SES 598

The Digital Downconverter

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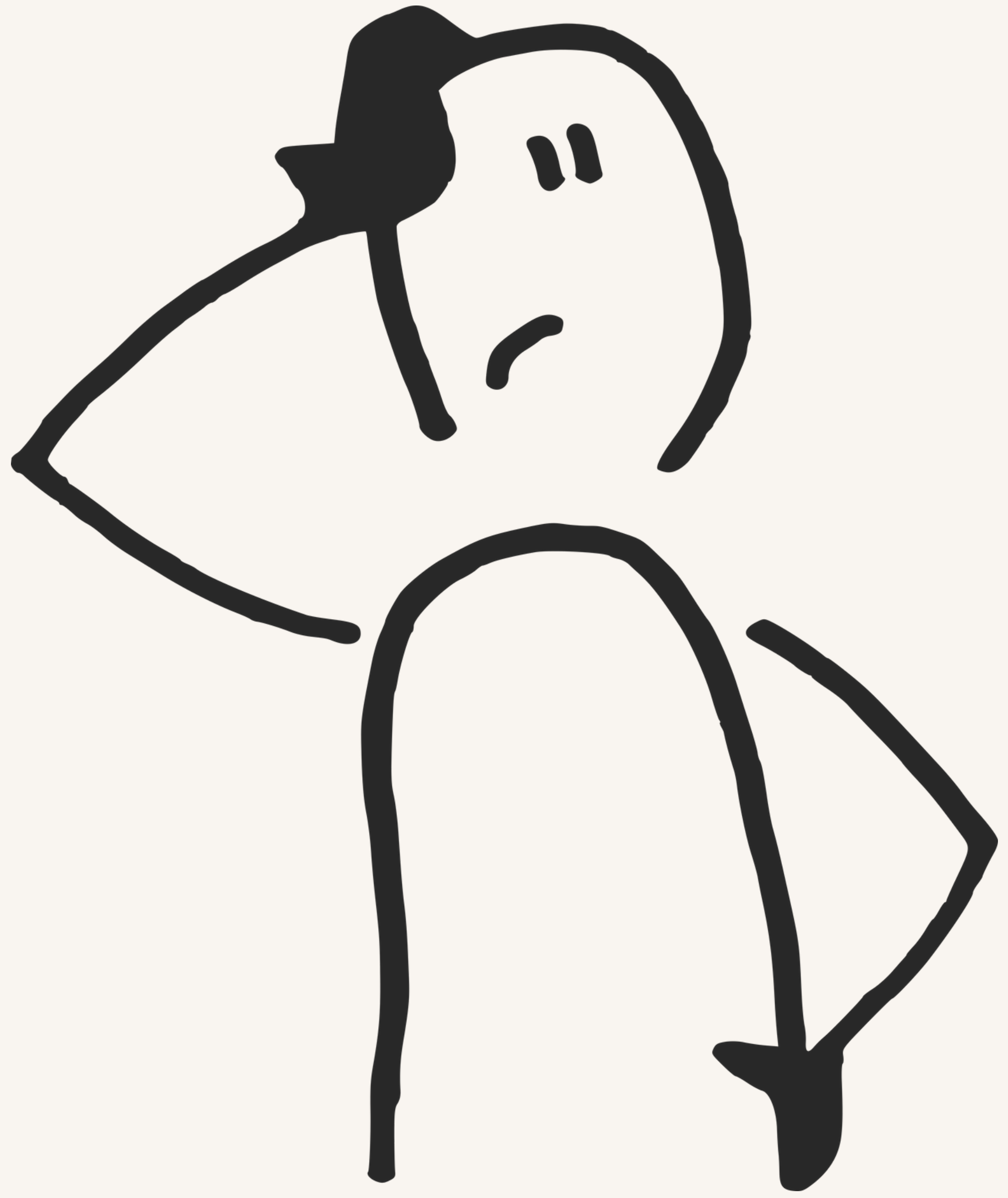
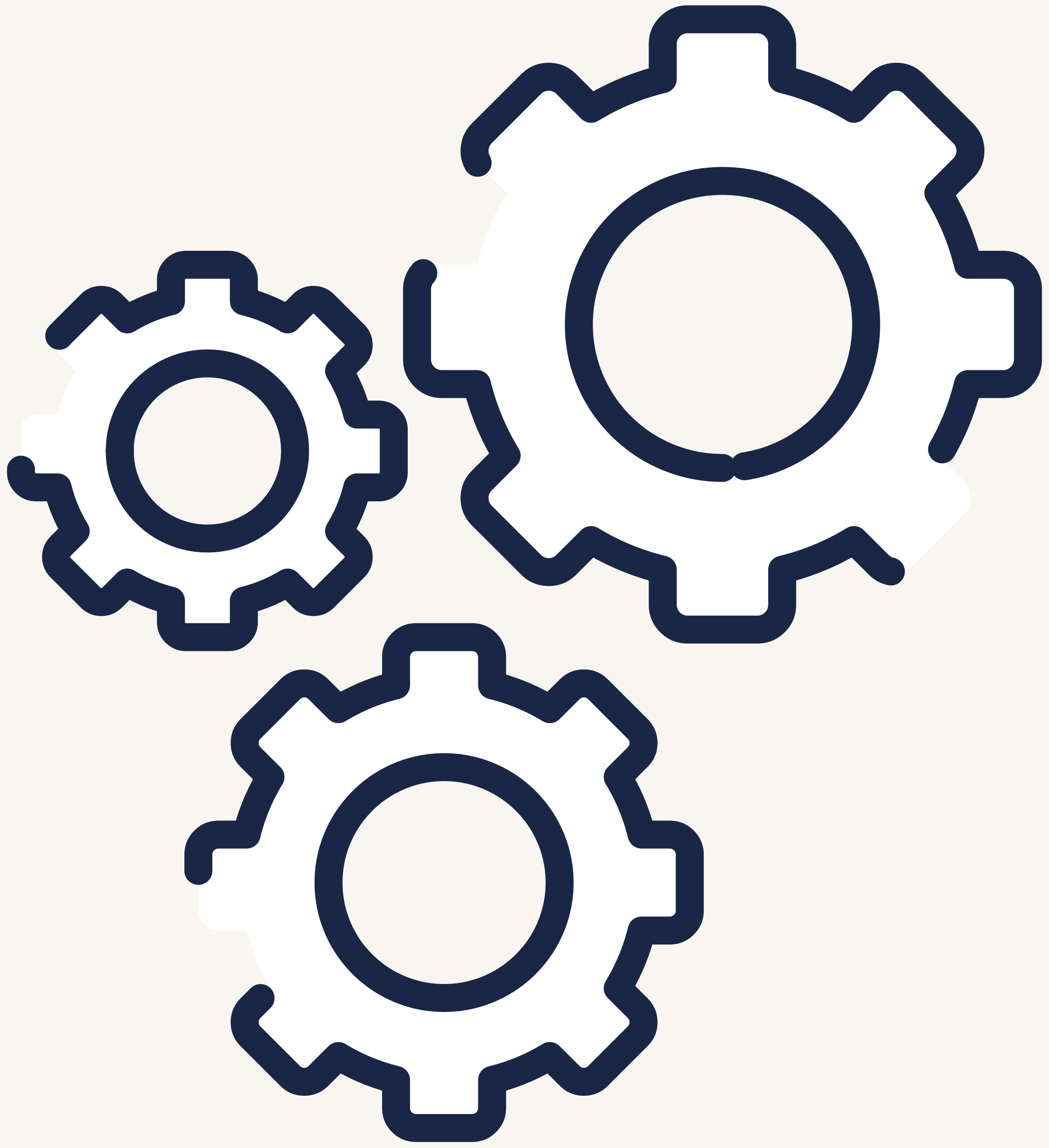
Why Digital Downconversion Matters

In radio astronomy, many astronomical signals arrive at frequencies too high to be received directly by digital instruments such as FPGAs. These signals are analog and noisy, and their bandwidth makes them too heavy for FPGAs to handle directly.

