Spectrum Analyzer

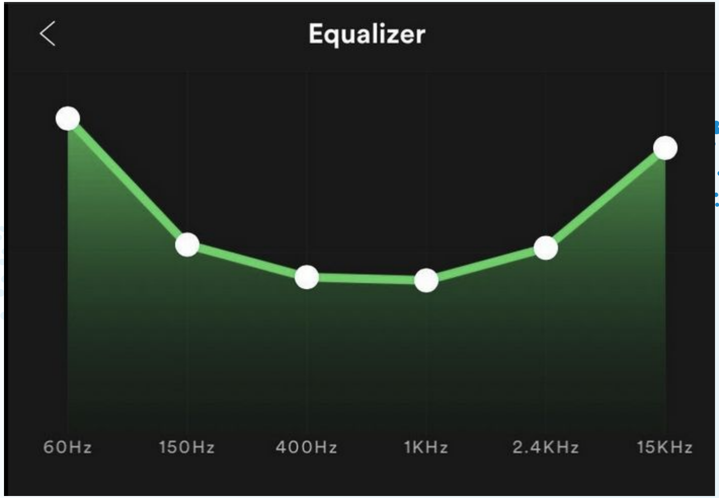
Project Description

SPECTRUM ANALYZER

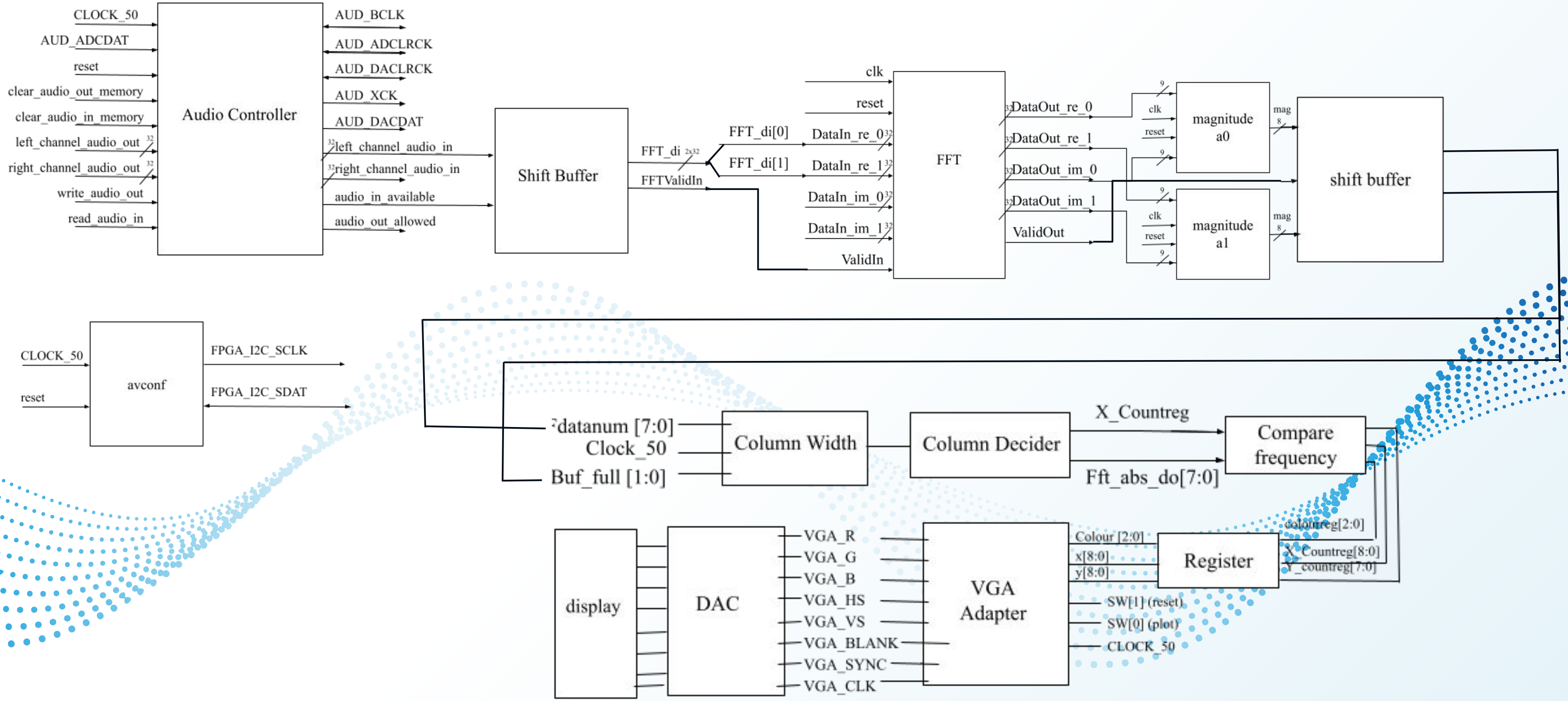
- Take in audio input from line in
- Send audio samples through FFT
- Displays the audio in the frequency domain in the form of moving vertical bars on the VGA display

WHY?

