## WES237C: Project 4 FFT and OFDM Receiver

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## 1. Fast Fourier Transform (FFT)

Our 1024-point FFT design starts with a bit reverse function to change the order of the input IQ samples so that the output of the FFT will be in an increasing numerical order. We then set up 10 stages of the FFT algorithm to run sequentially to generate the output. We separated the first and last stage since we know the bound and so we can optimize further in this aspect.

The first optimization we did was to separate the input and output matrix of each function. By doing this we avoid data being read and written to the same matrix during the same cycle. Additionally, this decreases the II from 2 to 1 which we used `#pragma pipeline II=1` to do.

The next optimization done was to make VITIS understand our loop bounds. The majority of the code runs in nested for loops with the outer loop iterating butterfly times and the inner loop iterating 1024 times. As the outer loop varies with FFT stages, it was a good idea to flip the fixed bound of the inner loop and the varying bound of the outer loop, so VITIS has a better idea of how long the loop is going to run. At this stage of development, we noticed that the latency for the bit-reverse function was over 2 times that of the FFT stages.

Finally, using separate inputs and outputs in the bit-reverse function, we are able to remove memory swapping and reduce the II of the stage to 1. This improved the latency of all functions to about 1000 or less, achieving a throughput of 1/(1042\*10ns) = 95.97kHz. See Figures 1 & 2 below for screenshots from our synthesis.

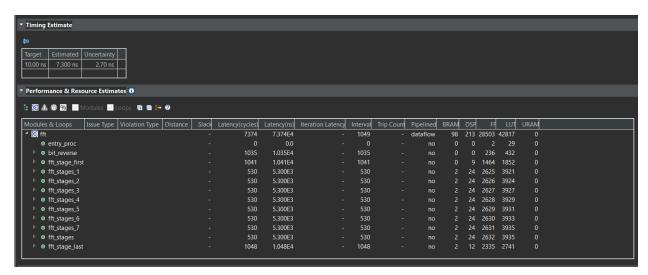


Figure 1: Performance and Resource Utilization

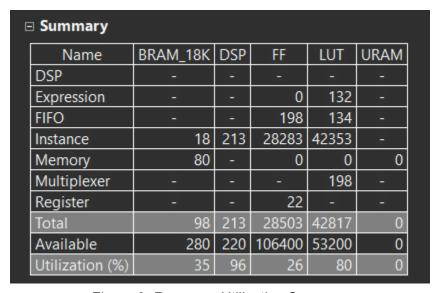


Figure 2: Resource Utilization Summary

## 2.OFDM Receiver

Similar to the FFT project, we started with the FFT bit-reverse function and FFT stages function copied to the OFDM project. The next thing we needed to do to complete the QPSK decode function was to decode the IQ samples into messages (integer values from 0 to 3). We created four if statements to check which quadrant the samples fall into and assigned different integer values to the samples that fell into each quadrant. The throughput calculation for our OFDM receiver is 1000/(1042\*10ns) = 95.97kHz. See Figures 3 & 4 below for screenshots from our synthesis.

```
34995 match: i: 34985
                   golden: 1
                              output: 1
34996 match: i: 34986
                    golden: 2
                              output: 2
34997 match: i: 34987
                    golden: 3
                              output: 3
                   golden: 0
34998 match: i: 34988
                              output: 0
34999 match: i: 34989
                   golden: 1
                              output: 1
35000 match: i: 34990
                   golden: 2
                              output: 2
35001 match: i: 34991
                   golden: 3
                              output: 3
35002 match: i: 34992
                   golden: 0
                              output: 0
35003 match: i: 34993
                   golden: 1
                              output: 1
35004 match: i: 34994
                   golden: 2
                              output: 2
35005 match: i: 34995
                   golden: 3
                              output: 3
35006 match: i: 34996
                   golden: 0
                              output: 0
35007 match: i: 34997
                   golden: 1
                              output: 1
35008 match: i: 34998
                   golden: 2
                              output: 2
35009 match: i: 34999
                    golden: 3
                              output: 3
35010 Comparing against output data
35011 *******************
35012 PASS: The output matches the golden output!
35013 *******************
35014 INFO: [SIM 1] CSim done with 0 errors.
```

Figure 3: CSIM Output Verification

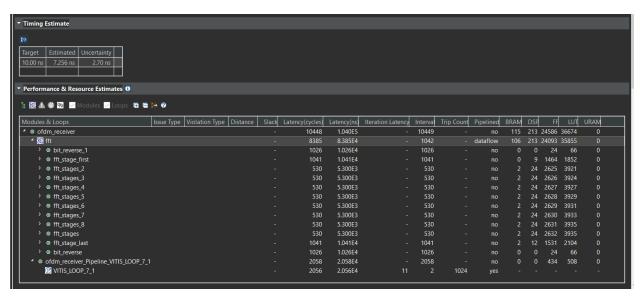


Figure 4: Performance & Resource Utilization