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SOFTWARE-DEFINED RADIO USING 'REDPITAYA'

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Abstract---*Most of the students lack empirical knowledge in communication systems. This project demonstrates a basic wireless communication system using a software-defined radio, how the signals are modulated, transmitted, received etc. Software defined radios have many applications and it is becoming increasingly popular among the users. The use of software-defined radio as a transmitter and receiver will make the students understand how the components that are implemented in hardware are replaced by software on a PC. With this project, the students will get to know more about software-defined radios, antenna and wireless communication system. Illustrations of the theoretical concepts as they are introduced can be vital in motivating students and helping their understanding. Software-defined radio offers a multitude of unique and effective tools to teach signals and communications. Redpitaya is a remote laboratory instrument that has everything which is needed to develop it as the core of SDR transmitter or receiver. By this project, students develop a clear picture based on their initial understanding of the concept.*

I. INTRODUCTION

Radio technology is used in a wide range of applications now and then. Earlier, when wired links were not possible for communications, radio technologies were used. Radio waves are used to transfer information between the transmitter and receiver in wireless RF communication. Now, this technology is used in different fields such as mobile communication, radar, satellites etc. Demonstration of wireless RF communication system within a classroom will help students understand its basic concepts. The conventional radio communication system includes very bulky and complex hardware which is not suitable for amateur radios. A software-defined radio (SDR) is the 'radio communicational system,' which uses software to implement components instead of implementing in hardware (e.g. mixers, filters, amplifiers, modulators or demodulator systems, detectors, etc.). SDR can be programmed into any type of radio or frequency. Software-defined radios are used in various fields such as mobile communication, military, amateur radio etc.

A Redpitaya is an "open-source hardware project aimed to be a substitute for various costly laboratory instruments". It can be used as oscilloscope, signal generator, LCD meter, spectrum analyzer etc. With the help of different applications of Redpitaya, it can be used to setup a communication system for laboratory purposes. A Redpitaya has everything that needs to develop it as the core of SDR transmitter or receiver. Here, we use Redpitaya as the transmitter. For the receiver section, SDR hardware platform chosen is the RTL-SDR. When compared to the existing software-defined radios, RTL-SDR is an inexpensive USB dongle which is used for the reception of live radio signaling without requiring internet. Many software which are compatible with RTL-SDR are available for controlling the SDR kit and for processing the radio signals from it.

II. SOFTWARE DEFINED RADIO

When technology advanced, the receiver (and transmitter) chain has switched from analog to digital software-based systems. These are called as software-defined radios (SDR), because most of the characteristics of these transceivers were defined by the software running at a given time. Software-defined radio (SDR) is a radio communication device, which instead uses software on a PC to incorporate devices that have been commonly used in hardware.

The basic architecture of an SDR is shown as Figure 1. It consists of a processing unit, digital front end, ADC, DAC, RF/IF converter and an antenna. The processing unit contains both hardware and software in it. Hardware consists of FPGA chip, DSPs and ASICs and the software consists of algorithms, middleware, CORBA etc. For the synchronization of communication, Sample Rate

Conversion (SRC) is done using digital front end in which rate of sample is converted from one to another. Another function of the digital front end is channel filtering which includes up conversion/ down conversion in the transmitter (Tr) or receiver (Rr) side.