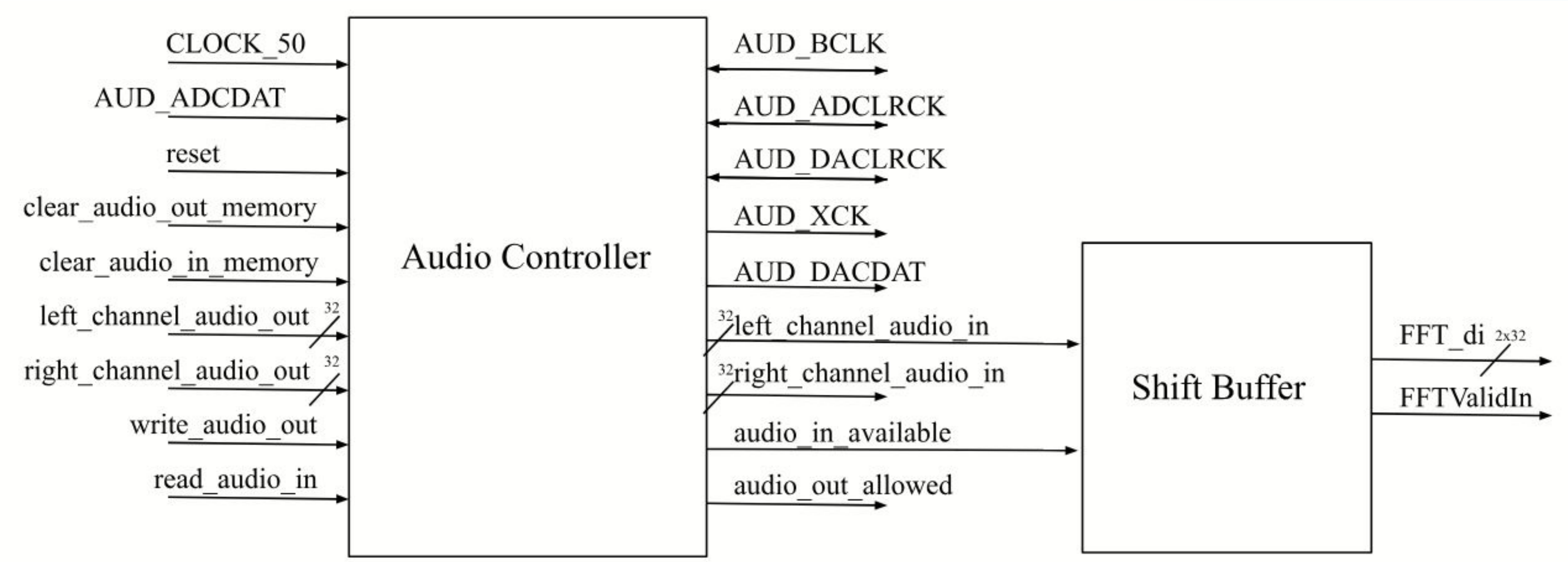
- Allows us to analyze audio from a different perspective
- Inspired by Spotify's Equalizer feature



