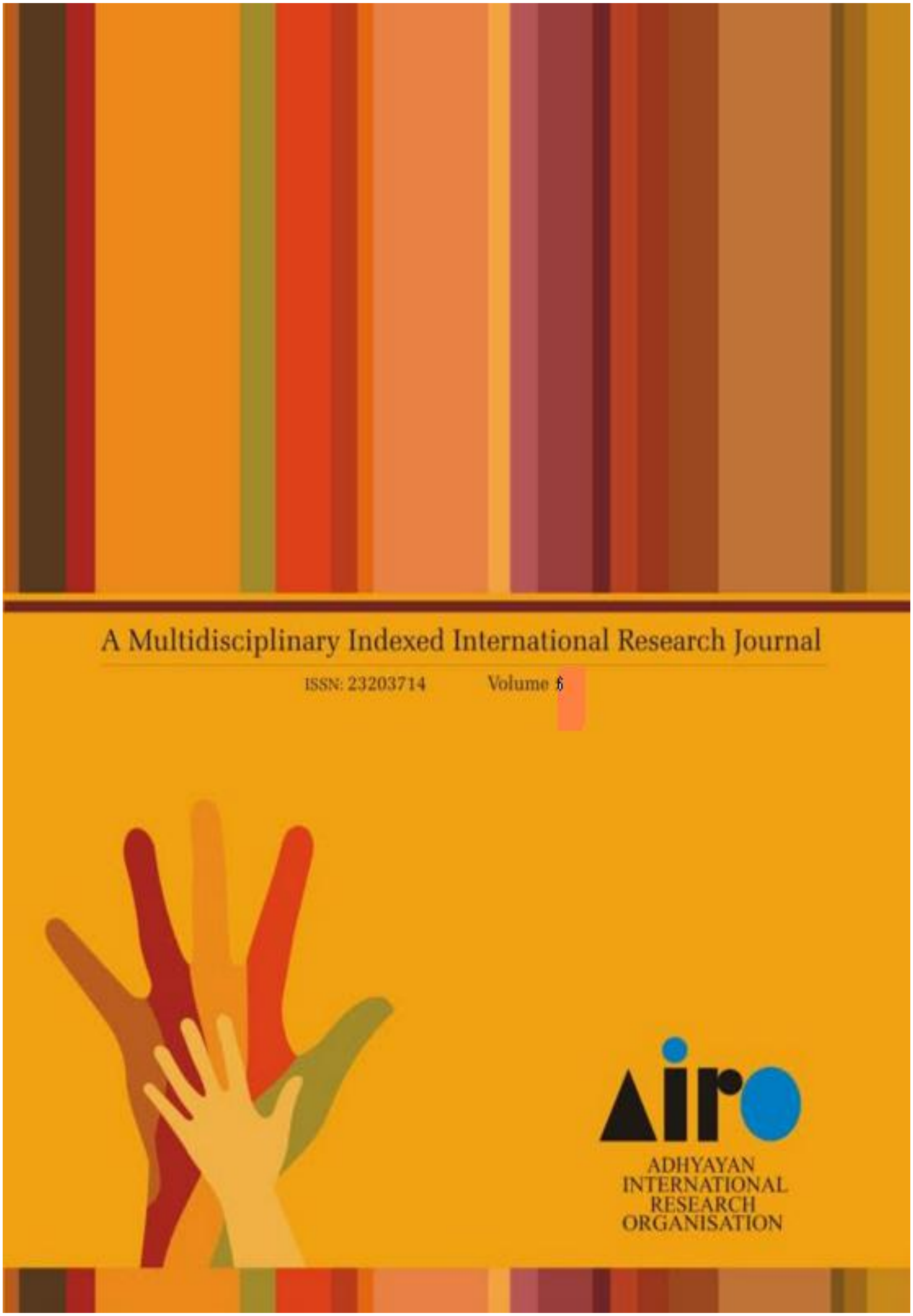
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A NEW SUBSTRATE INTEGRATED SIX-PORT SOFTWARE-DEFINED RADIO RECEIVER PLATFORM FOR DIFFERENT COMMUNICATION SCHEMES

SK.MASTHANBASHA[1]
Research Scholar
Acharya Nagarjuna University, Guntur
masthanbasha.s@gmail.com

