LAB2-Windowing

December 25, 2023

[6]:
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import numpy as np
import matplotlib.pyplot as plt
from numpy.fft import fft, ifft, fftshift
#from scipy. fft import fft , ifft , fftshift
from scipy.signal.windows import hann, flattop

# Generating signals
#Variant 6
f1 = 600  # Hz
f2 = 600.25  # Hz
f3 = 599.75  # Hz
#|x[k]|max = 3
fs = 800 #Hz
N = 2000


amplitude = 3
k = np.arange(N)
x1 = amplitude * np.sin(2*np.pi*f1/fs*k)
x2 = amplitude * np.sin(2*np.pi*f2/fs*k)
x3 = amplitude * np.sin(2*np.pi*f3/fs*k)

#Generating Windows
wrect =np.ones(N)
whann=hann(N, sym=False)
wflattop= flattop(N, sym=False)
plt.plot(wrect , "C0o-" , ms=3, label="rect ")
plt.plot(whann, "C1o-" , ms=3, label="hann")
plt.plot(wflattop, "C2o-" , ms=3, label="flattop")
plt.xlabel(r"$k$")
plt.ylabel(r"window␣$w[k]$")
plt.xlim(0, N)
plt.legend()
plt.grid(True)

#DFT spectra uding FFT algorithm
X1wrect = fft(x1)
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X2wrect = fft(x2)
X3wrect = fft(x3)
X1whann= fft(x1 * whann)
X2whann= fft(x2 * whann)
X3whann= fft(x3 * whann)
X1wflattop= fft(x1 * wflattop)
X2wflattop= fft(x2 * wflattop)
X3wflattop= fft(x3 * wflattop)

# this handling is working for N even and odd:
def fft2db(X):
    N=X.size
    Xtmp=2/N * X # independent of N, norm for sine amplitudes
    Xtmp[0] *= 1/2 #bin for f=0Hz is existing only once, #so cancel *2 from␣
 ↪above
    if N%2==0: # fs/2 is included as a bin # fs/2 bin is existing only once, so␣
 ↪cancel *2 from above
        Xtmp[N//2] =Xtmp[N//2] / 2
        return 20 * np.log10(np.abs(Xtmp)) # in dB

# setup of frequency vector this way is independent of N even/odd:
df = fs/N
f =np.arange(N) * df

#Solution
plt.figure(figsize=(16/1.5, 10/1.5))
plt.subplot(3, 1, 1)
plt.plot(f , fft2db(X1wrect), "C0o-" , ms=3, label="best␣case␣rect ")
plt.plot(f , fft2db(X2wrect), "C3o-" , ms=3, label="worst␣case␣upper␣rect ")
plt.plot(f , fft2db(X3wrect), "C4o-" , ms=3, label="worst␣case␣lower␣rect ")
plt.xlim(175, 225)
plt.ylim(-60, 20)
plt.xticks(np.arange(175, 230, 5))
plt.yticks(np.arange(-60, 20, 10))
plt.legend()
#plt.xlabel("f / Hz")
plt.ylabel("A␣/␣dB")
plt.grid(True)

plt.subplot(3, 1, 2)
plt.plot(f , fft2db(X1whann), "C0o-" , ms=3, label="best␣case␣hann")
plt.plot(f , fft2db(X2whann), "C3o-" , ms=3, label="worst␣case␣upper␣hann")
plt.plot(f , fft2db(X3whann), "C4o-" , ms=3, label="worst␣case␣lower␣hann")
plt.xlim(175, 225)
plt.ylim(-60, 20)
plt.xticks(np.arange(175, 230, 5))
plt.yticks(np.arange(-60, 20, 10))
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plt.legend()
#plt.xlabel("f / Hz")
plt.ylabel("A␣/␣dB")
plt.grid(True)

plt.subplot(3, 1, 3)
plt.plot(f , fft2db(X1wflattop), "C0o-" , ms=3, label="best␣case␣flattop")
plt.plot(f , fft2db(X2wflattop), "C3o-" , ms=3,␣
 ↪label="worst␣case␣upper␣flattop")
plt.plot(f , fft2db(X3wflattop), "C4o-" , ms=3,␣
 ↪label="worst␣case␣lower␣flattop")
plt.xlim(175, 225)
plt.ylim(-60, 20)
plt.xticks(np.arange(175, 230, 5))
plt.yticks(np.arange(-60, 20, 10))
plt.legend()
plt.xlabel("f␣/␣Hz")
plt.ylabel("A␣/␣dB")
plt.grid(True)

