Polyphase Filtering: A Physicist's Understanding

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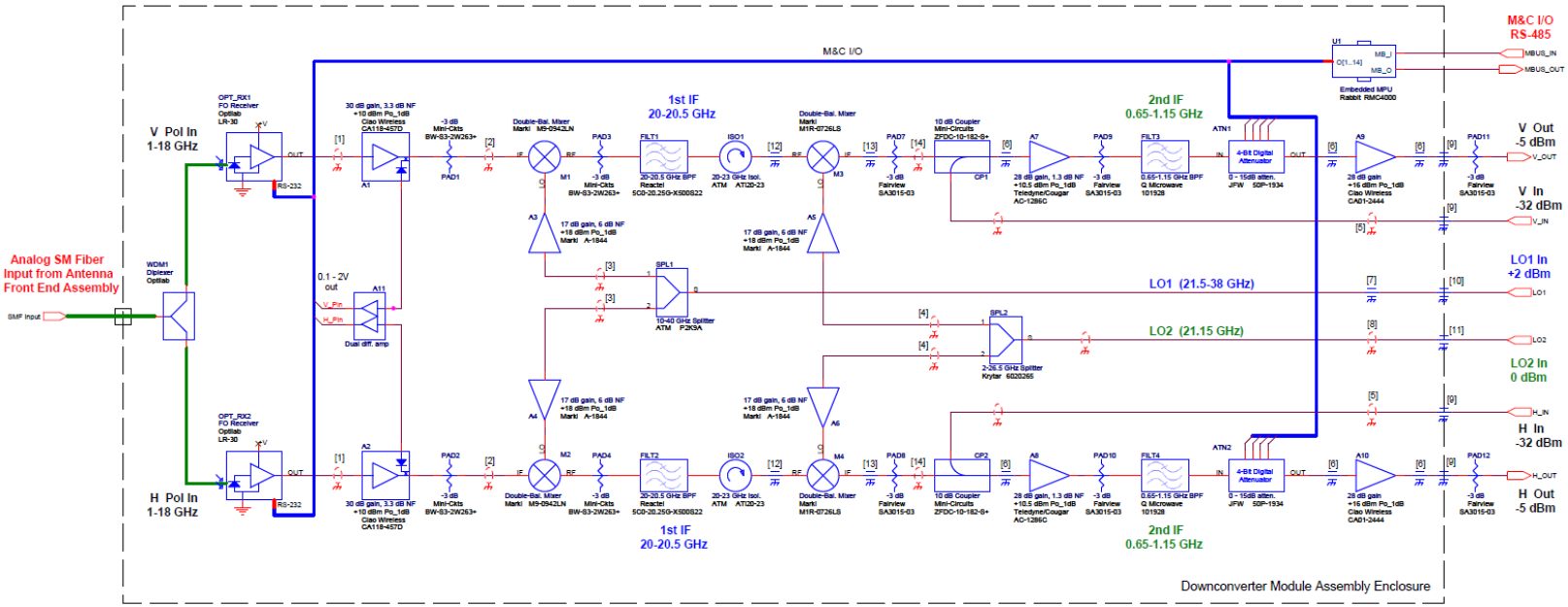
Introduction



[1]

The digital revolution has changed many aspects of modern life. Scientific instrumentation has been no exception.