Dr.HABIBULLAKHAN[2]
Dean (Student affairs)
K.L. University, Vijayawada
habibulla@kluniversity.in

Abstract

Software Defined Radio (SDR) has been identified as one potential method to enhance the flexibility of wireless communication systems. Comparing to the traditional radio communication systems, SDR omits all the hardware and replaces them by pure software. This solution also gives a great advantage in flexibility because a SDR receiver is able to decode all the signals. Past decades deals with many communication standards and even today also many researches are going on. In the past, the operating speed limitation of analog digital converter (ADC) and processing ability limitation of re-configurable chips for signal processing have slowed down the development of SDR for useful commercial application. In this paper, the receiver is demonstrated to support Quadrature phase-shift keying and 16 Quadrature amplitude modulation schemes. System-level simulation is made and prototype circuits are fabricated to evaluate the system performance. Finally proposed method reduces the computational cost and also a high potential for software reuse in future wireless communication systems.

Keywords: Software Defined Radio (SDR), 16-QAM, substrate integrated waveguide (SIW), Digital receiver, Quadrature amplitude phase shift keying (QPSK)

1. INTRODUCTION

The idea of implementing radio functions in software rather than hardware had already been established when, in 1991, JOSEPH MITOLA coined the term ‘Software Radio’. SDR Technology was originally conceived as a means to facilitate better communications between the different forces of the US military. SDR was seen as a technology that could facilitate the interworking of all different radios and radio systems used within the forces. The aim was to eventually reduce the number of different radio systems used by the different military services. However, implementation of such software radio is not possible with current processor technology and it will even be unnecessary for many applications. In some cases the possibility to connect to only a small number of different air interfaces might suffice, while in other cases only higher layer functionality needs reconfiguration with the radio configuration remaining unaltered. Until processors reach sufficient capabilities and processing power to fully implement all functions within a radio in software, compromises and customized solutions for terminals able to connect via multiple modes will have to be made. In the military domain, the main aim of SDR Technology was to reduce the number of different radio systems and to increase interworking between the different systems. In contrast, in the commercial domain SDR Technology can help to increase service offerings through temporal allocation of extra frequency bands.

Software Defined Radio (SDR) is an Information Transfer System (ITS) that combines technology from the historically separate fields of computers and radios. Emerging from military applications, SDR has been receiving much attention among researchers working on wireless communications. The essence of an SDR is the ability, without introducing new hardware, to change operating characteristics such as operating frequency range, modulation type, bandwidth, maximum radiated or conducted output power and network protocols by changing the software programs executing in processing resources. In software defined radio, operating parameters are determined by software. This enables a single wireless device to be reprogrammed to use different modulation, coding, and access protocols.

During recent years, six-port technology has been used for microwave and millimeter-wave measurement applications. In general, the circuitry of a six-port is used as an alternative to vector network analyzers. whereas in the field of communication, they have been used as direct conversion receivers of Quadrature phase shift keying (QPSK) signals and direct digital receiver in software-defined radio (SDR), which are less complex and allow a higher integration level compared to conventional heterodyne receivers.

2. NEED FOR SOFTWARE-DEFINED RADIOS

In the past decades, the area of wireless communications has been developing and emerging in a rapid form. All new electronic devices implement some sort of wireless communications, may be in the form of Wi-Fi, Bluetooth, or cellular technologies like CDMA or LTE. Specific protocols are defined for each of these different radio systems. So Software Defined Radio can be defined as a radio communications transceiver system in which all the typical components of a communication system are present such as mixers, modulators/demodulators, detectors, amplifiers that are implemented through software rather than hardware. The development of SDR leads to the scope of developing a system which is compatible with more than one mobile communication standard. This can be achieved by using reconfigurable hardware and swapping the software for different technologies.

3. SOFTWARE DEFINE RADIO

SDR is a combination of adaptable hardware and the software that decides on the functioning of hardware. Without introducing new hardware, an SDR can modify its properties such as the operating frequency range, modulation type, bandwidth, maximum radiated or conducted output power, and the network protocols by changing the software programs that control the processing resources. This great flexibility of SDR provides a tremendous opportunity for solving interoperability problems between many different existing standards, implementing new standards, and minimizing the amount of hardware necessary to perform required communications across these different standards. SDR allows effective spectrum utilization by facilitating spectrum sharing. It also allows equipment to be reprogrammed to more efficient modulation types. Its capability of being programmed also enhances interoperability between different radio services. The conventional radio systems were having the problems of Image frequency due to the Intermediate Frequency Conversions performed in the mixer units of receivers. These Image frequencies demanded a separate unit for Image Frequency Rejection thereby increasing the cost and size of the receivers. And so we moved to direct conversion receivers those directly converted the RF signals to baseband signals thereby eliminating image frequency problems. SDR receivers perform this direct down conversion with the help of port structures. Normally six or five port structures are used in SDR receivers.