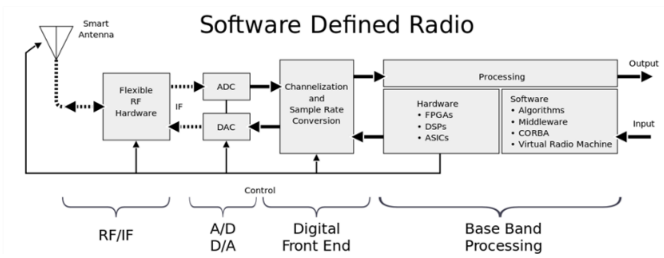

Figure 1: Architecture of Software-Defined Radio

III. REDPITAYA

A Redpitaya (Figure 2) is an open-source hardware project designed as an alternative for many expensive laboratory instruments for measurement and management. It is basically a customer-server relationship, where customers can ask for any facilities. Redpitaya is available in two versions, STEM 125-10 or STEM 125-14. Though they offer same functions and features, there is difference in the technical specifications of high frequency inputs and outputs, RAM capacity, etc. STEM 125-10 version has ADC and DAC has 10 bit I/O channels whereas, STEM 125-14 version has 14 bit I/O channels. The main marketing factor is 2x 125MS / s RF inputs and 2x 125MS/s RF outputs, which have analog bandwidth of 50 MHz and analog to analog and digital to analog converters 14 bit. It includes an oscilloscope, a spectrum analyzer, a signal generator, an LCR meter and a 50MHz 2x2 MIMO PID control unit for additional costs of 400 euros. It can be reorganized into other phones, since all the I/O ports are linked to an FPGA network. There are also extra ADC (250kS/s) and digital IO. It also has three USB 2.0 ports, Wi-Fi and Ethernet connectors. It uses the operating system Linux internally. The micro-SD card is the mass storage device which is available for the operating system. Because of the large ADC and DAC bandwidth, Redpitaya can also be used in other radio frequency applications as a defined radio receipt and transmitter software.

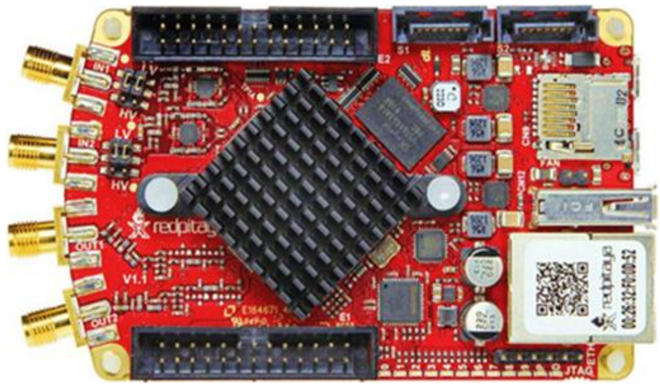

Figure 2: Redpitaya

A. 'REDPITAYA' AS A TRANSMITTER

Redpitaya board can be controlled remotely using MATLAB, SCILAB, Python, and LABVIEW through Redpitaya SCPI (Standard Commands for Programmable Instrumentation) list of commands. SCPI uses commands that are known to the instruments so that they can take actions accordingly. To control Redpitaya using MATLAB, IP address of Redpitaya should be known. For getting IP address, from the Redpitaya window, select development and then SCPI server and press RUN. IP address will be shown in the window. SCPI server and other web applications of Redpitaya cannot be operated in parallel. MATLAB codes for generating continuous signals at the outputs of Redpitaya is available in its manual. Using the code, an input with desired frequency up to 50 MHz can be generated and transmitted. Using "audioread", audio can be read in MATLAB and frequency modulated. Using SCPI server commands, this modulated signal can be send to one of the outputs of Redpitaya. The code for obtaining custom waveform is given in the manual of Redpitaya. By editing the IP address, giving the desired function and frequency of signals, signal waveform is generated at the output of Redpitaya.

IV. TRANSMITTER ANTENNA

Antennas are transducers that convert voltage from transmitter into a radio signal and vice versa. A voltage at the desired frequency is given to the feed of antenna. The voltage across the elements of antenna and current through them develops the electric and magnetic waves. At the receiver side, the EM waves passing over the receiver antenna induces a small voltage. For maximum power transmission, transmission line should be matched with antenna and receiver or transmitter. If impedance are not matched, there will be reflections and a high Standing Wave Ratio (SWR) will be produced.

