RECONFIGURABLE SOFTWARE DEFINE RADIO : A REVIEW

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Abstract*— Communication is a way of exchanging information between two different places. Due to the invention of radio, communication has expanded and the world has come closer. Currently, radio communication has become an essential part of everyday life and for public safety, national safety and emergency communication system it is very important. Emergency situations like natural disasters, plane crashes and terrorist attacks or any inter-operability problems are faced by military and civil safety agencies, since they essentially need the radios working in different frequency bands, waveforms and protocols. At the same time these radio need to be flexible, low cost, small size, portable, and require low power to operate. Software Defined Radio (SDR) technology is used to solve these problems by implementing radio that can operate in different frequency bands and protocols controlling by software. This paper reviews the SDR concept, architecture of SDR, modulation and demodulation methods.

***Keywords*—SDR,Architecture,Modulation and Demodulation**

I. BASIC INTRODUCTION OF SDR

The term Software Defined Radio (SDR), as the name suggests, is a radio communication technology in which the radio transceiver is implemented using software, or some similar reconfigurable medium, thus reducing the amount of hardware required. Since an SDR can be programmed to adjust its own parameters, it can used to changing conditions and standards. Thus, it is a radio in which some or all of the physical layer functions are defined in software. In upgrading a software-defined radio design, the most essential part is software and the rest is improvements in hardware. In short, software-defined radios represent shift from fixed, hardware-intensive radios to multiband, multimode, software-intensive radios. Software Define Radio is an new technology being developed in the 20^{th} century. SDR replace hardware by pure software, this gives great advantage in flexibility because a SDR receiver is able to decode all the signals.

The US Air Force‘s Integrated Communications Navigation and Identification Avionics (ICNIA) system offers an example of an early SDR developed in the late 1970‘s. The system used a reprogrammable digital signal processor (DSP) to operate multi-function multi-band airborne radios in the 30 MHz to 1,600 MHz spectrum. The term “software radio” was coined in 1984by a team at the garland, texas Division of baseband receiver. In 1984 software radio was a digital baseband receiver that provided programmable interference cancellation and demodulation for broadband signals.

In 1991, Joe Mitola independently reinvented the term software radio for a plan to build a GSM base station. Mitola was introduced as “godfather” of software radio in 1997 at first international conference on Software radios[1].

In the 1990s, a US government program specified the first fully programmable SDR system, Speakeasy; the so-called —PC of the communications world. SPEAKeasy, the military software radio was formulated by Wayne Bonser. Speakeasy used open hardware and software architectures to support a family of voice, multimedia, and networking waveforms in the 2 MHz to 2 GHz frequency range. Another government program, the Joint Tactical Radio System (JTRS), uses Speakeasy technology in a family of interoperable, multi-band, networked SDRs. The JTRS program aims to replace existing US-military radios with equipment that vendors can upgrade by downloading new software. This program relies on the Software Communications Architecture (SCA) open standard.

II. ARCHITECTURAL DIFFERENCE (HDR VS SDR)

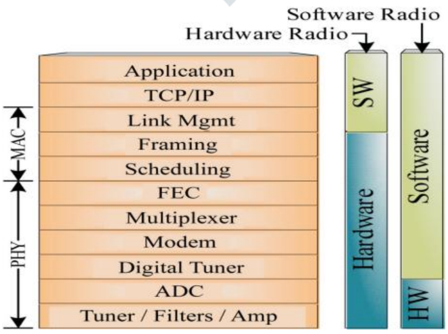

Fig. 1 General Block diagram of architectural difference between HDR and SDR

Traditional hardware radios are implemented with analog and solid poly-Si elements. In SDR, the traditional hardware is replaced by software modules as shown in Fig. 1.

In Hardware Defined Radios (HDRs), the full range of capability was provided by hardware elements. As growing the software engineering, manufacturers moved to developing Software Controlled Radios (SCRs), with limited functions being changeable by software. Today we are fielding true Software Defined Radios (SDRs) – radios that implement a specified range of capabilities through elements that are software configurable.

In a HDR, legacy platforms are made to support only one type of waveform. That is, the physical layer of the waveform was embedded in specific hardware solutions and the Radio Frequency (RF) front end was also optimized for the same waveform. Within a SDR, the radio contains several processing elements (GPPs, DSPs, and FPGAs) that can be programmed by the waveform to deliver the required functionality. As a result, SDRs has prompted the development of open standards, to make it easier to develop waveforms that can run on multiple platforms with minimal change[2].

