REPORT

Zajęcia: Analog and digital electronic circuits
Teacher: prof. dr hab. Vasyl Martsenyuk

Lab 9
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Topic: "IIR filter"
Variant 2

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1. Problem statement: The objective is to investigate IIR filtering technique for different parameters
of filtering

2. Input data:
M = 2
b_0 = 1
b_1 = 1
b_2 = 2

3. Commands used (or GUI):

a) source code

Bode plot definition

```
def bode_plot(b, a, N=2**10, fig=None):  # for IIR if length of b and a are the same
    if fig is None:
        fig = plt.figure()

    z, p, gain = signal.tf2zpk(b, a)
    W, Hd = signal.freqz(b, a, N, whole=True)

    # print('number of poles:', len(p), '\npole(s) at:', p,
    #       '\nnumber of zeros:', len(z), '\nzero(s) at:', z)

    gs = fig.add_gridspec(2, 2)
    # magnitude
    ax1 = fig.add_subplot(gs[0, 0])
    ax1.plot(W/np.pi, np.abs(Hd), "C0",
             label=r'$|H(\Omega)|$)',
             linewidth=2)
    ax1.set_xlim(0, 2)
    ax1.set_xticks(np.arange(0, 9)/4)
    ax1.set_xlabel(r'$\Omega \,/\, \pi$', color='k')
    ax1.set_ylabel(r'$|H|$', color='k')
```

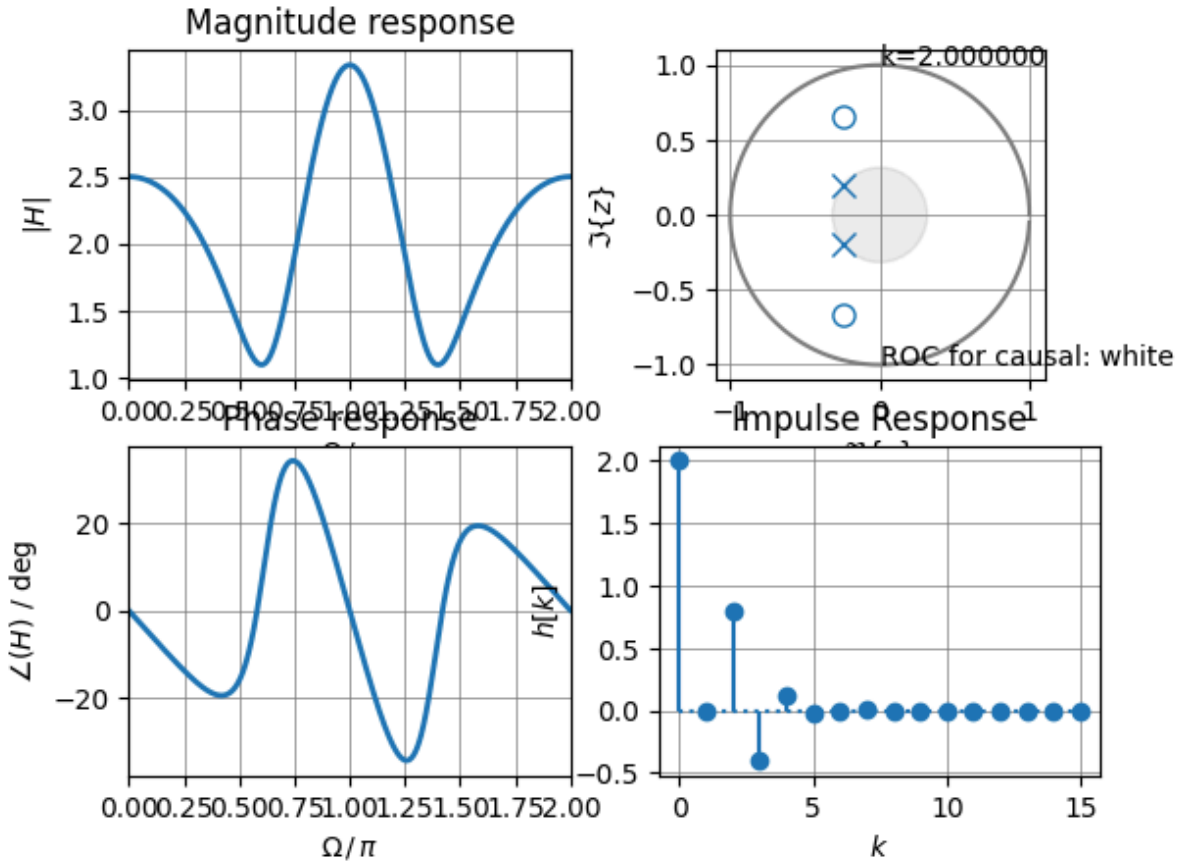
```
ax1.set_title("Magnitude response", color='k')
ax1.grid(True, which="both", axis="both",
        linestyle="-", linewidth=0.5, color='C7')

# phase
ax2 = fig.add_subplot(gs[1, 0])
ax2.plot(W/np.pi, (np.angle(Hd)*180/np.pi), "C0",
        label=r'$\mathrm{angle}(H(r'\omega))$',
        linewidth=2)
ax2.set_xlim(0, 2)
ax2.set_xticks(np.arange(0, 9)/4)
ax2.set_xlabel(r'$\Omega \,/\, \pi$', color='k')
ax2.set_ylabel(r'$\angle(H)$ / deg', color='k')
ax2.set_title("Phase response", color='k')
ax2.grid(True, which="both", axis="both",
        linestyle="-", linewidth=0.5, color='C7')

# zplane
ax3 = fig.add_subplot(gs[0, 1])
zplane_plot(ax3, z, p, gain)

# impulse response
N = 2**4  # here specially chosen for the examples below
k = np.arange(0, N)
x = np.zeros(N)
x[0] = 1
h = signal.lfilter(b, a, x)
ax4 = fig.add_subplot(gs[1, 1])
ax4.stem(k, h, linefmt='C0', markerfmt='C0o',
        basefmt='C0:')
ax4.set_xlabel(r'$k$')
ax4.set_ylabel(r'$h[k]$')
ax4.set_title('Impulse Response')
ax4.grid(True, which="both", axis="both", linestyle="-",
        linewidth=0.5, color='C7')
```

Plotting result for given input parameters

bode_plot(np.array([2.0, 1.0, 1.0]), np.array([1.0, 0.5, 0.1]))

https://github.com/wm64167/AADEC

4. Outcomes:



5. Conclusions:

This lab explored the behavior of IIR filters with various parameter settings. By plotting the magnitude response, poles, phase response, and impulse response, we gained knowledge about the filter's frequency selectivity, stability, phase behavior, and transient response. This allows for selection of IIR filter parameters to achieve the desired signal processing effect.