

Digital Communications and Laboratory

Second Homework

Faccin Dario, Santi Giovanni

Problem 1

Problem 2

A flat fading channel with only one tap $h_0(nT_c)$ was studied, assuming a *Rice factor* of $k=2$ dB and normalized M_{h_0} . Moreover, a classical *Doppler Spectrum* with $f_d T_c = 40 \cdot 10^{-5}$ was considered. The schematic model to generate the coefficient h_0 of the channel is given in Figure 1.

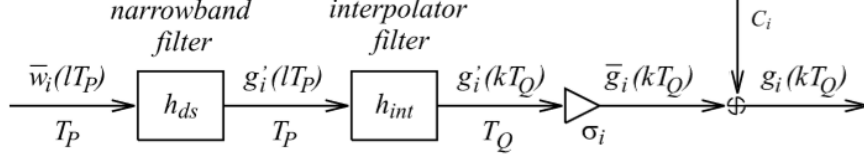


Figure 1. Model to generate the coefficient h_0 of the time-varying channel.

The Doppler Spectrum can be generated using a filter h_{ds} such that $|\mathcal{H}_{ds}(f)|^2 = D(f)$. In Table 1 are shown the coefficients used for such filter [1]:

| $H_{ds}(z) = B(z)/A(z)$ | | $f_d T_p = 0.1$ | |
|-------------------------|---------------------|-----------------|------------|
| $\{a_n\}$, | $n = 0, \dots, 11:$ | | |
| 1 | -4.4153 | 8.6283 | -9.4592 |
| 6.1051 | -1.3542 | -3.3622 | 7.2390 |
| -7.9361 | 5.1221 | -1.8401 | 2.8706e-1 |
| $\{b_n\}$, | $n = 0, \dots, 21:$ | | |
| 1.3651e-4 | 8.1905e-4 | 2.0476e-3 | 2.7302e-3 |
| 2.0476e-3 | 9.0939e-4 | 6.7852e-4 | 1.3550e-3 |
| 1.8076e-3 | 1.3550e-3 | 5.3726e-4 | 6.1818e-5 |
| -7.1294e-5 | -9.5058e-5 | -7.1294e-5 | -2.5505e-5 |
| 1.3321e-5 | 4.5186e-5 | 6.0248e-5 | 4.5186e-5 |
| 1.8074e-5 | 3.0124e-6 | | |

Table 1. Coefficients for the IIR filter

The graphical representation of the impulse response of the IIR filter and the Doppler Spectrum is shown in Fig. 2. To obtain h_0 , following the scheme of Fig. 1, the noise component $w \sim \mathcal{CN}(0, 1)$ was filtered with the IIR filter previously described. Note that the frequency response of this filter is $H_{ds}(f) = \sqrt{D(f)}$ while the PSD of the noise is constant and equal to 1. For this reason, the equivalent impulse response of this part is equal to $D(f) = 1 \cdot |H_{ds}|^2$ which is actually the Doppler spectrum.

The output of the filter was affected by a transient, which we have avoided by considering only values after $5N_{eq}T_p$, where $N_{eq} = \left\lceil -\frac{1}{\ln(|p|)} \right\rceil$ is the equivalent time constant, and p is the pole with the highest magnitude. Then, after having scaled the coefficient such that $M_{h_0}/\sqrt{E_{h_{ds}}} = 1$, the signal was filtered with an interpolation filter of factor $1/T_Q = T_p/T_c = 250$. The interpolator

output signal was then multiplied by a constant $\sigma_0 = \sqrt{M_d}$ to impose the desired power delay profile, and finally added up with another constant, C , which included the deterministic component according to [1], Page NUMERO PAGINA.

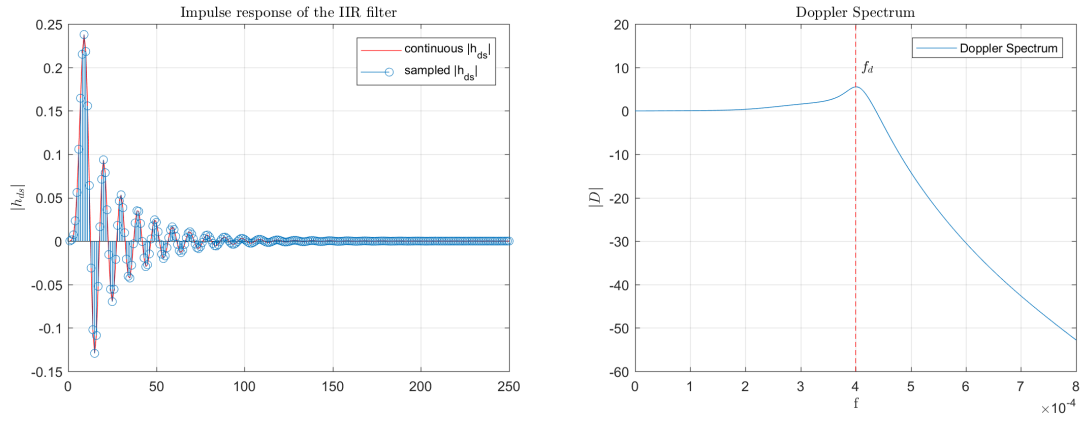


Figure 2. Impulse response of the IIR filter and Doppler Spectrum

Bibliography

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