A. MAGNETIC LOOP ANTENNA

A single turn loop antenna is a metallic conductor bent into the shape of a closed curve, such a circular or rectangular with a gap in the conductor to form terminals. There are small loop antennas and large loop antennas. Large loop antennas, also called as resonant antennas have high radiation efficiency. These antennas have the total length of wire approximately equal to the wavelength. Small loop antennas, also called as magnetic loop antenna are less resonant and the total length of the wire is approximately equal to 1/10th of the wavelength in the case of receiving. The total wire length of small transmitting loop antennas is less than ¼ of its wavelength. The current in every part of the loop is equal phase and magnitude. It has less radiation efficiency as compared to large loop antennas. The construction of magnetic loop antenna is simple. If magnetic loop antenna is used as a transmitter antenna, impedance mismatch will be a problem. Small loop antennas are basically in circular or square shapes. Polarization of loop antenna varies vertically or horizontally with the feed position. The radiation pattern of these antennas will be same as that of the horizontal short-dipole antenna. A loop can be tuned by placing a capacitor across the terminals of antenna and this may cause a large voltage to appear across the terminals. Most amateur antennas are used by tuning.

B. SIMULATION

Numerical Electromagnetics Code (NEC), a popular antenna designing software for wire and surface antennas is used to design and simulate antenna. NEC is widely used for designing antennas for televisions, radio antennas, ham radio, and shortwave radio. NEC-2 is the most commonly used version of NEC antenna designing software.

The frequency of the magnetic loop antenna is 30MHz and wavelength is 9.93m. A transformer coupled loop antenna is designed and simulated here. Input is given to the coupling loop whose diameter is 1/5th of the diameter of main loop. Main loop or the resonant loop is tuned using a capacitor of value 9pf.

