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Low Cost Android Radio Spectrum Analyzer Using RTL-SDR Dongle

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Abstract: Spectrum analyzer is a very important tool in signal processing. Most of the spectrum analyzers available in the market are expensive. Android application is an ever present paradigm in modern era. This paper presents a low cost android radio spectrum analyzer using RTL-SDR dongle. Signal amplitude, gain, frequency, power, and bandwidth can be measured using this mobile application. Application is implemented using android studio which uses high level java language in the software section.

Keywords: spectrum analyzer, RTL-SDR, android, java.

I. INTRODUCTION

Communication becomes nonexistent without the existence of signals and without communication modern life will come to a full stop. Signals convey information about the different characteristics of a phenomenon. So analysis and processing of signals is an important aspect in communication system. When we design or manufacture a communication system, we need a tool that helps us in analyzing the signal that passes through the system. The analysis of the signal helps us in understanding the various drawbacks of the system and by eliminating those draw backs, we can improve system performance and increase its efficiency. Noise is an unwanted signal. So by analyzing a noise signal and understanding its behavior, it becomes easier to eliminate it.

When we want to analyze a signal in time domain, we make use of an oscilloscope. All the frequency components are summed together and displayed in time domain in an oscilloscope. Some systems make use of technologies like Frequency Division Multiplexing (FDM) and Frequency Division Multiple Access (FDMA) and these technologies are frequency oriented. So in order to know the behavior of these systems signals are analyzed in frequency domain. Moreover the frequency domain measurements have several distinct advantages.

A device which displays signals in frequency domain is called a spectrum analyzer. In a spectrum analyzer, all the complex signals with more than one frequency in it are separated into its frequency components and amplitude level of each frequency is displayed. By using a spectrum analyzer we get information about a lot of parameters like gain, SNR, bandwidth, amplitude, frequency, power, distortion etc.

The two basic types of frequency domain measurements are Fourier transform and swept tuned spectrum analyzers. In Fourier analyzer time domain signal is digitized using digital sampling and it is converted into frequency domain using mathematical equation. As Digital Signal Processing (DSP) techniques and Analog to Digital Converters (ADC) are advancing, Fourier analyzers are becoming more prevalent. Here we are using a Fast Fourier Transform (FFT) algorithm for implementation of spectrum analyzer. Swept tuned receiver is most widely accepted spectrum analyzer. They work on the same principle of a heterodyne receiver. They are now replaced by their alternatives.

The spectrum analyzer usually consists of a Radio Frequency (RF) input attenuator, mixer, Intermediate Frequency (IF) gain, IF filter, video filter, sweep generator, local oscillator, and Liquid Crystal Display (LCD). These hardware components of a spectrum analyzer can now be implemented using software tools. Software Defined Radios (SDR) is one such popular and cheapest software tools used in spectral analysis. RTL-SDR dongles are used for capturing signals here.

Android applications are ever-present scenarios in this era. Android applications are applications that run on android devices such as mobile phones, tablets etc. The user interface of android is mainly based upon direct manipulation. So making use of all these technologies, we are introducing a portable low cost android radio spectrum analyzer in this paper.

II. RELATED WORKS

Conventional spectrum analyzers were implemented using analog circuits. As communication technology flourished need of analyzers with precise and accurate measurement became necessary. So spectrum analyzers which make use of digital technologies came in to being. Spectrum analyzers using android phones as well as spectrum analyzers using RTL-SDRs are already presented in the market. The RTL-SDR spectrum analyzers used are mostly implemented using MATLAB, GNU octave etc. These are run on a personal computer, Personal Digital Assistant (PDA) or laptops. But in this paper, we introduce

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a method to implement it using mobile phones. As one out of two people carry mobile phones, it seems a viable option. Analyzers using android system are also available. But in those systems, either real time signals are not given as input or the signals are captured and given through expensive circuitry. This paper introduces a method which amalgamates the advantages of both systems to make a cheap real time radio frequency spectrum analyzer. The basic concepts of this method are explained in the section below.

III.PROPOSED METHODOLOGY

The block diagram and software implementation of proposed methodology is explained below. The android application is developed using android studio. World-class code editing, debugging, performance tooling, a flexible build system, and an instant build/deploy system etc are some of the notable features of this software. The programs in android studio are written in java.

