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The implementation of software defined radio receiver using a simple OCF antenna

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Abstract— The Software Defined Radio (SDR) is an emerging technology that has been prevalent in the communication system as an active research field for the past decade. The technology designed for audio broadcasting over short wave bands is SDR. Most of the traditional hardware radios implement protocols with the help of electric circuits. SDR uses software program to implement the radio protocol. It is easy to modify, upgrade and edit the functionality of SDR due to the use of software. With the help of a simple OCF antenna the working of SDR receiver is explained in this paper.
Keywords— Signal processing, Software Defined Radio (SDR), Antenna, DRM

I. INTRODUCTION

In everyday life without our knowledge radio is an essential part of our communication. The first thing which comes to our mind when we hear the word radio is the AM or FM radio, CB radio, car radio, hand held radio, etc. The fact is that the radio is not limited to these devices. Some of the technology which is widely used by us such as the Wi-Fi adapters in computers, Bluetooth earpiece, etc. uses the radio communication. Thus a device which receives any information wirelessly with the help of electromagnetic waves called radio waves is called a radio.

The conventional radios were made from a single hardware design which was depending on the electrical circuits thus were called hardware defined radio. After the hardware defined radio was the SDR in which the software decided the type of radio being implemented. Due to the many advantages of SDR researchers and developers have started working on improvising the existing SDR. The radio in which the modulation technique with narrow band and wide band operations are performed using software control is named as SDR. The communication security and waveform requirements for broad range of frequency can be achieved. In simple words, the radio communication system in which the hardware components have been replaced and implemented using software is called SDR. The software upgrades helps the wireless devices with multi-mode, multi band and multi-functional operations can be easily adapted, enhanced and updated free of cost. The wireless network and user terminal have enabled architectures which are re configurable since the SDR has a collection of software and hardware. The SDR has replaced many analog components and digital devices with programmable devices including the data converters which are ADC and DAC, air interface and modulation and coding techniques. The conventional radio makes use of the operator interface where the user makes use of the switches and knobs for tuning. In SDR the tuning is performed by the Graphical User Interface (GUI) which can be updated easily. Programmable Digital Signal Processing (DSP) functions such as the AGC, IF offset, etc. can be included in the SDR. The signals may or may not be received at the center of the spectrum. Noise gets added to the signal if the signal is away from the center of the spectrum. To avoid the addition of noise the signal can be brought to the center of the spectrum by adjusting the scale of the spectrum. A personal computer with soundcard, data converters and RF front end form a basic model of SDR. Most of the signal processing operations is performed by the processor instead of the hardware. Different radio protocols can be received by this system. Most of the existing SDRs use high end antenna set up such as the mini whip antenna, monopole antenna, telescopic antenna, discone antenna, omnidirectional antenna, adaptive array smart antenna, switched beam smart antenna, sector antenna, spiral antenna, sky loop antenna, helical antenna, half wave dipole antenna, delta loop antenna, long wire antenna, OCF antenna, etc. most of the antennas listed above are expensive. Also they need large area for mounting them. Among the above said antennas, the long wire antenna, delta loop antenna and OCF antenna were inexpensive compared to the rest. The drawback of long wire antenna was that the noise level was very high and the signal received could not be heard clearly. The delta loop antenna worked perfectly well with higher frequency range, but the lower frequency ranges were redirected and was not received. The OCF antenna was best suited for both lower and higher frequency ranges with low level of noise. Thus OCF antenna is used due to its simple design, efficient working and low cost.

II. HARDWARE

A. Antenna

Antenna is an electrical device which is used to convert electric power into radio waves. It can be used by both transmitter and receiver. A part of the power of electromagnetic wave is intercepted by the antenna at the receiver end. This is then converted into small voltage value which is fed to the receiver for amplification. The antenna discussed in this paper is the OCF antenna. The Buckmaster Off Center Feed (OCF) antenna has its feed point away from the center. The OCF is a multi-band antenna which works well on its third harmonic. If the antenna is used with a coaxial cable with an impedance of 50Ω then its best to avoid even harmonics. It works well without a tuner. The reason for off center band is for similar feed impedances over a number of frequency bands. One wire leg is much longer than the other. Thus the length of coaxial cable required is very less compared to the center feed antenna.

B. Tayloe Detector

The Tayloe detector performs quadrature down conversion. There are four different positions in the rotary switch. The rate at which the switch revolves is equal to the carrier frequency. A sampling capacitor is attached to each of the four switch positions. The carrier amplitude is tracked for one quarter of the cycle by each capacitor. For the remaining cycle the value is held. The antenna with an impedance of 50Ω preferably is connected to the rotor. The signal is sampled at 0^0, 90^0, 180^0 and 270^0 respectively by the rotating switch. These are then summed to obtain the in phase and quadrature phase signals I and Q respectively. The figure 1 illustrates the working of Tayloe detector.

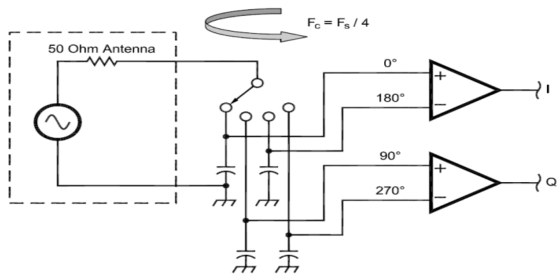

Fig. 1. Tayloe detector

C. CODEC

An ultra-low power stereo audio CODEC is used. The SNR of the stereo audio DAC is 100dB with 4.1mW at 48ksps of stereo DAC playback. The SNR of stereo audio ADC is 93dB with 6.1mW at 48ksps of audio record feature. It supports three fully differential or six single ended analog inputs. It also supports stereo analog and digital microphone inputs. The outputs can be stereo headphone or stereo line. It has a very low noise PGA.