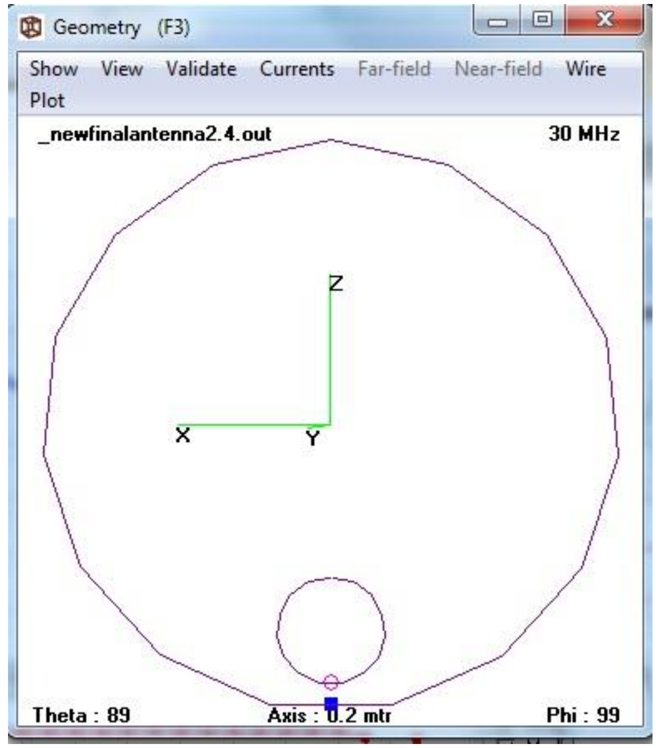

Figure 3: Magnetic loop transmitting antenna

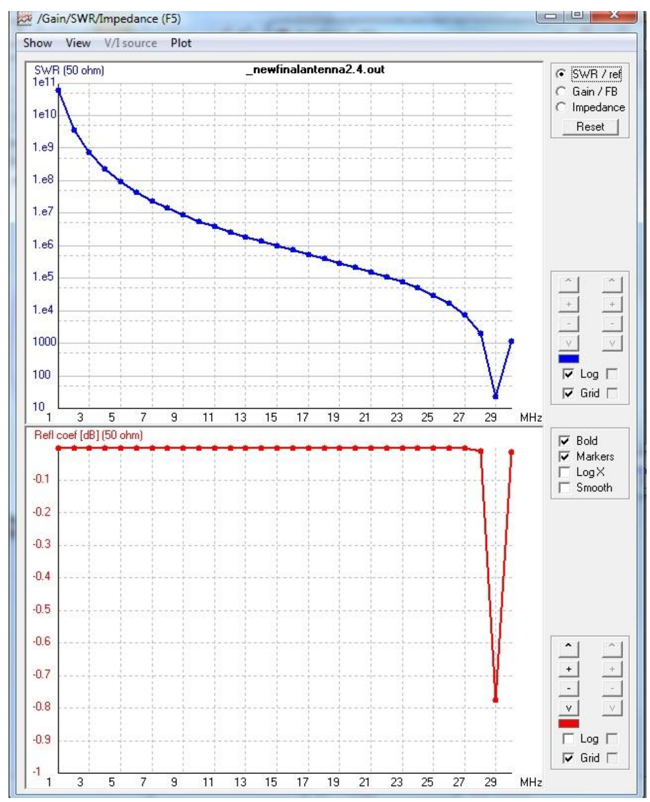

Figure 4: Graph showing SWR and Reflection coefficient against Frequency

V.TESTING ANTENNA

A single turn magnetic loop antenna is used for testing purpose with a total perimeter of 0.768m. The design of single turn small loop antenna is based on the ARRL antenna handbook. According to ARRL antenna handbook reccomendations, the total perimeter should be less than 0.1 times the wavelength of the signal transmitting or 0.08 times the wavelength. Here, we transmit a signal of frequency 30MHz with a wavelength of 9.96m and thus the perimeter of the antenna is 0.08 times the wavelength ie., 0.768m. the current flowing in he loop is uniform in all positions of loop. A small loop differs to a large loop by the manners of its response to the radio signal. The small loop antenna response to the magnetic field components of waves. Thus it is less sensitive to the local electromagnetic interference source such as powerlines and appliances.

VI. RTL-SDR

The RTL-SDR is an inexpensive software-defined radio based on DVB-T TV dongle with RTL2832U chips. It can be used as a wide-band radio-scanner for the reception of live radio signals in your area without internet. It could receive frequencies from 25 MHz to 1.75GHz. RTL-SDR kit is provided with a highly efficient telescopic antenna. The sample rate of RTL-SDR is 3.2 MS/s (mega samples per second). The RTL-SDR at this point, however, is unreliable and may lose samples. The average sample rate without falling samples is 2.56 MS / s. The original resolution is 8 bits, but an average Effective Bit Number (ENOB) is ~7. The input impedance of dongles will be about 75 Ohms, although it is impossible to be perfectly 75 Ohms over the whole frequency range. For most general GUI-based software defined radio applications, a dual core processor will be needed. There are many software-defined radio packages which supports RTL-SDR. SDR# (pronounced as "SDR Sharp") is currently the most popular free software compliant with RTL-SDR. Compared to other SDR applications, it is relatively easy to use and has a simple set-up process. HDSDR is another software for RTL-SDR which is based on WinRAD-SDR program. There are also noise reduction and noise blanker capabilities and an advanced algorithm for frequency centering to dynamically focus the signal. Other software available compatible to RTL-SDR areSDR-RADIO.COM V2, GQRX, Studio1, SDRUno, WebRadio etc.

VII. RTL-SDR AS A RECEIVER

RTL-SDR is used in the receiver side of the wireless communication system. HDSDR, a software available for software-defined radio is used here for viewing the signal that is received by the RTL-SDR. Applications of HDSDR are Radio listening, Ham Radio, SWL, Radio Astronomy, NDB-hunting and Spectrum analysis. It has separate large spectrum and waterfall display for input and output signals. HDSDR supports the RTL-SDR through use of an ExtIO.dll module. To install HDSDR, download the program from the link on the main HDSDR page, then to use the RTL-SDR, download the ExtIO_RTL2832.dll file and place it into the HDSDR folder. The sound signal can be heard using this software.