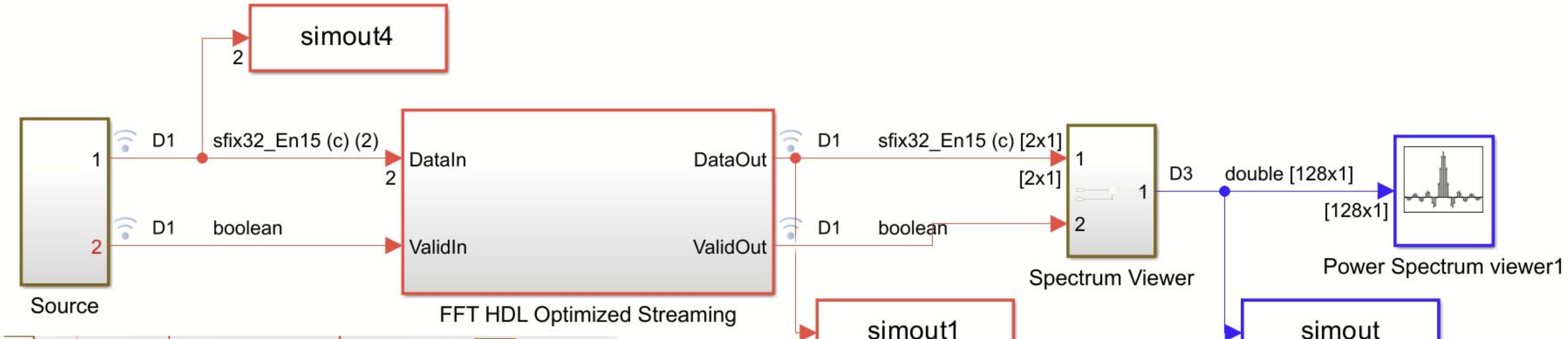
High Level Block Diagram

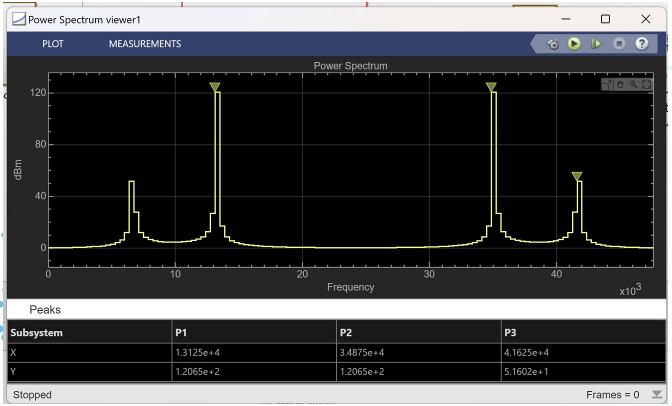


Block Diagram: Audio Input to Buffer



Block Diagram: Fast Fourier Transform MATLAB/Simulink





Peaks

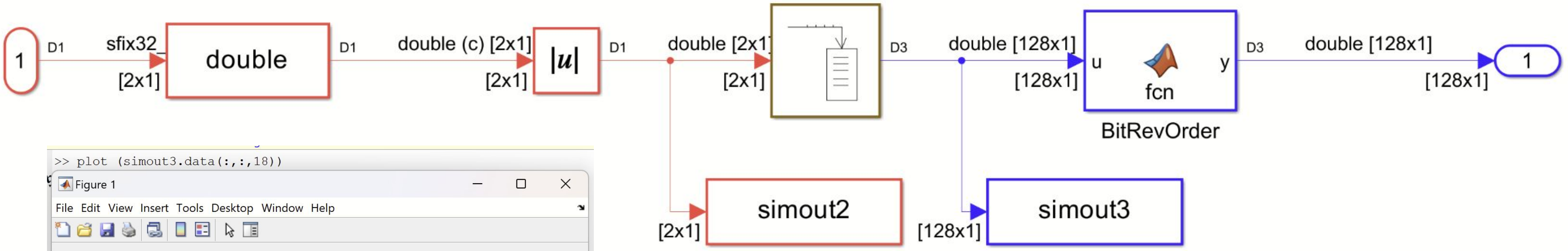
Subsystem	P1	P2	P3
X	1.3125e+4	3.4875e+4	4.1625e+4
Y	1.2065e+2	1.2065e+2	5.1602e+1

Stopped

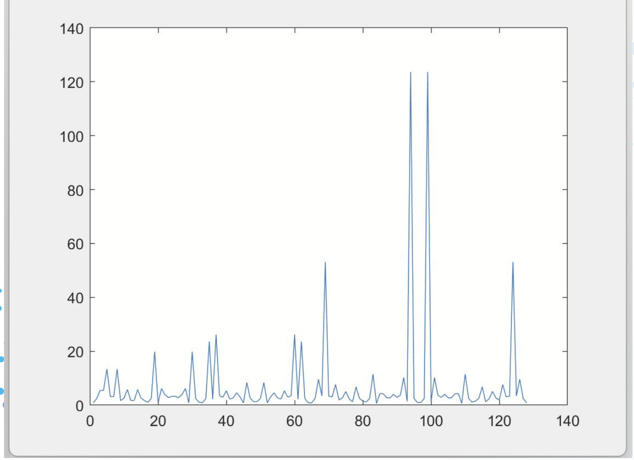
Frames = 0

- Testing with 2 sin waves
- Frame size = 2, output data size = 128, buffer size = 128
- Code generated for FFT HDL Optimized Streaming block using HDL Coder

