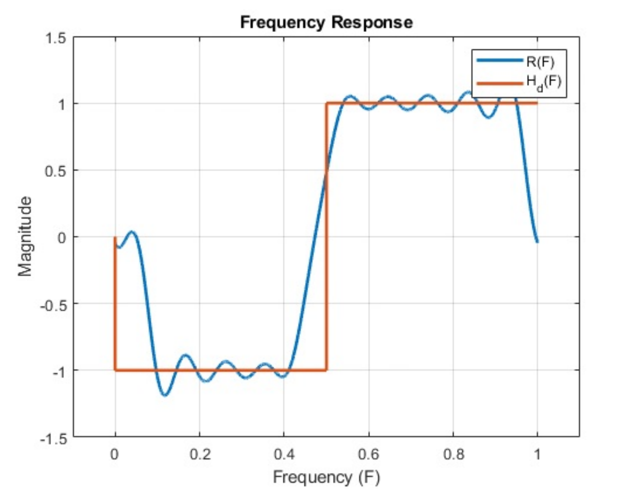
1.

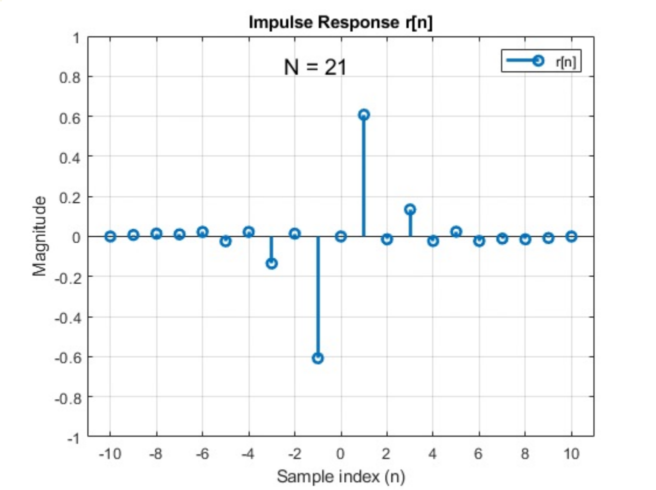
Code 中 k 選用 10，transition band 為 $\frac{1}{2k+1}$ $(-0.0476i)$

$\frac{k}{2k+1}$ $(-0.04762i)$

$\frac{k+1}{2k+1}$ $(0.5238i)$

$\frac{2k}{2k+1}$ $(0.9524i)$





2.

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

δ_1、$\delta_2 = 0.01$

$\Delta F = (6000 - 5000) \times 0.00005 = 0.05$

$$\Rightarrow N = \frac{2}{3 \times 0.05}\log\left(\frac{1}{10 \times 0.01^2}\right)$$

$\Rightarrow N = 40$

3、

在實際應用上此方法的運算量太大，因此不會拿來實務應用，但理論上可行

4.

Type 4 : $R(F) = \sin(\pi F)\sum_{n=0}^{k_1} S_1[n]\cos(2\pi nF)$

$\Rightarrow R(F) = \sum_{n=0}^{k_1} \frac{1}{2} S_1[n] \sin[2\pi F(n+\frac{1}{2})] - \sum_{n=0}^{k_1} \frac{1}{2} S_1[n] \sin[2\pi F(n-\frac{1}{2})]$

$\Rightarrow R(F) = \sum_{n=1}^{k_1+1} \frac{1}{2} S_1[n-1] \sin\{2\pi F(n-\frac{1}{2})] - \sum_{n=0}^{k_1} \frac{1}{2} S_1\{n] \sin\{2\pi F(n-\frac{1}{2})]$

$\Rightarrow R(F) = -\frac{1}{2}S_1\{0] \sin\{2\pi F(-\frac{1}{2})] + \sum_{n=1}^{k_1} \frac{1}{2}(S_1[n-1) - S_1(n)) \sin\{2\pi F(n-\frac{1}{2})] + \frac{1}{2}S_1\{k_1] \cos[2\pi F(k_1+\frac{1}{2})]$

$\Rightarrow R(F) = \frac{1}{2}S_1\{0] \sin\{\pi F] + \frac{1}{2}(S_1\{0] - S_1\{1]) \sin\{2\pi F(\frac{1}{2})] + \sum_{n=2}^{k_1} \frac{1}{2}(S_1[n-1] - S_1(n]\sin\{2\pi F(n-\frac{1}{2})] + \frac{1}{2}S_1\{k_1]\cos[2\pi F(k_1+\frac{1}{2})]$

