CIC filter: solution

Introduction to digital Low-Level Radio Frequency Controls in Accelerators

Lab 9

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Contents

1 Solution

1.1 Plot frequency response of USPAS CIC filter

[5]:
```
%matplotlib inline
from numpy.polynomial import polynomial
import numpy as np
from scipy import signal
import matplotlib.pyplot as plt

plt.rcParams['figure.figsize'] = [6, 4]
plt.rcParams['axes.grid'] = True
plt.rcParams['axes.grid.which'] = "both"
plt.rcParams['grid.linewidth'] = 0.5
plt.rcParams['grid.alpha'] = 0.5
plt.rcParams['font.size'] = 8
```

[6]:
```
wave_samp_per = 5
cic_period = 23
R = cic_period * wave_samp_per
M = 1
N = 2
fs = 115e6  # Hz
num1 = np.zeros(R)
num1[0] = 1
num1[-1] = -1
npt = 4096

b = polynomial.polypow(num1, N)
a = polynomial.polypow([1,-1], N)
w, h = signal.freqz(b, a, worN=npt, fs=fs);
```

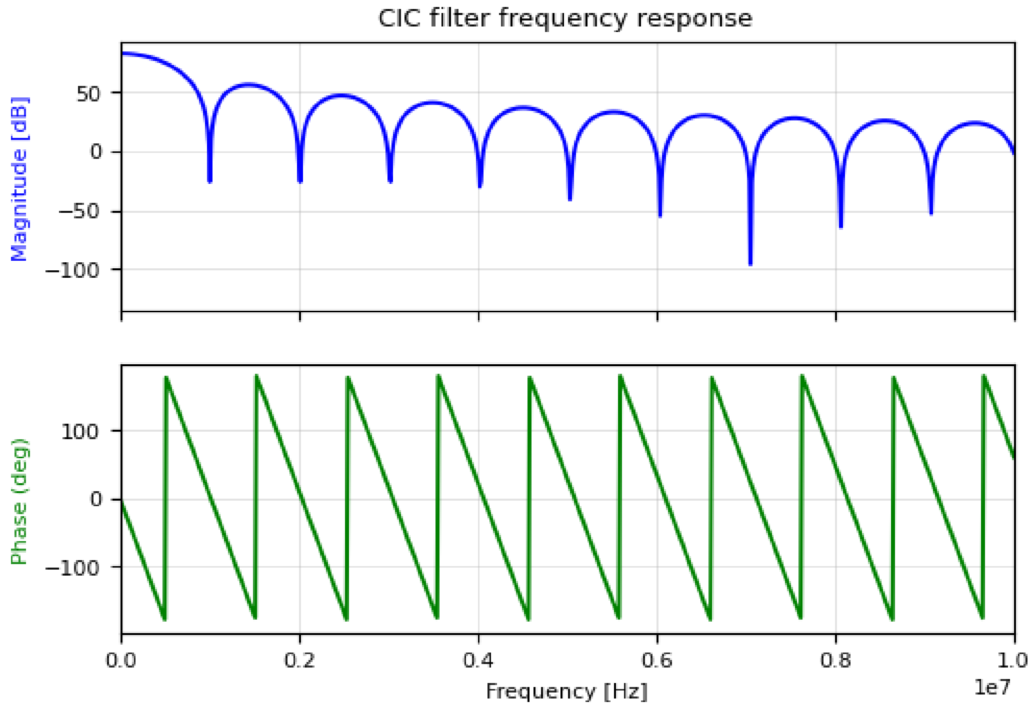
[7]:
```
fig, ax = plt.subplots(2, sharex=True)

w = w[1:]
h = h[1:]
phase = np.angle(h, deg=True)

ax[0].set_title('CIC filter frequency response')
ax[0].plot(w, 20 * np.log10(abs(h)), 'b')
ax[0].set_ylabel('Magnitude [dB]', color='b')

ax[1].plot(w, phase, 'g')
ax[1].set_ylabel('Phase (deg)', color='g')
```

```
ax[-1].set_xlabel('Frequency [Hz]')
ax[-1].set_xlim(0, 1e7);
```



How much is the bit growth?

Total gain:

$$G = (RM)^N$$

Total bit growth:

$$\log_2(G) = N \log_2(RM)$$

[4]:
```
N * np.log2(R * M)
```

[4]: 13.69098010188875