**Lab Assignment # 5 Digital Signal Processing**

**Submitted By: Tallal Ahmed**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Task** | **Measurements and Comments** | | | | | | | |
| **2.1** | Δf=156.25, f1=625 | | | | Integer number of periods (4), actual spectrum of the original signal is observed; freq. component at 625. | | | |
| **2.2** | Δf=156.25,  f1=703.125 | | | | Due to non-integer periods (4.5) artificial high frequency components show up in FFT and noise is also observed as higher side lobe levels. Also, we can: 156.25x4.5=703.125 | | | |
| **2.3** | N=64, Δf=156.25,  f1=1250, f2=1406.25 | | | | Smearing effect was observed. Side lobe of strong component masked with the main lobe of weak component. | | | |
| **2.4** | N=1024, Δf=9.7656,  f1=1201.1, f2=1298.8 | | | | By increasing the number of samples smearing error was reduced and frequency components that were smeared in 2.3 were separated and clearly observed. However, increasing N leads higher computation. | | | |
| **2.5** | N=64, Δf=156.25, | | | | Keeping the N small and changing the phase the smearing was reduced. | | | |
| **2.6** | Periods 10 (integer) | | | | Like 2.1 | | | |
| **2.7** | Periods 9.5 (non-int) | | | | Difference in amplitude | | | |
| **2.8** | Chck ph | | | | Side lobe level was reduced by applying Hann window. The weak component also become visible as interference was reduced. | | | |
| **2.9** | A uniformly distributed white Gaussian noise spectrum was observed. | | | | | | | |
| **2.10** | Distortions increase when noise was added. | | | | | | | |
| **2.11** | Interference was reduced when Hann window was applied, and the weak component became visible. | | | | | | | |
| 2.8+  2.11 | It was also observed that windowed FFT of a signal with DC offset will produce the shape of the FFT of the window function around DC bins, which may mask out the interested signals at those bins [2]. | | | | | | | |
| **2.12** | | **Strong Comp.** | | **Weak Comp.** | | | **DC** | **Observations** |
| F(rad/s) | A(d) | F(rad/s) | | A (dB) | A(dB) |
| Rect. | | 0.7 | -6.056 | 0.6143 | | -30.06 | -5.805 | Overall, the spectrum was distorted, and weak component was not visible, but by zoom and close observation estimation was taken at point of interference. |
| Bartlet | | 0.7 | -6.023 | 0.5918 | | -43.09 | -5.892 | weak component was not differentiable because of interference between strong component’s SL and weak’s ML, but estimation at merging point was taken. |
| Hann | | 0.7 | -6.024 | 0.6021 | | -45.97 | -5.893 | By applying Hanning window, the weak component’s ML became separated and visible however side lobes of both components were observed merging. |
| Hamm. | | 0.7 | -6.029 | 0.5989 | | -42.56 | -5.88 | The peak become more prominent at the cost of poor drop off rate of side lobes, so if the amplitude weak comp. is much smaller it can be masked by SL of strong one |
| Black-man | | 0.7 | -6.022 | 0.6016 | | -45.63 | -5.894 | The SL level in Blackman window is much lower than hamming window and the width of its main lobe is also less than Kaiser window. |
| Kaiser  (a=10) | | 0.7 | -6.021 | 0.6009 | | -45.46 | -5.895 | Both components are visible. The Kaiser window has lowest side lobes level but due to the wider main lobe width, there are chances of smearing. |

It is observed that the amplitude of the DC components is almost constant for all the windows..

Chart, histogram

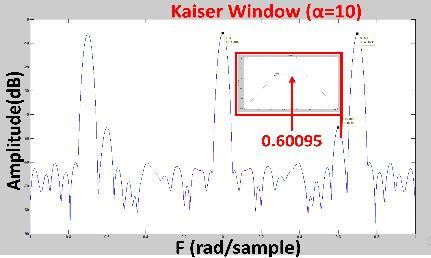
Description automatically generatedA picture containing histogram

Description automatically generatedGraphical user interface, chart

Description automatically generated

Graphical user interface

Description automatically generatedGraphical user interface, chart

Description automatically generated

Text

Description automatically generatedFigure: Task 2.12 FFT spectrums after different windows (detailed frequency and amplitudes are mentioned in Table)

**References:**

DiSi, Prof Stefen Bruckl, Lecture and lab notes Signature: