iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** V **Month of publication:** May 2017

DOI:

Volume 5 Issue V, May 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Communication system in aircraft using Software Defined Radio (SDR)

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Abstract: Software Defined Radio (SDR) is a hot topic of wireless communication research in recent trends. The idea of SDR is to use ultra-high speed sampling and ADC/DAC modules directly measure the received radio signal and decode whatever it contains. Software Defined Radio (SDR) or Soft NET Radio is one of the most important technologies for the modern wireless communication system.SDR-2010, SoftNET Radio, is a dual channel radio with simulataneous operation in V/UHF & L-Band. SDR makes it possible to implement the radio communication process simply with software. The fundamental intent is to shift from employing a traditional hardware-focused, application- specific approach to radio implementation to using a software application to perform the radio tasks on a computing platform. SDR omits all the hardware and replaces them by pure software. This solution gives a great advantage in flexibility because a SDR receiver is able to decode al the signals. SDR is a radio which can tune to any frequency band, implement different modulation and demodulation techniques and different standards in the same devices by using reconfigurable hardware and powerful software. The radio is capable of voice and data communication in fixed frequencies and frequency hopping modes. SDR provides flexible ,upgradeable ,multi-standard and longer lifetime radio equipment for both the military and civilian communication infrastructure.
Keywords: SDR, DSP Processor Unit, IF, RF, FPGA, ADC, DAC, Cognitive Radio(CR)

I. INTRODUCTION

In the past, Radio systems were used to communicate using one or two signals operating at different frequencies. Thus, different groups of people using different types of radio systems could not communicate with each other due to incompatibility between their radios. This was a major problem during war. The problem of communication among people using different types of radio equipment can be solved by using Software Programmable Radios.

SDR is an emerging technology that has been an active research topic for over a decade .The term 'Software Radio' was coined by J.Mitola [1] in 1991 .During theearly1990's, the first large scale SDR, SPEAK Easy [3] & Joint Tactical Radio System (JTRS) were exploited by US Military. It was only after the year 2000, along with the development of powerful signal processing chips, most of the existing SDR platforms were developed.Fig.1 shows the SDR transceiver. One of the most commonly used SDR hardware platforms is the Universal Software Radio Peripheral (USRP).

Before SDR, radio developers used to build tailored radio system: one radio platform supports one particular frequency. The SDR platform is generic, means one platform supports multiple signals of different frequencies. Thus the number of platforms required for communication is reduced. So we can say in Hardware Intensive Radio, capability fully depends on hardware. In Software Controlled Radio (SCR), limited functions are changeable by software whereas, in SDR, broader range of capability depends on elements which are software configurable. Thus, the term Software Radio generally refers to a radio that derives its 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, communications security functions (such as hopping) and waveform requirements of current and evolving standards over a broad frequency range." Hence, two major advantages of SDR are-Flexibility and Easy adoption.SDR-2010 is a Software Defined Radio where in the various modulation schemes and TRANSEC and COMSEC features can be programmed through predefined Waveforms. Each Waveform can be independently ported as and when the user desires. Currently SDR-2010 is offered in extended ¾ ATR size comprising of mainly three insert able Modules namely Digital Module, L-Band RF Module and V/UHF RF Module.

Software defined radio technology is advancing at a very fast rate .It provides a foundational snapshot at a point in time, and is designed to serve as an engineering baseline upon which to build – it is anticipated that later volumes in this series will address specialized aspects of technology and applications as they develop.

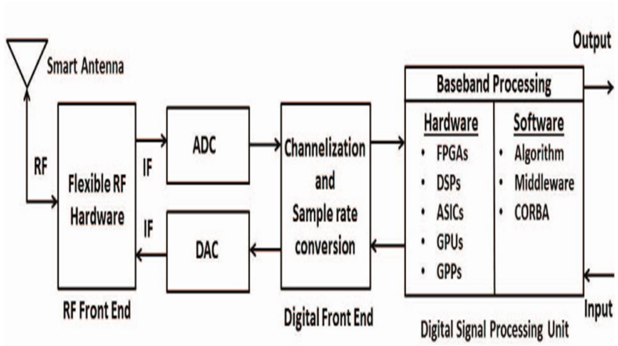

Fig. 1. SDR transceiver

II. METHODOLOGY

In SDR, most of the signal processing, tuning, channel selection, modulation and demodulation are performed in digital domain through software. Thus, the ultimate goal of SDR is to move the Analog-to-Digital Converter (ADC) / Digital-to- Analog Converter (DAC) as close as possible to the antenna so that all signal processing can be done digitally via software. SDR transceiver is divided into four main parts: intelligent antenna/smart antenna, an analog/RF front-end, digital front end and the digital signal processing unit [4]-[7]. In this paper, we present a new SDR platform with the following characteristics:

Small size: The dimensions for a 1U Cube Sat (10×10×10 cm) and meets all other Cube Sat standard requirements [3].