4. PROPOSED SYSTEM MODEL

A software defined radio is a transmitter and receiver system that uses digital signal processing (DSP) for coding, decoding, modulation, and demodulation. This allows much more power and flexibility when choosing and designing modulation and coding techniques. The Texas Instruments TMDSK6713 evaluation board with the TMS320C6713 DSP chip was selected to implement the radio. The system functions are shown in Fig. 1

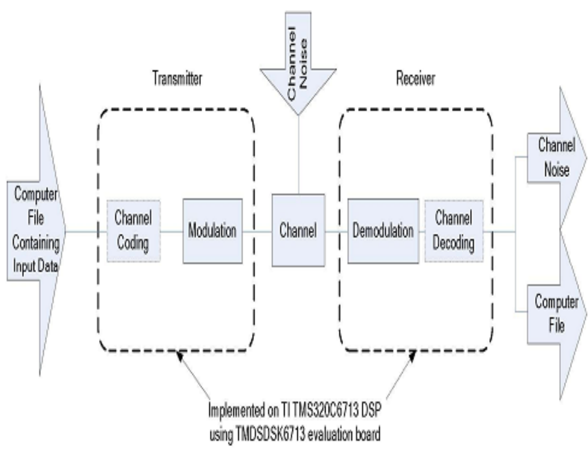

Figure 1: I/O block diagram for transmitter and receiver radio systems

An overall block diagram for the software radio project is shown in Fig. 4. The inputs to the system are a digital data source (computer file) and channel noise. The output of the system is the recovered input data. The recovered data should be received exactly as transmitted. This can be displayed on an oscilloscope coming out of the DSP evaluation board and/or stored on a computer file for further verification and analysis.

The input from the digital data source will be sent into the transmitter. There it will have channel coding applied to provide protection from data corruption introduced by noise. This part will not be implemented in this project. After that, the encoded digital signal will then be modulated with an appropriate modulation technique and transmitted through the channel. An appropriate model and representation for the channel also needs determined. After this, the receiver demodulates the signal and applies appropriate channel decoding. From there the reconstructed digital signal will be available for further analysis.

The input to the system will be digital data in a computer file. This data will be modulated by the transmitter and sent to the channel. The channel will introduce interference to the signal in the forms of attenuation, phase delay, and noise. At the receiver side, the signal will be demodulated and reconstructed to produce the original transmitted message.

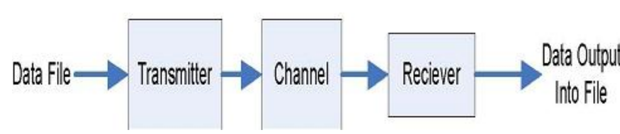

Figure 2: System Breakdown of the Software Radio

The transmitter shown in Fig.3 will generate the signal that will be transmitted through the channel. The transmitter signal is constructed using demultiplexing, Quadrature amplitude modulation (QAM), orthogonal frequency division multiplexing (OFDM), and up mixing.

