

lab8

May 16, 2024

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[1]: import numpy as np
import matplotlib.pyplot as plt
from matplotlib.markers import MarkerStyle
from matplotlib.patches import Circle
from scipy import signal

[2]: def zplane_plot(ax, z, p, k):
    """Plot pole/zero/gain plot of discrete-time, linear-time-invariant system.

    Note that the for-loop handling might be not very efficient
    for very long FIRs

    z...array of zeros in z-plane
    p...array of poles in z-plane
    k...gain factor

    taken from own work
    URL = ('https://github.com/spatialaudio/signals-and-systems-exercises/'
          'blob/master/sig_sys_tools.py')

    currently we don't use the ax input parameter, we rather just plot
    in hope for getting an appropriate place for it from the calling function
    """
    # draw unit circle
    Nf = 2**7
    Om = np.arange(Nf) * 2*np.pi/Nf
    plt.plot(np.cos(Om), np.sin(Om), 'C7')

    try: # TBD: check if this pole is compensated by a zero
        circle = Circle((0, 0), radius=np.max(np.abs(p)),
                        color='C7', alpha=0.15)
        plt.gcf().gca().add_artist(circle)
    except ValueError:
        print('no pole at all, ROC is whole z-plane')

    zu, zc = np.unique(z, return_counts=True) # find and count unique zeros
    for zui, zci in zip(zu, zc): # plot them individually
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plt.plot(np.real(zui), np.imag(zui), ms=8,
         color='C0', marker='o', fillstyle='none')
if zci > 1: # if multiple zeros exist then indicate the count
    plt.text(np.real(zui), np.imag(zui), zci)

pu, pc = np.unique(p, return_counts=True) # find and count unique poles
for pui, pci in zip(pu, pc): # plot them individually
    plt.plot(np.real(pui), np.imag(pui), ms=8,
             color='C0', marker='x')
    if pci > 1: # if multiple poles exist then indicate the count
        plt.text(np.real(pui), np.imag(pui), pci)

plt.text(0, +1, 'k={0:f}'.format(k))
plt.text(0, -1, 'ROC for causal: white')
plt.axis('square')
plt.xlabel(r'$\text{Re}\{z\}$')
plt.ylabel(r'$\text{Im}\{z\}$')
plt.grid(True, which="both", axis="both",
        linestyle="-", linewidth=0.5, color='C7')

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[3]: def bode_plot(b, N=2**10, fig=None): # we use this here for FIRs only
    if fig is None:
        fig = plt.figure()

    a = np.zeros(len(b)) # some scipy packages need len(a)==len(b)
    a[0] = 1

    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'$\Omega \backslash, \wedge, \pi$', 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')

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# 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'$\Omega \backslash, / \backslash, \pi$', 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**3 # here specially chosen for the examples below
k = np.arange(N)
x = np.zeros(N)
x[0] = 1 # create a Dirac
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')

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[4]: figsize = (12, 9)
b = [0, 1, 1]
bode_plot(b, fig=plt.figure(figsize=figsize))

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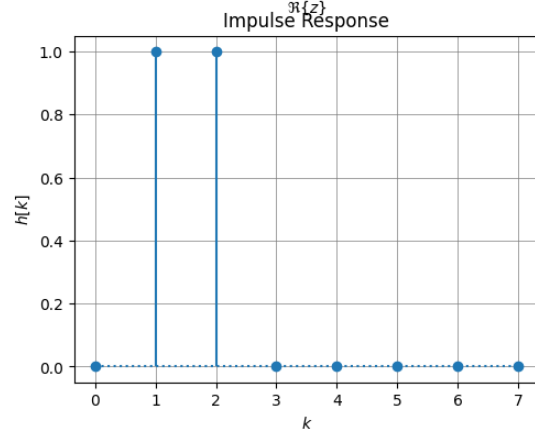
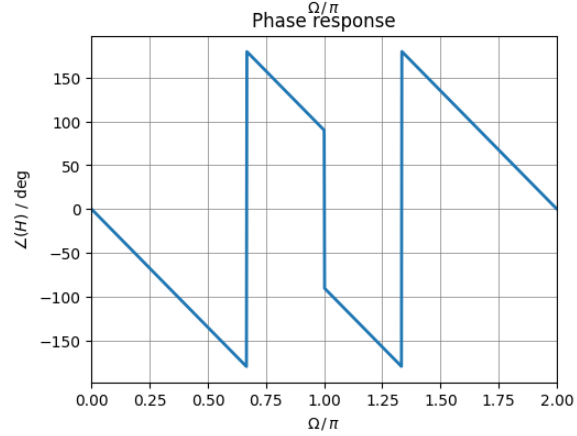
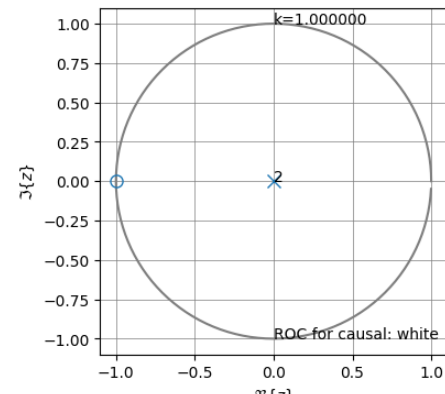
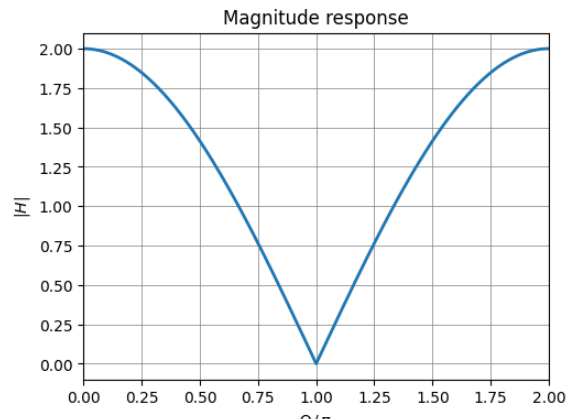
C:\Users\aga54\AppData\Local\Programs\Python\Python312\Lib\site-packages\scipy\signal_filter_design.py:1109: BadCoefficients: Badly conditioned filter coefficients (numerator): the results may be meaningless

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b, a = normalize(b, a)
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number of poles: 2
pole(s) at: [0. 0.]
number of zeros: 1
zero(s) at: [-1.]

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