Software Defined Radio Based Receivers Using RTL - SDR: A Review

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***Abstract*— Software defined Radio is one of the most important and latest technique for modern wireless communication. SDR is a radio which can be tuned to any frequency band which the hardware supports, implement different modulation and demodulation schemes and different signal types and standard(s) in the same device by using reconfigurable hard-ware and using powerful soft-ware. This paper provides a detailed analysis of SDR based radio receivers that can be implemented by using SDR systems. The main types of devices that can be implemented using SDR are only Radio Receiver, only Radio Transmitter and a Transceiver which provide function for both transmitter and receiver. Implementation of SDR devices using MATLAB, Simulink, GNU Radio and Single Board Computer is also discussed in this paper. The availability of low cost SDR hardware with good functional capability has reduced the overall cost of SDR system. This paper also provides a comparison between different types of radio systems developed using SDR and their performance analysis is also provided.**

Keywords: Software Defined Radio (SDR), RTL-SDR, Single Board Computer, Simulink, GNU Radio, Raspberry Pi, FM Receiver, and MATLAB

I. INTRODUCTION

Software Defined Radio (SDR) is one of the most significant and latest technologies for modern wireless communication related systems. SDR is a radio which can tune any frequency in range which the hardware supports, implement various modulation and demodulation schemes and various, standards in the same device / hardware by using reconfigurable hardware and software system. The SDR platform is basically a standard, means single platform supports multiple signals of different frequencies. Thus the number of platforms required for communication purpose is reduced [3]. In the hardware intensive radio type, capability fully depends on the hardware. In Software Controlled Radio (SCR), limited amount of functions are changeable by software whereas, in SDR, broader range of capability depends on elements which are particularly software configurable [8]. The term Software Radio mainly refers to radio that has the flexibility through software while using a static hardware platform. Definition of SDR by SDR Forum: "SDR provides software control of a variety of modulation techniques, wideband or narrow band operation, communication security functions (such as hopping) and waveform requirements of current and evolving standards over a broad frequency range". The two major advantages of Software Defined Radio are – Flexibility and Easy adaption.

II. SDR WORKING

In the SDR the signal processing work, channel selection, tuning, modulation – demodulation are done in digital domain. Thus, the goal of SDR is to have Analog-to-Digital Convertor (ADC) / Digital-to-Analog Convertor (DAC) as near as possible to antenna section so that all signal processing work can be done via software. The four major sections of SDR transceiver is shown in the fig. 3 are intelligent antenna / smart antenna, an analog/RF front end, digital front end and the digital signal processing unit section. A simple description of an SDR is that it is a radio system which is divided into two parts. One part is analog front-end, which deals with antenna transmission and reception, filtering, amplification and frequency shifting to/from an intermediate frequency. The analog front-end is designed to be as capable as possible, in terms of the bandwidth, noise figure and carrier frequency. The second part is a digital back-end, which is used for processing the baseband signal [5]. This signal processing is performed by FPGA, a digital signal processing unit and/or a general purpose computer. There is DAC in the transmitter and ADC converter in the receiver. [10]

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III. SDR BASED RADIO CONFIGURATIONS

The major three types of radio systems implemented using SDR are of the given types.

(a) SDR based Radio Receiver only, fig. 1
(b) SDR based Transmitter only, fig. 2
(c) SDR based Transceiver

In the SDR based Receiver only single function of receiving a particular frequency is possible, in Transmitter only transmission of signal possible using a SDR.