VIII. RESULT

A signal with a frequency of 3khz is frequency modulated to 30MHz using MATLAB. This signal is obtained in the outputs of Redpitaya and is transmitted through an antenna. RTL-SDR which is connected to a laptop receives the signal that is transmitted through the antenna and is displayed using a software SDRsharp. RTL-SDR demodulates the wave and shown.

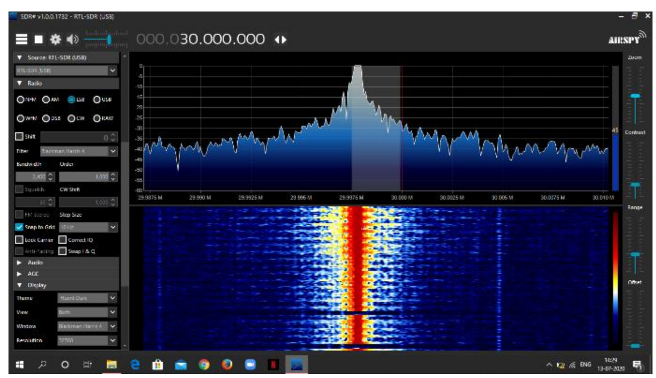

Figure 5: Signal received by RTL-SDR displayed in SDRsharp software

IX. CONCLUSION

For getting a clear understanding about the fundamental concepts of science and technology for students, demonstrations helps to a greater extent. This project demonstrates a basic wireless communication system using a software-defined radio, how the signals are modulated, transmitted, received etc. Software defined radios have many applications and it is becoming increasingly popular among the users. The use of software-defined radio as a transmitter and receiver will make the students understand how the components that are implemented in hardware are replaced by software on a PC. With this project, the students will get to know more about software-defined radios, antenna and wireless communication system. By using software-defined radio for communication, spectral graphs of a whole band can be seen while it is operating.

REFERENCES

[1] Sruthi M B, Abirami M, Akhil Manikkoth, Gandhiraj R, Soman K P -"Low cost digital transceiver design for Software Defined Radio using RTL-SDR", 2013 International Multi- Conference on Automation, Computing, Communication, Control and Compressed sensing (iMac4s), Date of Conference: 22-23 March 2013 - Year: 2013- Publisher: IEEE

[2] Carlos J. Garc´ıa-Orellana, Miguel Mac´ıas-Mac´ıas, Horacio Gonz´alez-Velasco, Antonio Garc´ıa-Manso and Ram´on Gallardo-Caballero Department of Electrical Engineering, Electronics and Automatics- "Remote laboratory experiments of Analog Electronics based on RedPitaya", 2016 Technologies applied to Electronics Teaching (TAEE), Date of Conference: 22-24 June 2016-Year-2016-Publisher-IEEE

[3] S. Abdullah, S. I. Syed Hassan, "Design small size of High Frequency (HF) helical antenna", 2009 5th International Colloquium on Signal Processing & Its Applications, Date of Conference: 6-8 March 2009, Publisher: IEEE-Year: 2009

[4] Peter S. Hall, Peter Gardner, and Antonio Faraone, "Antenna Requirements for Software Defined and Cognitive Radios", - Proceedings of the IEEE | Vol. 100, No. 7, July 2012, Page(s): 2262 – 2270, Publisher: IEEE-Year: 2012

[5] P.K. Vermal , S.K. Soni, Priyanka Jain3 and Amit Kumar, "An Experimental Study of Wireless Transceiver of Modulation Schemes using Software Defined Radio", 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES-2016), Date of Conference: 4-6 July 2016, Publisher: IEEE-Year:2016