PE Course: Signal Processing

http://www.cs.aaue.dk/~yang/course/filter08.html
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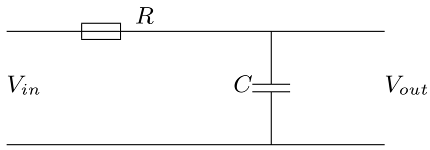
Exercise Solution for MM1

2. Determine the types (IIR or FIR) of following systems and explain the reason.

- $h[n] = u[n] - u[n-3]$ - FIR system
- $h[n] = \begin{cases} ln(n+1) & \text{for } n \geq 0 \\ 0 & \text{for } n < 0 \end{cases}$ - IIR system
- $H(z) = 1 + z^2 - z^{-4}$ - FIR system
- $H(e^{j\omega}) = \frac{1}{1-2e^{-j\omega}}$ - IIR system

3. Consider the following analog circuit, where resistance $R = 1k\Omega$ and capacitor $C = 1\mu F$.



- Calculate the *impulse response function* $h(t)$ of above system by regarding voltage V_{in} as the input and V_{out} as the output.

  $h(t) = \frac{1}{RC} exp(-\frac{t}{RC}) = 10^3 exp(-10^3 t)$

- Calculate an *impulse response sequence* $h[n]$ by following the formula: $h[n] = T_d h(nT_d)$, where $h(t)$ is the obtained function in the above exercise and $T_d = 1/8000$.

  $h[n] = T_d h(nT_d) = 1/8000 * 10^3 exp(-10^3 n/8000) = 0.125 exp(-0.125n)$.

- Obtain the system function $H(z)$ and frequency response $H(e^{j\omega})$ of above sequence $h[n]$.

  $H(z) = \frac{0.125}{1-e^{-0.125}z^{-1}} = \frac{0.125}{1-0.8825z^{-1}}$
  $H(e^{j\omega}) = \frac{0.125}{1-0.8825e^{-j\omega}}$.

- Is the system $H(z)$ stable? and why?

  This filter is stable, because the pole $p = 0.8825$ locates within the unit circle.

- Is this analog circuit acting as a low-pass or high-pass filter?

  This filter is a lowpass filter.

This can be observed from the bode plot of this system:
Open Matlab, then type

```
≫ bode(tf([1],[0.001 1]))
≫ grid
≫ title('Bode plot of analog filter H(s)=1/(1+0.001s)')
≫ figure
≫ sys=tf([0.125 0],[1 -0.8825],8000)
≫ bode(sys)
≫ title('Bode plot of discrete-time filter H(z)=0.125z/(z-0.8825)')
≫ grid
```

