



Interference Detection and Identification with LNA Integration for Improving Radio Telescope Performance Within Diverse Environments

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Abstract

We introduce the general types of radio interference and describe how they can be identified then filtered using various methods. The research will then move on to the implementation of a low noise amplifier on the radio telescope, and finally presenting the most suitable type of filtering that can be applied to the radio telescope. The theory behind electromagnetic waves and how they radiate, is occupying a rather big part of this paper, as it is essential in understanding how radio telescopes function. Examples and an explanation of radio signals and noise is included to bring even more clarity on the subject.

Introduction / Background

The project focused on signal interference and low noise amplifier that reduces the quality of the radio telescope's ability to capture the desired signals. These signals are usually weak and can be easily interfered with by other stronger waves, such as radio, television, mobile phone, and airplane signals, as well as other devices that emit frequencies considered unwanted. To reduce this interference, the first step was to identify the sources of these frequencies by analyzing them. For this purpose, we used the FFT (Fast Fourier Transform) method, which is one of the basic analysis techniques in MATLAB. The goal of this analysis was to determine the type of source. In addition, we used an electronic device called an LNA (Low Noise Amplifier), which amplifies weak signals and filters out noise. As a result, we can determine the most suitable method for canceling the interference, in order to improve the quality and clarity of the received data.

Proposed Solution / Main Idea

Radio frequency interference (RFI) is seriously problematic for radio telescopes, particularly those with sensitive low-noise amplifier (LNA) receivers operating in the real world. In this paper, we concentrate on state-of-the-art techniques in signal processing for RFI detection and identification in real-time. We investigate approaches such as statistical methods, time-frequency analysis and machine learning for detecting and analyzing interference by frequency, bandwidth, modulation, and source. Precise detection facilitates targeted suppression measures (adaptive filtering, blanking) at the LNA output. These algorithms, when deployed on a data pipeline, are expected to provide substantial enhancements in data quality and scientific productivity for radio telescopes in high RFI region.

Environment	Interference Source	Power (dBm)	Severity
Urban	Wi-fi	-65 dBm	High
Urban	4G	-72 dBm	Medium
Rural	Satellite	-80 dBm	Low
Rural	Unknown	-68 dBm	High

Table 1. Detected Interference Sources and Signal Strength.

Results / Simulation / Discussion

This code simulates a 1.42 GHz hydrogen atom signal reception system using a radio telescope, and how its accuracy can be improved using MATLAB. The signal is generated with noise and interference, and is amplified by a low-noise amplifier (LNA) to improve the quality of the waveform reception before filtering. Then, a spectrum analysis is performed to find the appropriate filter to remove the interference and improve the signal-to-noise ratio (SNR). Finally, the results will be presented in the form of a graph showing an accurate comparison between the four scenario: Light interference and heavy interference, before and after filtering, and another graph showing the signal before and after using the LNA. The results show that filtering is very effective, and that the application of a low-noise amplifier is essential as it improves the detection efficiency. In addition, we would like to point out that the interference damage doubles the closer it gets to the hydrogen frequency, unlike distant interference such as Wi-Fi which can be easily addressed.

