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ELEC 301 Homework 2 Report

Question 1

a) As it can be seen from Fig.1, as β increases, the oscillations in time domain decrease gradually. It is also clear to see that β =1 provides the fastest decay.

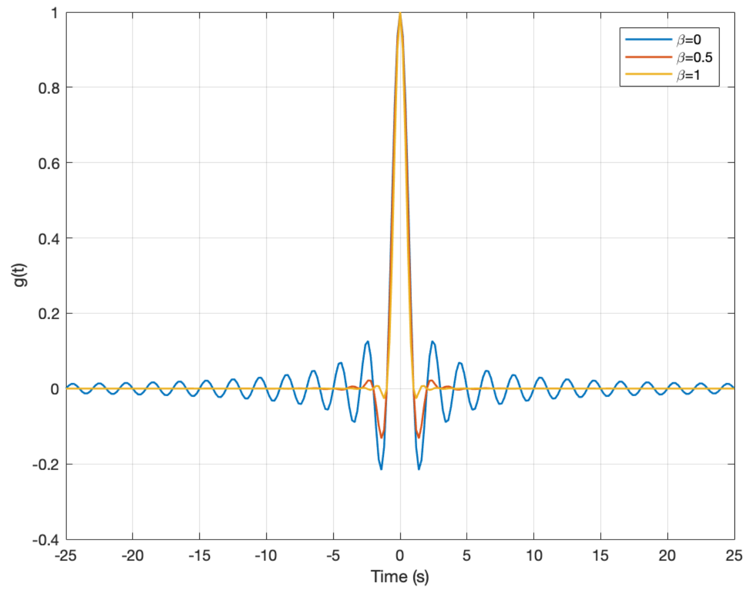

Figure 1: g(t) in Time Domain

b) Fig. 2 shows the behavior of the generated raised cosine pulses in the frequency domain. It can be observed that the bandwidth of the signal gets wider as β increases, and β=0 provides the narrowest bandwidth.

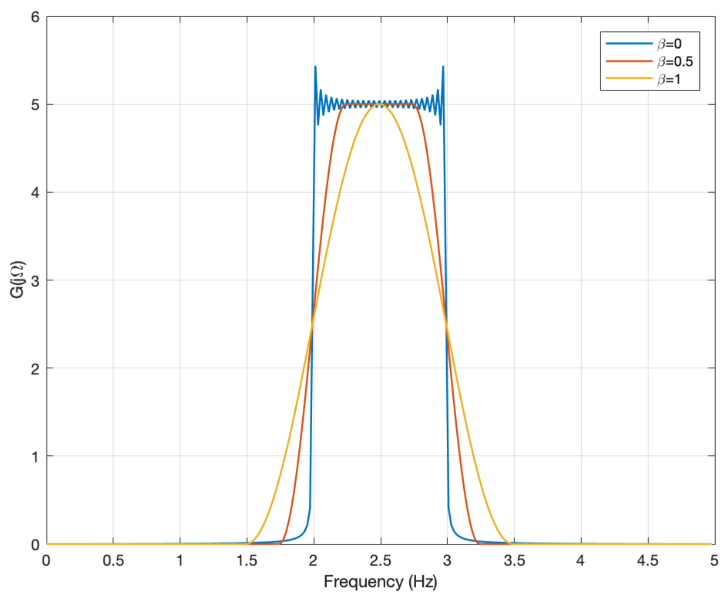

Figure 2: G(jΩ) in Frequency Domain

c) One of the biggest advantages of using a raised cosine filter is that the effective bandwidth can be shaped by modifying the pulse, which is an important concept in communications, and is widely used thanks to this property. A disadvantage can occur because of the uncertainty principle of the Fourier transform: as β decreases, and makes the bandwidth narrower, it will cause the signal in time domain to get wider. This may at the end cause the signal to be unrealizable.