III. TYPICAL SDR ARCHITECTURE

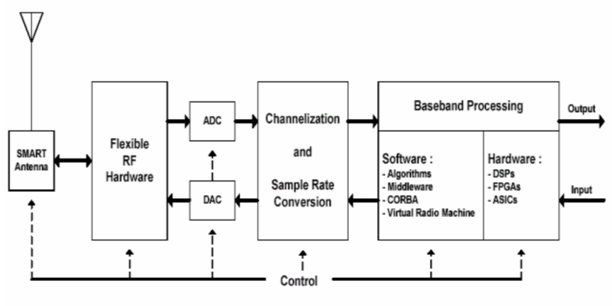

Fig.2 Block diagram of SDR

The SDR is advanced radio communication system consists of three main functional blocks:

-RF section,
-IF section, and
-Baseband section.

The receiver begins with a SMART antenna that inhibits certain characteristics to minimize interference, multi-path, and noise. The SMART antenna provides similar benefits to the transmitter. Most software radios digitize the signal as early as possible using ADCs in the receiver chain, while keeping the signal in the digital domain and converting o the analog domain as late as possible for the transmitter using DAC. Often, the received signals are digitized in the Intermediate Frequency (IF) band. The IF signals are then mixed exactly to baseband. Digitizing the signal with an ADC in the IF range eliminates the last stage in the conventional model in which problems like carrier offset and images/replicas are encountered. Digital filtering (Channelization) and sample rate conversion are needed to interface the output of the ADC to the baseband processor used to. Likewise, digital filtering and sample rate conversion are often necessary to interface the digital hardware that creates the modulated signals to the DACs. Baseband Processing is performed in software using Digital Signal Processors (DSP), Field Programmable Gate Arrays (FPGA), or Application Specified Integrated Circuits (ASIC). The algorithm used to modulate and demodulate the signal may use variety of software methodologies, such as middleware, common object request broker architecture (CORBA), or virtual radio machines.

A. SDR Transmitter

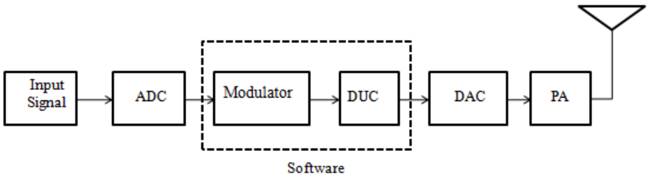

Fig.3 Block diagram of SDR Transmitter

B. SDR Receiver

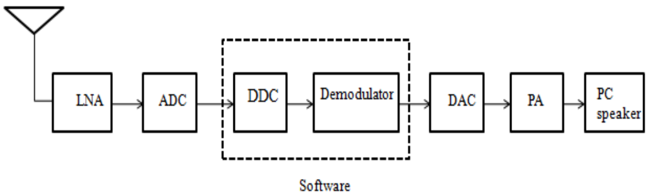

Fig.4 Block diagram of SDR Receiver

IV. MODULATIO AND DEMODULATION

In radio communication system the signal with high frequency has been transmitted. The height of antenna has a strong relationship with signal frequency. The lower the frequency is the higher the antenna is since for the low frequency signal transmission, signal modulates to a high frequency signal.

Modulation can be realized by varying one or more features of a carrier signal. The signal used to carry message is called carrier signal; typically it is a high frequency sinusoid or cosine waveform. The carrier signal can be transmitted via the air over a long distance. The process of making the radio frequency carrier signal carry the information signal with low frequency is modulation. When the receiver receives a modulated signal, it has to process the modulated carrier signal and get the original information; this process is demodulation. Its function is opposite to that of modulation[1].

A. Analog Modulation and Demodulation

The modulation is the process of varying one or more features of a carrier signal. If the modulating signal is analog and the variations for the parameters of carrier signal based on the modulating signal is continuous, the modulation is treated as analog modulation. The parameters can be changed in carrier signal are amplitude and angle, while the angle contains frequency ω and phase θ. When the amplitude of carrier signal varies as the modulating signal, it is amplitude modulation (AM); if the other two parameters are changed, it is called frequency modulation (FM) and phase modulation (PM) respectively.

B. *Digital Modulation and Demodulation*

The modulation process is digital modulation when the modulating signal is digital. Compared with analog modulation, digital modulation has a lot of advantages, for example greater noise immunity, greater security, etc.. Similar with analog modulation, there are three features can be modulated on carrier by digital information. Thus three major kinds of digital modulation technologies are used in radio communication system. They are Amplitude-Shift Keying (ASK), Frequency-Shift Keying (FSK) and Phase-Shift Keying (PSK).