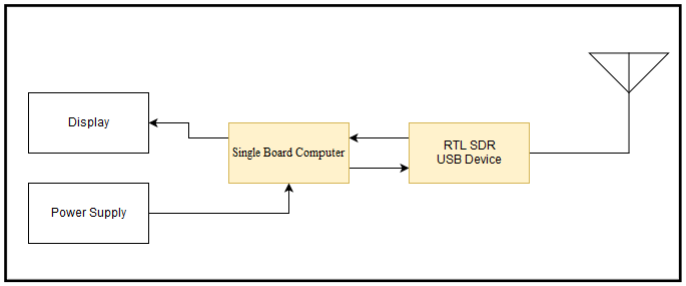

Figure 1 Computer based SDR Receiver

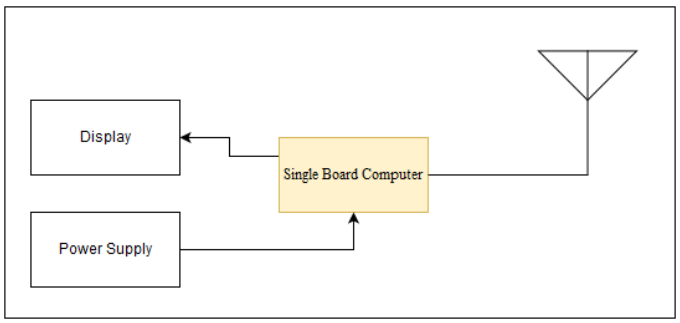

Figure 2 Single Board Computer based Transmitter

IV. RTL – SDR DONGLE

RTL – SDR is a compact, small, and easy – to – use USB device that is capable of receiving RF radio signals shown in fig. 3. RTL is derived from the chip name which used in these dongles RTL2832 chip [5]. These devices are originally designed for use as digital video broadcast – terrestrial (DVB-T) receivers. It was found that that these devices could be placed in test mode in which the DVB signal decoding is bypassed and produced raw 8-bit I/O data samples, internal blocks of dongle shown in fig. 4. It is possible to use these dongle for range of 25MHz to 1.75 GHz. The RTL2832 chip is Realtek based DVB Receiver [9].

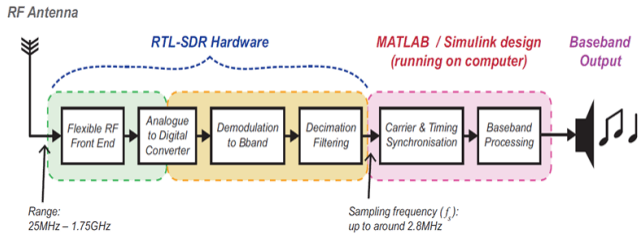

Figure 3 RTL - SDR Working

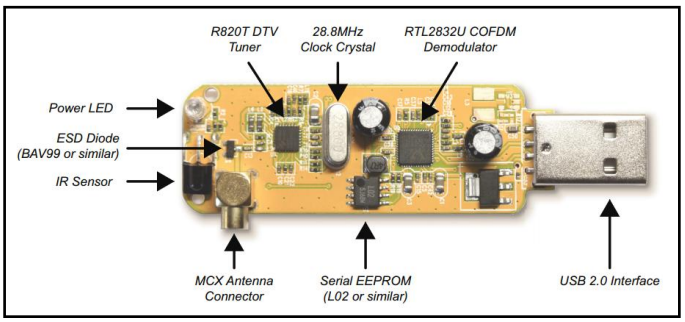

Figure 4 RTL - SDR Circuit Blocks

V. COMPUTER AND SDR

The Raspberry Pi Version II Model B, which is second generation Raspberry Pi model, is a small size single board computer equipped with quad core Broadcom BCM2836 ARM v7 processor running at a frequency of 900 MHz, despite of its low cost it has 1GB of RAM, a 40 pin general purpose input output (GPIO) connector, four USB ports, a HDMI port, a micro-SD card slot and an ethernet port (RJ-45). We can use a single board computer with a USB SDR dongle to perform function of SDR using a small set-up [7].

VI. LITERATURE SURVEY

Low Cost and Power Software Defined Radio using Raspberry Pi for Disaster Effected Regions

Vijendra Singh Tomar and Vimal Bhatia [1], In this paper a low cost and low power radio system is designed using Raspberry Pi, RTL – SDR. The RTL – SDR USB Dongle is connected to the Raspberry Pi board. The analog signal received using the antenna is sent to the analog-to-digital (ADC) converter component of the RTL – SDR; analog signal is digitised and sent to the down converter which is controlled by the software. Base-band signal is then sent to the Raspberry Pi computer for extraction of information from the signal. A transmitter design is also proposed by the authors using Raspberry Pi GPIO Pins. The Raspberry Pi hardware is meant to generate Spread Spectrum signals for clock purposes on GPIO pins this is used to generate FM signals. Raspberry Pi is programmed to output a waveform of central frequency. The PWM hardware of Raspberry Pi is used to change the frequency corresponding to incoming signal. The frequency of FM Transmitter is software configurable and can be changed as per requirement.

