## Universidad Rey Juan Carlos Topic 2: The Communications Channel Academic Year 2013 - 2014

**P1.-** A stochastic process  $X \sim N(2,3)$ , stationary and with independent samples, is introduced into a communications channel that can be modeled as an LTI system with impulse response:

$$h(t) = \delta(t) + 0.5\delta(t-1) + 0.1\delta(t-2)$$

Obtain:

- a) The PDF of the stochastic process to the channel output.
- b) The autocorrelation of the stochastic process to the channel output.
- c) The power of the stochastic process to the channel output.

**P2.-** Consider the discrete system shown in the Figure 1:



Figure 1.- Communication system.

The discrete stochastic processes  $x_1[n]$  and  $x_2[n]$  are i.i.d. Both distributions are Gaussian processes:  $X_1 \sim N(0,2)$  and  $X_2 \sim N(1,3)$ . These processes are the signals transmitted by two different users to a base station. Both are transmitted by a channel modeled by an LTI system, represented in the Figure 1 by  $h_1[n]$  and  $h_2[n]$ , respectively, with impulse responses:

$$\begin{split} h_1[n] &= 2\delta[n] - \delta[n-1] \\ h_2[n] &= \delta[n] - 0.5\delta[n-1] + 0.1\delta[n-2] \end{split}$$

As shown in the Figure 1, the received signal is added to a noise w[n] (Gaussian, white and discrete, with zero mean and power spectral density  $N_0/2$ . Obtain:



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Consider now that the signal  $y_1[n]$  is centered around a frequency  $f_1$ , with bandwidth 2B; and  $y_2[n]$  is centered around a frequency  $f_2$ , with bandwidth 2B.  $f_1$  and  $f_2$  are far apart, so that the signals do not overlap in frequency. Assume further that the ideal filter located at the end of the scheme has a bandwidth of 2B, and is centered at  $f_1$ .

e) Obtain the SNR of  $y_5[n]$ .

**P3.-** Suppose you have a passive attenuator (L = 6dB) and an amplifier (G = 15dB;  $F_{amp} = 9dB$ ). Obtain the noise factor of a system consisting of:

- a) The attenuator followed by the amplifier.
- b) The amplifier followed by the attenuator.

**P4.-** Consider a nonlinear amplifier having a noise temperature at the input of 17°C and these data:

- Signal power at the input =  $2 \cdot 10^{-10}$  W
- Noise power at the input =  $2 \cdot 10^{-18}$ W
- Power gain =  $10^6$
- Internal noise power =  $6 \cdot 10^{-12}$ W

Obtain:

- a) The SNR at the input (in dB).
- b) The SNR at the output (in dB).
- c) The noise factor (in dB).

**P5.** Obtain the total noise factor of a cascade of three amplification stages. Every amplifier with noise factor = 3dB and power gain = 10dB.

**P6.-** Obtain the noise temperature of a device whose noise figure is 6dB.



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