IMPLEMENTATION OF SDR FOR VARIOUS RADIO APPLICATIONS

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ABSTRACT

Software-defined radio (SDR) is a self-contained, embedded software system with hardware components and real-time constraints. SDR is the basis for many of today's wireless communications systems. Because SDR combines basic digital signal processing, circuitry, and software elements. This paper explains about the basics of SDR and Software used to implement various modulation schemes on SDR. 16,64-QAM has been implemented along with file transfer applications using GMSK and FM modulation techniques.

Keyword: - *SDR, GNU, QAM, GMSK, FM.*

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1. SDR

Software Defined Radio (SDR) or Software Radio is one of the most important technologies for the modern wireless communication system. SDR is a radio which can tune to any frequency band, implement different modulation and demodulation schemes and different standards in the same device by using reconfigurable hardware and powerful software. SDR provides flexible, upgradeable, multi-standard and longer lifetime radio equipment for both the military and for civilian wireless communications infrastructure. This paper provides a detailed analysis of SDR hardware and its operation focusing on analog front end and digital front end. The paper also highlights the benefits of SDR. However, it was expected to implement SDR since the third generation of wireless communication but many practical challenges that SDR faces, causing SDR evolution slower. This paper also discusses some of the current issues impacting the SDR technology and investigates how they are being resolved work.

Software-defined radio (SDR) is a radio communication system where components that have been traditionally implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on a personal computer or embedded system.

Software Defined Radio takes what used to be physically ingrained within the radio and provides a variety of hardware and software alternatives that add to it more flexibility and functionality.

1.1 Working Principle of SDR

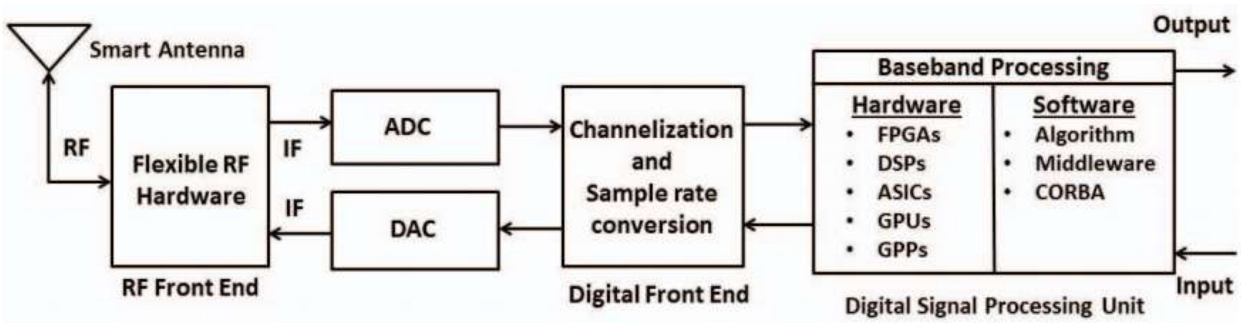


Fig. 1. SDR transceiver

In SDR, most of the signal processing, channel selection, tuning, 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-toAnalog Converter (DAC) as close as possible to the antenna so that all signal processing can be done digitally via software.
A SDR transceiver is shown in Fig 1. 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.

The hardware for a software defined radio is a particularly important element of the overall design. While the whole idea of the radio is that it is fundamentally driven by software, it still needs the basic hardware to enable the software to run. The software defined radio hardware presents some interesting challenges to the hardware development engineer. The performance of the hardware will define exactly how much can be done within the software.

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 center 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.

1.2 Software Requirements for SDR

GNU Radio is a free software development toolkit that provides signal processing blocks to implement software-defined radios and signal-processing systems. It can be used with external RF hardware to create software-defined radios, or without hardware in a simulation-like environment. It is widely used in hobbyist, academic, and commercial environments to support both wireless communications research and real-world radio systems
GNU Radio, Python, and Ubuntu.
GNU radio is a free software toolset for building and implementing SDR. It is a signal processing package which provides a variety of signal processing blocks as well as the ability to develop ones own blocks. The signal processing blocks are written in C++ and are accessed, called, and implemented by Python; much in the manner an m-file would control a Simulink file. GNU radio, when implemented with the USRP2 must be on a Linux-based system.