Block Diagram: Data Transformation MATLAB/Simulink

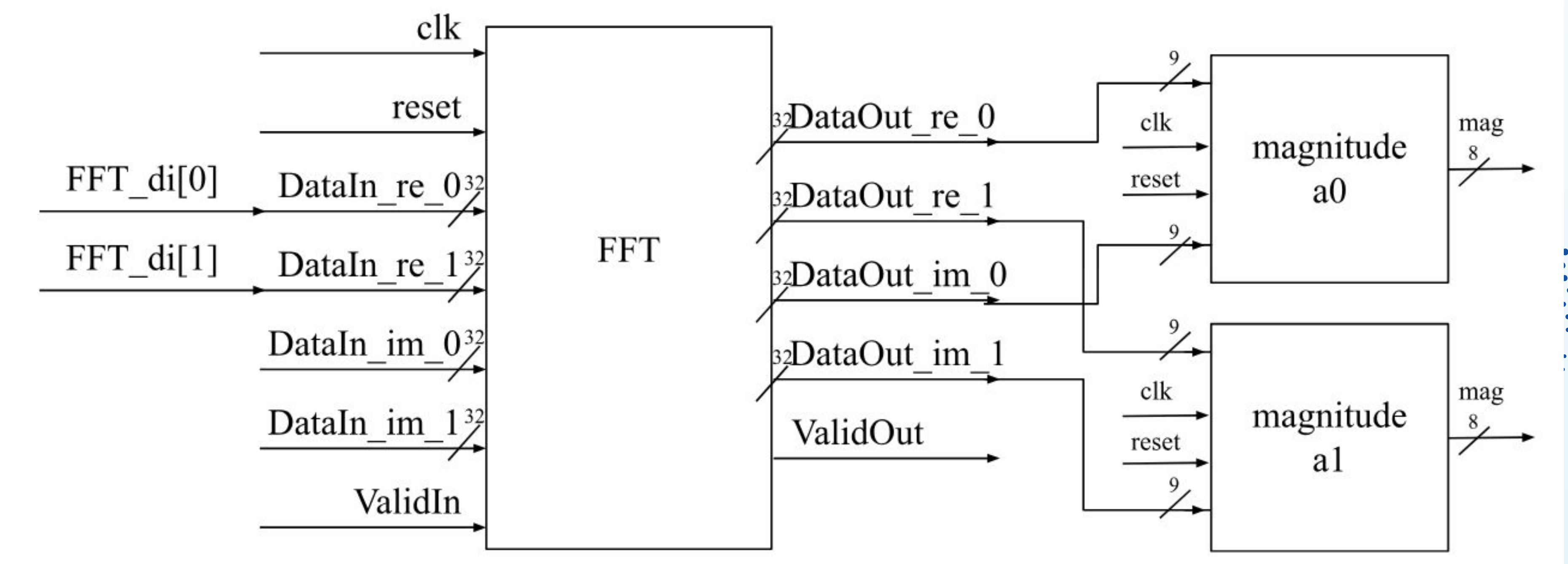


```
>> plot (simout3.data(:,:,18))
```