Question 2

a)

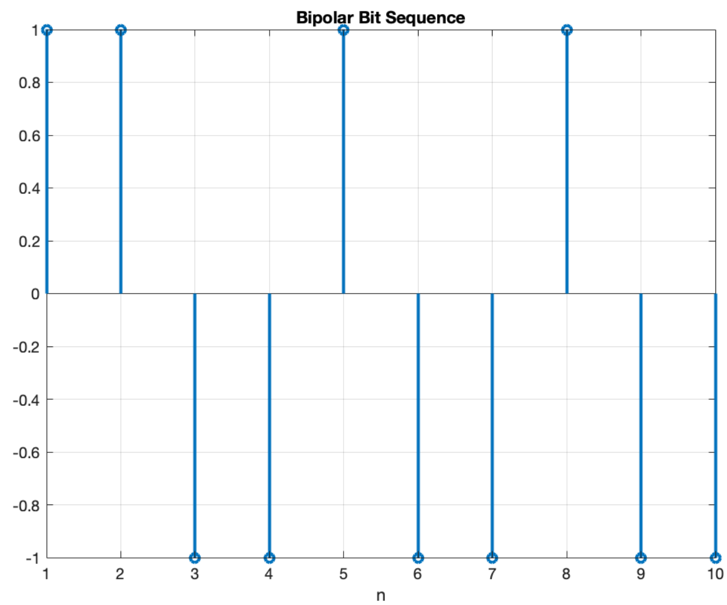

Figure 3: Generated Bipolar 10-bit Sequence

b) In order to modulate the signal, I first iterated through the bit sequence that can be seen in Fig. 3, considering two bits at a time. Depending on the sequence (-1-1, -11, 1-1, 11), I have concatenated a ones array, resembling a pulse that has the length of one period, times cosϕ[n] to store I(t), and a ones array, resembling a pulse that has the length of one period, times sinϕ[n] to store Q(t). The phases that correspond to the sequences can be found in Table 1. I have also stored the values of I(t) and Q(t) directly, during iteration, to test the end result. After the iterations are complete, I have obtained $s(t) = I(t)cos(\Omega t) - Q(t)sin(\Omega t)$, where Ω=2πf (f is the bitrate 10000) The resulting plots of the modulated signal and its in-phase and quadrature components can be seen in Fig. 4, where the red lines are the plots of I(t) and Q(t), and the plots behind them are their waveform. The bandwidth required to transmit this signal can be calculated as $\dfrac{\frac{\pi}{T}(1+\beta)}{2\pi} = \dfrac{f}{2}(1+\beta) = 6250Hz.$

Sequence	Phase
-1-1	$\frac{\pi}{4}$
-11	$\frac{3\pi}{4}$
1-1	$\frac{5\pi}{4}$
11	$\frac{7\pi}{4}$

Table 1: Binary Bit Sequences and Corresponding Phases

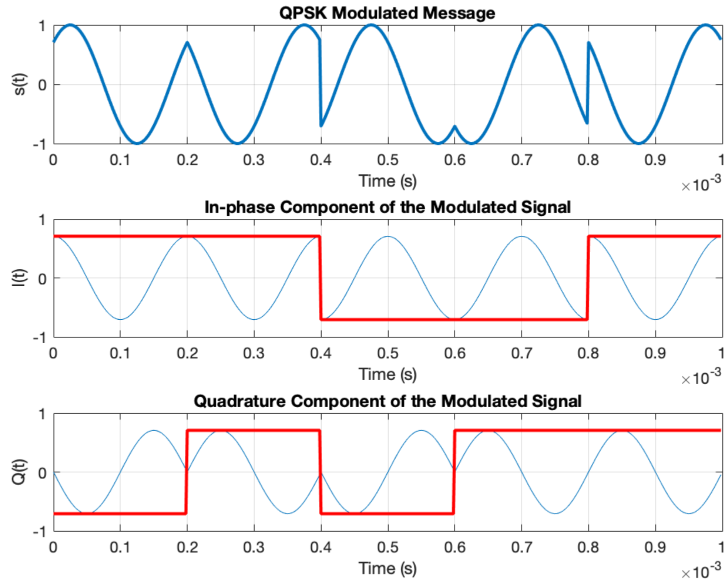

Figure 4: The QPSK Modulated Signal in Time Domain and its In-Phase and Quadrature Components

