Design and Implementation of BPSK Audio Transmitter & Receiver Using SDR

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Abstract—To meet the requirements of wireless communication industry Software-Defined Radio (SDR) provides an efficient, re-configurable and high performance platform to integrate all individual functions for various modulation and demodulation techniques. The key design step is to determine the digital hardware components of a software radio. This system consists of the BPSK Modulated Radio transmitter and receiver using Linux based GNU radio system. This work presents how the GNU Radio Companion (GRC) and USRP have been used to transmit/receive signals for a wide range of frequencies. The main advantage of this project is that we can implement any transmitter or receiver system without changing the hardware. We have to just change the parameters of software blocks [2] and the low bit error rate.

Keywords—GNU Radio, USRP, BPSK Modulation.

I. INTRODUCTION

Software-defined radio (SDR) is a radio communication system where components that have been typically implemented hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on a personal computer or embedded system [3]. While the concept of SDR is not new, the rapidly evolving capabilities of digital electronics render practical many processes which used to be only theoretically possible.

A basic SDR system may consist of a personal computer equipped with a sound card, or other analog-to-digital converter, preceded by some form of RF front end. Significant amounts of signal processing are handed over to the general-purpose processor, rather than being done in special purpose hardware (electronic circuits). Such a design produces a radio which can receive and transmit widely different radio protocols (sometimes referred to as waveforms) based solely on the software used.

II. GRC FOR TASKS USING THE EXISTING FUNCTIONALITY IN GNU RADIO

The GNU Radio project provides a set of signal processing blocks that can be aggregated to build flow-graphs. These blocks are written in C++ and run in Python, which brings several advantages, such as easy instantiation and connection of existing blocks and easy GUI (Graphical User Interface) creation, as shown in Fig. 1. The working of each block can be properly known to the user once the algorithms that process the samples in frames (or blocks) are studied.

![GNU Radio graphical user interface.](image-url)

The existing blocks in GNU Radio cover various applications from simple mathematical operations, modulators/demodulators; channel coding blocks, voice codec and others. Special classes of blocks are the input/output blocks. The real world interface can be created by the most known UHD (USRP hardware driver) blocks and Audio blocks. To put/get signals from wireless medium UHD blocks are created to use the USRP. Thus the audio blocks put/get the signal from sound card.

III. GRC ARCHITECTURE

The block diagram shows transmission and reception of file source via GNU radio. In this system Host Computer is any normal Laptop / CPU with GNU Radio installed over it or running with the help of live USB environment. For
interfacing of USB, system requires USB 3.0 port with USB high speed data cable. Ettus B200 board which has in-built all FPGA, ADC/DAC, RF Front end, RX/TX terminals blocks.

**Fig. 2** GRC Architecture for Transmitter and Receiver

**IV. WIRELESS TRANSMISSION USING USRP**

**A. Equations**

To access to a USRP use the GNU Radio to transmit signals through wireless channels. As an example of the procedures, this subsection presents a wireless digital communication using BPSK (binary phase-shift keying) modulation [4]. In BPSK modulation only two symbols are used, representing the bits 0 or 1. As mentioned in the constellation diagram binary 1 and binary 0 are represented by different carrier phases each is 180 degree apart. As two different phases are used to represent the two binary digits, thus know as binary phase-shift keying (BPSK).

The resulting transmitted single for one bit time is:

$$S(t) = A \cdot \cos(2\pi f_c t) \quad \text{for binary 1}$$

$$S(t) = A \cdot \cos(2\pi f_c t + \pi) \quad \text{for binary 0}$$

Where

t is time, $0 \leq t \leq T$;

$f_c$ is the carrier frequency.

**Fig. 3** BPSK constellation diagram

**B. Design**

The blocks used in a bit transmitter flow graph of BPSK are shown if Fig. 4. The block Vector Source sends a vector specified by the user. When executing this project, the vector is composed by 0s and 1s; the block repeats the vector whenever it reaches the end. The Vector Source output is connected to a Packet Encoder which is responsible for encoding the data, such that the receiver can find the beginning of the transmitted data.
After the encoder, the encoding data are sent to PSK Mod which is responsible to modulate the information using PSK [6]. The value of the samples in PSK Mod output is modified (multiplied by a constant) by multiply Const block, such that the power of modulated signal can be changed. Thus in transmitter, the signal is sent to UHD: USRP Sink block which is responsible for interact with the USRP. This block has several parameters that are used by the hardware like sampling frequency, carrier frequency.

Fig. 5 Output Constellation plot of Transmitter.

Fig. 6 shows the blocks used in reception of wireless BPSK signals. The UHD: USRP Source block abstracts all the hardware in reception and its outputs are the samples of the received signal in baseband. In this block, like the UHD: USRP Sink, it is possible to define several parameters of the hardware. The UHD: USRP Source output is connected to BPSK Demodulator block that demodulates the BPSK signal, recovering the encoding data. After the demodulation, the encoding data is sent to Packet Decoder block which decodes the data and outputs the bits (the information sent by Vector Source). Once the information was recovered, the Char to float block converts the byte in float, so that the information can be used by others blocks [7].

Fig. 6 GNU Radio BPSK receiver flow graph.

Fig. 7 Output Constellation plots of Receiver
C. USRP SDR B200 Module

Fig. 8 RTL-SDR Transmitter & Receiver Setup

This wireless TX-RX kit allows implementing and studying several telecommunication concepts, such as modulation development [8].

V. CONCLUSIONS

In the implemented transmitter & receiver an audio file is transmitted using BPSK modulation. The BPSK transmitter flow graph is build in GNU radio software having frequency of 2.54 GHz (ISM band). The analog audio is converted into digital form by USRP sink block and transmitted via antenna of SDR B200 module. The DVB-T+FM+DAB 820T2 RTL SDR dongle captures these transmitted frequencies. At BPSK receiver side digital signal is converted into analog signal by RTL-SDR source block and processed further. Path is given to audio sink block, where the received audio is saved as binary file. Rhythm box is used to play the audio file as music, speech, announcement etc & bit error rate is observed very less.

REFERENCES