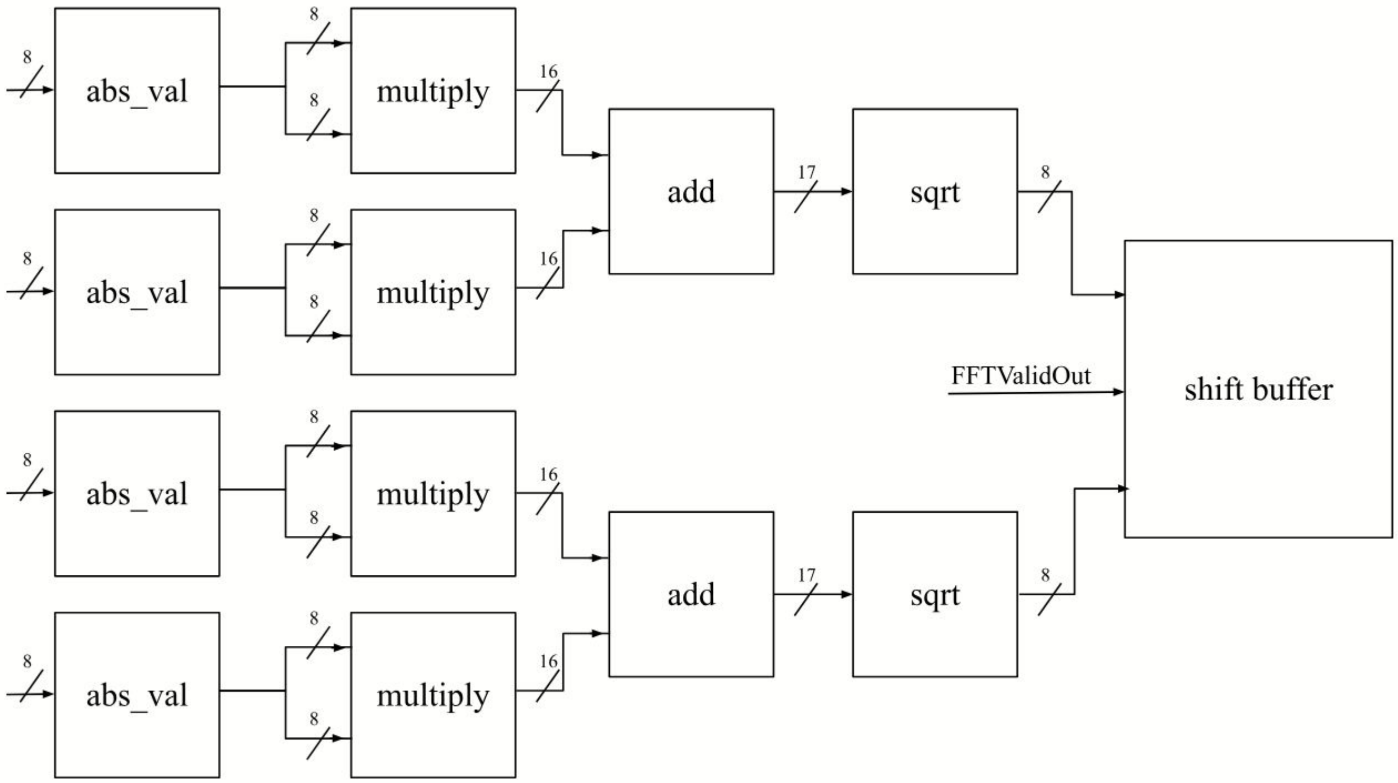


- Used “spectrum viewer” data transformation process as guide
- Checked data form throughout implementation (e.g. simout3)

