Computer Simulations of Communication Systems

Final, 6/14/2016

2×3 3×1024 3×2 2×1024

1. Make sure that your programs are executable when you hand in them.
2. Unless specified, you cannot use special built-in routines

(1) (20%) A MIMO system is given as **y** = **Hx**+**w** where **x** is the transmit signal vector, **y** the received signal vector, and **H** the channel matrix. Find the estimated **x** with the ZF and MMSE methods, and the corresponding symbol error rates (Given: x_1, y_1, H, vw, vx, Return: xzf_1, xmmse_1, SER_zf, SER_mmse). *Hint*:

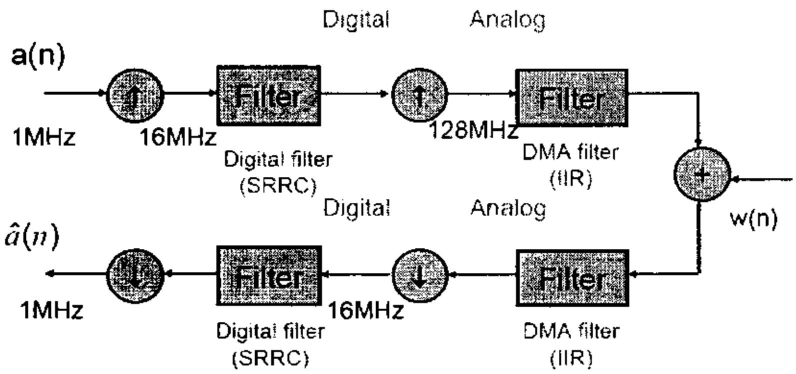
$$\mathbf{W}=\mathbf{H}^H\left(\mathbf{H}\mathbf{H}^H+\rho^{-1}\mathbf{I}\right)^{-1}, \quad \text{if } n_T > n_R$$

$$\mathbf{W}=\left(\mathbf{H}^H\mathbf{H}+\rho^{-1}\mathbf{I}\right)^{-1}\mathbf{H}^H, \quad \text{if } n_T \le n_R \qquad {}^{*}\rho=\frac{\sigma_x^2}{\sigma_w^2}$$

2×3 3×2 mmse ?

(2) (20%) Construct a communication system with hybrid pulse shaping. The required SNR is at least 25dB for a noiseless channel. (Given: a_2, Return: a_2h, SNR)

8 16)128 128 0



Note: The roll-off factor of the SRRC is 0.3 and the one-side span is 5. You can call the function of the SRRC; e.g., h=rcosine(1,16,'fir/sqrt',0.3,5).

(3) (20%) Consider an IF demodulation system shown below. Let f_c=32MHz and f_{IF}=2MHz. Design a receive DMA filter and construct the system. The required SNR is at least 25dB for a noiseless channel. (Given: a_3, Return: a_3h, SNR). The given $a(n)$ is a real signal. If the reconstruct signal is complex, explain why.

$-\frac{1020}{119} = c$ 30 34 120 40 1020

$28a = 20$ $5 = 17b$

$a = \frac{20}{28} = \frac{5}{7}$ $b = \frac{5}{17}$ $\frac{30}{7} + \frac{30}{17} + c = 0$ 25 dB noiseless channel

$14a - 34b = 0$

$14a + 34b = 20$

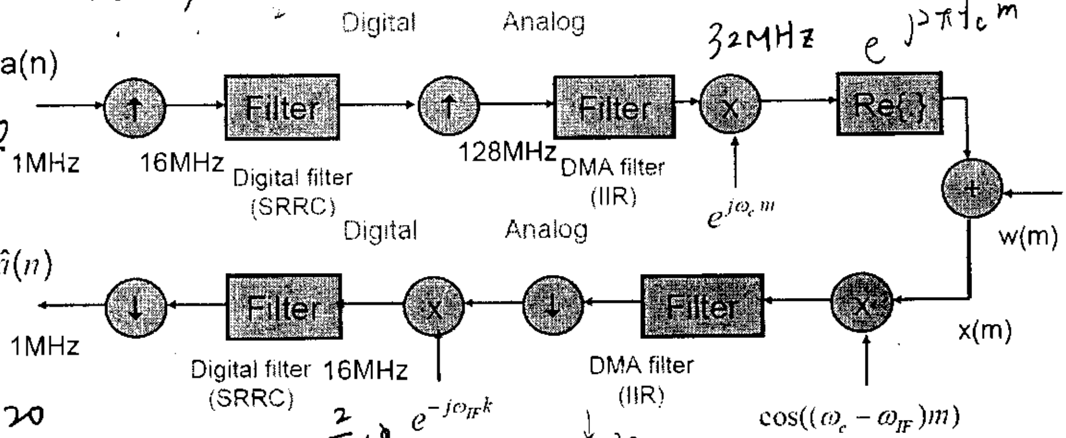
$24a + 24b + 4c = 0$

$6a + 6b + c = 0$

$7a - 17b = 0$

$-10a + 10b - 4c = 20$

32MHz $e^{j2\pi f_c m}$



$10^{-1} = 0.1$

$4\ \frac{2}{32} \times 8$ 2MHz 30

$-5 + 12$

(4) (20%) A communication system is shown below. It is known that f_c=32MHz and there is a frequency offset in the carrier of the transmitter. Try to find the frequency offset (in terms of PPM) and compensate it at the receiver (after ADC). (Given: a_4, x_4, return, a_4h, cfo). 10^{-6}

