IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727
PP 34-38
www.iosrjournals.org

A Survey on Importance and Challenges of Radio Waves in Wireless Communications

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Abstract: *The achievement of social developments goal is doubtful without sufficient opportunity not only to propagate information to various parts of the society but also to communicate effectively and reliably. This survey studies position its main objective to investigate the major challenges and importance in the use of radio technology especially cognitive radio and software defined radio for wireless communications. With this in view, the study will proceed to explore the major challenges in the use of cognitive radio, especially in digital communications and the unique opportunities to employ radio technology as one of a means of development in wireless communication, by considering the following specific objective to find out possible solutions for the major obstacle that delay the effective and efficient use of radio waves for wireless communication. Secondly, for wire line communication (like a twisted telephony line), if you have to lay long cables your expenses will grow significantly, whereas for radio communication it doesn't really matter how long your subscriber length is to some extent of course.*
Keywords **-** *CR, SDR, Wireless communication.*

I. Introduction

1.1 Electromagnetic Spectrum

The waves are defined as the disturbance through any medium of substance. The electromagnetic waves are the waves which are generated by coupling of magnetic field with electric field. These waves are in perpendicular direction to both the electric and magnetic and also perpendicular to each other[2,3 & 9].

An electromagnetic spectrum (Figure1) is the spectrum containing all possible range of frequencies coming in the electromagnetic wave. These waves do not need the medium for their propagation. These waves can be polarized and are transverse in nature. Examples are radio waves, light waves, x-ray, etc.

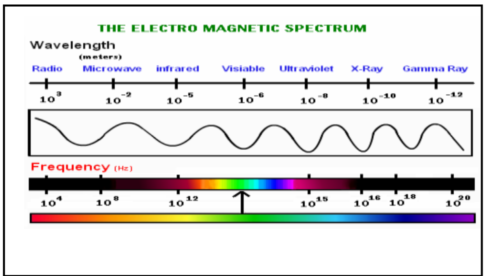

Figure1. Electromagnetic Spectrum with 7 Types of Waves**.**

A radio is a box filled with electronic components that catches radio waves sailing through the air, a bit like a baseball catcher's mitt, and converts them back into sounds your ears can hear. Radio was first developed in the late-19th century and reached the height of its popularity several decades later. Although radio broadcasting is not quite as popular as it once was, the basic idea of wireless communication remains hugely important: in the last few years, radio has become the heart of new technologies such as wireless internet, cell phones and RFID (radio frequency identification) chips.

1.2 Radio Waves

In 1887 *Heinrich Hertz* was experimenting with a spark coil. He noticed that whenever it produces a spark, another spark operated across the ends of an open metal ring several meters away. Radio waves, produced by the first spark, had been transmitted across the room. Later Guglielmo Marconi found a way of using these radio waves to carry sound. In 1907 he was able to transmit the first sound signal across the Atlantic. Marconi's discovery was the key to the widespread use of radio waves for communication.

The air around us is filled with many different radio waves, all day, every day. Although many carry sound signals, we cannot hear them without special receivers. Charged particles are accelerated in many different ways to produce electromagnetic waves of various frequencies or wavelengths. These form an electromagnetic spectrum. In our day to day life we use lots of waves, for communication, for heating food, etc. The different types of waves used for communication comes under the categories of radio waves. Hence, waves with relatively low frequencies or long wavelengths are known as radio waves.

In general, any frequency less than 300 GHz is termed as radio waves. The radio waves are the very starting point of the EM spectrum. The Radio Wave Wavelength lies in 1 millimeter to 100,000 kilometers. And the Radio Wave Frequency lies between as low as 3 Hz to as high as 300 GHz. The radio waves are generally used in communication systems [1, 4, 5, 6 & 8]. The Radio Wave Frequency band is generally divided into several categories according to their wavelength and uses. You might think "radio" is a gadget you listen to, but it also means something else. Radio means sending energy with waves. In other words, it's a method of transmitting electrical energy from one place to another without using any kind of direct, wired connection. That's why it's often called wireless. The equipment that sends out a radio wave is known as a transmitter. The radio wave sent by a transmitter speed through the air maybe from one side of the world to the other and completes its journey when it reaches a second piece of equipment called a receiver.

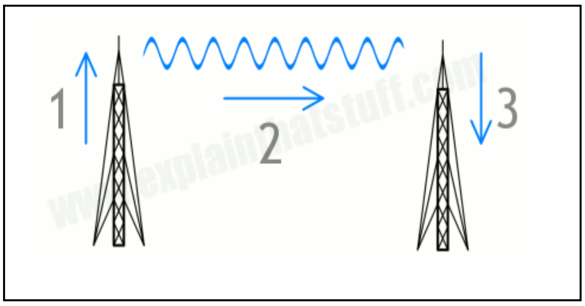

Figure2. Transmission of Radio Waves.

Figure2 shows how the radio waves travel from a transmitter to a receiver. 1. Electrons rush up and down the transmitter, shooting out radio waves. 2. The radio waves travel through the air at the speed of light. 3. When the radio waves hit a receiver, they make electrons vibrate inside it, recreating the original signal. This process can happen between one powerful transmitter and many receivers which is why thousands or millions of people can pick up the same radio signal at the same time.