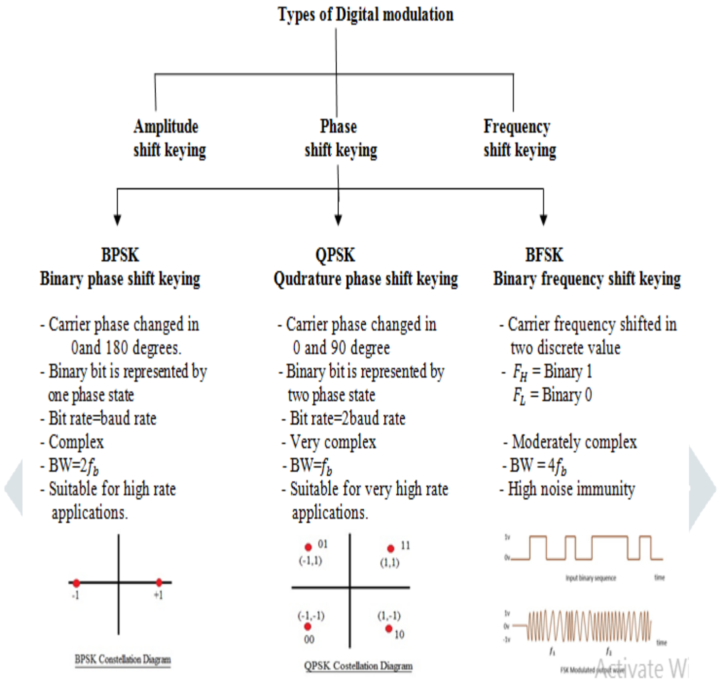

Fig. 5 Types of Modulation Techniques

Today's SDR technology is required to handle multiple waveforms, modulation techniques, pulse shaping techniques and transmit power. The important factors deciding the choice of modulation scheme are

a) Spectrally efficient modulation which gives least amount of interference for adjacent channel & neighboring channels.

b) Robust performance in fading multipath fading channels, Doppler frequency

c) How does the Bit Error Rate varies with the energy per bit available in the system when white noise present.

d) The cost efficient modulation scheme.

e) Easy to implement circuitry, small size and weight.

The modern wireless communication devices required higher bit rates. Hence to increase the speed of information transmission, bit rate can be increased by sending more number of bits per symbol, with the help of advanced modulation techniques. The bit rate can be increased by providing larger bandwidths, which gives higher symbol rates resulting in higher bit rates [3].

The different applications for variety of digital modulation techniques are described in Table 1

TABLE I: THE APPLICATIONS FOR DIFFERENT MODULATION [3]

Modulation format	Application
MSK, GMSK	GSM, CDPD
BPSK	Deep space telemetry, cable modems
QPSK, π/4 DQPSK	Satellite, CDMA, NADC, TETRA, PHS, PDC, LMDS, DVB-S, cable (return path), cable modems, TFTS
OQPSK	CDMA, satellite
FSK	GFSK DECT, paging, RAM mobile data, AMPS, CT2, ERMES, land mobile, public safety
8, 16 VSB	North American digital TV (ATV), broadcast, cable
8PSK	Satellite, aircraft, telemetry pilots for monitoring broadband video systems
16 QAM	Microwave digital radio, modems, DVB-C, DVB-T
32 QAM	Terrestrial microwave, DVB-T
64 QAM	DVB-C, modems, broadband set top boxes, MMDS
256 QAM	Modems, DVB-C (Europe), Digital Video (US)

V. TECHNOLOGICAL SOLUTION AND CHALLENGES

The combination of programmable digital baseband engines and reconfigurable analog front-end circuits is an effective solution to implement SDR. For the programmable digital baseband engine, important factors are flexibility and energy efficiency. Flexibility should only be introduced where its impact on the total average power is sufficiently low or where it offers a broad range of control options. For the reconfigurable analog front end, architectures and circuits should be designed for a broad range of requirements in carrier frequency, channel bandwidth and noise performance with minimal power consumption, while also offering energy scalability. A major challenge is to enable low energy reconfigurable radio implementations, suited for handheld multimedia terminals and competitive with fixed hardware implementations. To make such terminals a reality; firstly effective energy scalability is enabled in the design of the radio baseband and front end. And secondly, the scalability is exploited to achieve low power operation by across layer controller that follows at run time the dynamics in the application requirements and propagation conditions.

Future communication systems will have to seamlessly and opportunistically integrate multiple radio technologies and heterogeneous wireless access networks to offer context dependent ubiquitous connectivity and content access. The growing demand for large data rates reveals an increasing spectrum scarcity. A continuously growing role for adaptive spectrum radios exploiting the capabilities of reconfigurable radio architectures is to be expected. Pushed to the limit, this leads to the disruptive concept of cognitive radio. Cognitive radio is defined as a radio that can autonomously change its transmission parameters based on interaction with the complex environment in which it operates. The spectrum data/mining and agile air interface requirements of such cognitive radios also claim for SDR based implementations [5].

VI. CONCLUSION

- SDR provide a low cost, low power solution & flexibility in customizing the design for different data rates, modulation type, carrier frequency, filter types etc. Making the design effectively reconfigurable.
- Change in any specification, the SDR is reprogrammed, saving both cost & time of discarding old hardware.
- Providing versatile platform for wireless communication like cellular, GPS & military grade communication.

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