2. Different Modulation Techniques used with SDR

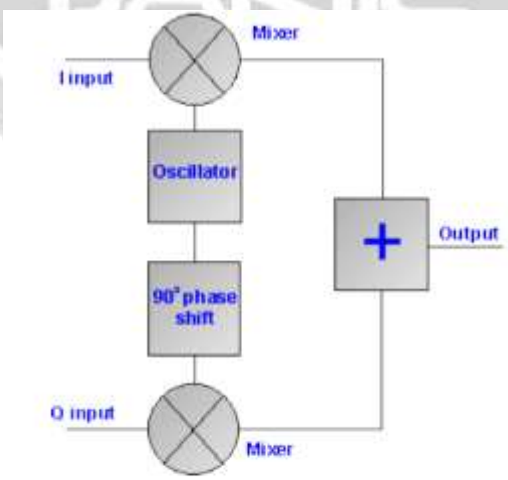
Software Defined Radio is Radio Communication System Which Uses Software for Modulation and Demodulation of Radio Signals. So various modulation schemes can be implemented by using SDR which are discussed below

2.1 Quadrature Amplitude Modulation (QAM)

The QAM modulator and QAM demodulator are key elements within any quadrature amplitude modulation system.
The modulator and demodulator are used to encode the signal, often data, onto the radio frequency carrier that is to be transmitted. Then the demodulator is used at the remote end to extract the signal from the RF carrier so that it can used at the remote end.
As quadrature amplitude modulation is a complex signal, specialized QAM modulators and demodulators are required.

QAM - Modulator

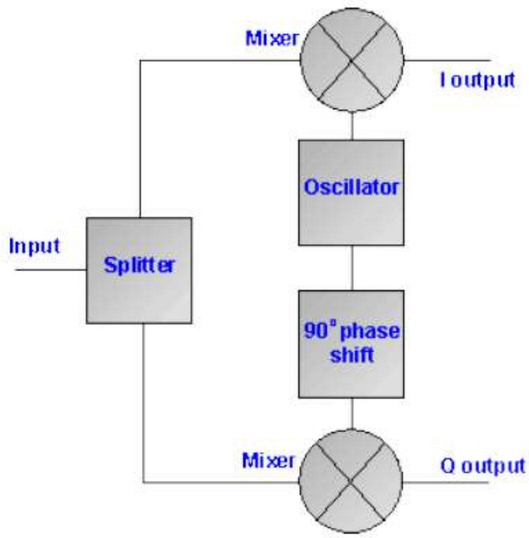
The QAM modulator essentially follows the idea that can be seen from the basic QAM theory where there are two carrier signals with a phase shift of 90° between them. These are then amplitude modulated with the two data streams known as the I or In-phase and the Q or quadrature data streams. These are generated in the baseband processing area.
The two resultant signals are summed and then processed as required in the RF signal chain, typically converting them in frequency to the required final frequency and amplifying them as required.



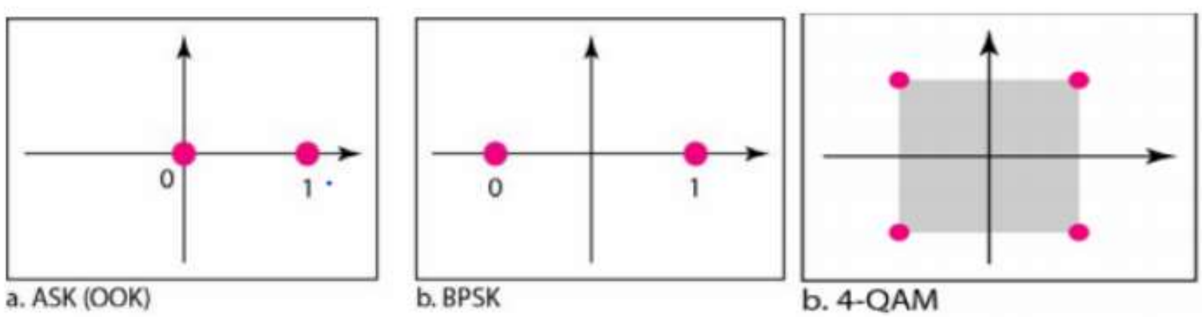
QAM - Demodulator

The QAM demodulator is very much the reverse of the QAM modulator. The signals enter the system, they

are split and each side is applied to a mixer. One half has the in-phase local oscillator applied and the other half has the quadrature oscillator signal applied.
The basic modulator assumes that the two quadrature signals remain exactly in quadrature.
A further requirement is to derive a local oscillator signal for the demodulation that is exactly on the required frequency for the signal. Any frequency offset will be a change in the phase of the local oscillator signal with respect to the two double sideband suppressed carrier constituents of the overall signal.
Systems include circuitry for carrier recovery that often utilises a phase locked loop - some even have an inner and outer loop. Recovering the phase of the carrier is important otherwise the bit error rate for the data will be compromised.



Constellation Diagram – used to represents possible symbols that may be selected by a given modulation scheme as points in 2-D plane
• X-axis is related to in-phase carrier: cos(ωct) ƒ the projection of the point on the X-axis defines the peak amplitude of the in-phase component
• Y-axis is related to quadrature carrier: sin(ωct) ƒ the projection of the point on the Y-axis defines the peak amplitude of the quadrature component • the length of line that connects the point to the origin is the peak amplitude of the signal element (combination of X & Y components) • the angle the line makes with the X- axis is the phase of the signal element 16-level QAM level QAM – the number of bits transmitted per T [sec] interval can be further increased by increasing the number of levels used.



