

Digital Communications - HW3

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Problem

We have to implement six different versions of the receiver structure in a QPSK modulation scheme. First we present the setup of the transmitter and the channel as given, then we analyze the different configurations one by one and give a brief discussion of the resulting probabilities of symbol error obtained from simulation over different values of the SNR at the channel output, Γ .

Transmitter and Channel

The system takes a sequence of input symbols a_k at sampling time $T = 1$ and applies an upsampling of factor 4, obtaining a'_k at $T/4$. This new sequence is then filtered by q_c as described by the following difference equation:

$$s_c(nT/4) = 0.67s_c((n-1)T/4) + 0.7424a_{n-5} \quad (1)$$

After the filtering white noise is added. The SNR at the channel output for all the configurations in this first phase is $\Gamma = 10$ dB, so from the following relations we can derive σ_w^2 , the variance of the complex valued Gaussian noise:

$$\Gamma = \frac{M_{s_c}}{N_0 \frac{1}{T}} = \frac{\sigma_a^2 E_{q_c}}{\sigma_w^2} \longrightarrow \sigma_w^2 = \frac{\sigma_a^2 E_{q_c}}{\Gamma} = 2\sigma_I^2 \quad (2)$$

where σ_I^2 is the variance per component. In addition we can also compute the PSD as $N_0 = \sigma_w^2 T_c = \sigma_w^2/4$, because the sampling time T_c at which we add the noise is $T/4$. In figure 1 we plot the impulse response and the frequency response of the filter q_c . This implementation of the transmitter is the same for all the following discussion.

Point A

Point B

Point C

Point D

Point E

Point F

Simulation results

nT_y	h	\hat{h}_{corr}	\hat{h}_{ls}
0	1.0000	1.0054	0.9991
1	0.9635	0.9247	0.9613
2	0.4641	0.5002	0.5062
3	-0.0001	0.0202	0.0255
4	-0.2155	-0.2549	-0.2253
	Real	Corr	LS
σ_w^2 [dB]	-8	-7.9776	-8.0404

Table 1: .

References

- [1] Nevio Benvenuto, Giovanni Cherubini, *Algorithms for Communication Systems and their Applications*. Wiley, 2002.

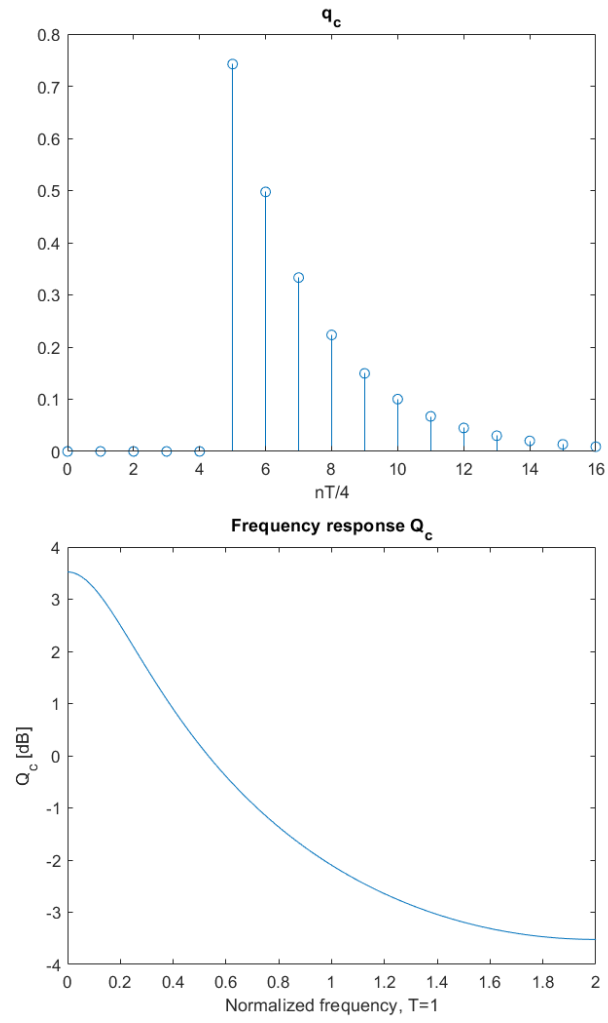


Figure 1: Impulse and frequency response of the filter q_c at $T/4$.

