Economical Antenna Reception Design for Software Defined Radio using RTL-SDR

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Abstract ***The field of wireless communication has become the hottest area and Software Defined Radio (SDR) is revolutionizing it. By bringing much functionality as software, SDR reduces the cost of hardware maintenance and upgradation. Open source hardware such as USRP (Universal Software Radio Peripheral) and software called GNU Radio-Companion are commonly used to do transmission and reception in SDR. Since the cost of USRP is high, a low cost set up is needed which is affordable by the student community. In this paper a low cost alternative to USRP is proposed using RTL-SDR (Realtek Software Defined Radio) which is only used for reception. In this paper we proposed a Quadrifilar Helical Antenna to receive various signals which is available at space using a low cost hardware RTL-SDR and software called SDR#, HDSDR.***

Keywords SDR, GNU, USRP and Real Tek SDR,SDR#,HDSDR

I. INTRODUCTION

Software Defined Radio [1] is the radio in which every hardware components is implemented on PC software. Hence, every problem related with the hardware now turns into software problem. It is easy to rectify software problems by just reconfiguring setup blocks. This approach obviously reduces the cost and time criticalness compared with hardware method. Fig. 1 shows the block diagram representation of GNU-RADIO platform. The GRC platform has a very stabilized in Graphical User Interface (GUI) which makes the development in the most efficient way. This interface makes the work to accomplish in the simple and easiest way. In the way to implement the SDR, the open source platform called as GNU radio is already present. Just drag and drop type of options are available which makes the beginners very comfortable to work with. The GNU radio companion is built using C++ programming for signal processing unit and python script codes for ports (or) edges which acts as a link to connect between the blocks.

Fig. 1. SDR PLATFORM

II. GNU-RADIO COMPANION AND USRP

It is an open source free-ware used to implement SDR and performs various operations like modulation, filtering, encoding, demodulation, etc. All these operations are performed and analyzed in a computer, thus ignoring the need to rely on the hardware and its circuitry. Instead everything is software based which can be reconfigured. An important feature of the GNU radio is its association with Graphical User Interface (GUI) by means of GNU radio companion (GRC) [4] [6]. The Universal Software Defined Radio Peripheral (USRP) acts as the interface to establish a communication between software and hardware. USRP (Universal Software Defined Radio Peripheral) N200 and N210 [2] are the best ones which provide higher bandwidth and dynamic ranges. Some of the features of USRP N210 are, it has dual 100ms/s, 14 bit ADC and dual 400 ms/s, 16 bit ADC and it follow up to 50 Ms/s Gigabit

Ethernet streaming[3]. It also has 1MB high speed SRAM. USRP is the hardware used for both reception and transmission (i.e., duplex). The main part of USRP is its FPGA which provides digital signal processing and also timing logics for the hardware. USRP has the mother board and each mother board has two daughter board slots which is half duplex, one slot for receiving and other one is transmitting only. Thus with these two types of daughter boards, USRP performs as a full-duplex. But, though it has very high performance and bandwidth, it is not suitable for low cost implementation purpose. This problem is catered by using dongle type of Real-Tek SDR which is an alternative for high cost USRP. The specification of Real-Tek SDR includes the highest sample-rate of 3.2 Ms/s and operating frequency of 64 MHz to 1800 MHz. Unlike USRP, it can only be used for reception purpose (half duplex) at the receiving side. The main advantage of Real-Tek SDR over USRP is that it avoids data traffic. i.e., many receptions are made possible by the use of Real-Tek SDR at the same time. Mixer can be introduced in the transmitting side for transmission purpose instead of using high cost USRP[6][7]. But Real-Tek SDR has no liabilities to receive below 64 MHz, thus it is operated along with mixer to gain access to all bands.

III. RTL-SDR

Till date USRP (Universal Software Radio Peripheral) is a popular hardware device for doing real-time communication experiments in SDR[8]. But now, a 20 dollars revolution from OSMO SDR has introduced a hardware called RTL-SDR Realtek RTL2832U which is the cheapest one .The DVB- T (Digital Video Broadcast Terrestrial) dongle proved to be efficient for SDR purposes as the chip is able to transmit raw I/ Q samples to the host. The operating frequency range of RTL-SDR is from 64 to 1700 MHz with sample rate of 3.2 MS/s

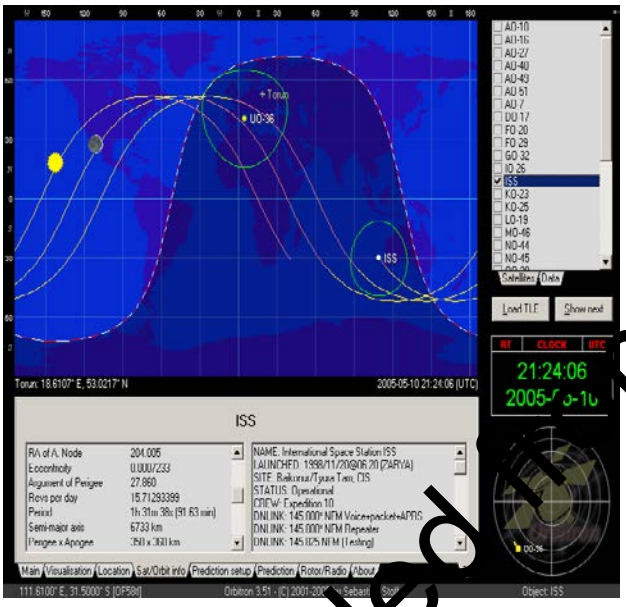


Fig. 3. USING ORBITRON SOFTWARE

IV. HDSDR, SDR #, ORBITRON

HDSDR is a freeware Software Defined Radio application for Microsoft Windows operating system. Separate large spectrum and waterfall diagram for both input and output signals can be obtained easily. It is an user-friendly environment and extremely low speed waterfall spectrum analysis could be made. The HDSDR software window is shown in Fig.2.

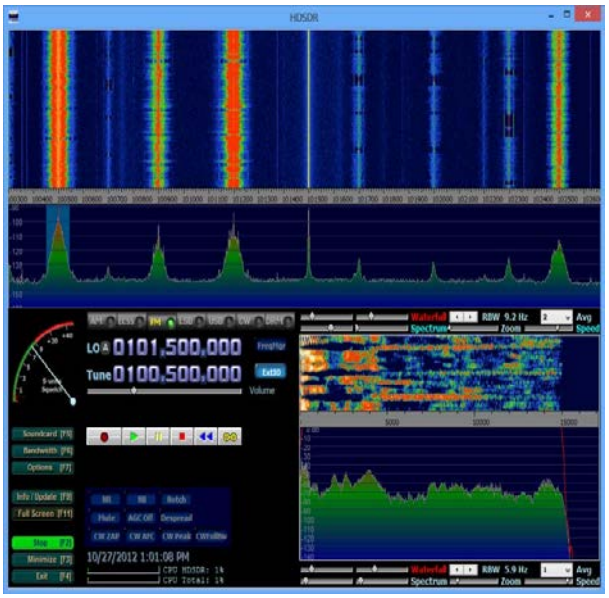


Fig. 2. USING HDSDR SOFTWARE

From Fig.4. SDR Sharp is a simple, intuitive, small and fast PC based application for SDR which is developed in C++. Its main purpose is to get hands on experience with the Digital Signal Processing techniques. SDR Sharp has an icon called as 'Correct IQ' which is an optimization algorithm called as 'Automatic IQ Correction' in order to compensate the gain and

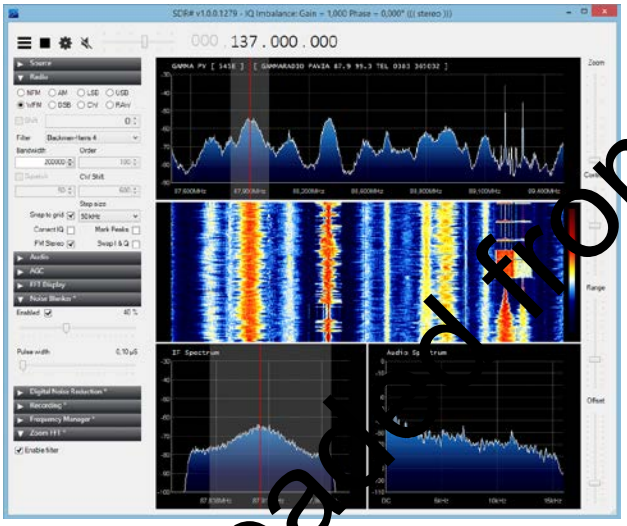


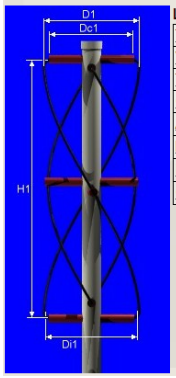
Fig. 4. USING SDR# SOFTWARE

phase imbalance between the IQ channels. Orbitron Fig.3. is a satellite tracking system for radio amateur and observing purposes. It gives the information about the current position of the satellite either in real time or through simulation. With the help of this software we could position our antenna at the right position with the corresponding azimuth and elevation. Further it has an option to alert the user when a desired satellite reaches a predefined location.

V. ANTENNA DESIGN PROCEDURE

The antenna used in our system is a low cost Quadrifilar Helical Antenna.[9][13]. A QFH is an omnidirectional antenna comprised of two square loops usually one wavelength long each twisted a half turn and offset 90 degrees from each other. This antenna could be constructed using a couple of PVC pipes of appropriate dimensions.

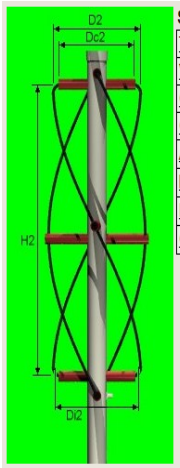
Wavelength	2181.8 mm
Compensated wavelength	2336.7 mm
Bending correction	6.4 mm



Larger loop

Total length		2397.4 mm
Vertical separator		889.6 mm
Total compensated length		2423.2 mm
Compensated vertical separation		859.6 mm
Antenna height	**H1=**	731.8 mm
Internal diameter	**Di1=**	315 mm
Horizontal separator	**D1=**	322 mm
Compensated horiz. separation	**Dc1=**	292 mm

Fig. 5. DIMENSIONS FOR THE OUTER LOOP OF QFH ANTENNA



Smaller loop

Total length		2278.3 mm
Vertical tube		845.8 mm
Compensated total length		2304 mm
Compensated vertical tube		815.8 mm
Antenna height	**H2=**	[illegible] mm
Internal diameter	**Di2=**	[illegible] mm
Horizontal separator	**D2=**	[illegible] mm
Compensated horiz. separation	**Dc2=**	[illegible] mm

Fig. 6. DIMENSIONS FOR THE INNER LOOP OF QFH ANTENNA

It consists of two loops of coaxial cable each one shorted with its own core. The outer loop is the larger loop and the inner loop is the smaller loop. All the dimensions required for the design of QFH is obtained from an online antenna design calculator[10].

Design frequency	137.5 MHz
Number of turns (twist)	0.5
Length of one turn	1 wavelengths
Bending radius	15 mm
Conductor diameter	7 mm (optimum: 20.5 mm)
Width/height ratio	0.44
	Calculate

Fig. 7. ONLINE CALCULATOR INPUTS.

The QHF antenna is designed for a frequency of 137.5 MHz. It is more suitable for receiving signals from NOAA weather satellites.