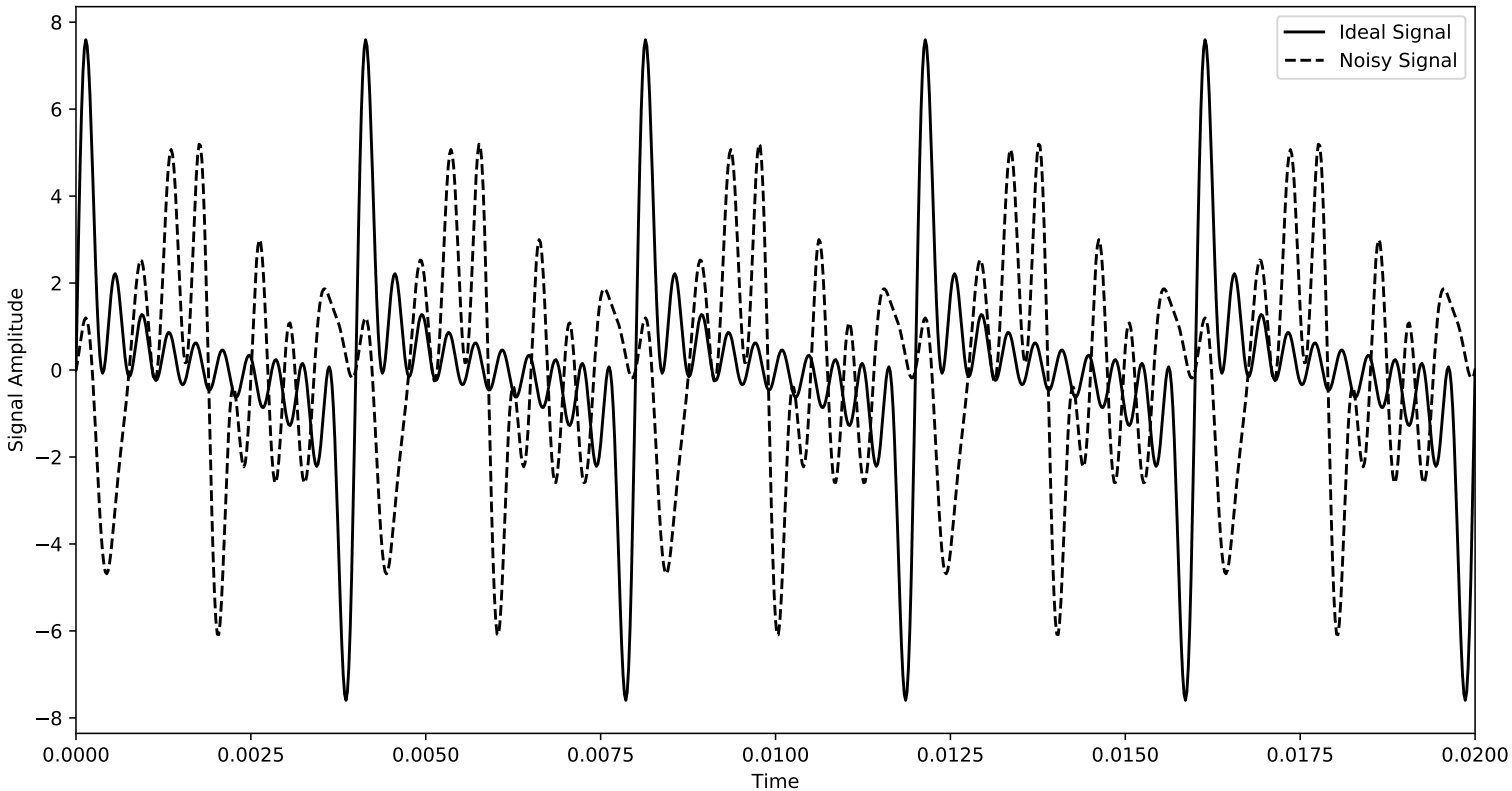
[1] *https://web.njit.edu/gary/728/assets/EOVSA_DCM.PNG*

Et Tu, Science? The Fall Analog.

In the EOVSA array, the signal is digitized at the receiver, then sent to the control room. Why?

Digital vs. Analog: A Phase Fight

In analog systems, the gain to phase balance of a signal cannot be maintained to better than 1% over a range of temperatures (Harris, 2005).[2]



[2] Paper Citation

Signals, Nyquist Theorem, and Frequency Resolution

How do we digitize signals?