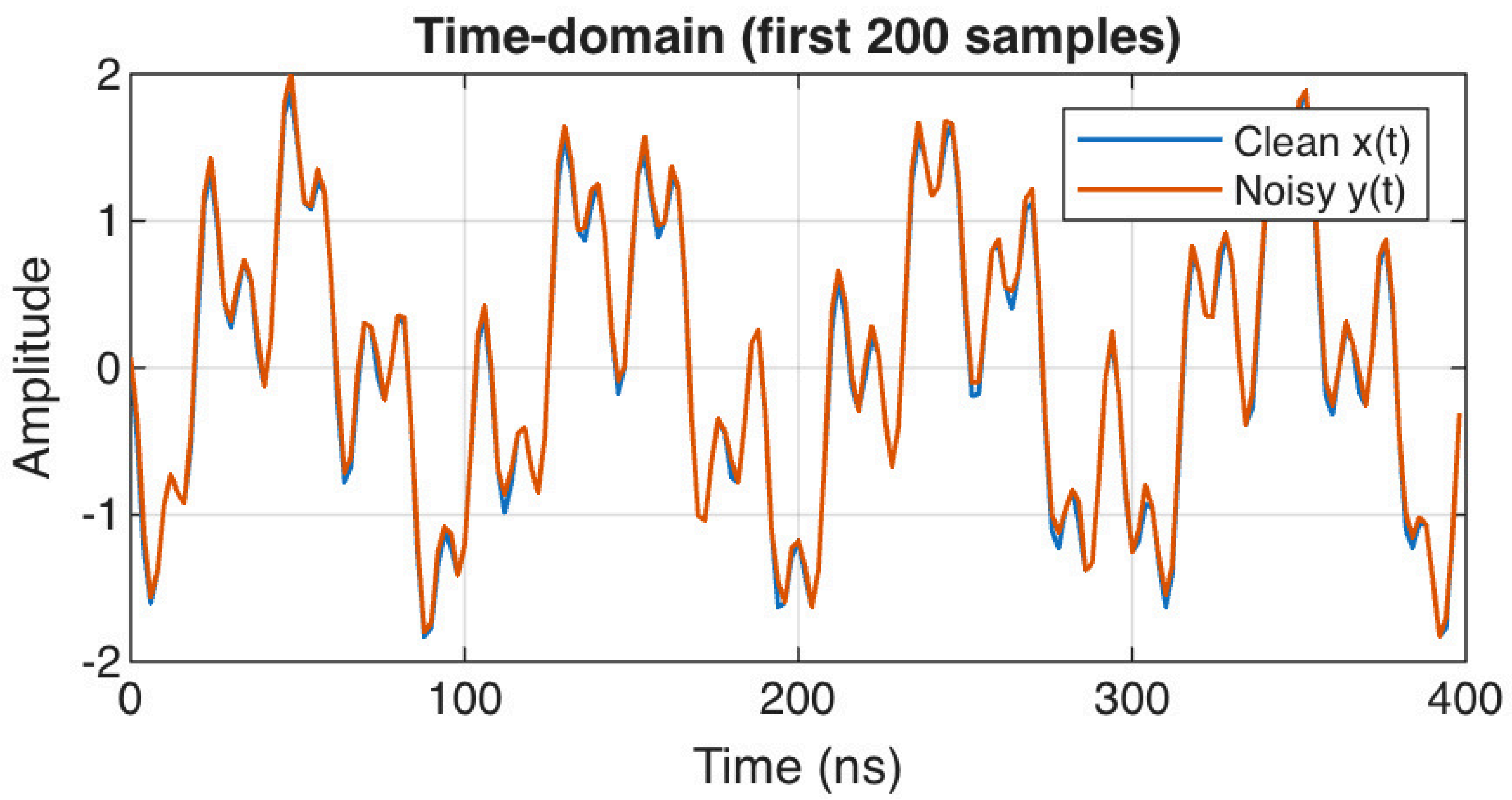


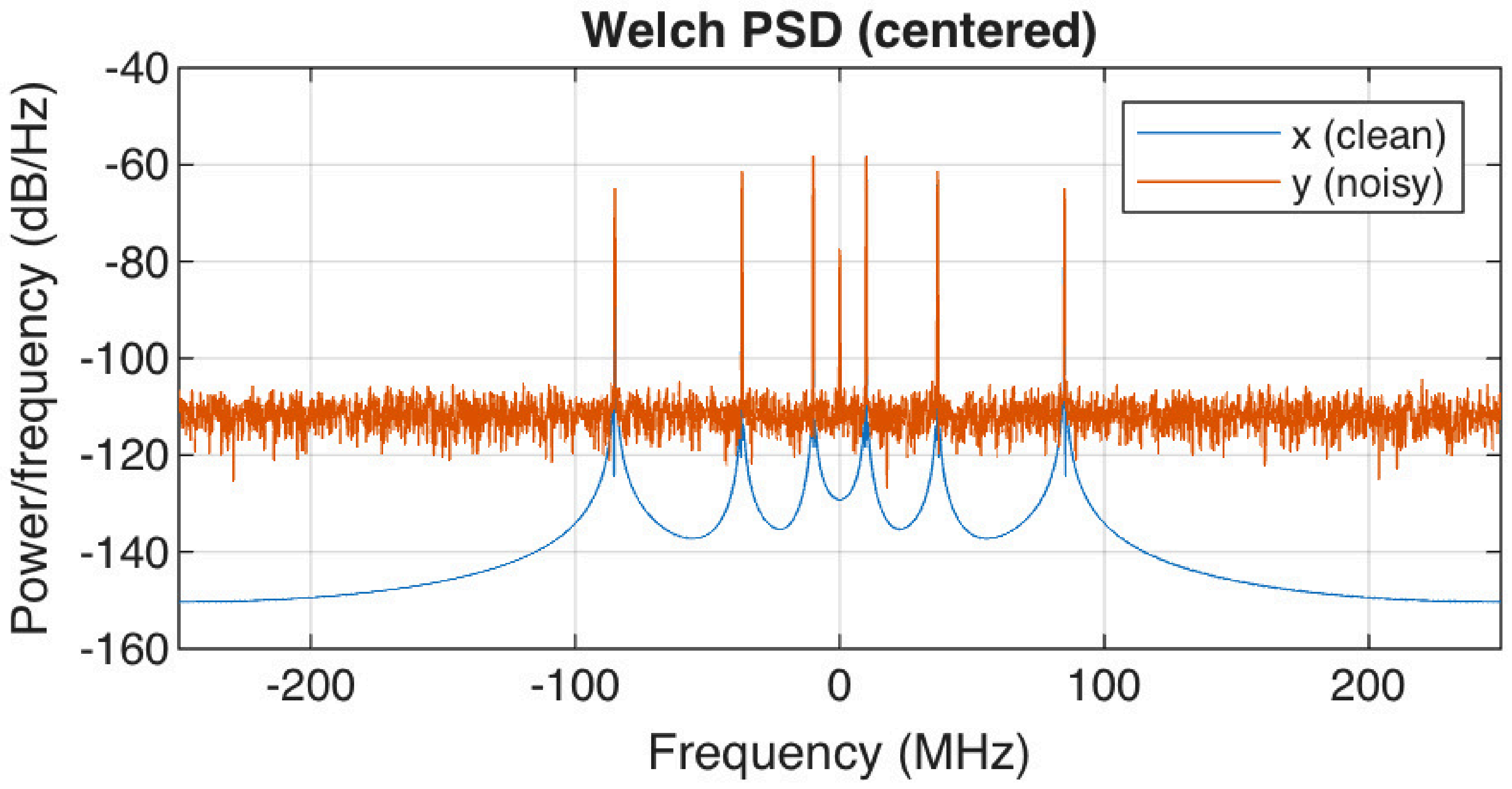
What Digital Downconversion Does

A digital downconverter acts as a middle-man, grabbing those signals before they reach the digital instrument. It shifts them down to a lower frequency, then downsamples and filters them, basically cleaning up the data so the FPGA can process it.