A. Block Diagram Description

The block diagram consists of an android phone, RTL dongle, and On–The–Go (OTG) cables. It is clearly depicted in Fig. 1. RTL dongle is comprised of R820T2 tuner and RTL2832U chipset. It is a DVB-T COFDM demodulator that gives USB2.0 interface support and has high performance.

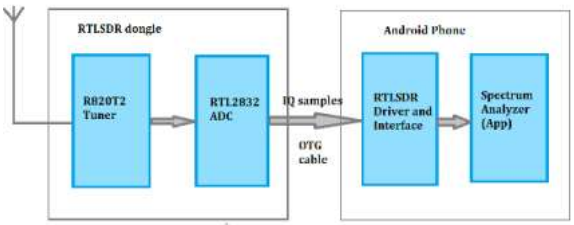

Fig. 1 Block Diagram

The main advantage of R820T2 tuners is that it supports intermediate and low frequencies. The antenna captures the signal and the received signal is tuned using R820T2 tuner to the range of the spectrum analyzer. The signal is filtered and then conditioned.

The signals are converted into samples inside the chipset. These samples are digitized using RTL2832U ADC. Its output is actually 8 bit I/Q samples. The I/Q samples are passed to the android phone using OTG cables. These samples communicate with the android application in the phone through RTL driver and interface.

Variable gain to the input signal is provided by the RTL driver. It also limits the bandwidth. The details of interface are given in the software section. The android application converts and displays the real time signal in frequency domain after converting it from time domain using FFT algorithm.

B. Software Section

The internal modules or structures of the app are as shown in Fig. 2. The blocks represented in grey are the modules which are to be connected externally. This RF analyzer requires external driver for using RTL-SDR dongles in android. The signals captured using the SDR antenna is converted directly to I/Q samples by the dongle. These samples are send to the android device with the help of this driver software. The I/Q source interface enables the scheduler file I/Q source to be independent of SDR hardware. This contains classes which collect the required data from the SDR hardware for implementing the analyzer.

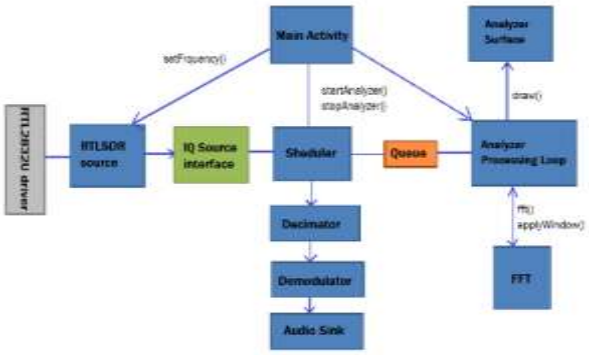

Fig. 2 Class Diagram of RF Analyzer

The scheduler will read the samples provide by the source continuously. This is done so as to prevent the device's receive buffers from filling up. The scheduler is nothing but the thread which forwards the sample from the input hardware to the processing loop and to the demodulator section. These samples are passed to the processing loop and to the demodulator at correct speed and format to avoid the possibility of any error that might occur. The sample packets are send to the processing loop using blocking queues.

The samples are first shifted to baseband and then given to the demodulator. To convert the signal to its baseband it is multiplied by a complex cosine before any sample rate decimation is possible. Here look up tables are used for converting the signed interleaved I/Q bytes for the SDR to floating point values as shown in the Fig. 3. If either demodulator or the analyzer processing loop are slow. Then the scheduler will prevent the buffer from being filled up by dropping the incoming samples.

The analyzer processing loop runs in a separate thread. It reads the sample packets which are present in the queue and these samples are then processed using FFT. The FFT is implemented using Blackman window functions. After the FFT algorithm is performed, the 'draw ()' in the analyzer surface is called. The 'draw ()' method or function plots the samples obtained after FFT implementation on a surface view.

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Multithreading can be used, as today's Smartphone have multi core CPUs. Hence each block in the receiving chain can use its own thread. Synchronization is the main problem for multithreading. Hence Array-Blocking-Queues are used to connect all these threads together.
The buffers can be reused so that memory allocation at run time can be avoided and thus reduce the amount of garbage. The buffer reuse can be done by passing them to the previous blocks after it is done processing with them.

