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Digital Signal Processing

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Graduate Homework I

**Problem 1:** Describe 5 advantages and 2 disadvantages of digital signal processing as compared to analog signal processing.

**Advantages:**

1. DSP has a high level of accuracy. The filters designed in DSP have firm control over output accuracy as compared to analog filters.
2. The reconfiguration in an analog system is very much tough because the entire hardware and its component will have to be changed. On the contrary, a DSP reconfiguration is much more comfortable as only the code, or the DSP program needs to be flashed after making the changes according to the requirements.
3. Implementation in digital is much more cost effective than its analog counterpart.
4. The combination of DSP interfaced with FPGA helps in designing the protocol stack of the whole wireless system like WiMAX, LTE, etc. In this type of architecture, as per the latency requirements, few of the modules are ported on FPGA and the other few on DSP.
5. The digital system in DSP can be easily cascaded without any problems in loading.

**Disadvantages:**

1. Digital Signal Processing(DSP) processes the signal at high speed and comprises of more top internal hardware resources. Because of this DSP dissipates higher power as compared to analog signal processing. Analog signal processing includes passive components that consume lower energy.
2. When using DSP, there is a need for using anti-aliasing filter before ADC ( Analog To Digital Converter) as well as using a reconstruction filter after DAC (Digital to Analog Converter). Due to the use of this extra two modules viz. ADC and DAC, the complexity of DSP based hardware increases.

**Problem 2:** For each of the following signals, state if it is periodic or not. If the signal is periodic, specify its periodicity, i.e. after how many seconds or samples the signal repeats itself.

1. xa(t) = 3 cos (5t + π/6):

Text, letter

Description automatically generated

1. x[n] = 3 cos (5n + π/6):

A piece of paper with writing on it

Description automatically generated with medium confidence

1. x[n] = 2ej(n/6−π):

A picture containing text, whiteboard

Description automatically generated

1. x[n] = cos (n/8) cos (πn/8):

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Description automatically generated

1. x[n] = cos (πn/2) − sin(πn/8) + 3 cos (πn/4 + π/3):

Text, letter

Description automatically generated

**Problem 3:** Consider an analog signal described by the following function:

𝑥a(𝑡)=3cos(600𝜋𝑡)+2cos(1800𝜋𝑡)

* 1. What is minimum sampling frequency required to avoid aliasing?

The components of the signal have frequencies F1 = 300 and F2 = 900 cycles per second (Hz). The largest frequency is F2 = 900 Hz.

To avoid aliasing we need to use the Nyquist rate as the minimum sampling frequency

* 2F2 = 2 (900) = 1800 samples per second.
  1. If the signal were to be sampled at 1000 samples/second, at what frequencies would the signal components be observed?
  2. Assume that the signal is being sampled with a 10-bit ADC. What is the SQNR observed at each of the two signal frequencies?

According to the formula:

The Expected amount of noise is **61.96 dB.**

Now we calculate the Quantization noise of each of these signals.

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As it can be seen the calculated Quantization Noise is actually very close to our expected value. Our error is:

Graphical user interface, text, application

Description automatically generated

The observed results are the same for the second signal with an error of: