Chapter 12
Universal Software Radio Peripheral/GNU Radio-Based Implementation of a Software-Defined Radio Communication System

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ABSTRACT

Challenges involved in space communications across wireless channels call for new approaches to radio systems. Due to the growing need for frequency change in modern wireless systems, an adaptive radio system has the highest demand. Software-defined radios (SDR) offer this type of adaptivity as well as compatibility with other standard platforms such as USRP/GNU radio. Despite limitations of this approach due to hardware components, viable modeling and simulation as well as deployable systems are possible using this platform. This chapter presents a detailed implementation procedure for a USRP/GNU radio-based SDR communication system that can be used for practical experiments as well as an academic lab in this field. In this experiment the USRP has been configured to receive signal from a local radio station using the BasicRX model daughterboard. The programmable USRP executes Python block code implemented in the GNU Radio Companion (GRC) on Ubuntu OS.

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INTRODUCTION

This chapter details the steps taken to apply SDR algorithms to USRP. One should be able to follow these steps with the specified set of hardware and software to get the same configuration on the proper USRP device. These projects were implemented under the supervision of NASA scientists and faculty advisors in dedicated NASA labs. Following lessons learned here and authors' previous experiences in data visualization and signal processing research and training relevant labs were designed to enhance the Computer Engineering program at the Virginia State University (VSU) (Sheybani, 1992, 2002, 2006, 2007, 2008, 2010, 2011, 2012, 2013, 2017; Javidi, 2008, 2010, 2014, 2015, 2017; Ouyang, 2010; Garcia-Otero, 2011).

The Universal Software Radio Peripheral (USRP) device provides entry-level RF processing capability (Muslimin, 2016). Its primary purpose is to provide flexible software defined radio (SDR) development capability at a low price. The frequencies to receive and transmit data can be controlled by installing different daughter-boards. With proper parameters and sinks one can receive a range of signals, record the signals and extract the in-phase (I) and quadrature phase (Q) data and plot the phase and magnitude plots of the signals. The latter part is implemented using the terminal along with proper MATLAB and Octave code. Furthermore, one can read the I/Q data and look at the Fast Fourier Transform (FFT) plot along with the I/Q data. With the proper equations, the direction of arrival, and the distance from the receiver to the exact location where the signal is being transmitted can be calculated (Badombena-Wanta, 2010; Luttamaguzi, 2017).

The recent advances in GNU-Based radio and the flexibility in design and development of systems using USRP technologies have met the challenges in transmission over wireless channels. Since different applications require different signal processing approaches of radio system, a highly reconfigurable radio system is on great demand as the traditional fixed and embedded radio systems are not viable to cater the needs for frequently change requirements of wireless communications. A software-defined radio (SDR) allows a standard, protocol, or signal processing method, to be deployed by using the same set of hardware and software such as USRP and GNU Radio respectively. This will extend studies in simulation domain into experimental domain. SDR is limited by the analog components of the hardware being used (Muslimin, 2016).

The advances in GNU-Based radio and USRP technologies have also resulted in the development of linear frequency modulated continuous wave (LFMCW) radar modulation process. With the new design considerations, the signal level at receiver will change inline with the variation of target distance. That is, if the target range is further, the signal level shrinks. This kind of implementation is also capable of detecting more than one target at varying distances. The difference in