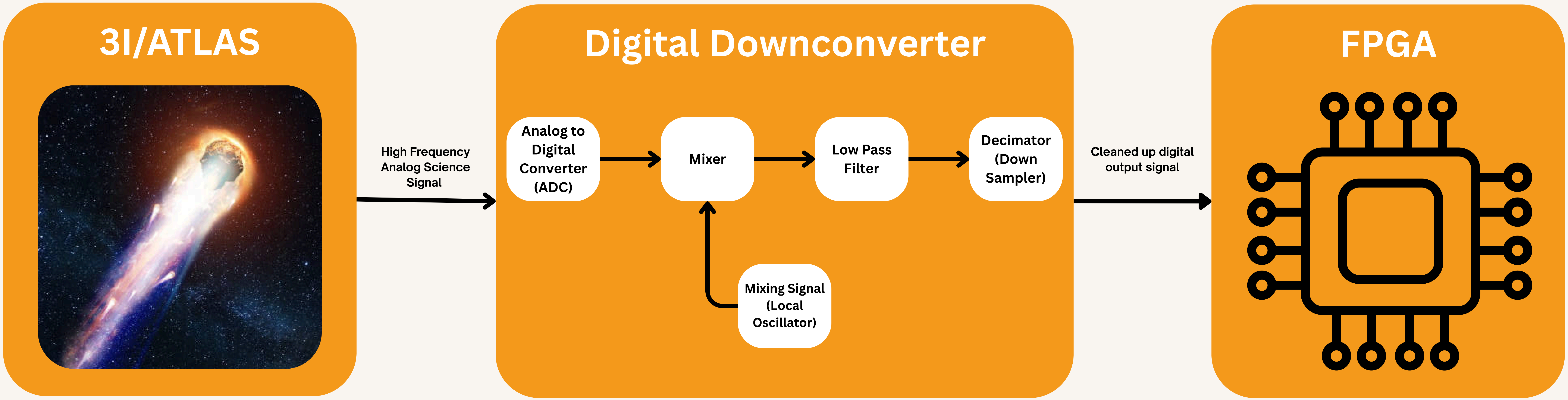


Incoming Science Signal