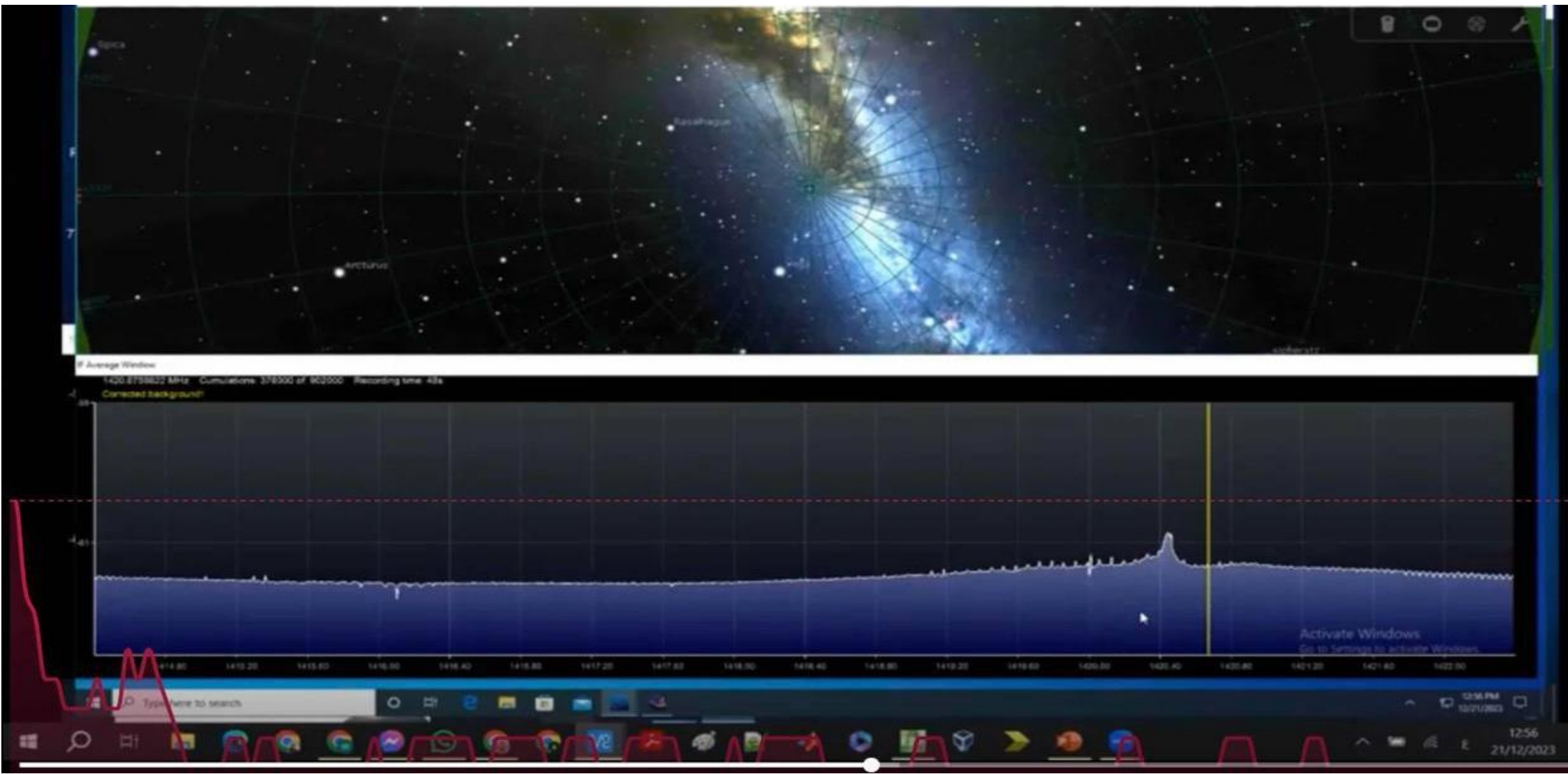


Figure 1(a). High Interference Detection on Telescope Radio Signal.

