2、

$$N = \frac{2}{3}\frac{1}{\Delta F}\log_{10}\left(\frac{1}{10\delta_1\delta_2}\right)$$

$$= \frac{2}{3}\cdot\frac{1}{6000-5000}\cdot\frac{1}{0.00005}\times\log_{10}\left(\frac{1}{10\cdot 0.01\cdot 0.01}\right)$$

$$= \frac{2}{3}\cdot\frac{1}{0.05}\quad 3$$

$$= 20$$

3、

large computation loading since it is a $\theta(N\log N)$ way

4、

$$R(F) = \sum_{n=1}^{k+\frac{1}{2}} s[n]\sin\left(2\pi(n-\tfrac{1}{2})F\right)$$

$$-\sin\left(2\pi(n-\tfrac{1}{2})F\right)+\sin\left(2\pi(n+\tfrac{1}{2})F\right) = \cos 2\pi nF\cdot\sin\pi F\times 2$$

$$\Rightarrow R(F) = (\sin\pi F)\sum_{n=0}^{k_1} s_1[n]\cos(2\pi nF)$$

$$= \frac{1}{2}\left(\sum_{n=0}^{k_1} -s_1[n]\sin\left(2\pi(n-\tfrac{1}{2})F\right)+\sum_{n=1}^{k_1+1} s_1[n-1]\sin\left(2\pi(n-\tfrac{1}{2})F\right)\right) = \sum_{n=1}^{k+\frac{1}{2}} s[n]\sin\left(2\pi(n-\tfrac{1}{2})F\right)$$

let $k_1 = k-\frac{1}{2}$

$$\Rightarrow s[n] = \begin{cases} s_1[0]-\frac{1}{2}s[1] & n=1 \\ -\frac{1}{2}s_1[n]+\frac{1}{2}s_1[n-1] & n=2,3\ldots k-\frac{1}{2} \\ \frac{1}{2}s_1[k-\frac{1}{2}] & n=k+\frac{1}{2} \end{cases}$$

$$err(F) = [R(F)-H_d(F)]W(F)$$

$$= \left((\sin\pi F)\sum_{n=0}^{k-\frac{1}{2}} s_1[n]\cos(2\pi nF)-H_d(F)\right)W(F)$$

$$= \left[\sum_{n=0}^{k-\frac{1}{2}}\left(s_1[n]\cos(2\pi nF)-H_d(F)\cdot\csc(\pi F)\right)\right]\cdot\sin(\pi F)\cdot W(F)$$

$$\Rightarrow \begin{cases} H_d(F)\to\csc(\pi F)H_d(F) \\ W(F)\to\sin(\pi F)W(F) \\ k\to k-\frac{1}{2} \end{cases}$$

then we can apply the algorithm in 58-61

5、

(a)

$$x_H[n] = x[n] * h[n]$$

$$\Rightarrow X_H(F) = \left(\sum_{k=-\infty}^{\infty} 2\pi\delta(2\pi(F-k)) + \frac{\pi}{j}\left(\delta(2\pi F - 1 - 2\pi k) - \delta(2\pi F + 1 - 2\pi k)\right)\right) \times H(F)$$

$$= \sum_{k=-\infty}^{\infty} 2\pi\delta(2\pi(F-k)) \times 0 - \pi\left(\delta(2\pi F - 1 - 2\pi l) + \delta(2\pi F + 1 - 2\pi k)\right)$$

$$x_H(n) = -\cos n$$

(b)

$$x_a[n] = x[n] + j x_H[n]$$

$$= 1 + \sin n - j\cos n$$

$$= 1 + e^{j2\pi(n - \frac{1}{4})}$$

6.

(a)

(ii) (iii) (iv)

(b)

(v), (vi) (vii)

7、

(a)

1、stable & invertible

2、causal

(b)

1、able to recognize signals with different delay

2、able to seperate convolution operations caused by multipath.