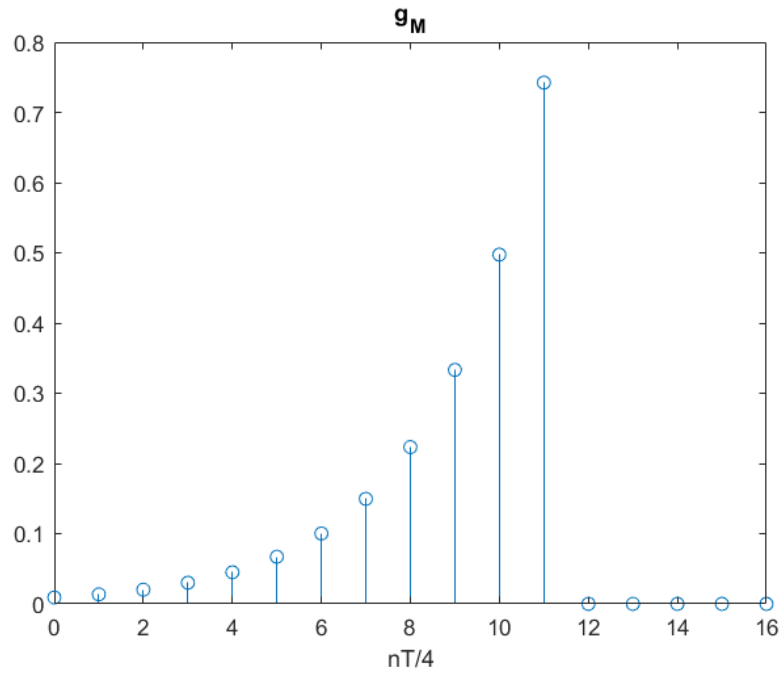


Figure 2: Impulse response of the matched filter g_M for the receiver in point A.

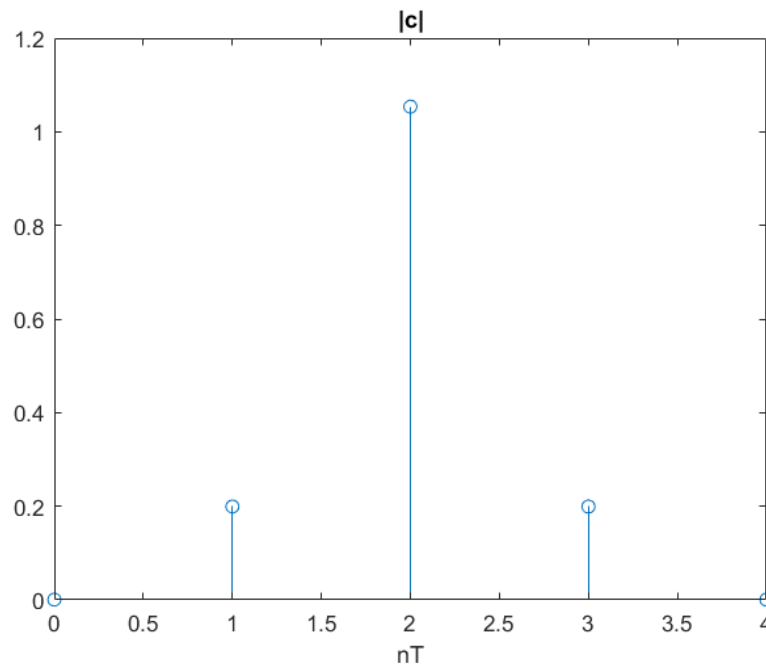


Figure 3: Magnitude of the impulse response of filter c in point A.