c) In order to demodulate the QPSK modulated signal, I first multiplied the modulated signal with cos(Ωt) and sin(Ωt), separately, and periodically integrated these two signals with respect to time. Then, I have compared these signals with 0 in order to obtain the I and Q components back. To do this, I have checked the intervals of the integrated signals in which they're either greater than 0 or less than 0. If the integrated form of the cosine-multiplied signal is greater than 0, it means that the I(t) component of the modulated signal is $1/\sqrt{2}$; or if the integrated form of the cosine-integrated signal is less than 0, it means that the I(t) component of the modulated signal is $-1/\sqrt{2}$. On the other hand, if the integrated form of the sine-multiplied signal is greater than 0, it means that the Q(t) component of the modulated signal is $-1/\sqrt{2}$; or if the integrated form of the sine-integrated signal is less than 0, it means that the Q(t) component of the modulated signal is $1/\sqrt{2}$. After recovering the I(t) and Q(t) parts of the signal, I first subtracted Q(t) from I(t) directly, but later realized that in some intervals, these components have the same values, and it wouldn't be possible to recover the original bit sequence from that subtraction. Therefore, I have multiplied I(t) with 2 and subtracted Q(t) from it. This way, I was able to recover the original bit sequence by periodically checking for certain values (i.e. $3/\sqrt{2}$ corresponding to 11, $1/\sqrt{2}$ corresponding to -1-1, $-1/\sqrt{2}$ corresponding to 1-1, and $-3/\sqrt{2}$ corresponding to -11). The resulting plots of the recovered I(t), recovered Q(t), and the recovered bit sequence can be observed in Fig. 5, and confirm with the pre-modulated and modulated correspondents of these signals.

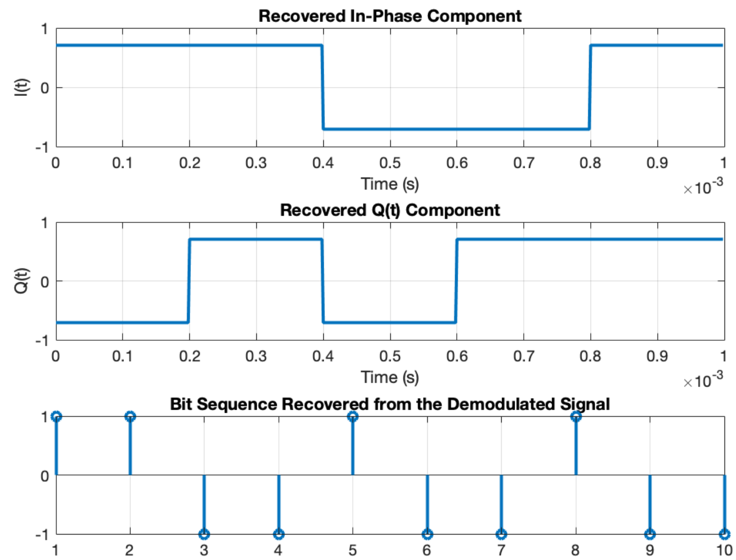

Figure 5: The Recovered In-Phase and Quadrature Components of the Demodulated Signal & Recovered Bit Sequence

The sequences containing 100, 1000, and 10000 bits have all been recovered with this demodulation technique, and can be seen in following

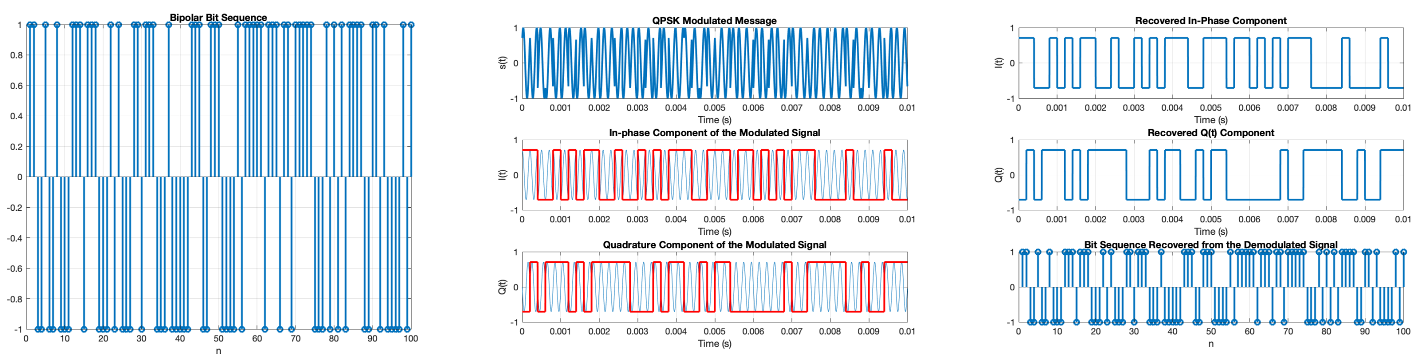

Figure 6: The Generated Bit Sequence, the Original and Recovered Forms of In-Phase and Quadrature Components of the Modulated and Demodulated Signals & the Recovered 100-bit Sequence