Let $k = k_1 + \frac{1}{2} \Rightarrow k_1 = k - \frac{1}{2}$

$\Rightarrow R(F) = (S_1\{0] - \frac{1}{2}S_1\{1])\sin\{\pi F] + \sum_{n=2}^{k-\frac{1}{2}} \frac{1}{2}(S_1[n-1] - S_1(n]\sin\{2\pi F(n-\frac{1}{2})] + \frac{1}{2}S_1\{k-\frac{1}{2}]\cos[2\pi F(k)]$

$$\Rightarrow \begin{cases} S_1[1] = S_1[0] - \frac{1}{2}S_1[1] \\ s[n] = \frac{1}{2}(S_1[n-1] - S_1[n]), \quad n = 2, 3, 4, \ldots, k-\frac{1}{2} \\ s[k+\frac{1}{2}] = \frac{1}{2}S_1[k-\frac{1}{2}] \end{cases}$$

4、

$$\mathrm{err}(F) = [R(F) - H_d(F)]\,W(F)$$

$$= \left[\sin(\pi F)\sum_{n=0}^{k-\frac{1}{2}} S_1[n]\cos(2\pi nF) - H_d(F)\right] W(F)$$

$$= \left[\sum_{n=0}^{k-\frac{1}{2}} S_1[n]\cos(2\pi nF) - \csc(\pi F)H_d(F)\right] \sin(\pi F)\,W(F)$$

$$\Rightarrow \begin{cases} H_d(F) \longrightarrow \csc[\pi F]\,H_d(F) \\ W(F) \longrightarrow \sin[\pi F]\,W(F) \\ k \longrightarrow k-\frac{1}{2} = \frac{N}{2}-1 \end{cases}$$

5.

$$x[n] = 1 + \sin(n)$$

$$X(F) = \frac{j}{2}\delta(F-1) + 2\delta(F) - \frac{j}{2}\delta(F+1)$$

$$X_H(F) = \frac{1}{2}\delta(F-1) + \frac{1}{2}\delta(F-1)$$

$$x_H[n] = \frac{1}{2}\exp[j(n)] + \frac{1}{2}\exp[-j(n)]$$

$$= \cos(n)$$

$$x_a[n] = 1 + \sin(n) + j\cos(n)$$

6.

(a)

(i), (ii), (iii), (iv)

(b)

(v), (vi), (vii)

7.

(a)

讓 forword、inverse tranform 穩定，且讓能量集中在 $n=0$，當 n 值很大時，minimal phase filter 值趨近 0

(b)

不需測量在不同的路徑中的 delay time，且在 cepstrum 中 $H(z)$ 為 stable

8.

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

(a)

$$1+z^{-1}-1.5z^{-2}+z^{-3} = \frac{5(2z^3+2z^2-3z+2)}{2z^3}$$

$$1-0.3z^{-1}-0.4z^{2} = \frac{10z^2-3z-4}{10z^2}$$

$$H(z) = \frac{5(2z^3+2z^2-3z+2)}{z(10z^2-3z-4)}$$

$$\begin{aligned}2z^3+2z^2-3z+2 &= (z+2)\left[z-\left(\tfrac{1}{2}+\tfrac{1}{2}i\right)\right]\left[z-\left(\tfrac{1}{2}-\tfrac{1}{2}i\right)\right]\\ &= z^3(1+2z^{-1})\left[1-\left(\tfrac{1}{2}+\tfrac{1}{2}i\right)z^{-1}\right]\left[1-\left(\tfrac{1}{2}-\tfrac{1}{2}i\right)z^{-1}\right]\end{aligned}$$

$$\begin{aligned}10z^2-3z-4 &= (z-0.8)(z+0.5)\\ &= z^2(1-0.8z^{-1})(z+0.5z^{-1})\end{aligned}$$

$$H(z) = \frac{5z^3(1+2z^{-1})\left(1-\frac{1+i}{2}z^{-1}\right)\left(1-\frac{1-i}{2}z^{-1}\right)}{z^3(1+0.5z^{-1})(1-0.8z^{-1})}$$

$$\Rightarrow \hat{x}[n] = \begin{cases} \log(5), & n=0 \\ \dfrac{(-2)^n}{n} + \dfrac{(-0.5)^n}{n} + \dfrac{(0.8)^n}{n}, & n<0 \\ \dfrac{\left(\frac{1+i}{2}\right)^n}{n} + \dfrac{\left(\frac{1-i}{2}\right)^n}{n}, & n>0 \end{cases}$$

8

(b)

$$H(z) = \frac{5(z+2)\left[z-\left(\frac{1}{2}+\frac{1}{2}i\right)\right]\left[z-\left(\frac{1}{2}-\frac{1}{2}i\right)\right]}{z\,(z-0.8)(z+0.5)}$$

$$H_1(z) = H(z) \cdot -2\,\frac{z-(-2)^{-1}}{z+2}$$

$$= \frac{-10(z+2)\left[z-\left(\frac{1}{2}+\frac{1}{2}i\right)\right]\left[z-\left(\frac{1}{2}-\frac{1}{2}i\right)\right]}{z\,(z-0.8)(z+0.5)}$$