Radio waves are much faster, longer, and more frequent than ocean waves. Their wavelength is typically hundreds of meters, so that is the distance between one wave crest and the next. But their frequency can be in the millions of hertz, so millions of these waves arrive each second. Radio waves travel unbelievably fast at the speed of light (300,000 km or 186,000 miles per second). These waves are emitted by radio stations or TV stations during transmissions, also emitted by stars. Waves are used by antennas. Waves are used for data transmission via modulation.

From TV broadcasts to GPS satellite navigation radio waves zap all kinds of handy information through the air, might be wondering why these very different signals don't get thoroughly mixed up? Now a day's digital broadcasting, it's a lot easier to keep radio signals separate from one another by using complex, mathematical codes. Hence, people can use hundreds of cell phones simultaneously in a single city street without hearing one another's calls.

1.3 Modulation

Communication is the basic asset of mankind through which he can exchange the information. It gives the idea of what is going around us. We communicate with many people in our daily life. We also need the entertainment media in our day to day life like TV, radio, browsing, News paper etc which also acts as a source of Communication.

Electronic communication includes TV, radio, Internet etc. Here we need to transmit the information bearing signal from one place to another. To do this we need to strengthen the signal. So the signal travels for long distances. This is called Modulation. Let us study more about the Modulation in this section.

1.4 Communication Systems

Communication is the basic process of exchanging information. The basic components of electronic communication system are: Transmitter, Communication channel and Receiver.

1.5 Wireless Communications

Wireless communication systems have existed for many years, yet as increasingly complex systems are built, we encounter problems that were never dreamed of by early wireless pioneers. Modern cellular systems use base stations which cover a specific geographical region, called a cell. Problems arise in deciding when to switch a user from one cell to another, in dealing with interference between cells, and in tracking the user. Even with these difficult problems, wireless communication has a strong, and perhaps lucrative, future. Attributes such as the freedom to communicate and move and the ability to bring communications to remote locations without cable make this technology an indispensible part of our society [10].

1.5.1 Analogue and Digital Signals

Radio waves, microwaves, infrared and visible light are all used to carry information, which can be sound, pictures or other data. The information is called the signal. It is added to an electromagnetic wave called the carrier wave so that it can be transmitted. When the wave is received the carrier wave is removed and the signal is reconstructed. There are two types of signal, analogue and digital[7, 8, &9].

An analogue signal changes in frequency and/or amplitude continually in a way that matches changes in the voice or music being transmitted.

A digital signal has just two values which are represented as 0 and 1 (or on and off). The signal is converted into a code of 0s and 1s. It becomes a stream of 0 and 1 values. These pulses are added to the carrier wave and transmitted. After the signal is received it is decoded to recover the original signal.

Wireless communication uses microwaves and radio waves to transmit information. The advantages of this are:

- No wires are needed to connect laptops to the internet, or for mobile phones or radio.
- Phone calls and e-mail are available 24 hours a day.
- Communication with wireless technology is portable and convenient.

II. Cognitive Radio

Cognitive Radio (CR) is one of the new long term developments taking place and radio receiver and radio communications technology. After the Software Defined Radio (SDR) which is slowly becoming more of a reality, cognitive radio (CR) and cognitive radio technology will be the next major step forward enabling more effective radio communications systems to be developed. The idea for cognitive radio has come out of the need to utilize the radio spectrum more efficiently, and to be able to maintain the most efficient form of communication for the prevailing conditions [2, 5, 6, 7, 8 & 9].

2.1 Intelligence and flexibility

Work is under way to determine the best methods of developing a radio communications system that would be able to fulfill the requirements for a CR system. Although the level of processing required may not be fully understood yet, it is clear that a significant level of processing will be needed. The radio will need to determine the occupancy of the available spectrum, and then decide the best power level, mode of transmission and other necessary characteristics. Additionally the radio will need to be able to judge the level of interference it may cause to other users. This is an equally important requirement for the radio communications system if it is to operate effectively and be allowed access to bands that might otherwise be barred.

A cognitive radio may be defined as a radio that is aware of its environment and the internal state and with knowledge of these elements and any stored pre-defined objectives can make and implement decisions about its behavior.

2.2 Cognitive Radio Architecture

In addition to the level of processing required for cognitive radio, the RF sections will need to be particularly flexible. Not only may they need to swap frequency bands, possibly moving between portions of the radio communications spectrum that are widely different in frequency, but they may also need to change between transmission modes that could occupy different bandwidths.

The conversion to and from the digital format is handled by digital to analogue converters (DACs) and analogue to digital converters (ADCs). To achieve the performance required for a cognitive radio, not only must the DACs and ADCs have an enormous dynamic range, and be able to operate over a very wide range, extending up to many GHz, but in the case of the transmitter they must be able to handle significant levels of power.

2.3 Cognitive Radio Network Advantages

The use of a cognitive radio network provides a number of advantages when compared to cognitive radios operating purely autonomously:

- ***Improved spectrum sensing:*** By using cognitive radio networks, it is possible to gain significant advantages in terms of spectrum sensing.
- ***Improved coverage:*** By setting up cognitive radio network, it is possible to relay data from one node to the next. In this way power levels can be reduced and performance maintained.

