

Prototype Development for a Hyperspectral Microwave Radiometer

Nathan Ho

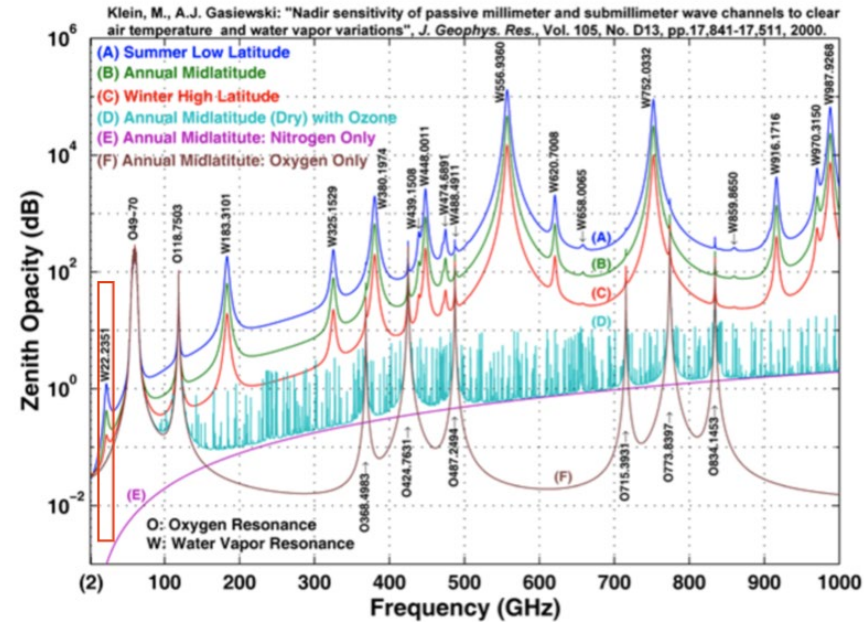
Mentors: Hu (Tiger) Yang

Background

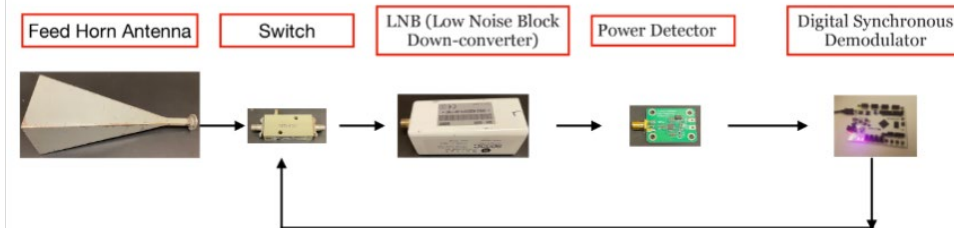
- Water content in the atmosphere can be observed by projecting microwaves and sampling their reflections
- The power of these reflections depends on a number of factors which help measure weather/precipitation
- Tool used to measure these reflections is called a Microwave Radiometer

Microwave Radiometer

- Collects reflections with a feed horn
- Switch converts reflection signal into square wave at certain sampling frequency
- Reflections (dB) are converted from power to voltage
- Voltage is sampled for data by digital synchronous demodulator



Wavelength and power level associated of different water vapor variations



Hardware flow-chart

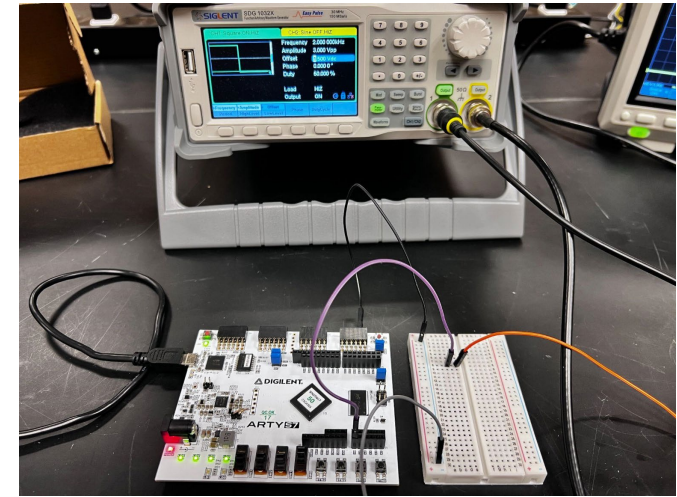
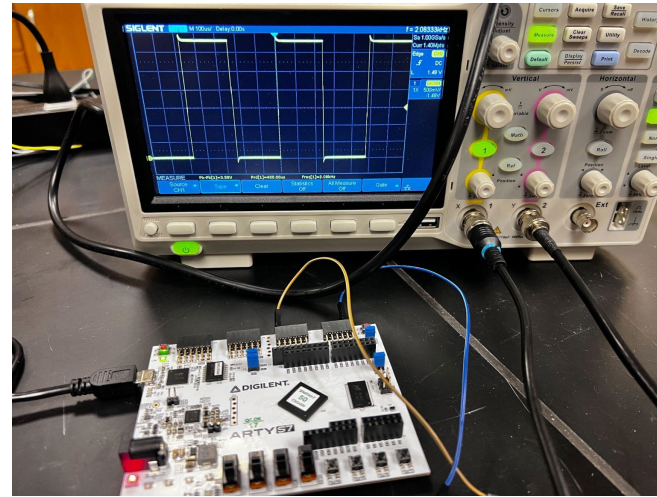
Project Objectives and Results