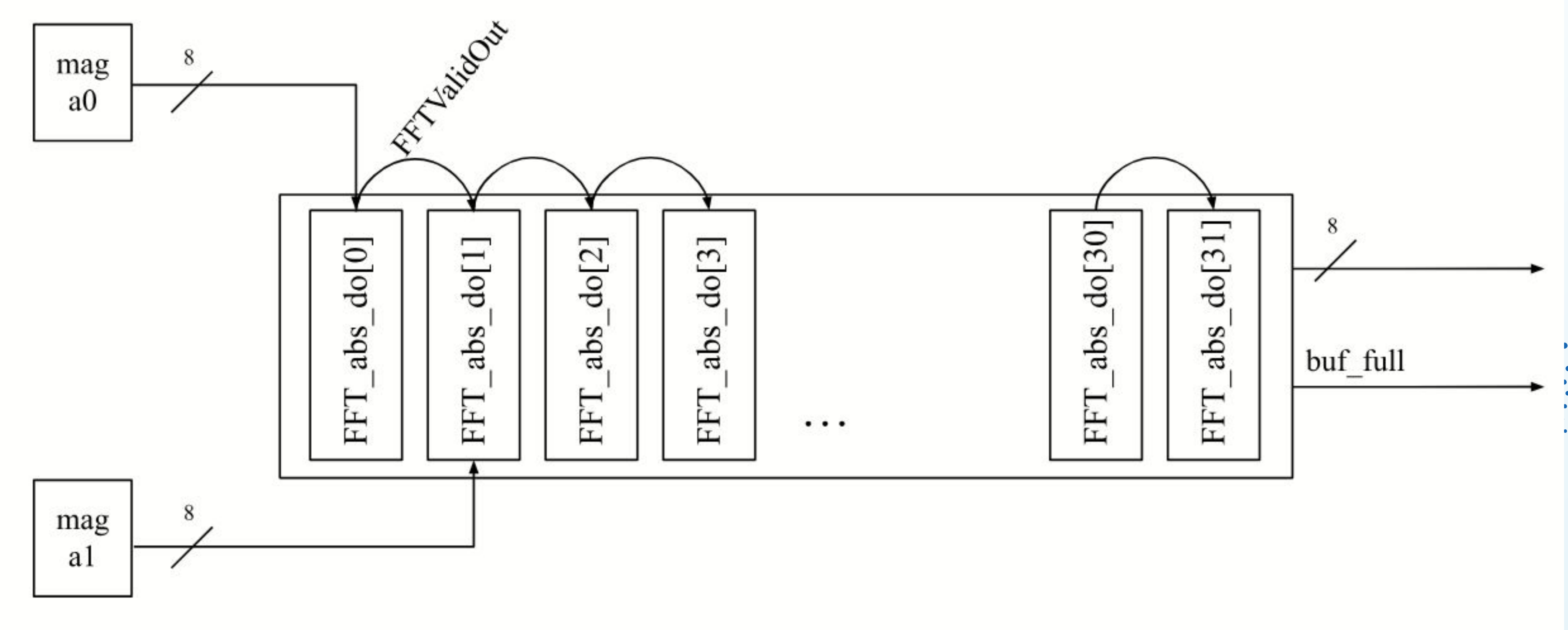
Block Diagram: Fast Fourier Transform



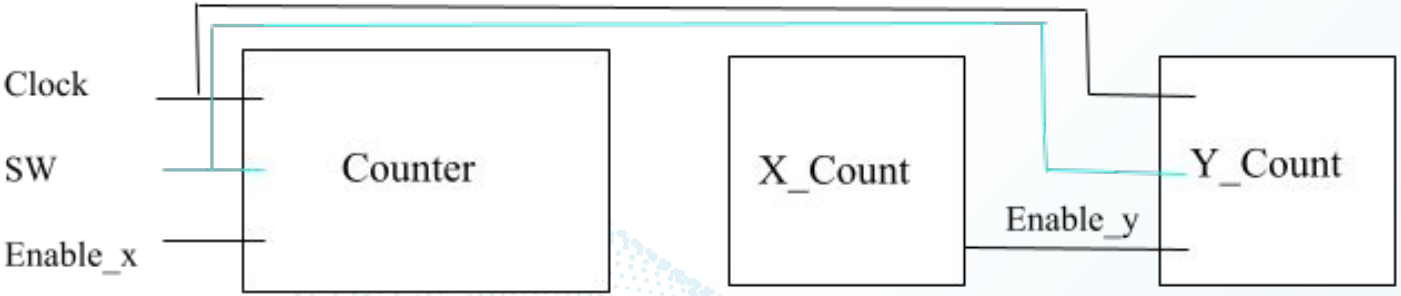
Block Diagram: Magnitude to Buffer



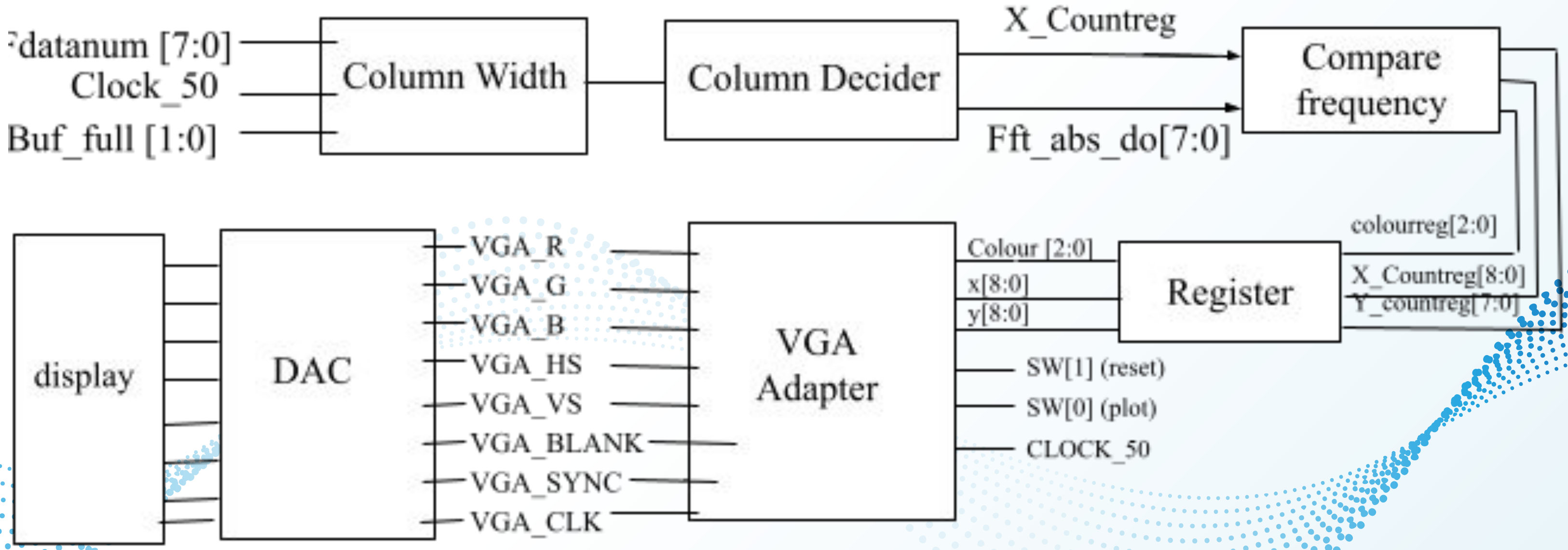
Block Diagram: Shift Buffer (32×8)