A Software Defined Radio Platform with Raspberry Pi and Simulink

Gianni Pasolini, Flavio Zabini, Alessandro Bazzi and Stefano Olivieri [9], In this paper Simulink based OFDM Transmitter is proposed. The Raspberry Pi 2 Board is used with the Simulink Software to design a Simulink Defined Radio System. The OFDM signal obtained is also analysed using a spectrum analyzer.

Software Defined Radio: Operation, Challenges and Possible Solutions

Devarpita Sinha, Anish Kumar Verma and Sanjay Kumar [3], In this paper Operation of SDR is discussed giving emphasis to the four main sections of SDR i.e. Intelligent / Smart Antenna, RF Front End, Digital front end, Digital signal processing unit. Various Challenges faced while implementing SDR systems is discussed in detail. Issues related to SDR implementation like Security Issues, malicious software, alteration and destruction of configuration data, overuse of processing, unauthorized use of SDR device discussed by the authors. High Speed of ADCs and DACs and their synchronisation with DSP is a difficult task and method to overcome by using RF Frontend is discussed.

A Low-Cost Desktop Software Defined Radio Design Environment Using MATLAB, Simulink, and the RTL-SDR

Robert W. Stewart et al [6], In this paper MATLAB, Simulink, and RTL – SDR based Software Defined Radio based system is discussed. The RTL – SDR based systems can be used for designing a SDR based receiver for working in the range of 25 MHz to 1.75 GHz. The working capability of RTL – SDR based system for AM and FM, ISM, GSM, LTE, and GPS applications are discussed by author. Laboratory Environment for RTL – SDR based radio is explained using MATLAB and Simulink software. Any computer with MATLAB installed can be used to design Software Defined Radio using RTL – SDR dongle. A hands on SDR communication workbook is also designed by the authors for understanding the RTL – SDR working using MATLAB and Simulink. Details about the RTL – SDR dongle circuit is provided and the programming of voltage controlled oscillator by RTL2832U over an I^2C interface is also discussed. The RTL-SDR device brings affordability of a device down to a level lower than the textbook; many of these successful courses can now also consider using RTL – SDR as standalone learning assignment. The RTL – SDR based learning is easy as compared to learning communication system using PCB circuit system.

Low Cost SDR Spectrum Analyzer and Analog Radio Receiver Using GNU Radio, Raspberry Pi II and RTL – SDR Dongle

E. G. Sierra and G.A. Ramirez Arroyave [2], In this paper a low cost spectrum analyzer is proposed using GNU Radio, Raspberry Pi, and RTL – SDR dongle. The GNU Radio software is configured on Raspberry Pi to perform the functioning of spectrum analyzer using RTL – SDR dongle. The GNU radio is also used to implement FM receiver using Raspberry Pi and RTL – SDR dongle.

Comparison of SDR Devices

Reference	Year	Technique used for SDR system design	Features
[1]	2015	SDR based emergency radio using single board computer.	Compact design, single board computer Raspberry Pi used.
[9]	2016	SDR based radio design using Simulink.	Can be designed using Simulink, added options and Raspberry Pi based design.
[6]	2015	SDR radio using MATLAB, Simulink	Added options for MATLAB based design.
[2]	2015	GNU Radio based design.	RTL – SDR based GNU Radio design, implemented using Raspberry Pi II, spectrum analyzing function available.

VII. SDR BENEFITS

The main benefit of using software based radio includes upgradability, customization, flexibility, and adaptability. The factors responsible for wide usage of software radios in commercial market are given below.

1.) Interoperability

An SDR can communicate with more than one radios and it supports various wireless standards. We can use RTL – SDR dongles with a large number of devices which includes Single Board Computer, Laptops, and Desktop computers [4].

2.) Easy manufacturing

The SDR devices can be manufactured in a industry and using Computer Aided Manufacturing. There is also an option to make upgrades in the system using software updates for SDR based systems.

