High-dynamic Range Radio Astronomy Systems, Interference Mitigation strategies, and an Experimental setup for Radio Dynamic Zones

D. Anish Roshi[1,2], E. Armas[1], C. Westcott[1,2], W. Dellinger[1], M. Burrett[3], W. Liu[4], D. Werthimer[4]
[1]Florida Space Institute, Orlando, [2]University of Central Florida, Oralndo, [3]Brigham Young University, Provo, [4]University of California, Berkeley.

A new spectrum management model proposed is the dynamic sharing of spectrum between different active and passive services. We present results from our ongoing research into the technological needs for dynamic spectrum-sharing for radio astronomy applications. The areas we focus on are the development of (1) high-dynamic-range receiver systems, (2) radio frequency interference (RFI) mitigation techniques, and (3) an experimental setup for real-time implementation and testing of mitigation algorithms. These results are from development work undertaken at the Experimental Astronomy Lab (EAL), University of Central Florida.

The coexistence of active services along with passive services, such as radio astronomy, introduces several challenges to receiver system design. For efficient operation of a radio telescope in a spectrum-sharing environment, receivers need to function effectively over a wide frequency range. Such a receiver will enable the detection of spectral lines in the transmission-free band and increase the sensitivity for continuum observations over the available bandwidth. However, the receiver must have sufficient dynamic range to operate in the linear regime when the transmission patterns of active services vary in frequency within the operating bandwidth. The receiver must also operate in the linear regime to effectively mitigate out-of-band RFI and possible adjacent channel noise leakage.

Our initial development setup consists of a 4-channel voltage recording system. Such a system will allow off-line development of RFI mitigation techniques both in the voltage and correlation domains. The system can bandpass sample signals with a bandwidth of up to ~120 MHz. We digitize the signals using 14-bit analog-to-digital converters in the RFSoC 4x2 FPGA board. The digitized data is transported to the acquisition computer through a 100 GbE link. The system can record samples from 4 channels to a solid-state disk for about 2 hours. The analog part of the system is designed to operate over a 10 - 3400 MHz radio frequency (RF) range. Plugin units such as bandpass and notch filters make the operation possible over the required RF frequency range. The plugin units are also helpful to achieve the necessary dynamic range for experimentation.

We plan to use the 4-channel voltage data acquisition system to acquire data from the DLITE station, Malabar, Florida, and from the 12m telescope at Arecibo Observatory (when available). Two channels will be connected to the telescope, and the other two will be connected to a dual polarization reference antenna. These data sets will be used to develop and test RFI mitigation strategies and techniques. In this talk, I will present the details of the system being developed and the results from the analysis of the data collected. We envision creating an experimental setup capable of acquiring data from a telescope and multiple reference antennas. This setup will help develop and test the real-time implementation of RFI mitigation techniques for radio astronomy. I briefly mention our thoughts on the experimental setup.