import numpy as np

import matplotlib.pyplot as plt

from scipy.signal import fftconvolve

import os

Fs = 20000

T  = 0.2

t  = np.arange(-T/2, T/2, 1/Fs)

def sinc\_lab(x):

    return np.sinc(x/np.pi)

def mag\_spectrum(x, Fs):

    X = np.fft.fftshift(np.fft.fft(x))

    f = np.fft.fftshift(np.fft.fftfreq(len(x), d=1/Fs))

    return f, np.abs(X)/len(x)

def lpf\_impulse(t, B):

    return 2\*B \* sinc\_lab(2\*np.pi\*B\*t)

B1 = 500

B2 = 400

f0 = 110

os.makedirs("plots", exist\_ok=True)

plot\_num = 1

def save\_plot(x, y, title):

    global plot\_num

    plt.figure()

    plt.plot(x, y)

    plt.title(title)

    plt.savefig(f"plots/plot\_{plot\_num:02d}.png", dpi=300)

    plt.close()

    plot\_num += 1

m = lpf\_impulse(t, B1)

g = lpf\_impulse(t, B2)

save\_plot(t, m, f"m(t) for B1={B1} Hz")

save\_plot(t, g, f"g(t) for B2={B2} Hz")

f, Mmag = mag\_spectrum(m, Fs)

save\_plot(f, Mmag, f"|M(f)| for B1={B1} Hz")

f, Gmag = mag\_spectrum(g, Fs)

save\_plot(f, Gmag, f"|G(f)| for B2={B2} Hz")

y\_full = fftconvolve(m, g, mode="full")

start = (len(y\_full) - len(m)) // 2

y = y\_full[start:start+len(m)]

save\_plot(t, y, f"y(t)=m\*g (B1={B1} Hz, B2={B2} Hz)")

f, Ymag = mag\_spectrum(y, Fs)

save\_plot(f, Ymag, f"|Y(f)| (B1={B1} Hz, B2={B2} Hz)")

m\_tones = sum((1.0/k) \* np.cos(2\*np.pi\*k\*f0\*t) for k in range(1, 6))

save\_plot(t, m\_tones, "m(t) five-tone")

f, Mtones = mag\_spectrum(m\_tones, Fs)

save\_plot(f, Mtones, "|M(f)| five-tone")

y\_full = fftconvolve(m\_tones, g, mode="full")

start = (len(y\_full) - len(m\_tones)) // 2

y\_tones = y\_full[start:start+len(m\_tones)]

save\_plot(t, y\_tones, f"y(t) five-tone via B2={B2} Hz")

f, Ytones = mag\_spectrum(y\_tones, Fs)

save\_plot(f, Ytones, f"|Y(f)| five-tone via B2={B2} Hz")