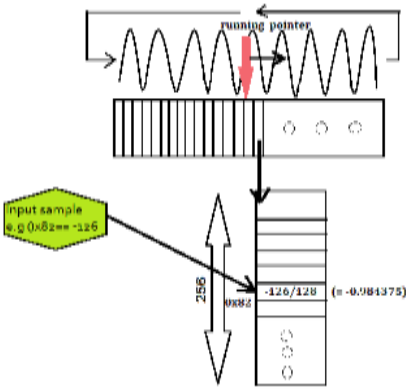

Fig 3 .Look up table for sample multiplied by cosine

can be set either to a fixed value or to automatic control. Demodulation of the wide band FM and AM with adjustable filters are possible.

IV. RESULTS AND DISCUSSION

After java programming is done in android studio, it can be run in an emulator or a physical android device such as mobile phone. The hardware and the software part are attached to work the spectrum analyzer efficiently in AM and FM range. The RTL-SDR is used as a signal source and the signal is processed using the android application developed using android studio. The characteristics of the signal like frequency and gain are calculated and displayed by the application.
The RTL-SDR frequency range varies with various dongles. 3.2 MS/s (Mega Samples/second) is the maximum sample rate for the RTL-SDR. However the RTL-SDR seems to be unstable at this rate and may drop samples. The maximum sample rate that does not drop samples is 2.4 MS/s. The RTL-SDR's resolution is 8 bits, but the effective number of bits is estimated at approximately 7. The spectrum analyzer output on various ranges of FM and AM mode and their characteristics like tuned frequency, gain and demodulation scheme are shown in Fig. 4.
The spectrum can be browsed horizontally and can be zoom in and out both horizontally and vertically. It is automatically retuned while scrolling and zooming. We can jump directly to a desirable frequency while working on other frequency at any time. The gain settings of the RTL-SDR dongle can be easily adjusted. The frame rate can be set either to a fixed value or to automatic control. Demodulation of the wide band FM and AM with adjustable filters.

Fig.4 Outputs of AM and FM mode

V. CONCLUSION

In this paper, a spectrum analyzer that captures the signal using RTL-SDR and processes it using an android application is presented.
This concept of spectrum analysis provides many advantages compared to other approaches which uses MATLAB, GNU radio, raspberry pi and USRP. The RTL-SDR provides more flexibility in terms of communication system. . As long as the tuner input frequency, ADC sampling rate and computing power are sufficient; it can be implemented in pure software, without any hardware changes. The android application used here is user friendly, robust and flexible build system. It is a real time system. This project is economically efficient and provides a flexible spectrum analyzer. Some SDR hardware drivers are not directly included to the app, but available as external apps and can be installed on the device. This technology can be further improved by adding programs to

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measure the signal characteristics like lower side band, upper side band and narrow band FM in the future work. As android phone is common nowadays, it makes the user to facilitate the application whenever needed. The implementation of the project is as shown in Fig. 5.

Fig.5 Implementation of Spectrum Analyzer

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REFERENCES

[1] Shete, Prasanna, et al. "Android Based Spectrum Analyzer." InternationalJournalofScientific& TechnologyResearch 2.10 (2013): 303r305.

[2] Thomas, Sibu, and Nishi Shahnaj Haider. "A Study on basics of a spectrum analyzer." International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 2.6 (2013): 2308.

[3] Hengjun, Zhu, and Wang Wenxing. "A design and Implementation of Portable Spectrum Analyzer." International Journal of Multimedia and Ubiquitous Engineering 10.12 (2015): 235-244.

[4] Costa, A., et al. "Spectrum analyzer with USRP, GNU Radio and MATLAB." 7th Conference on Telecommunication, Portugal. Disponible en http://www. av. it. pt/conftele2009/papers/114. pdf. 2009.

[5] Sierra, E. G., and GA Ramírez Arroyave. "Low cost SDR spectrum analyzer and analog radio receiver using GNU radio, raspberry Pi2 and SDR-RTL dongle." Communications (LATINCOM), 2015 7th IEEE Latin-American Conference on. IEEE, 2015.

[6] Stewart, Robert W., et al. Software Defined Radio using MATLAB & Simulink and the RTL-SDR. Strathclyde Academic Media, 2015.

[7] Pantham, Satyaraj. Pure JFC: 2D Graphics and Imaging: A Code-Intensive Premium Reference. Sams, 1999.