VI. EXPERIMENTAL SETUP

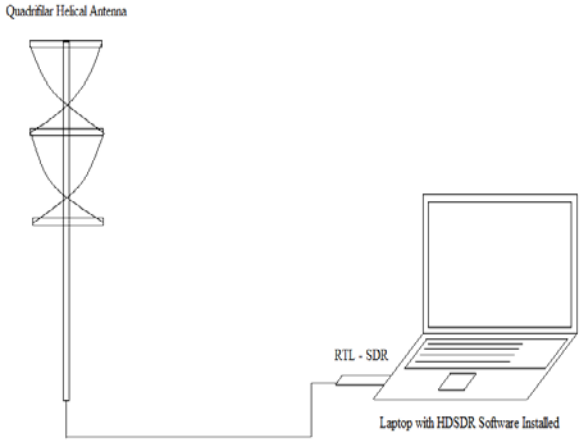


Fig. 8. BLOCK DIAGRAM OF THE EXPERIMENTAL SETUP

The experimental setup consists of a laptop running on Windows OS with HDSDR or SDR# software installed in it.

The RTL-SDR dongle is connected to the laptop through the USB port. The homemade QFH antenna is connected to the RTL-SDR dongle.

Select the device as RTL-SDR in the receiver section of the HDSDR software then adjust the frequency to 137MHz in order to receive signals from NOAA satellites[11]. From the obtained waterfall diagram the received signal could be analyzed.

Further the obtained signal could be filtered and given as an input to the WXtoIMG software through software audio cable for reconstructing the satellite image[12].

The experiments could be carried out based on the data from orbitron software so that clear reception of signals from the desired satellites is possible.

VII. OUTPUT AND RESULTS

From Fig.9.The QFH antenna is designed by using coaxial cable and it is mounted on the terrace for signal reception. The gain of the antenna is sufficient enough for receiving signals from the satellites. The probe of the antenna is connected with the RTL-SDR dongle and then the corresponding frequency is set in HDSDR, the waterfall diagram of the received signal is obtained as shown. Finally the parameters of the signal are analyzed.

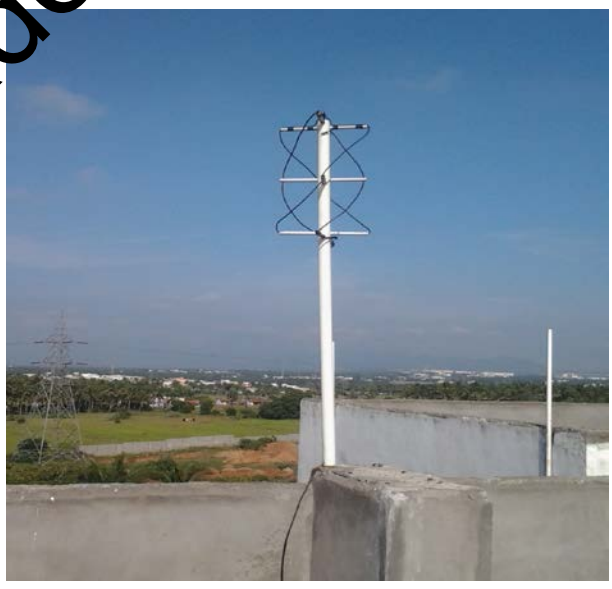


Fig. 9. THE HOMEMADE QFH ANTENNA MOUNTED ON ROOFTOP

CONCLUSION

SDR based RF communication system is highly reliable and cost-effective. In future all the wireless communication networks will be based on SDR because of its simplicity in design and its flexibility. Further as the system deals with real-time signals it would help the students community to learn wireless technologies practically at very low cost. USRP could be used to do the same over a wide range of frequency but the main disadvantage is its high cost, which a college student could not afford. The design of Quadrifilar Helical Antenna (QHF) proposed is very simple and it can be constructed even at home with easily available plumbing parts. Since this antenna is omnidirectional it could be used over a wide range of frequency for almost all the lab experiments. All the software's used are open source thus it reduces the cost further.

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