III. Software Defined Radio Definition

Although it may sound a trivial exercise, creating a definition for the software defined radio is not as simple as it seems. It is also necessary to produce a robust definition for many reasons including regulatory applications, standards issues, and for enabling the SDR technology to move forwards more quickly [1, 2, 3, 4, 5, 6, & 7].

Many definitions have appeared that might cover a definition for a software defined radio, SDR. The SDR Forum, they have defined the two main types of radio containing software in the following fashion:

- ***Software Controlled Radio:*** Radio in which some or all of the physical layer functions are Software Controlled. In other words this type of radio only uses software to provide control of the various functions that are fixed within the radio.
- ***Software Defined Radio:*** Radio in which some or all of the physical layer functions are Software Defined. In other words, the software is used to determine the specification of the radio and what it does. If the software within the radio is changed, its performance and function may change.

  To achieve this the software defined radio technology uses software modules that run on a generic hardware platform consisting of digital signal processing (DSP) processors as well as general purpose processors to implement the radio functions to transmit and receive signals.

  In an ideal world the signal at the final frequency and at the correct level would emanate, and similarly for reception, the signal from the antenna would be directly converted to digits and all the processing be undertaken under software control. In this way there are no limitations introduced by the hardware. To achieve this, the Digital to Analogue conversion for transmission would need to have a relatively high power, dependent upon the application and it would also need to have very low noise for receive. As a result full software definition is not normally possible.

3.1 Levels Of Sdr

It is not always feasible or practicable to develop a radio that incorporates all the features of a fully software defined radio. Some radios may only support a number of features associated with SDRs, whereas others may be fully software defined. In order to give a broad appreciation of the level at which a radio may sit, the SDR Forum (now called the Wireless Innovation Forum, WINNF) has defined a number of tiers. Although these SDR tiers are not binding in any way, they give a way of broadly summarizing the different levels of software defined radios that may exist.

3.2 Sdr Security

Another area of growing importance is that of SDR security. Many military radios, and often many commercial radio systems will need to ensure the transmissions remain secure, and this is an issue that is important for all types of radio. However, when using a software defined radio, SDR, there is another element of security, namely that of ensuring that the software within the radio is securely upgraded. With the growing use of the Internet, many SDRs will use this to medium to deliver their updates. This presents an opportunity for malicious software to be delivered that could modify the operation of the radio or prevent its operation altogether. Accordingly SDR software security needs to be considered, if the Internet is used for software delivery or where there could be security weaknesses that could be employed maliciously.

3.3 Sdr Hardware Architecture

Although there are many different levels of SDR and many ways in which a software defined radio may be designed, it possible to give some generalized comments about the basic structures that are used. Apart from the control and management software and its associated hardware, a software defined radio (SDR) can be considered to contain a number of basic functional blocks as detailed below:

- **RF Amplification:** These elements are the RF amplification of the signals travelling to and from the antenna. On the transmit side the amplifier is used to increase the level of the RF signal to the required power to be transmitted. It is unlikely that direct conversion by the DAC will give the required output level. On the receive side signals from the antenna need to be amplified before passing further into the receiver. If antenna signals are directly converted into digital signals, quantization noise becomes an issue even f the frequency limits are not exceeded.

- **Frequency conversion:** In many designs, some analogue processing may be required. Typically this may involve converting the signal to and from the final radio frequency. In some designs this analogue section may not be present and the signal will be converted directly to and from the final frequency from and to the digital format. Some intermediate frequency processing may also be present.
- **Digital conversion:** It is at this stage that the signal is converted between the digital and analogue formats. This conversion is in many ways at the heart of the equipment. When undertaking these conversions there are issues that need to be considered. On the receive side, the maximum frequency and number of bits to give the required quantization noise are of great importance. On the transmit side, the maximum frequency and the required power level are some of the major issues.
- **Baseband processor:** The baseband processor is at the very centre of the software defined radio. It performs many functions from digitally converting the incoming or outgoing signal in frequency. These elements are known as the Digital Up Converter (DUC) for converting the outgoing signal from the base frequency up to the required output frequency for conversion from digital to analogue. On the receive side a Digital Down Converter (DDC) is used to bring the signal down in frequency. The signal also needs to be filtered, demodulated and the required data extracted for further processing.

  One of the key issues of the baseband processor is the amount of processing power required. The greater the level of processing, the higher the current consumption and in turn this required additional cooling, etc. This may have an impact on what can be achieved if power consumption and size are limitations. Also the format of any processing needs to be considered general processors, DSPs, ASICs and in particular FPGAs may be used. FPGAs are of particular interest because they may be reconfigured to change the definition of the radio.

IV. Conclusion And Future Work

This survey submits the importance and architecture of the radio waves. The report says the importance of radio waves in wireless communications in various networks also in aquatic network. Now days everybody roaming with hand held wireless devices. Hence we should optimize the usage of radio waves in digital world. This paper gives the report of advantages and the issues of the one of electromagnetic spectrum in this digital era.

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