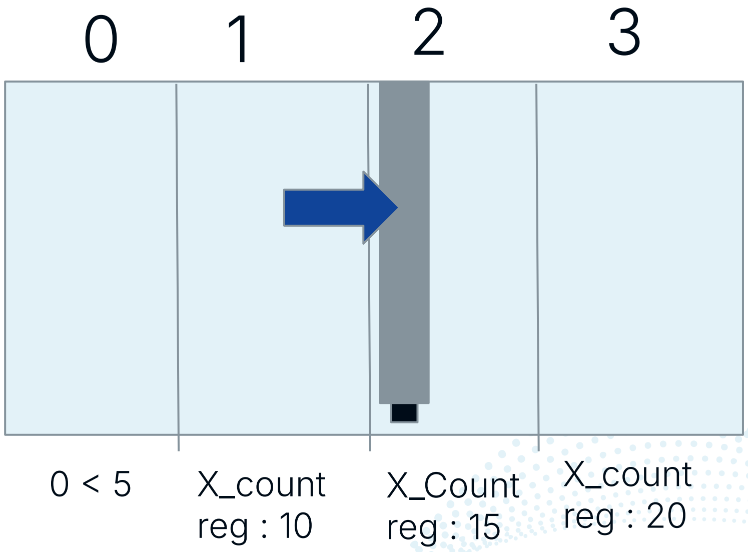
Block Diagram: Pixel Location



Block Diagram: overview of audio to VGA process



Block Diagram: Column Width and Decider



0 1 2 3

0 < 5

X_count reg : 10

X_Count reg : 15

X_count reg : 20

i = 2

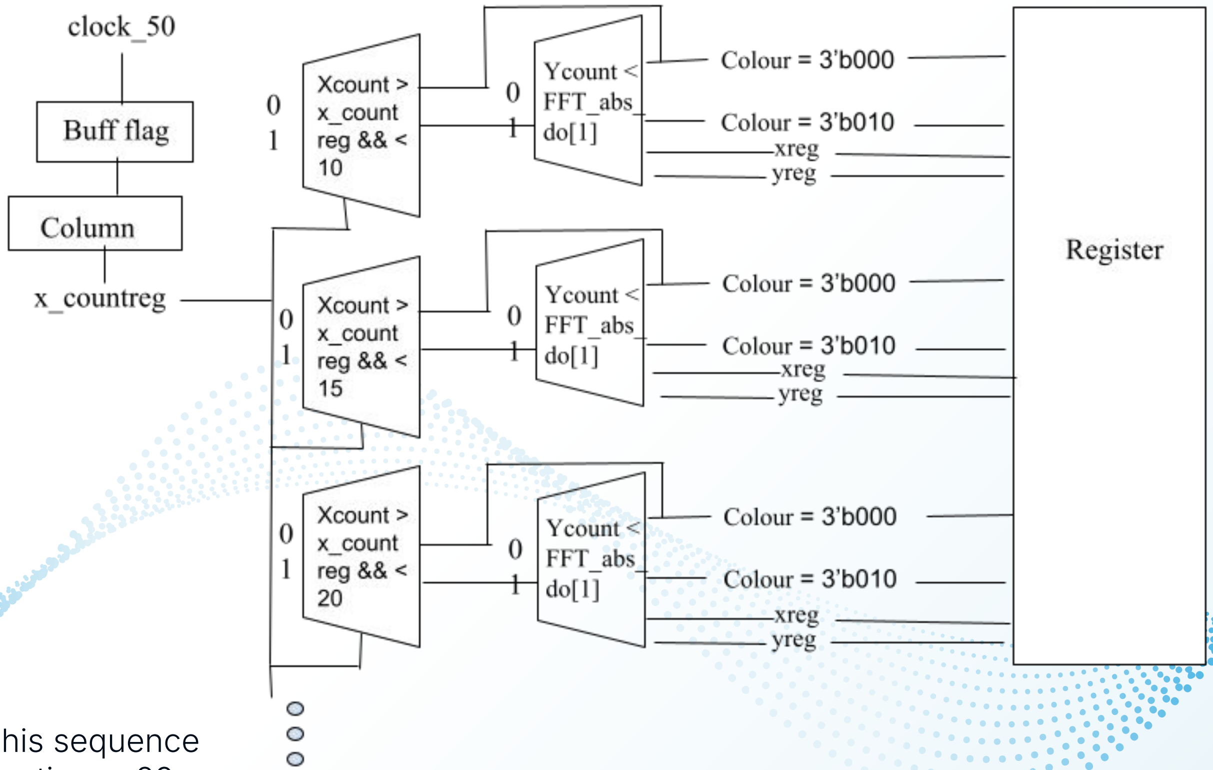
X_Countreg = i * 5

If X_count > X_count Reg & X_count < upper limit

X_Count = 12

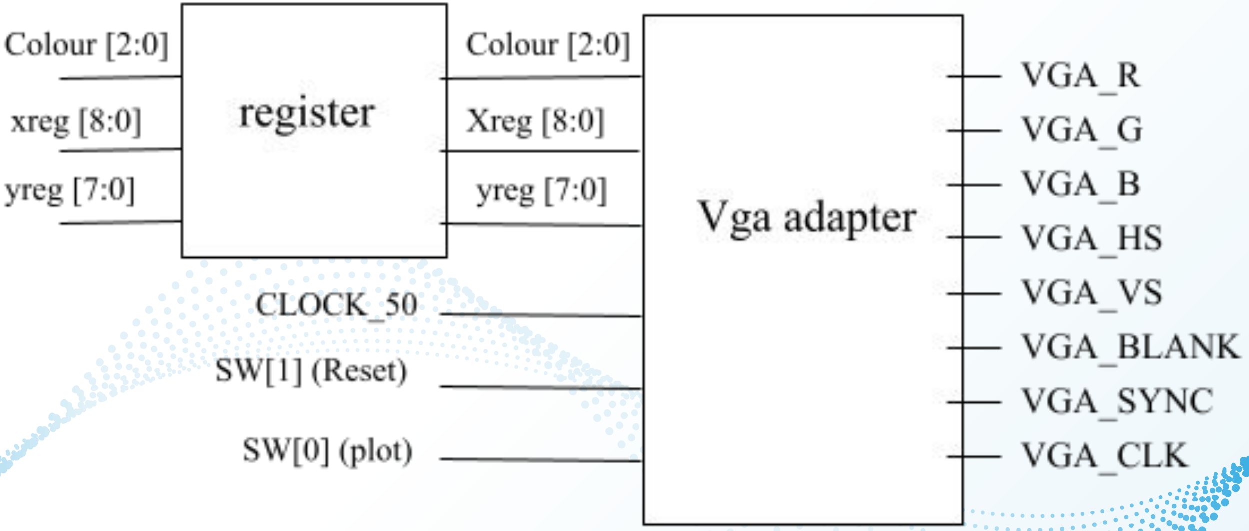
- Column Width takes an integer i, into a for loop while i < Fdatanum (32)
  - X_Countreg stores the width of the bar multiplied by integer i
  - This places the frequency data in the correct position

Block Diagram: Column Width and Decider

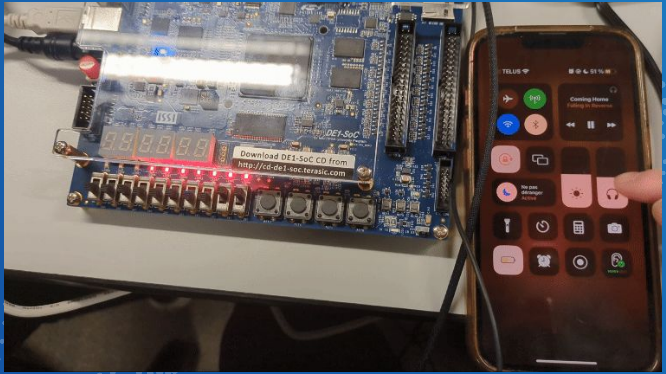


This sequence continues 29 more times

Block Diagram: Register to VGA adapter



The Result


DE1-SoC
Download DE1-SoC CD from
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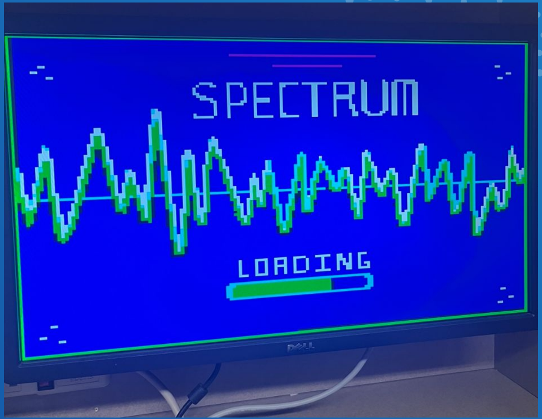
Coming Home


SPECTRUM
LOADING
DELL

Bugs and Issues: Sara

Instantiating VGA Adapter

- Errors when instantiating multiple instances of the vga adapter in other files

Result

- Needed to choose which component to prioritize. The logic for the pixel bars was added into the main file with the spectrum data

Unexpected pixel Behaviour

- When I first uploaded the play button from memory it did not match the MIF file.

Solution

- After using ModelSim I discovered that the issue was with my y_count and that it was enabling at the wrong times.

Unexpected bar behaviour