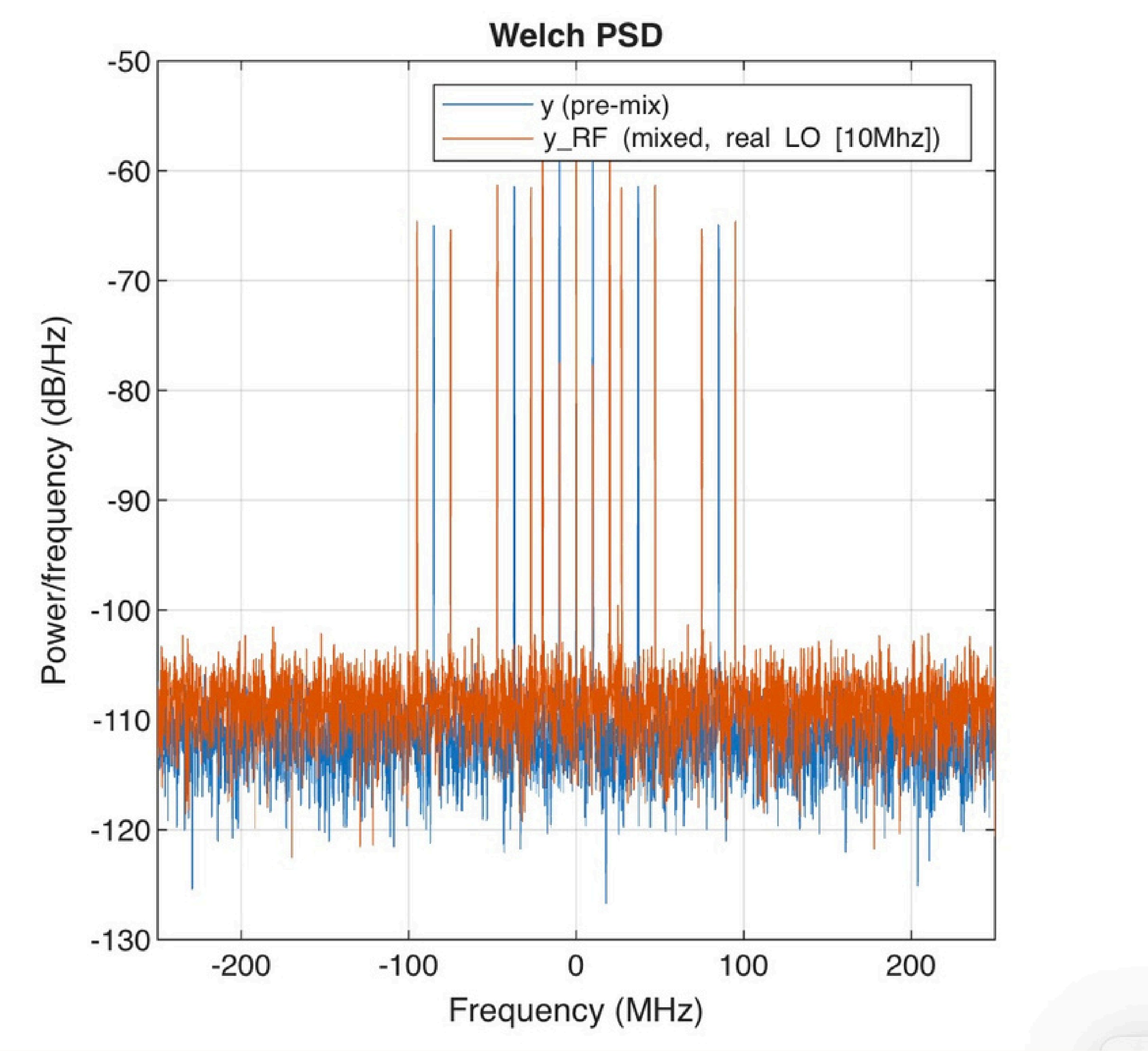




Inside the Digital Downconverter (Block Diagram)