Re-configurability: The system can support any number of encoding, modulation, and other signal processing schemes.

Plug and play: For plug and play capabilities it uses Plug-and- Play Avionics (SPA) protocol.

Open source: Such that others can adapt it to for their projects it uses open source hardware and software

A. Intelligent Antenna / Smart Antenna

The very basics of frequency band selection and adaptation with advance strategies like interference cancellation & mobile tracking are used to illustrates the word “intelligent”. Self-adapt, self-align and self-healing antenna are some characteristics for SDR [4] which has a feature of complete adaptation to its required application and the transmission environment. Self-adaptability is a capability that the antenna system would adjust its basic parameters such as gain according to the selected frequency band and required system gain of the application. As soon as the system was set up, self-alignment enables the antenna to direct itself based on the maximum signal reception with an aid provided by a telemetry data or a Global Positioning System (GPS). Self-healing is a feature that helps the system to combat any friendly or hostile interference by proper use of techniques such as array processing, beam-steering and even variable polarization.

B. RF Front End

It uses analog RF circuitry and at different operating frequencies it receives and transmits the signal, coupling the radio to the antenna or its feeder. It also changes the signal to or from the Intermediate Frequency (IF). The digital samples are converted into analog signal by the DAC which is the input to the RF front end in the transmission path; the analog signal is later mixed with high frequency carriers by a mixer and modulated to a pre- determined RF frequency and transmitted over the air.

In the receiving path, the RF signal is captured by the antenna. The front end is connected to the antenna input using matching circuitry to ensure the optimum signal power transfer. The low noise amplifier (LNA) is usually located close to the antenna and is used to amplify weak signals without significantly increasing the noise level. The amplified signal is applied to a mixer along with a signal from a Local Oscillator (LO) to down convert it to the Intermediate Frequency (IF).

C. Digital Front end

It has two major functions. Sample rate conversion with channelization which internally includes up/down conversion in the transmitter and receiver side respectively and filtering. System. A digital baseband signal the input to the transmitter side of an SDR system, typically generated by a DSP stage. The digital hardware block named Digital Up-Converter (DUC) in the transmitting side, translates the baseband signal to the IF frequency. The DAC that follows DUC, converts the digital IF samples into the analog IF signal. Next, the RF up- converter converts the analog IF signal to RF frequencies. In the receiving side, the ADC digitizes the IF signal thereby converting it into digital samples. These samples are fed to the next stage which is the Digital Down Converter (DDC). DDC includes digital mixer, numerically controlled oscillator and after DDC, resampling and filtering are performed. Using of DDC can extract the baseband digital signal from ADC, and after passing through digital front end, this digital baseband signal will be send to the high-speed digital signal processor for processing.

D. Digital signal processing unit

The DSP module consists of digital signal processor (DSP) and a wide variety of programmable digital chips. These chips contain Application Specific Integrated Circuit (ASIC), Field-Programmable Gate Array (FPGA), Graphics Processing Units (GPUs), General Purpose Processors (GPP) or a combination thereof DSP is the heart of SDR which performs the baseband signal, processing, modulation and demodulation, timing synchronization, encoding and decoding. Containing a high- speed processing block a DSP processes the signal by retrieving instructions and data from memory, performs requested operations, and stores the results back to memory. Embedded digital signal processing algorithms in the processing engine are responsible to make all the promises of SDR come true. DSPs use microprocessor-based architectures and support programming in high level languages like C, which offer flexibility.

III. BENIFITS

A. The main objective of concentrating towards SDR is its flexibility. [8].

1) Ease of upgrades
2) Interoperability
3) Multi functionality
4) Opportunistic frequency reuse
5) Compactness & power efficiency
6) Ease of upgrades

IV. CONCLUSION

The aim of SDR is implementing a single device which contains software controlled digital hardware that can emulate any radio signal of evolving wireless standard by updating software without replacing the hardware platform. The mode of communication mentioned in this article have 99 channels for both voice and data communication. Although SDR flat form faces several problems, many positive approaches are being introduced to overcome them.

V. FUTURE WORK

The wireless technology is being more evolved, to overcome drawbacks of SDR, cognitive radio is proposed. Cognitive Radio (CR) is a radio which can be programmed and configured to use the best wireless channels in its vicinity. Cognitive radio detects which are used and which are not used channels.

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