8、

(a)

$$H(z) = \frac{1 + z^{-1} - 1.5z^{-2} + z^{-3}}{1 - 0.3z^{-1} - 0.4z^{-2}} = \frac{(1 + 2z^{-1})(1 - z^{-1} + 0.5z^{-2})}{(1 + 0.5z^{-1})(1 - 0.8z^{-1})} = \frac{2z^{-1}(1 + \frac{1}{2}z)(1 - z^{-1} + 0.5z^{-2})}{(1 + 0.5z^{-1})(1 - 0.8z^{-1})}$$

$$\hat{H}(z) = \log|H(z)| + j\arg[H(e^{j2\pi F})]$$

$$= \log 2 - \log z + \log\left(1+\tfrac{1}{2}z\right) + \log\left(1-z^{-1}+0.5z^{-2}\right) - \log\left(1+0.5z^{-1}\right) - \log\left(1-0.8z^{-1}\right)$$

$$\Rightarrow \hat{h}[n] = \begin{cases} \log 2, & n=0 \\ \left(-(0.5+0.5j)^n - (0.5-0.5j)^n - 0.5^n + 0.8^n\right)\cdot\frac{1}{n}, & n>0 \\ \frac{2^{-n}}{n} & n<0 \end{cases} \#$$

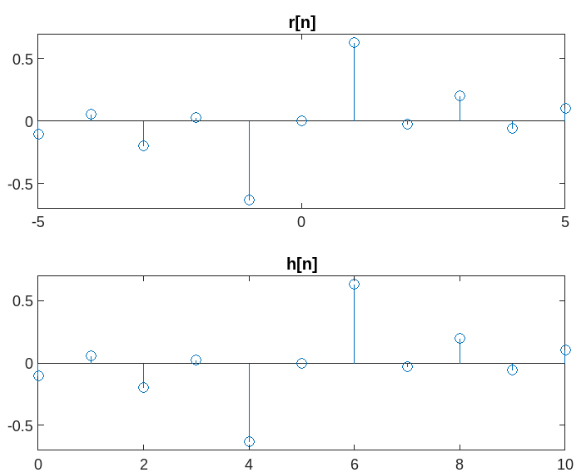
(b)

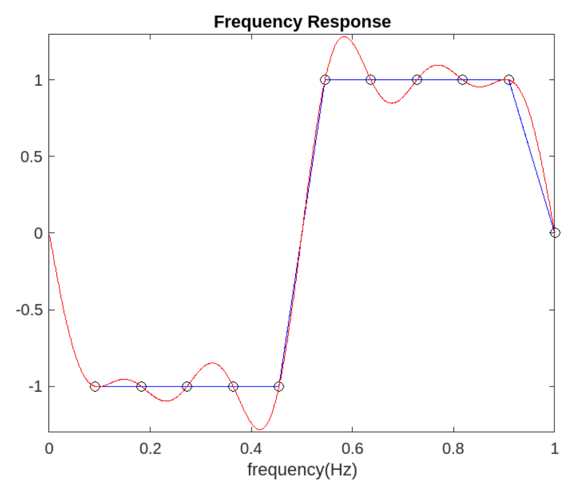
$$H(z) = \frac{(1+2z^{-1})(1-z^{-1}+0.5z^{-2})}{(1+0.5z^{-1})(1-0.8z^{-1})}$$

$$= \frac{(z+2)(z^2-z+0.5)}{z(z+0.5)(z-0.8)} \Rightarrow \text{only } z+2 \text{ is out of unit circle}$$

$$\Rightarrow H_{mp}(z) = H(z)\cdot 2\cdot\frac{z-\frac{1}{2}}{z-2} = \frac{2(z-\frac{1}{2})(z^2-z+0.5)}{z(z-2)(z+0.5)(z-0.8)} \#$$

1. ex: $k=5$





Frequency Response: show real part of filter $r[n] = \sum_n H_d(F)\, e^{j2\pi nF}$

imagine part of filter $R(F) = \sum_n r[n]\, e^{-j2\pi nF}$

since $r[n]$ should be real & $R(F)$ should be imagine

(Also, $\text{imag}(r[n]) \doteq 0$ & $\text{real}(R(F)) \doteq 0$ by matlab calculation #