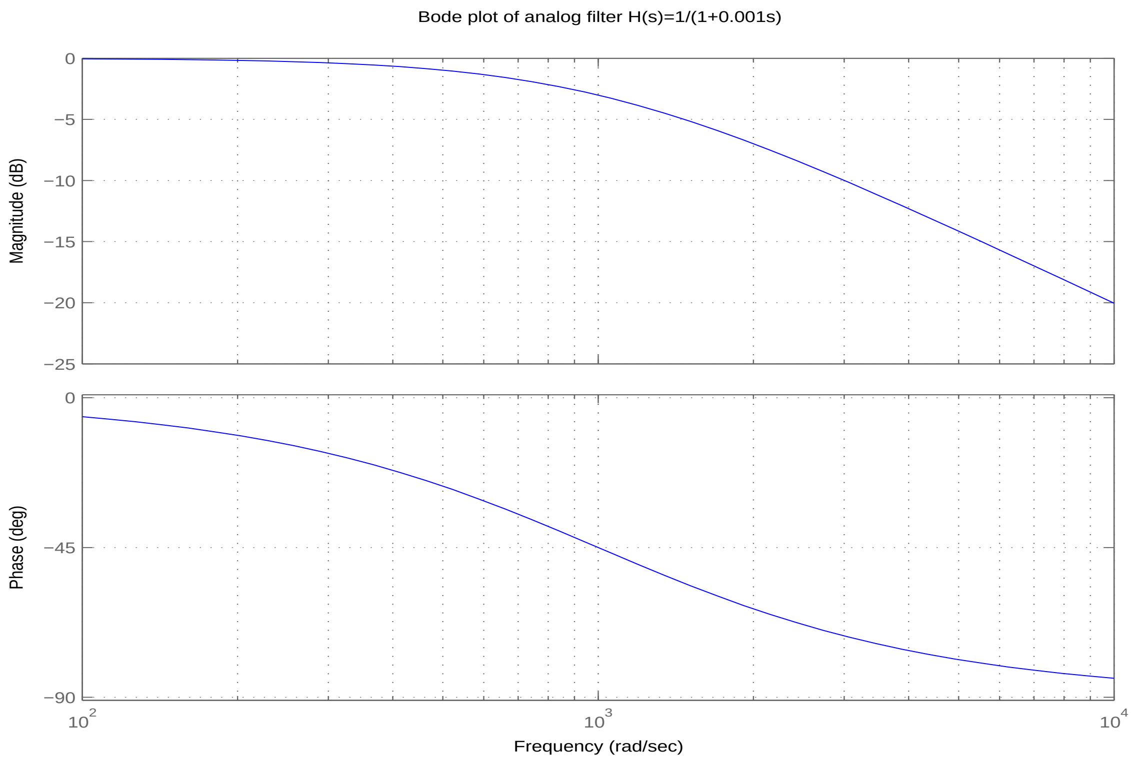


Figure 1: Fig.1 Bode plot of analog filter H(s)=1/(1+0.001s)

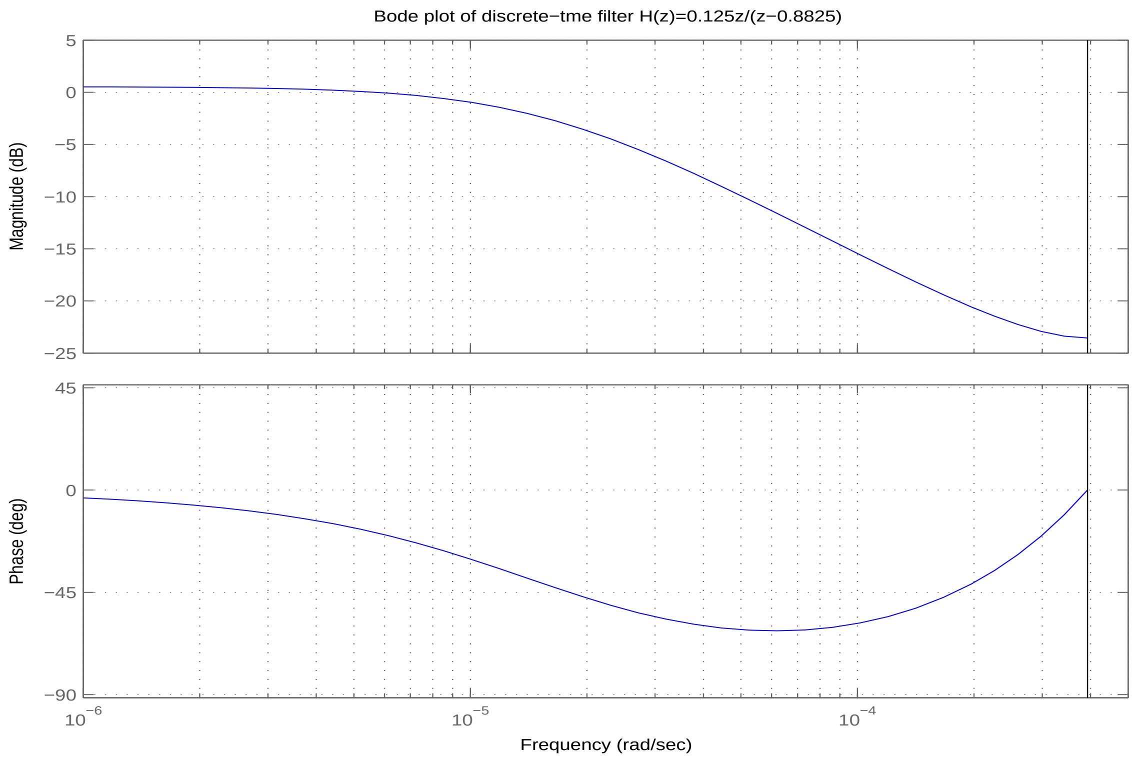


Figure 2: Fig.2 Bode plot of discrete-time filter H(z)=0.125z/(z-0.8825)