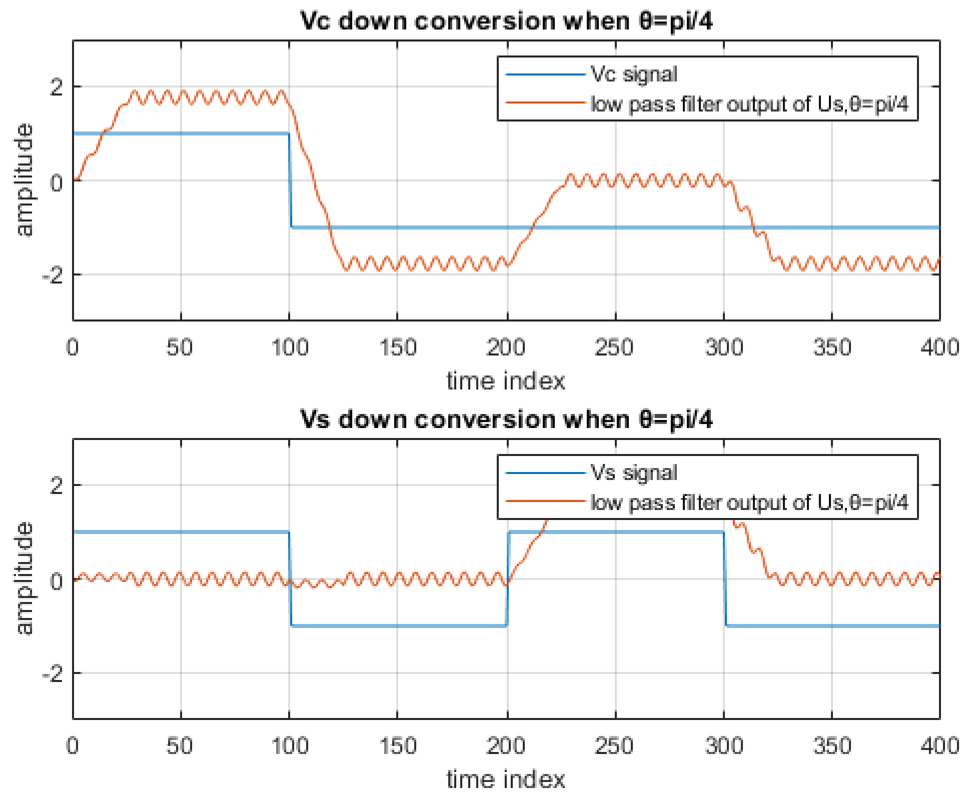
Conv %it convolves the 2 sequences

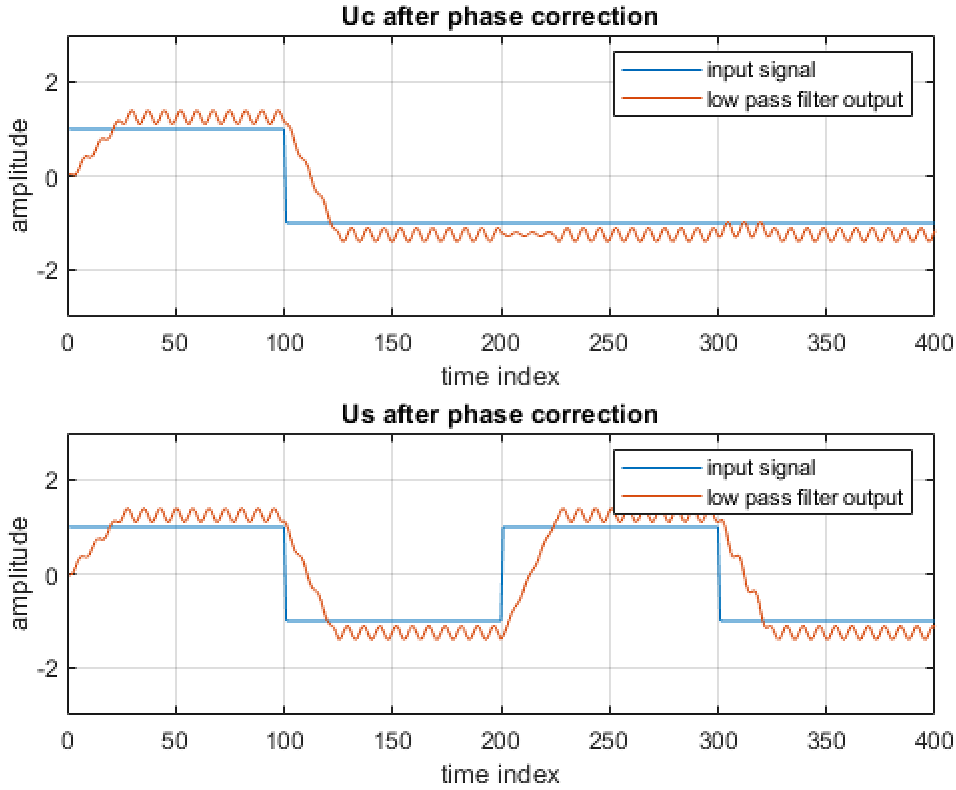
cos(x) % this command gives the values of cos(x)

Sin(x) %this command gives the values of sin(x)

Plots:


4 bit stream (uc)
amplitude
time index
4 bit stream (us)
amplitude
time index


Vc down conversion when θ=pi/4
Vc signal
low pass filter output of Us,θ=pi/4
amplitude
time index
Vs down conversion when θ=pi/4
Vs signal
low pass filter output of Us,θ=pi/4
amplitude
time index



Inferences/comments:

1) Vc and Vs are same as Uc and Us after the phase correction
2) Yes, we can read off the corresponding bits bc[n] and bs[n] from eyeballing the plots.