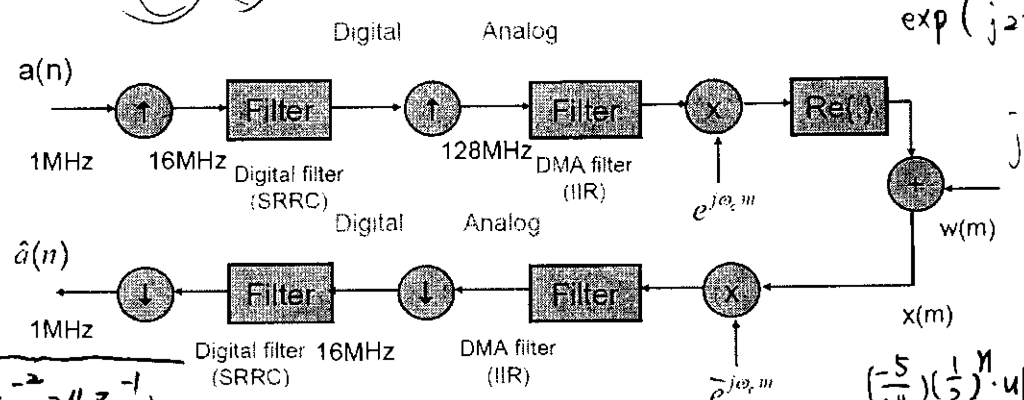
$a(6z^{-2} + 7z^{-1} - 10)$

$b(6z^{-2} - 17z^{-1} + 10)$

$c(z^{-2} \quad -4)$

$\exp(j2\pi(f_c + f_{cfo})m)$

$j2\pi f_c m + j2\pi f_{cfo} m$



$\frac{1}{H(z)} = \frac{20}{6z^{-3} - 5z^{-2} - 24z^{-1} + 20}$

$(-\frac{5}{14})(\frac{1}{2})^n u[n] + (\frac{5}{34})(-\frac{1}{2})^n u[n]$

$\frac{204}{119}(\frac{6}{5})^{-n} u[-n-1]$

Hint: Remove the transmit signal and then calculate the angle rotation rate.

(5) (20%) Consider a baseband equivalent model shown below. Let the channel response be {1,-1.2,-0.25,0.3}. Suppose that the total number of taps for the equalizer is 20, i.e., 20 multipliers. Implement a ZF equalizer (an FIR cascaded with an IIR filters). (Given: a_5)

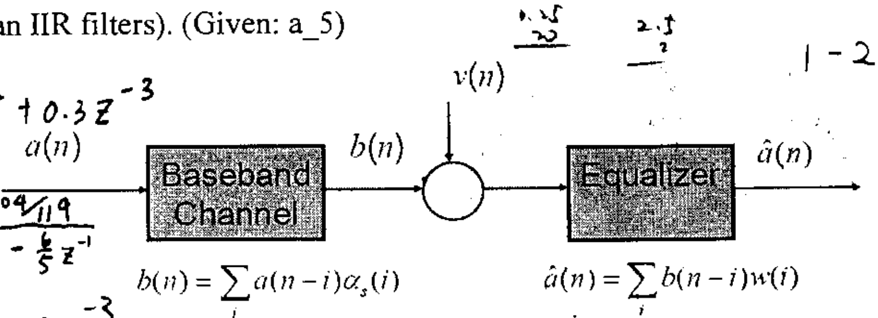
$= 20\left(\frac{a}{z^{-1}-2} + \frac{b}{z^{-1}+2} + \frac{c}{6z^{-1}-5}\right)$

$= \frac{5/7}{z^{-1}-2} + \frac{5/17}{z^{-1}+2} - \frac{1020/119}{6z^{-1}-5}$

$H(z) = 1 - 1.2z^{-1} - 0.25z^{-2} + 0.3z^{-3}$

$= \frac{-5/14}{1-\frac{1}{2}z^{-1}} + \frac{5/34}{1+\frac{1}{2}z^{-1}} + \frac{204/119}{1-\frac{6}{5}z^{-1}}$

$1-2 \overline{)\,6-5-24+20}$ $6+7-10$; $6-12$; $7-24$; $7-14$; $-10+20$



$\frac{1}{H(z)} = \frac{1}{1 - 1.2z^{-1} - 0.25z^{-2} + 0.3z^{-3}}$

(1) Plot the impulse response of the equalizer and that of the equalized channel (Return, imp_e).

$\frac{6}{5}$ $\frac{1}{2}$ $-\frac{1}{2}$

(2) Calculate the SNR of the equalized signal ($v(n)$=0). (Return, a_5h, SNR_e)

(3) Add 20-dB noise and re-calculate the equalized SNR. (Return, SNR_n)

$\frac{10}{12}$ $-\frac{24}{12}$ $\frac{5}{6}$ -2

$6\ \ -5 \quad \frac{-7 \pm \sqrt{49+240}}{12} = \frac{-7 \pm \sqrt{289}}{12} = \frac{-7 \pm 17}{12}$

$1 \quad 2$

$30 - 25 - 120 + 100$

$6 - 5 - 24 + 20$

$(x-2)(6x^2 + 7x - 10) = (x-2)(6x-5)(x+2)$