P116B Homework 5

Due 3/13/2020

1. We design an experiment in which it takes 1ms to read out all the data from the detector, during which time no new data can come in. What's the maximum average event rate we can sustain, in Hz, if we want to keep the dead time fraction below 10%?

2. Let's assume we want to redo the data acquisition in the previous example to be deadtimeless. If it has 100,000 channels, each being digitized at 1 Gs/s to 16-bit accuracy, how much total buffer memory do we need, in bytes, assuming it takes 4μsec to make a trigger decision and 1μsec to read out the data?

3. We want to produce "CD quality" digitized audio: 44.1 kHz, 16-bit *stereo* audio.

   (a) What is the 3 dB bandwidth limit for this digitization rate?

   (b) What is the total byte rate (kb/sec) for this digitization?

4. In the previous example, we want to avoid aliasing by oversampling by a factor or two, digitally filtering, then "decimating" by a factor of two down to the 44.1kHz rate; that is, we will sample at 88.2 kHz.

   To do the filtering, we use a 100-tap FIR filter. Assuming each digital processing step is a single operation, how many MegaFLOPs (million floating point operations per second) will we need to perform to accomplish this, assuming there are no parallel operations? Remember, we're working in stereo.

5. Now, instead of a 22.05 kHz stereo audio signal, let's assume we want to digitize a single channel 16-bit 100 MHz RF signal.

   (a) What's the minimum digitization rate we need to get this bandwith?

   (b) If we want to oversample by a factor of two and implement a 100-tap FIR filter, what processing rate would we need, in MFlops?

   (c) In the previous question, you presumably got an unworkably large number. If we wish to do the processing in an FPGA and implement the oversampled filter using "systolic" parallel processing, how large must our memory buffer be, in bytes?