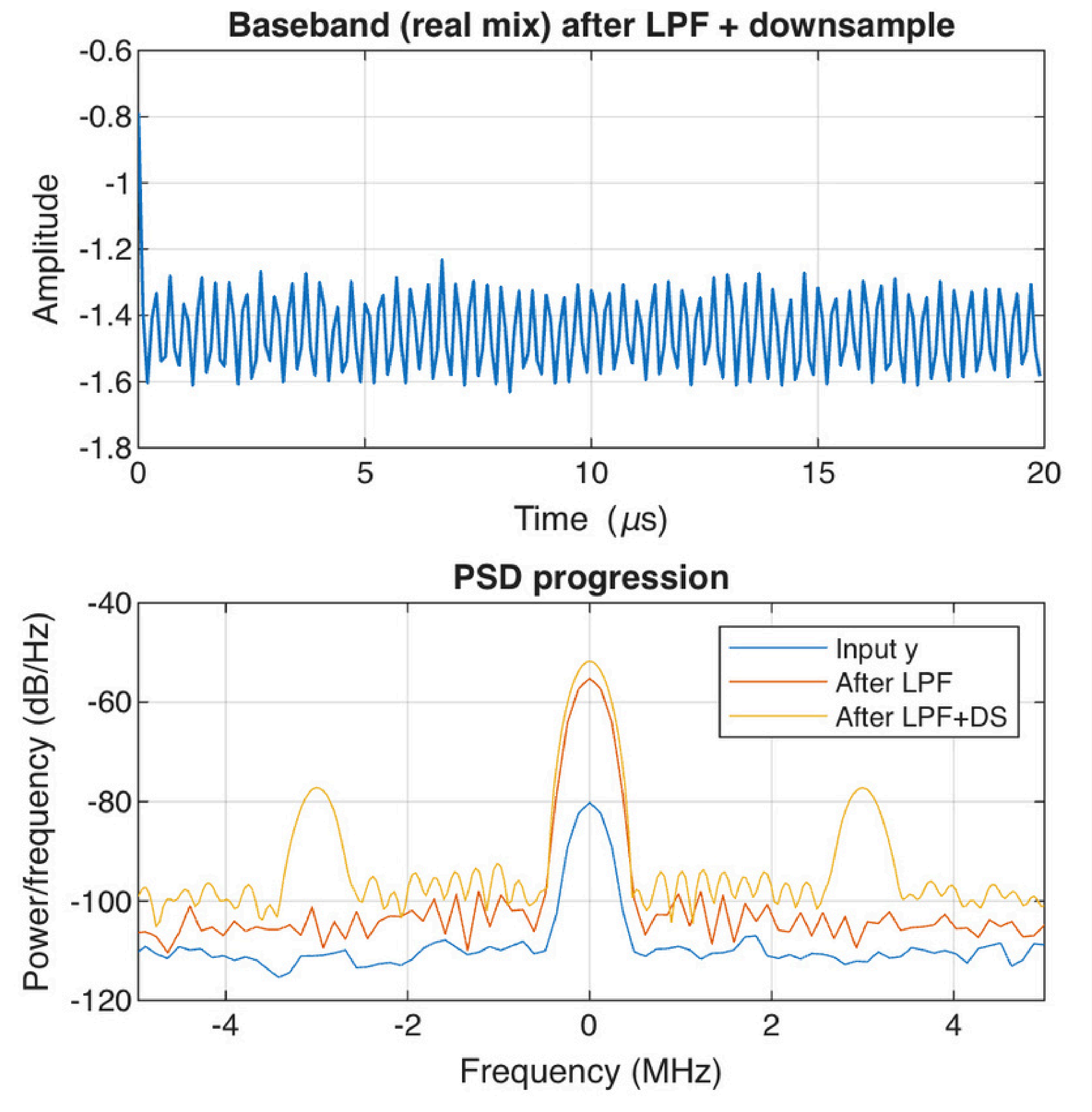
The Mixing Stage



- A frequency of 10 MHz is chosen to mix into the science signal
- The trig identity: $cos\alpha cos\beta = \frac{1}{2}[cos(\alpha - \beta) + cos(\alpha + \beta)]$ will be used to mix the signals
- This results in difference and sum components: $(f_{sig} \pm f_{LO})$
- This difference component (magic frequency) is kept for the LPF and downsampling steps

The Low Pass Filter and Downsampler

- These last two steps clean up the mixed signal and prepare it for processing
- The low-pass filter removes high-frequency noise and the unwanted sum components
- The MATLAB function lowpass() is used with a cutoff frequency of 2 MHz and a sampling rate of 500 MHz
- Lastly, the signal is downsampled by a factor of 50, reducing the data size and enhancing the visibility of the magic frequency



What Was Learned?

Overall, digital downconverters are essential tools in signal processing, especially when it comes to receiving and processing high-frequency analog signals from interstellar objects. The three key steps, mixing, filtering, and downsampling are now understood and ready for execution. Future questions and research will focus on how to select an appropriate local-oscillator frequency, determining viable cutoff frequencies, and choosing optimal downsampling factors.