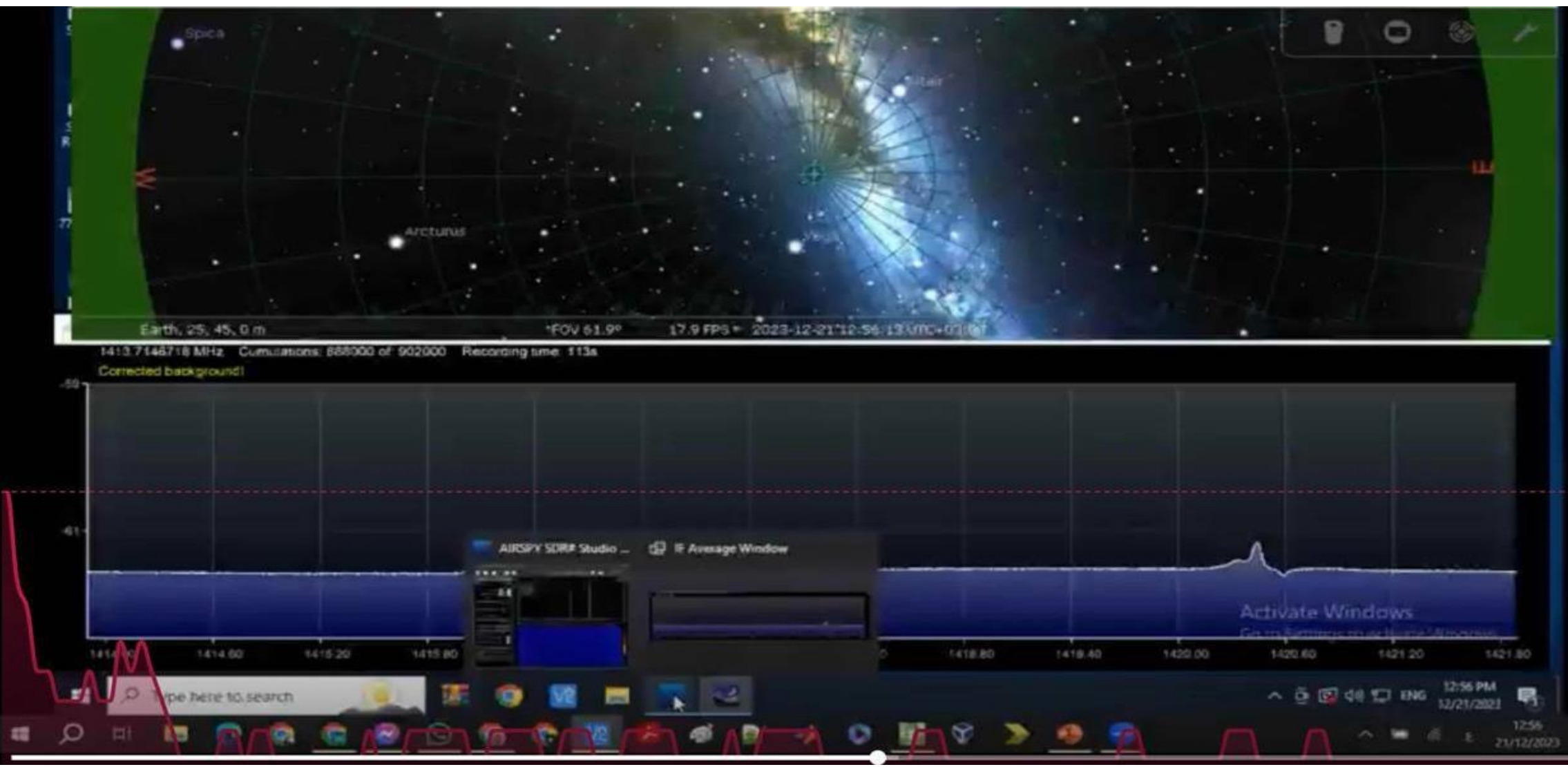


Figure 1(b). Low Interference Detection on Telescope Radio Signal.

System Model / Methodology

The proposed system for refining the radio interference digital signals was developed with the help of artificial intelligence and the study of electromagnetics and Maxwell's equations, and simulated using MATLAB. It follows a four-stage process: generating the input signal, simulating the effect of the Low Noise Amplifier (LNA), detecting and classifying interference, and finally applying appropriate filtering to clean the signal