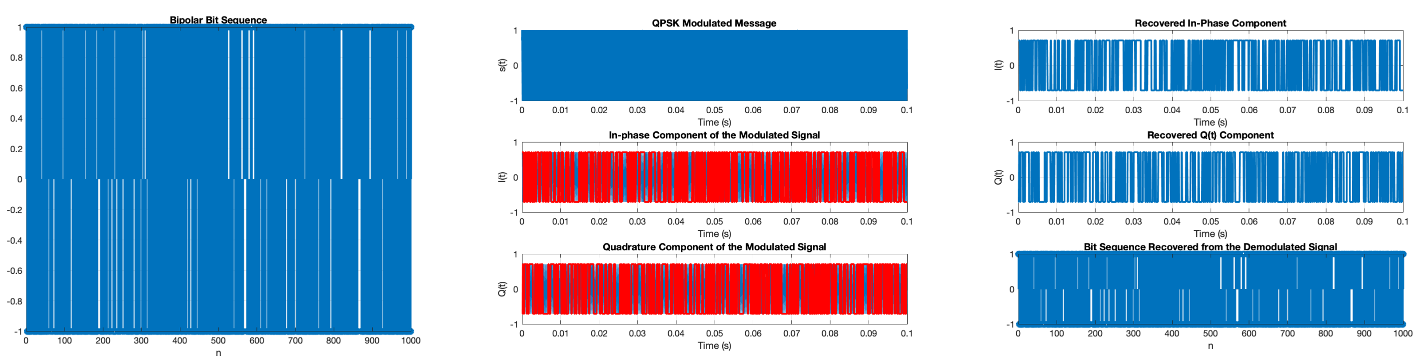

Figure 7: The Generated Bit Sequence, the Original and Recovered Forms of In-Phase and Quadrature Components of the Modulated and Demodulated Signals & the Recovered 1000-bit Sequence

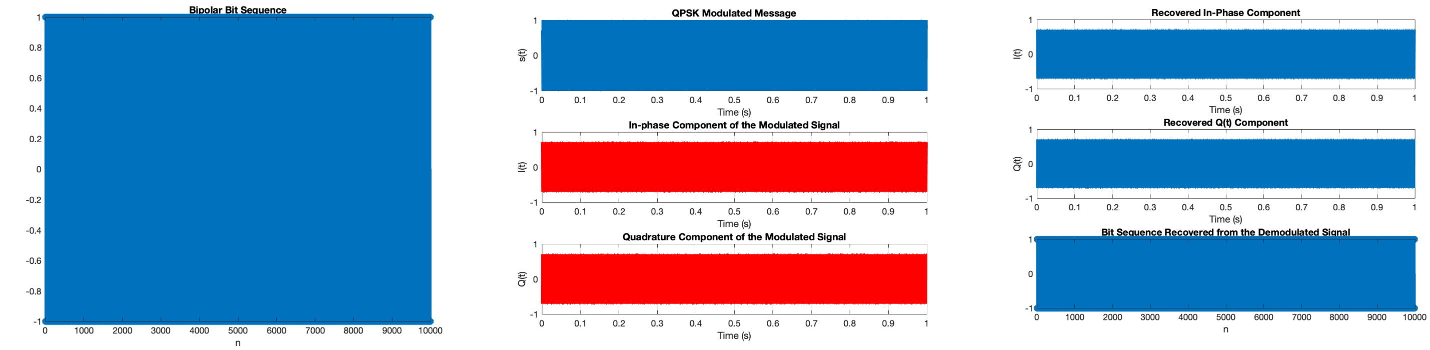

Figure 8: The Generated Bit Sequence, the Original and Recovered Forms of In-Phase and Quadrature Components of the Modulated and Demodulated Signals & the Recovered 10000-bit Sequence