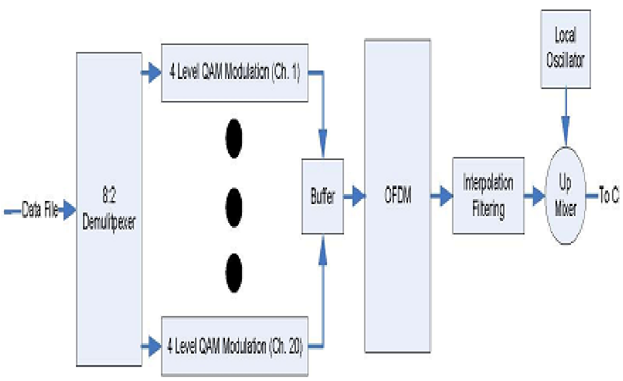

Figure 3: Transmitter Subsystem Detailed Diagram

The demultiplexing block takes a byte of binary data and then breaks the byte into four 2-bit streams. These 2-bit streams are each fed into a QAM modulation channel. Once the QAM channels have modulated the input data, a buffer collects a group of 20 QAM symbols that represent 5 bytes of data. The group of symbols is then passed into the OFDM block. The OFDM system multiplexes the QAM signals together to produce the final modulated output. Interpolation increases the sampling rate and conditions the signal for transmission before it is modulated. This is implemented using a combination of up sampling and filtering. Mixing is done to meet the bandwidth requirements of the channel. The up mixer increases the frequency of the OFDM signal by multiplying it by a greater carrier frequency. The OFDM signal is imbedded in the carrier signal that the local oscillator produces. The output of the mixer is contained in bandwidth of the channel.

4.1 Receiver Architecture and Operating Principle

One key point of SDR is to have a digital processing kernel with almost infinite processing ability. Although DSP and semiconductor technology have developed rapidly in the past ten years, the operating speed level of current DSP chip can't completely support a high speed mu lti-channel multi-modulation SDR at IF level. Therefore certain software radio systems adopt multi-chips architecture and parallel algorithm, thereby increasing the design complexity and potential cost. Instead of digitalizing signals at IF, signals can be digitalized at baseband to reduce the processing requirement for DSP chips. As a new solution of SDR design, a direct demodulator architecture, based on six port technology, or 'multi-port demodulator', is used in our proposed RF software receiver. Signals are down converted from Radio frequency (RF) to baseband directly by a six-port module. This paper presents recent results obtained on the analysis of SDR technology in direct RF six-port receiver designed for multi-mode wireless communications.

Six-port technology was originally developed as an amplitude and phase measurement methodology for high frequency signals. In 1994, Ji Li, R. G. Bosisio and Ke Wu proposed application of this technology for direct receiver. In principle, the circuitry of a six-port consists of dividers and combiners interconnected in such a way that four different sums of a reference signal and the signal to be measured are produced. Different lengths transmission lines between the components, the two signals generate different phase values at output ports, resulting in constructive or destructive interference. The signal levels of the four combined signals are detected using Schottky diode detectors. By applying suitable algorithms, the magnitude and phase of the unknown microwave signal can be determined for any given modulation scheme from the four power values and physical calibration or regenerative data calibration obtained from incoming signal.

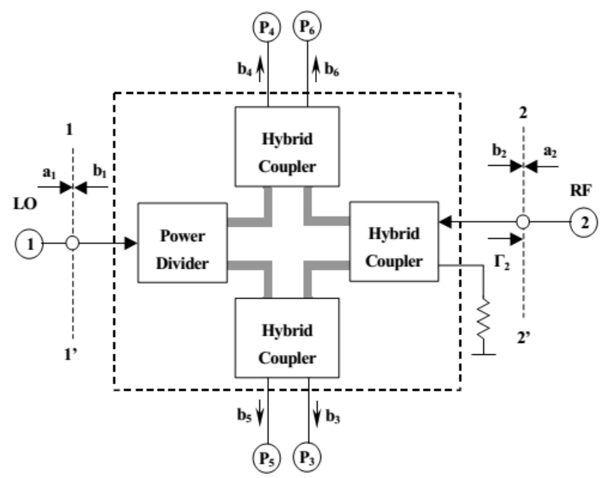

Figure 4: Six-port circuit

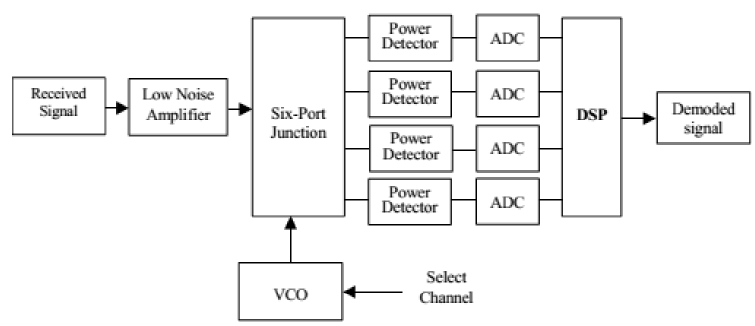

Figure 5: Architecture of software six-port receiver

The structure of a software six-port receiver is shown in Fig.4. A block diagram of six-port circuit is also included. The circuit consists of one power divider and three hybrid couplers. Six-port circuit works as a RF down converter in the proposed receiver. Port 2 connects to RF signal and port1 connects to reference signal, the other four ports are connected with power detectors. The receiver is designed to operate at center frequency of 24 GHz and operates over a wideband of 22-26GHz for multi-mode schemes.