System Model - MATLAB Simulation Flow

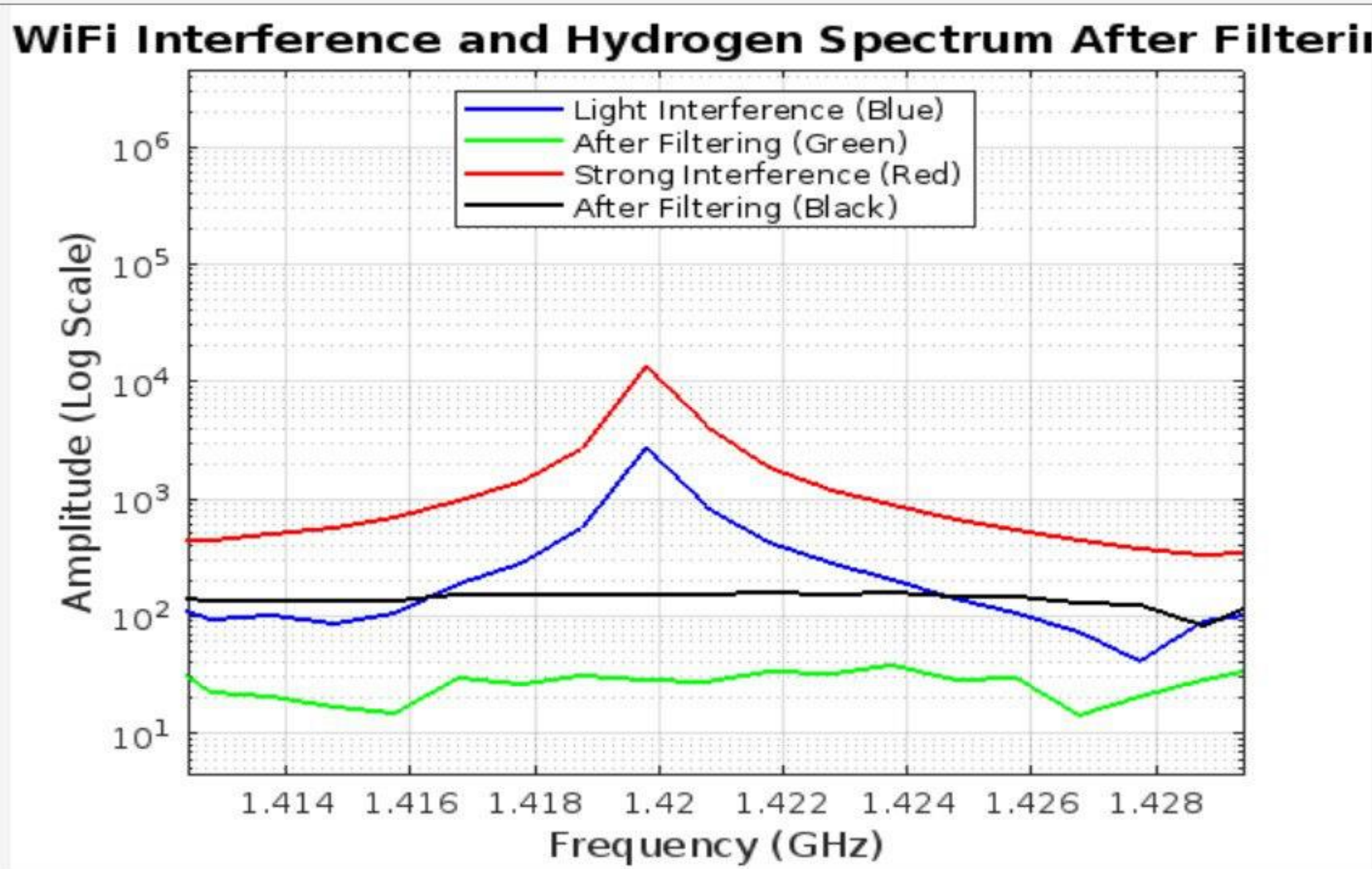
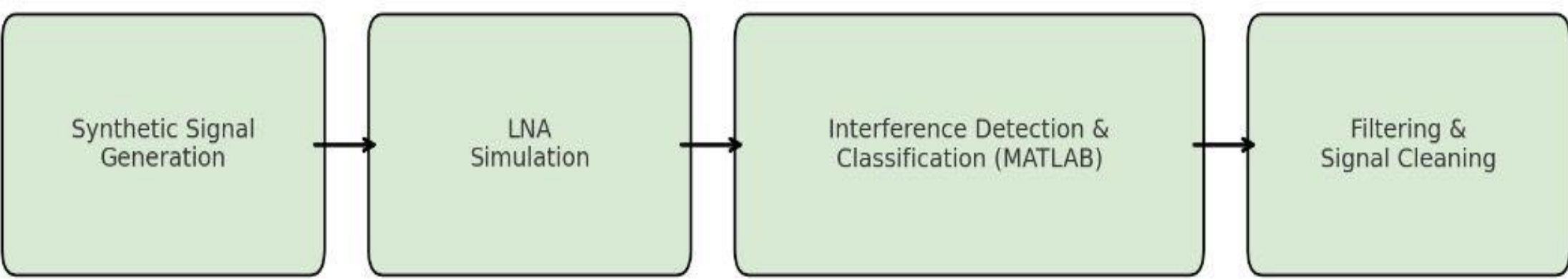


Chart 1. Interference Impact on Hydrogen Spectrum and Filtering MATLAB Outcome.

Conclusions

The effectiveness of radio telescopes in interference-heavy environments depends on accurate detection and mitigation of radio frequency interference (RFI). This study demonstrates that combining interference avoidance techniques with improved Low Noise Amplifier (LNA) design significantly enhances signal clarity and system stability. Results showed a clear improvement in signal-to-noise ratio (SNR) and sensitivity, especially under simulated high-interference conditions. Unlike previous work focusing on isolated solutions, our integrated approach combines hardware and software improvements for better performance in complex environments. Future work will explore real-time machine learning for interference mitigation, advanced LNA materials and designs, and scaling the system to larger telescope arrays using edge computing for local interference handling.

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