- When testing the bars on the VGA they initially took up the whole screen regardless of the parameters changed

Solution

- After looking at the demo code I realized that moving objects need to be "erased" after they move from their initial position

Bugs and Issues: Madeline

Compilation Time

- Took 30+ minutes to compile if FFT was connected to an output (e.g. LEDRs)

Result

- Reduced frame size of FFT from 8 to 2
- Fitter resource usage dropped from 26% to 5%
- Still takes 5-10 minutes

Data Transfer VGA

- Struggled to conduct proper data conversion
- Needed to deliver a bunch of data at once

Result

- Tried using Altera floating point square root IP
- Used another form of approximation which performed well
- Used shift buffer to hold data

Testing in General

- Visualization of large amounts of data is difficult without display
- Audio input is difficult to properly simulate

Result

- ModelSim for as many components as possible (magnitude, bit reversal)
- Used LEDRs to indicate volume
- Could not effectively test for timing or buffer content

Future Improvements

Higher precision

- Currently displaying 32 pieces of 7-bit data
- Goal was 128-256 pieces of 8-bit data

Equalizing Component

- Add the option to alter the output sound based on user input

VGA Display

- Create the bars from the bottom of the screen to be more intuitive for users
- Transition to using waveforms to display data instead of bars
- Fix pixel glitches at high volume

Thank You!