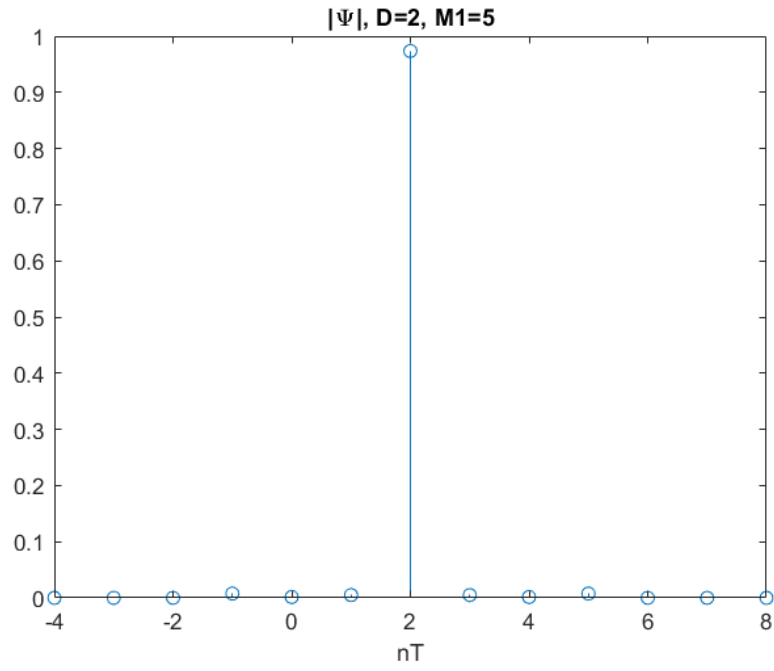


Figure 4: Magnitude of the impulse response of the system ψ in point A.

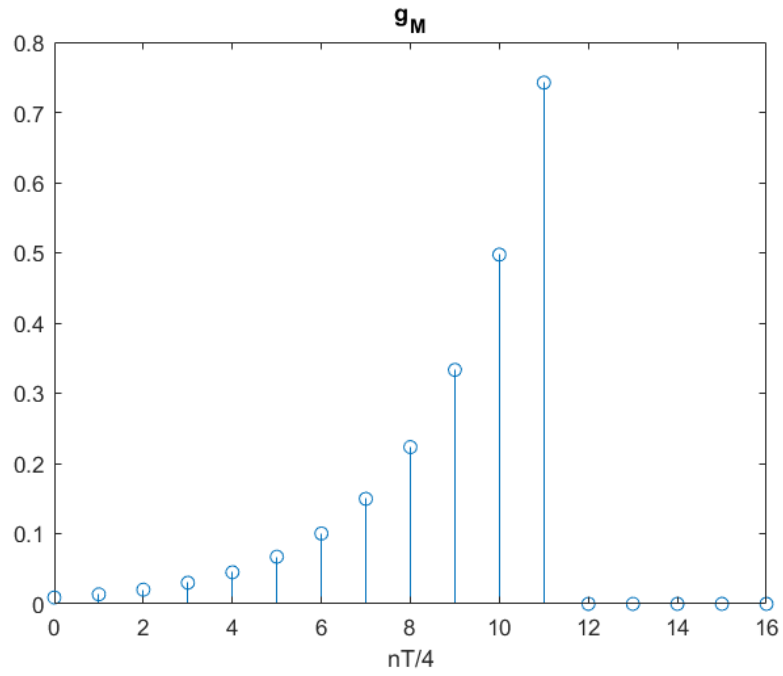


Figure 5: Impulse response of the matched filter g_M for the receiver in point B.