#Preparations for solutions
def winDTFTdB(w):
    N = w.size #get window length
    Nz = 100 * N #zeropadding length
    W = np.zeros(Nz) #allocate RAM
    W[0:N] = w # insert window
    W = np.abs(fftshift(fft(W))) # fft , fftshift and magnitude
    W/=np.max(W) #normalize to maximum, i.e. the mainlobe #maximum here
    W = 20 * np.log10(W) #get level in dB #get appropriate digital frequencies
    Omega = 2 * np.pi/Nz * np.arange(Nz) - np.pi #also shifted
    return Omega, W

plt.plot([-np.pi , +np.pi ] , [-3.01, -3.01], "gray")#mainlobe bandwidth
plt.plot([-np.pi , +np.pi ] , [-13.3, -13.3], "gray")# rect max sidelobe
plt.plot([-np.pi , +np.pi ] , [-31.5, -31.5], "gray")#hannmax sidelobe
plt.plot([-np.pi , +np.pi ] , [-93.6, -93.6], "gray")# flattop max #sidelobe


Omega, W = winDTFTdB(wrect)
plt.plot(Omega, W, label="rect")

Omega,W = winDTFTdB(whann)
plt.plot(Omega,W, label="hann")

Omega,W = winDTFTdB(wflattop)
plt.plot(Omega,W, label="flattop")
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plt.xlim(-np.pi , np.pi)
plt.ylim(-120, 10)
plt.xlim(-np.pi/100, np.pi/100) #zoom into mainlobe
plt.xlabel(r"$\Omega$")
plt.ylabel(r"|W($\Omega$)|␣/␣dB")
plt.legend()
plt.grid(True)
```

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C:\Users\Adam\AppData\Local\Temp\ipykernel_6716\977850643.py:109:
RuntimeWarning: divide by zero encountered in log10
  W = 20 * np.log10(W) #get level in dB #get appropriate digital frequencies
```

