Communication Theory Report 1

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1 Question 1

1.1 (a)

The following signals have been constructed:

1. $u_c(t)$

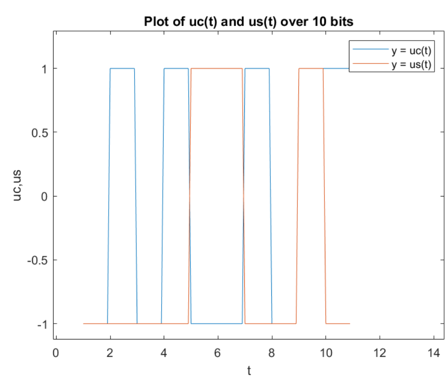
$$u_c(t) = \sum_{n=1}^{100} b_c(n)p(t-n)$$

2. $u_s(t)$

$$u_s(t) = \sum_{n=1}^{100} b_s(n)p(t-n)$$

where

$$p(t) = \begin{cases} 1 & 0 \leq t \leq 1 \\ 0 & o.w \end{cases}$$

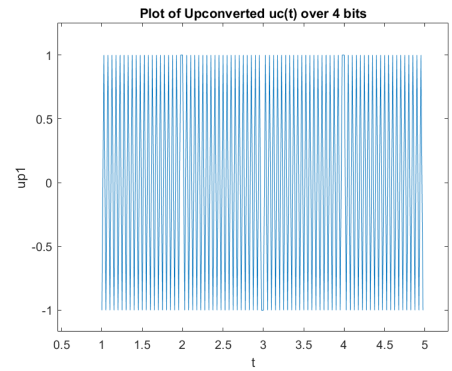


1.2 (b)

The signal $u_c(t)$ was up-converted by multiplying by $cos(40\pi t)$

1.3 (c)

The up-converted signal $u_{p,1}(t)$ is plotted w.r.t. time. This is a BPSK(Binary Phase Shift Keyed) signal.

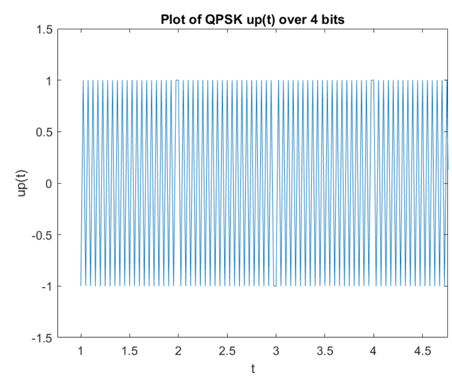


1.4 (d)

The Q component is added and the new signal $u_p(t)$ is generated.

$$u_p(t) = u_c(t)cos(40\pi t) - u_s(t)sin(40\pi t)$$

This is a QPSK(Quarternary Phase Shift Keyed) signal.



1.5 (e)

Now, we down-convert the pass-band signal $u_p(t)$ by multiplying it with $2cos(40\pi t+\theta)$ and $-2sin(40\pi t+\theta)$ and then passing it through a low-pass filter with $h_1(t) = I_{[0,0.25]}(t)$ to get the **Q** and **I** components respectively.

We define

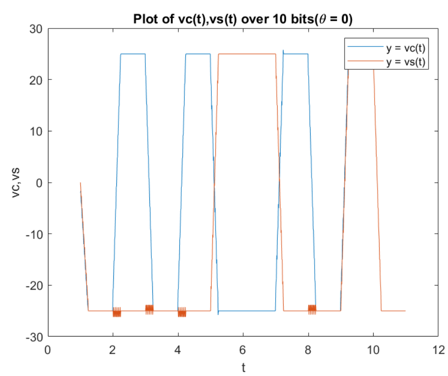
$$u_{p1}(t) = 2u_p(t)cos(40\pi t + \theta)$$

$$u_{p2}(t) = -2u_p(t)sin(40\pi t + \theta)$$

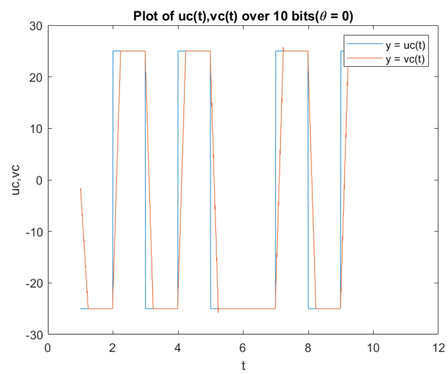
And hence if $u_{p1}(t)$ and $u_{p2}(t)$ are passed through the low-pass we get

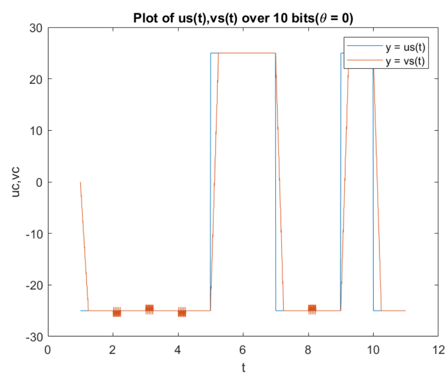
$$v_c = u_{p1}(t) * h_1(t)$$

$$v_s = u_{p2}(t) * h_1(t)$$



From the following plots, it is clear that the down-converted **Q**,**I** components ($v_c(t)$ and $v_s(t)$) closely follow the signals $u_c(t)$ and $u_s(t)$. The signals $u_c(t)$ and $u_s(t)$ are scaled up to show the correlation clearly.