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5. SIMULATION RESULTS

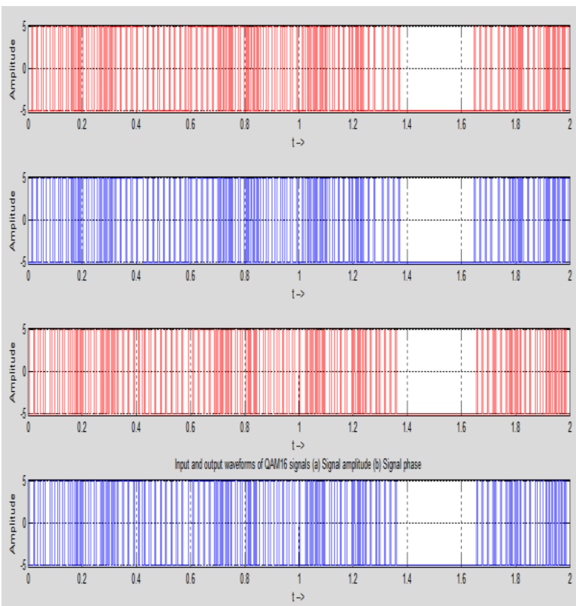

Fig 6: Input and output waveforms of QPSK and QAM 16signals

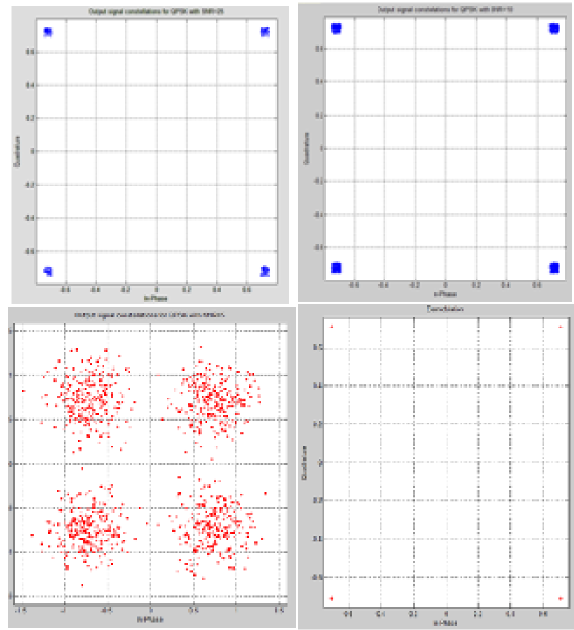

Fig. 7: Simulated output signal constellations for QPSK with different SNR.