Nyquist Theorem

$$f_{crit} = \frac{f_{samp}}{2} \qquad (1)$$

In radio astronomy, to measure a 10 GHz signal, we would need to process 20 billion samples, or around 160 Gigabytes of data, a second. Seem unreasonable? It is.

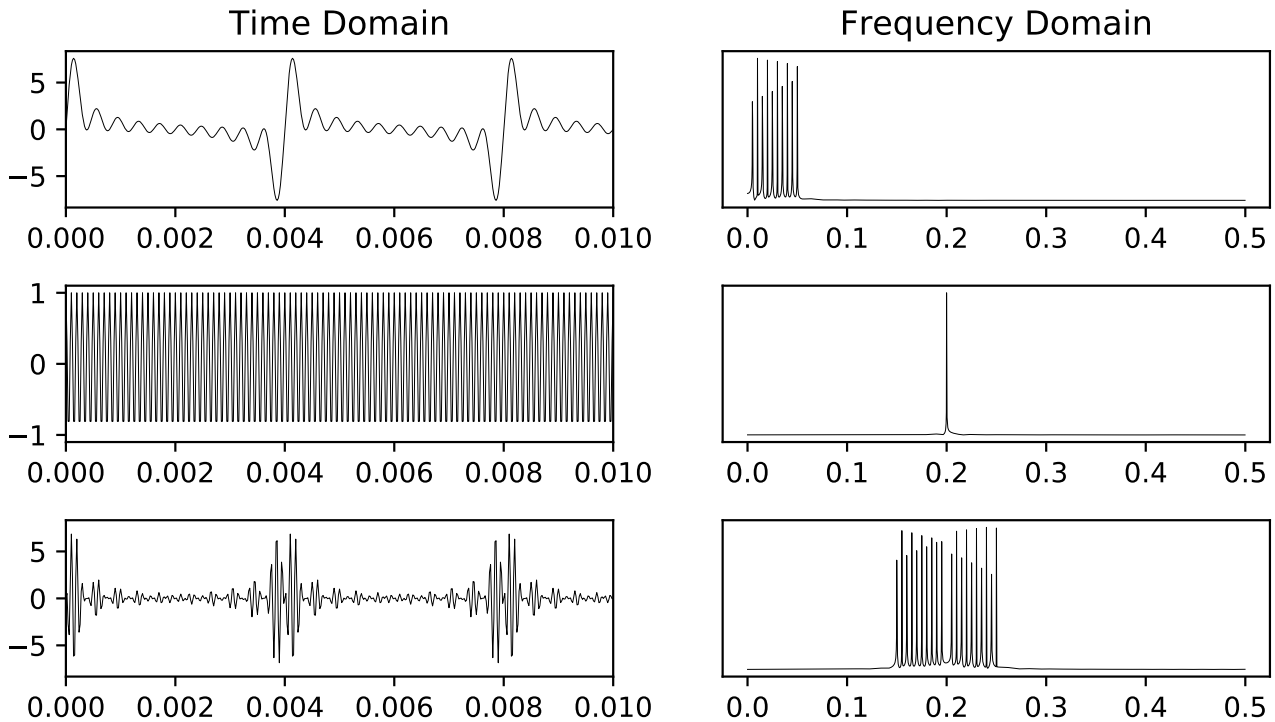
Along with Nyquist, there is a limit to how much resolution there is between frequencies when using Fast Fourier Transform(FFT), which is given by

$$f_{res} = f_{samp}/N \qquad (2)$$

where N is the number of sample points given to the FFT.

Downconversion: The Hero Gotham Deserves

Downconversion allows us to get around the absurd data requirement above. But how?



Downconversion: The Hero Gotham Deserves

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Side Lobes: A Pain in the Power Spectra

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Windowing Functions: The Good, the Bad, and the Unresolved

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Filter Banks

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The Polyphase Implementation: An Example

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When Windows Break: Channelizers and Polyphase Implementation

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Complicate the Theory, Simplify the Hardware?

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The Universe Talks in Channels?

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