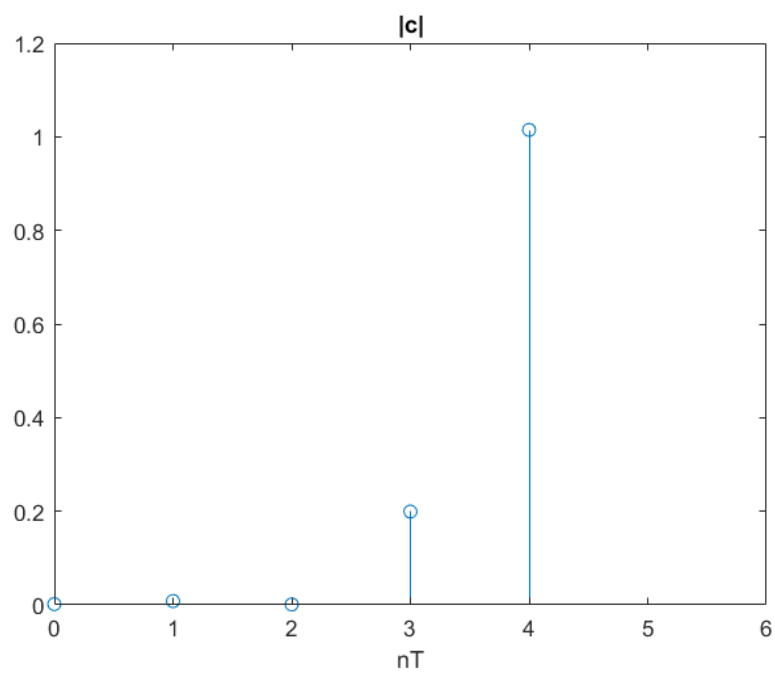


Figure 6: Magnitude of the impulse response of the filter c (feedforward filter) for the receiver in point B.

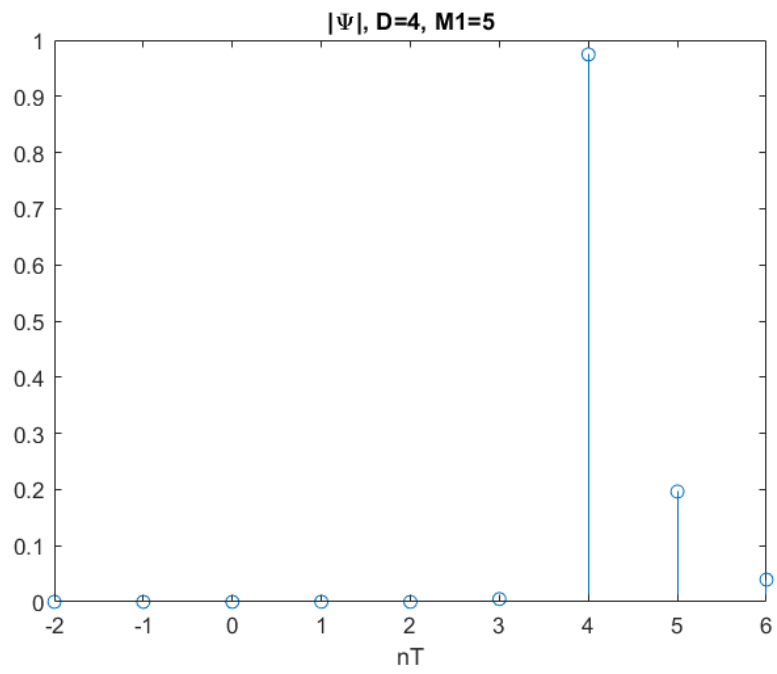


Figure 7: Magnitude of the impulse response of the system ψ in point B.