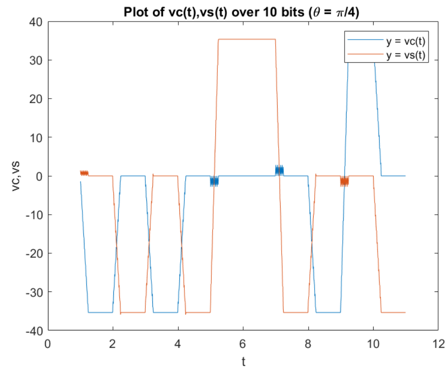




Therefore, it is possible to eyeball the v_c and v_s values to find out what the u_c and u_s values were.

1.6 (f)

If the θ value is changed to $\pi/4$, the signals $v_c(t)$ and $v_s(t)$ change as well, and their plots are shown below.



We also see that it becomes impossible to eyeball the v_c and v_s values to find out what the u_c and u_s values were.

1.7 (g)

We can try to rectify the values of u_c and u_s if we simply modulate the low-pass filter in such a way that there is enough shift in the frequency domain in order to pass the actual lower frequency components of the signals $u_{p1}(t)$ and $v_s(t)$.

Using the complex base-band representations of u,h and v signals, we can derive the following corrective formulae for the new genie-theta-predicted-phase shift;

Let us define two new signals

$$n_1(t) = cos(\theta t)$$

$$n_2(t) = sin(\theta t)$$

and now, let the new low-pass impulse responses be

$$h_{11}(t) = h_1(t)n_1(t)$$

$$h_{12}(t) = h_1(t)n_2(t)$$

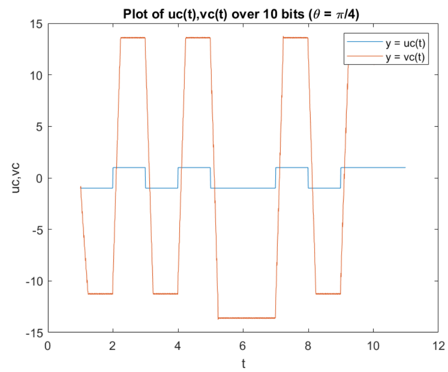
and thus,

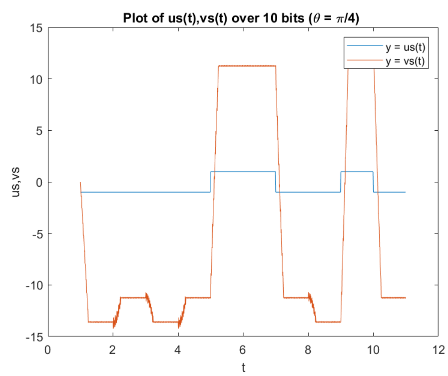
$$v_c'(t) = \frac{1}{2}\{u_{p1}(t) * h_{11}(t) - u_{p2} * h_{12}(t)\}$$

$$v_s'(t) = \frac{1}{2}\{u_{p1}(t) * h_{12}(t) + u_{p2} * h_{11}(t)\}$$

The signals $u_c(t)$ and $u_s(t)$ with their respective signals $v_c(t)$ and $v_s(t)$ are plotted to show the clear correlation of the reconstructed and the original **Q** and **I** components.

We can see some irregularities in the us,vs plot and this is caused due to the fact that our Low-pass filter was crude and better versions would lead to even closer plots.





2 Codes

1. "CTA1_1Random.m" was used to create the sequences $b_c(n)$,$b_s(n)$. The functions used are "randi()" which creates a vector of random numbers between 2 input numbers.

2. "CTA1_1a.m" was used to generate the two signals $u_c(t)$ and $u_s(t)$. This was done by simply repeating the respective b_c or b_s symbol numerous times. A time vector 't' was created to use as the x axis.

3. "CTA1_1b.m" was used to Up-convert the $u_c(t)$ signal. A new time vector

't1' was created as the base time vector for all the other operations. Up-converted signal was plotted for 10 symbols/bits of $b_c(n)$.

4. "CTA1_1d.m" was used to create the total QPSK signal up and this signal was plotted with t1 as the x axis.

5. "CTA1_1e.m" was used to down-convert the QPSK signal with h1 as impulse response for the crude low-pass. The resultant Q,I components were plotted wrt the original components.Many superficial changes in the second half of the code was done to plot the required vectors.

6. "CTA1_1g.m" was used to test out the corrective formulae used when the phase shift was given as input. The variable 'g' represents the theta value. The same code set from the previous code was used for plotting purposes.