Objectives

- Implement existing features of microcontroller-based signal processing system on new FPGA hardware
- Verify all original functionality on new hardware
- Write detailed documentation about implementation for further refactoring and improvement

Results

- Original functionality successfully implemented on brand-new hardware
- In-lab testing shows that the FPGA performance meets expectations
- Analog-digital conversion data resolution increased from 10 to 12 bits (400% improvement)
- Packaged documentation and design together for ease of use in the future (git)



In-lab testing apparatus

Name	Slice LUTs (32600)	Slice Registers (65200)	F7 Muxes (16300)	Slice (8150)	LUT as Logic (32600)	Bonded IOB (210)	BUFGCTRL (32)	XADC (1)
radiometer	128	136	1	63	128	11	1	1
a (adc)	61	62	0	30	61	0	0	1
d (adc_clock_divide)	34	33	0	18	34	0	0	0
xadc (xadc_wiz_0)	0	0	0	0	0	0	0	1
s (switch_controller)	35	34	0	21	35	0	0	0
u (uart_tx)	32	40	1	17	32	0	0	0

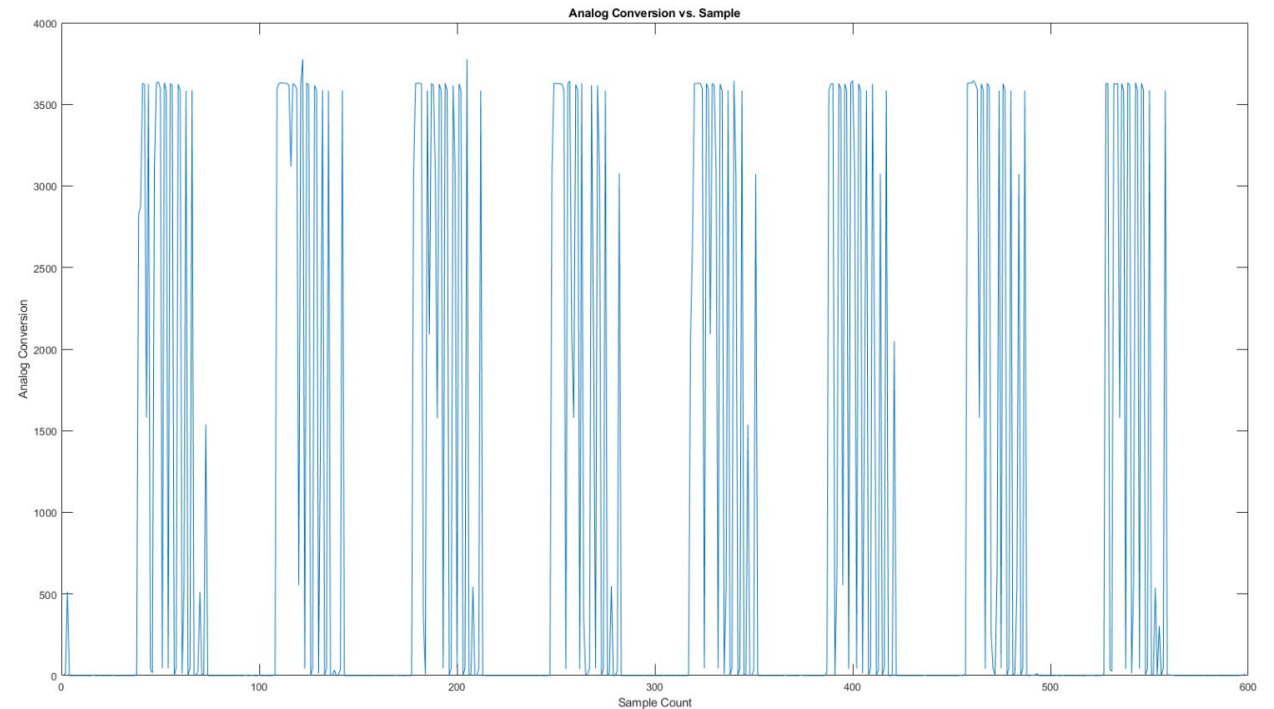
Hardware utilization of design

Data

- In order to verify the functionality of the analog-digital conversion module, output data had to be sampled from the FPGA and plotted
- The input wave was a standard 2KHz square wave @ 50% duty cycle
- The plot of the output data reflects the input wave, which shows the ADC is functioning

Future Objectives

- Push the limit for sampling speeds and data processing
- Implement FFT or other signal processing algorithms on-board
- Implement faster data transfer protocol between external devices and FPGA to prevent bottlenecking data throughput/collection



MATLAB plot of square wave post-ADC