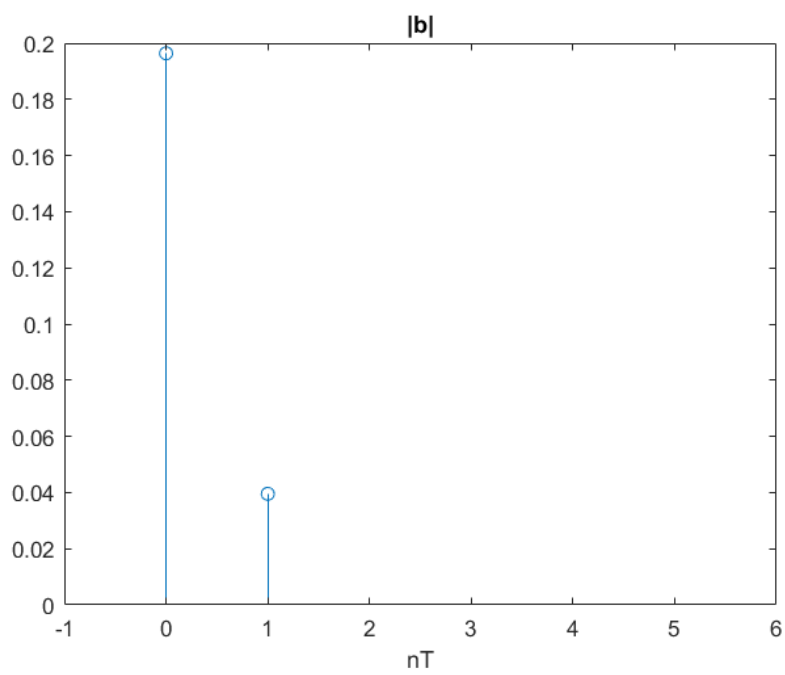


Figure 8: Magnitude of the impulse response of the filter b (feedback filter) in point B.

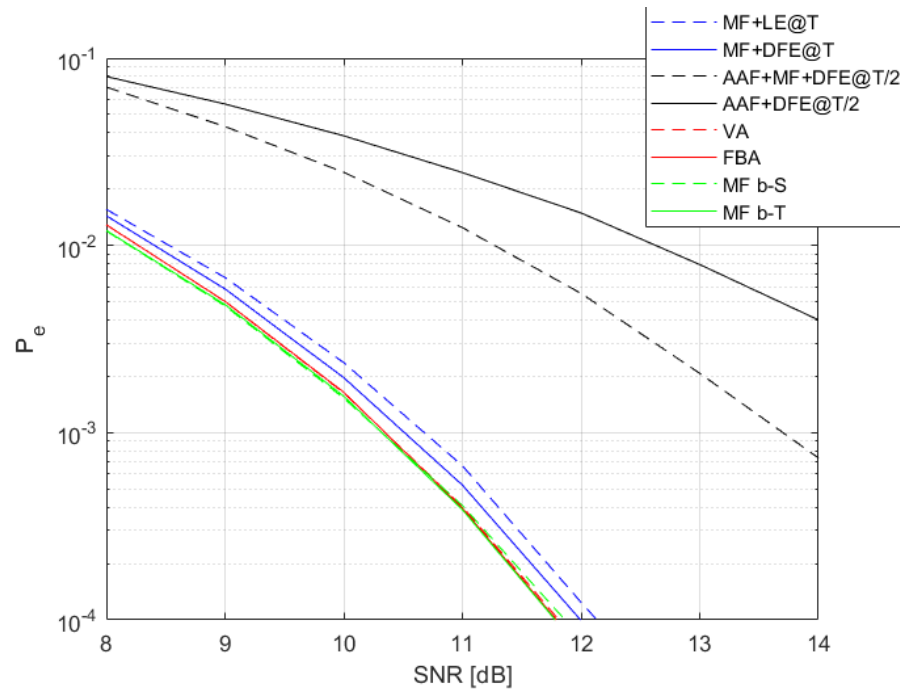


Figure 9: Results of the simulation over values of the SNR at the channel output from 8 dB to 14 dB.