III. SOFTWARE

A. HDSDR

The High Definition Software Defined Radio (HDSDR) is free ware software which runs on Windows. It is an advanced version of WinRad software. Some of the features of HDSDR are listed below.

1) The screen display area is used efficiently and is flexible.
2) There are two types of display for input and output signals which are waterfall display and spectrum display.
3) The waterfall display can be viewed at low speed for detection of noise pattern and to monitor the short wave condition.
4) It allows AM, SSB, FM and CW demodulation techniques.
5) Special provision for autocorrelation display and cepstrum display.
6) The waterfall and spectrum display are optically zoomed to fit the screen.
7) Provision of record and play back for RF, IF and AF signals in .wav format is available in the recording scheduler.
8) The frequency manager is used to list Ham band, EiBi, radio band and user frequency.

IV. ALGORITHM

A. Automatic Gain Control

The hang time is chosen such that it increases by 46msec. The first step of AGC is to check if it is turned ON and increment the AGC loop. The AGC hang time is looped by the counter. The envelope of demodulated signal is detected. The peak magnitude

VPK is obtained. The gain factor relative to 50% of full scale value is computed to prevent divide by zero error. The maximum gain is used to limit the gain. The next step is to decide if the gain has to be increased or decreased. This is done with the help of the previous gain value. Two cases occur as follows.

1) Gain < previous gain then the gain is ramped down by 44 samples.
2) Gain > previous gain then the gain is ramped up by 44 samples.

The final step is to hard limit the final gain value to avoid integer variable overflow of output buffer.

V. WORKING PRINCIPLE

The block diagram of the system is shown below in figure 2. The RF signal are picked up by the OCF antenna and fed to the Tayloe detector. The Tayloe detector produces the in phase (I) and quadrature phase (Q) signals. The Fast Fourier Transform is applied on these I and Q signals. Due to the presence of noise the signal is off shifted by a frequency value 11.02 KHz. This off shift is removed by the amplitude and phase correction block. Inverse transform is applied to get back the original signal. Remaining noise is removed by the filter. Since the gain of output is less, a digital automatic gain control algorithm is applied on the output. The final output has higher gain and the signal is strong.

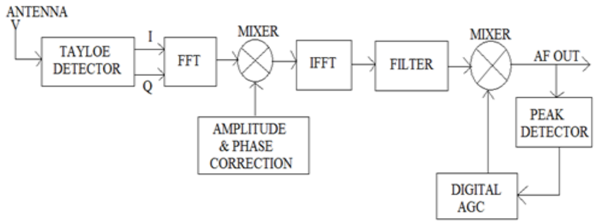

Fig. 2. Block diagram of the system

VI. ADVANTAGES AND DISADVANTAGES

A. Advantages

1) Reduced power consumption of approximately 40%.
2) Increased coverage area.
3) Easy operation.
4) Improved reception quality for both indoor and outdoor.
5) Additional audio and data services.
6) Easy handling of receivers.

B. Disadvantages

1) Sometimes dependent on computer.
2) Difficult to run on older computers.
3) Limitations on the availability of required software.
4) Transmitting is more costly.

VII. RESULT

On implementing the above said system, the following result will be obtained. Figure 3 shows the working of the device at 15.350MHz. Similarly figure 4 shows the frequency 17.510MHz.

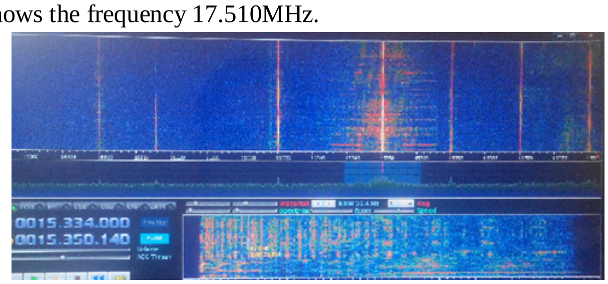

Fig. 3. 15.350MHz frequency being received by the system

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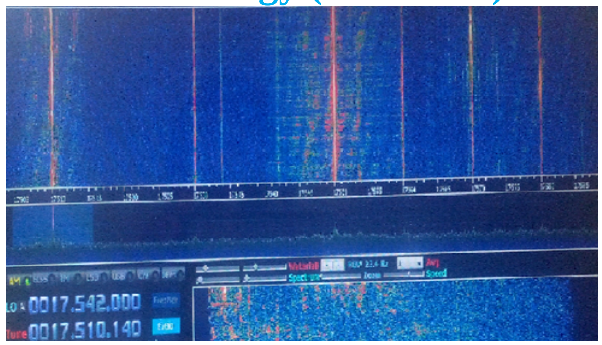

Fig. 4. 17.510MHz frequency being received by the system

In the first case, 15.350MHz, it can be observed that the frequency is at the center of the spectrum and the signal strength is very strong. The audio quality received is excellent. In the second case, 17.510MHz, the frequency is at the side of the spectrum and the signal strength is very weak. The audio quality received has a lot of distortions and disturbance. Thus it is always better to have the desired receiving frequency at the center of the spectrum for better audio quality and strong signal.

VIII.CONCLUSION

This paper illustrates how the SDR receiver can be built with simple components which are inexpensive. A few problems were faced during the implementation of the system. A few components which were initially designed for the system were unavailable in the market. The system had to be redesigned with alternative components. The change in components did not cause any change in the working of the system. There was a dilemma as to which antenna had to be used for receiving strong signals. The cost and area to be mounted in had to be kept in mind while selecting the antenna. Among the many antennas which are used for SDR, the best antenna which fit the criteria was the OCF antenna.

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