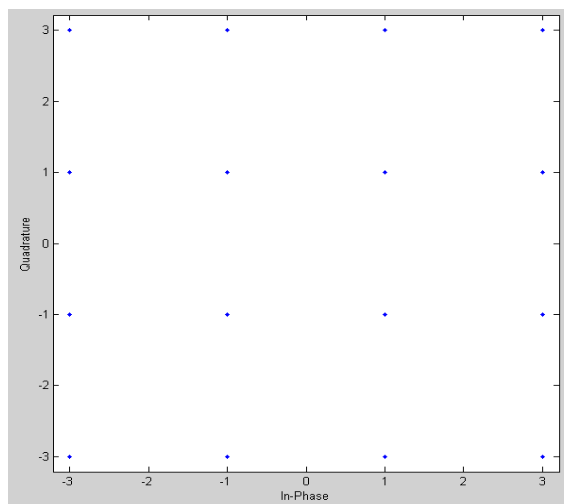

Fig. 8: Simulated output signal constellations for QAM 16

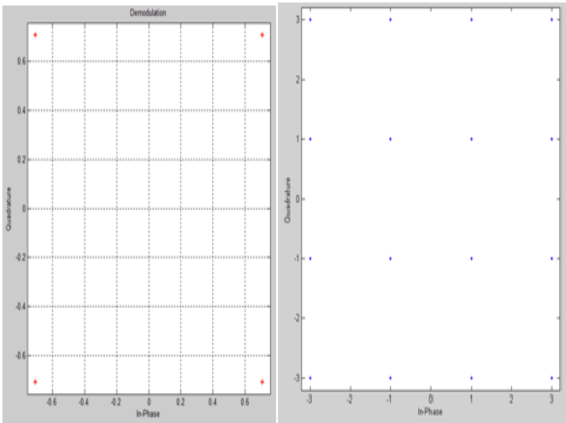

Fig. 9: Six port receiver output signal for QPSK and QAM 16

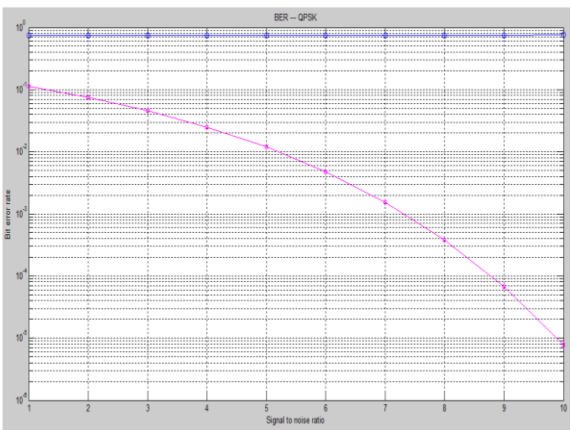

Fig. 10: Simulated BER for QPSK.

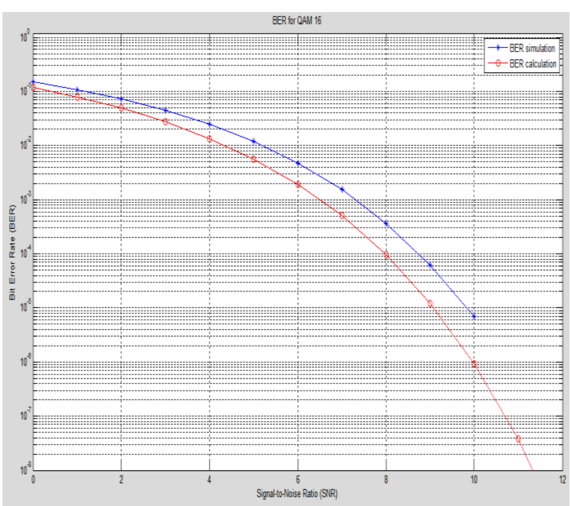

Fig. 11: Simulated BER for QAM16

6. CONCLUSION

The development of SDR technology based on six-port receiver scheme has been proposed and presented. The transmission characteristics are simulated using an actual hybrid integrated six-port circuit. The results of BER vs. Eb/N0 of SDR receiver for two different modulation schemes have been described. Software defined radio has offered many compelling benefits to the radio system designers , but the only open question is how to effectively implement and manage flexibility in a wireless system. Software radio platforms offer researchers and developers the ability to develop their applications in advance of designing customized hardware. Finally software defined radio is very helpful in terms of operating parameters (band width), and this will become a great tool in communications with the help of developing technology in coming years.

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SK. Masthan Basha: Received the B.Tech degree in ECE from JNTUH, Hyderabad, M.Tech degree in VLSI DESIGN from SATHYABAMA UNIVERSITY, Chennai, and is currently doing the research work in ACHARYA NAGARJUNA UNIVERSITY, Guntur, Andhra Pradesh, INDIA. His research interested areas includes wireless communications, Tele communications and VLSI Design and having more than 7 international, national journals/ conference papers in his credit.

Prof. Habibulla khan born in India, 1962. He obtained his B.E.from VRSiddhartha Engineering College, Vijayawada during 1980-84. M.E from C.I.T, Coimbatore during 1985-87 and PhD from Andhra University in the area of Antennas in the year 2007.He is having more than 25 years of teaching experience and having more than 50 international, national journals/ conference papers in his credit. Prof. Habibulla khan presently working as Dean (Student affairs), K.L.University. He is a fellow of I.E.T.E, Member IE and other bodies like ISTE. His research interested areas includes Antenna system designing, microwave engineering, Electro magnetics and RF system designing