Digital Communications and Laboratory
Second Homework

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Problem 1

Problem 2

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

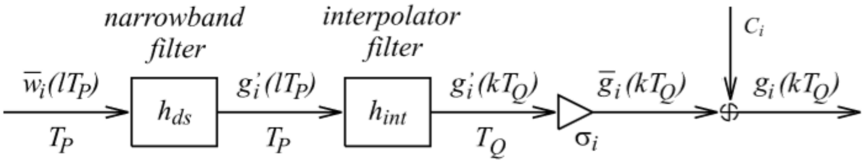

Figure 1. Model to generate the coefficient h_0 of the time-varying channel.

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]:

$H_{ds}(z) = B(z)/A(z)$	$f_dT_p = 0.1$		
$\{a_n\}$,	$n = 0, \ldots, 11$:		
1	-4.4153	8.6283	-9.4592
6.1051	-1.3542	-3.3622	7.2390
-7.9361	5.1221	-1.8401	2.8706e-1
$\{b_n\}$,	$n = 0, \ldots, 21$:		
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 $w \sim \mathcal{CN}(0,1)$ is filtered with the IIR filter previously described. Note that the frequency response of this filter is $\mathcal{H}_{ds}(f) = \sqrt{\mathcal{D}(f)}$ 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 $\mathcal{D}(f) = 1 \cdot |\mathcal{H}_{ds}|^2$ which is actually the Doppler spectrum.
The output of the filter is affected by a transient, which we 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 scaling the coefficient such that $M_{h_0}/\sqrt{E_{h_{ds}}} = 1$, the signal is filtered with an interpolation filter of factor $1/T_Q = T_p/T_c = 250$.

The interpolator output signal is 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 307.

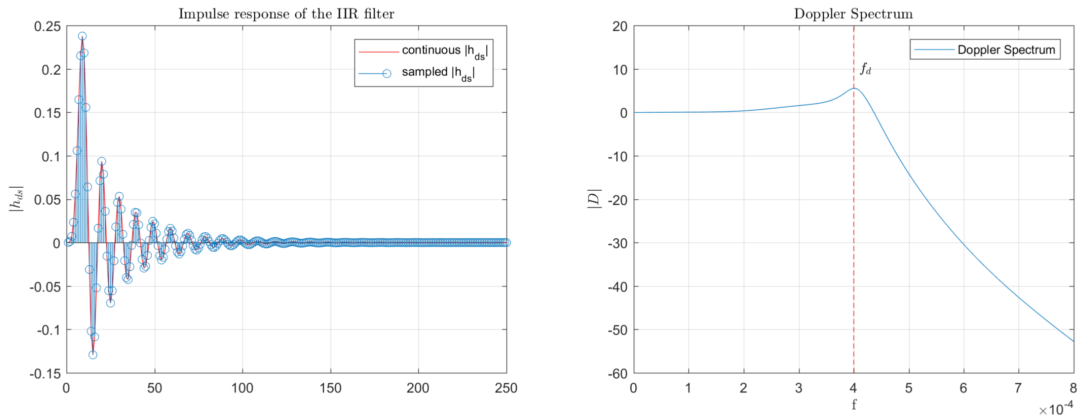

Figure 2. Impulse response of the IIR filter and Doppler Spectrum

Estimate of $\frac{|\mathbf{h_0}|}{\sqrt{\mathbf{M}_{|\mathbf{h_0}|}}}$

Bibliography

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