3.) Power efficient

The SDR device or systems mostly function at low voltages so it is power efficient and various power management related functions can be implemented in SDR system using programming.

4.) Ease of upgrades

Various technology advancements requires the up gradation of existing devices for proper functioning. The SDR provides functionality to upgrade the software easily without making any hardware changes.

VIII. SDR CHALLENGES

1.) Security issues in SDR

The wireless communication has some security related issues, particularly in SDR security threat is a major as it is having capability of reconfiguring. With remote access to the SDR system the setting can be changed. Attackers can install software which can change the working of SDR system so proper firewall and network management is required for SDR system [3].

2.) High complexity and increased cost

In SDR multiple signals are handled by using a single platform. The complexity of the hardware gets increased in SDR due to requirement of multiple functions a SDR device can perform.

IX. CONCLUSION

The main goal of SDR is implementing a single radio device which having a software controlled digital hardware. The SDR can be used to emulate any radio signal of evolving or the present wireless standard. The growth and advancement in SDR depends on development of components used such as signal converters, ADCs / DACs. Development of amplifiers, memory registors, also plays important role in overall development of SDR performance. Availability of digital signal processor at low cost has made it possible to design SDR at reduced cost. SDR device like Universal Software Radio Peripheral (USRP) can be used for transmission and reception of radio signals but it is costly. The RTL-SDR dongle is available at low cost and it provides great options to explore SDR. Software like MATLAB, Simulink, GNU Radio are very helpful in designing SDR based systems. Single board computer based SDR devices are compact and provide good functionality.

X. REFERENCES

[1] Vijendra Singh Tomar and Vimal Bhatia, " Low Cost and Power Software Defined Radio using Raspberry Pi for Disaster Effected Regions" , 2015 – Second International Symposium on Computer and the Internet, Springer, pp 401 – 404.

[2] E. G. Sierra and G.A. Ramirez Arroyave, "Low cost SDR spectrum analyzer and analog radio receiver using GNU radio, raspberry Pi2 and SDR-RTL dongle", 2015 - Communications (LATINCOM), 2015 7th IEEE Latin-American Conference, pp 1 – 6.

[3] Devarpita Sinha, Anish Kumar Verma and Sanjay Kumar, "Software Defined Radio: Operation, Challenges and Possible Solutions", 2016 - Intelligent Systems and Control (ISCO), 2016 10th International Conference, pp 1 – 5.

[4] Lawrence Goeller, David Tate, "A Technical Review of Software Defined Radios: Vision, Reality, and Current Status", IEEE Military Communications Conference, 2014, pp 1466 – 1470

[5] Raymond J. Lackey and Donald W. Upmal, "Speakeasy: The Military Software Radio" , IEEE Communications Magazine (Volume: 33, Issue: 5, May 1995), pp 56 – 61.

[6] Robert W. Stewart, Louise Crockett, "A Low Cost Desktop Software Defined Radio Design Environment Using MATLAB, Simulink and the RTL-SDR.", IEEE Communication Magazine, 2015, pp 64 – 71.

[7] Boonyarit Uengtrakul, "A cost efficient software defined radio receiver for demonstrating concepts in communication and signal processing using Python and RTL-SDR", Digital Information and Communication technology and it's Applications (DICTAP), 2014 Fourth International Conference, pp 394 – 399.

[8] Sruthi M B, Abirami M, Akhil Manikkoth and Gandhiraj R ; Soman K P, "Low cost digital transceiver design for Software Defined Radio using RTL-SDR", Automation, Computing, Communication, Control and Compressed Sensing (iMac4s), 2013 International Multi-Conference, pp 852 – 855.

[9] Gianni Pasolini ; Falvio Zabini ; Alessandro Bazzi ; Stefano Olivieri, "A Software Defined Radio Platform with Raspberry Pi and Simulink ", 2016 24th European Signal Processing Conference (EUSIPCO), pp 396 – 402.

[10] A. Fanan , "Comparison of Spectrum Occupancy Measurements using Software Defined Radio RTL-SDR with a Conventional Spectrum Analyzer approach", 23rd Telecommunications forum TELFOR 2015, IEEE, pp 200 – 203.