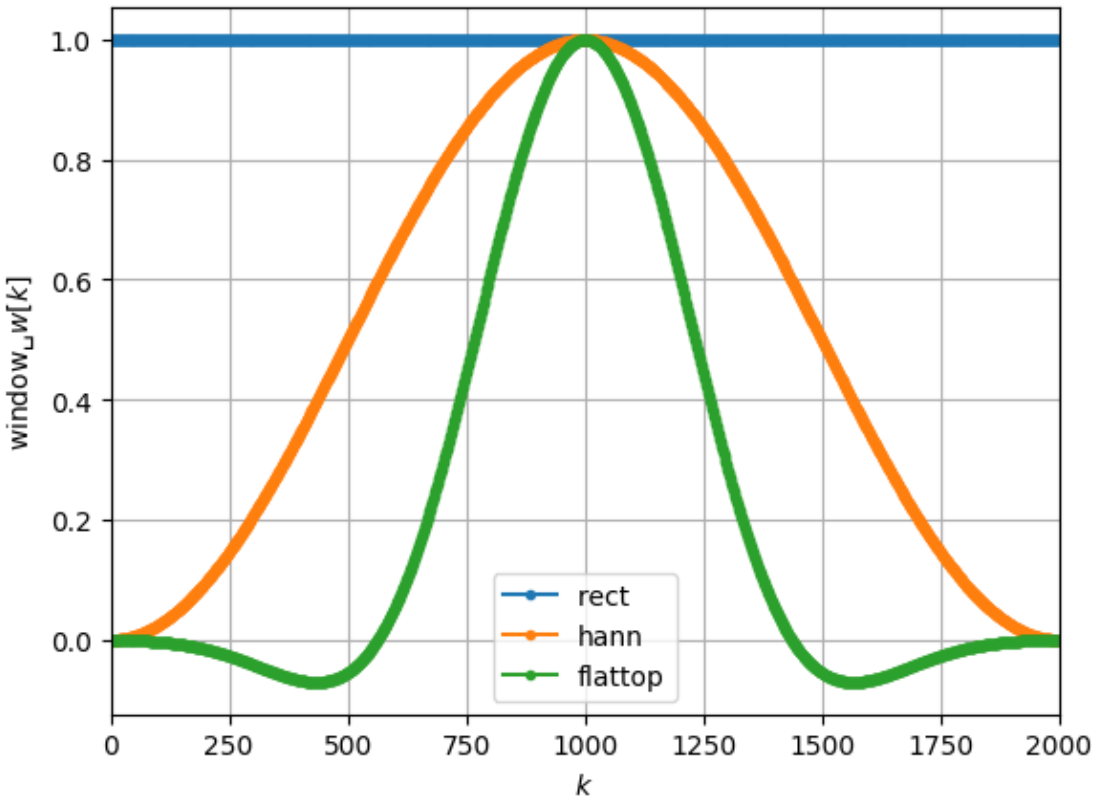

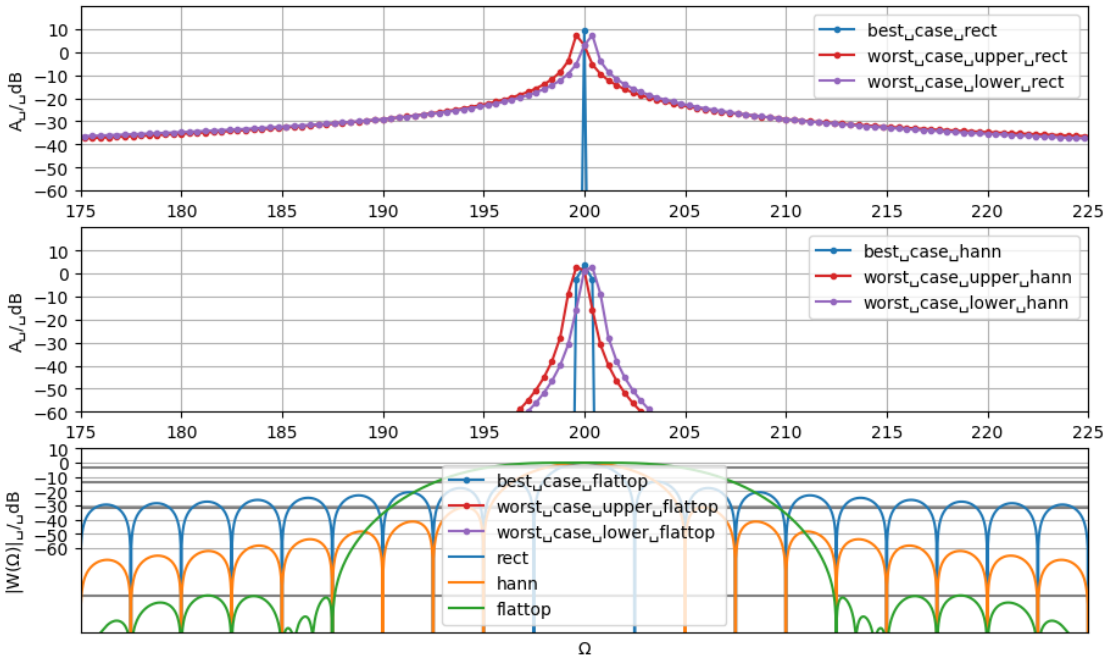
best␣case␣rect
worst␣case␣upper␣rect
worst␣case␣lower␣rect
A␣/␣dB
best␣case␣hann
worst␣case␣upper␣hann
worst␣case␣lower␣hann
A␣/␣dB
best␣case␣flattop
worst␣case␣upper␣flattop
worst␣case␣lower␣flattop
rect
hann
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|W(Ω)|␣/␣dB
Ω

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