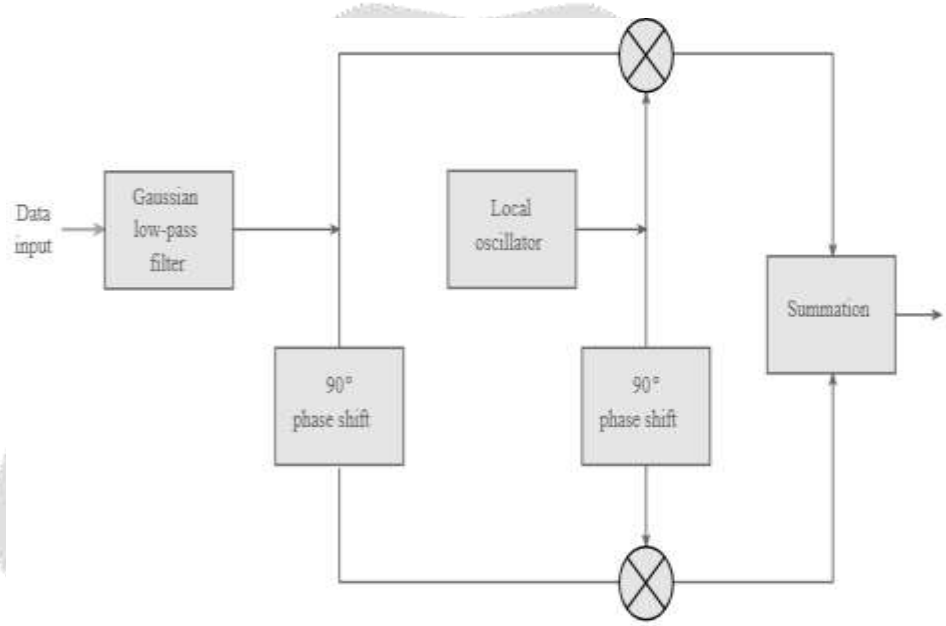
2.2 Gaussian Minimum-Shift Keying

In digital communication, Gaussian minimum shift keying or GMSK is a continuous-phase frequency-shift keying modulation scheme.

GMSK is similar to standard minimum-shift keying (MSK); however, the digital data stream is first shaped with a Gaussian filter before being applied to a frequency modulator, and typically has much narrower phase shift angles than most MSK modulation systems. This has the advantage of reducing sideband power, which in turn reduces out-of-band interference between signal carriers in adjacent frequency channels.

However, the Gaussian filter increases the modulation memory in the system and causes intersymbol interference, making it more difficult to differentiate between different transmitted data values and requiring more complex channel equalization algorithms such as an adaptive equalizer at the receiver. GMSK has high spectral efficiency, but it needs a higher power level than QPSK, for instance, in order to reliably transmit the same amount of data.

GMSK is most notably used in the Global System for Mobile Communications (GSM) and the satellite communications, e.g. in the Automatic Identification System (AIS) for maritime navigation.



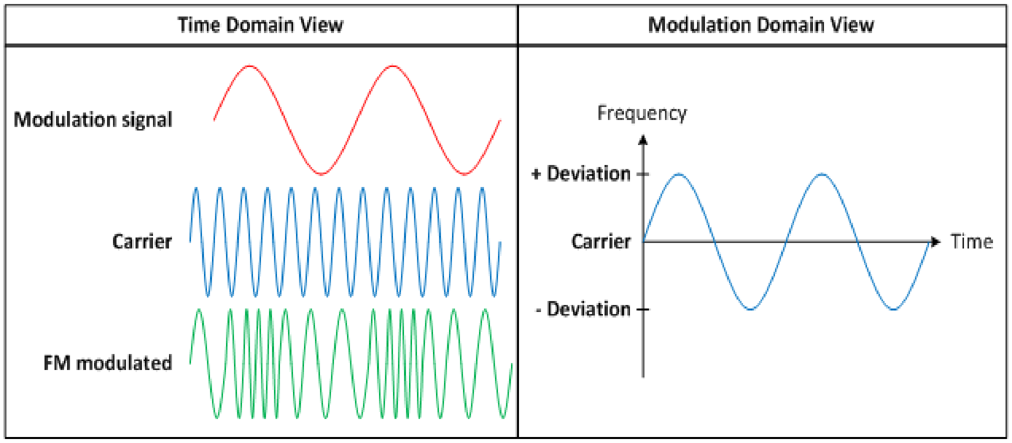
2.3 Frequency Modulation

In telecommunications and signal processing, frequency modulation (FM) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave.

In analog frequency modulation, such as FM radio broadcasting of an audio signal representing voice or music, the instantaneous frequency deviation, the difference between the frequency of the carrier and its center frequency, is proportional to the modulating signal.

Digital data can be encoded and transmitted via FM by shifting the carrier's frequency among a predefined set of frequencies representing digits – for example one frequency can represent a binary 1 and a second can represent binary 0. This modulation technique is known as frequency-shift keying (FSK). FSK is widely used in modems such as fax modems, and can also be used to send Morse code. Radio teletype also uses FSK.

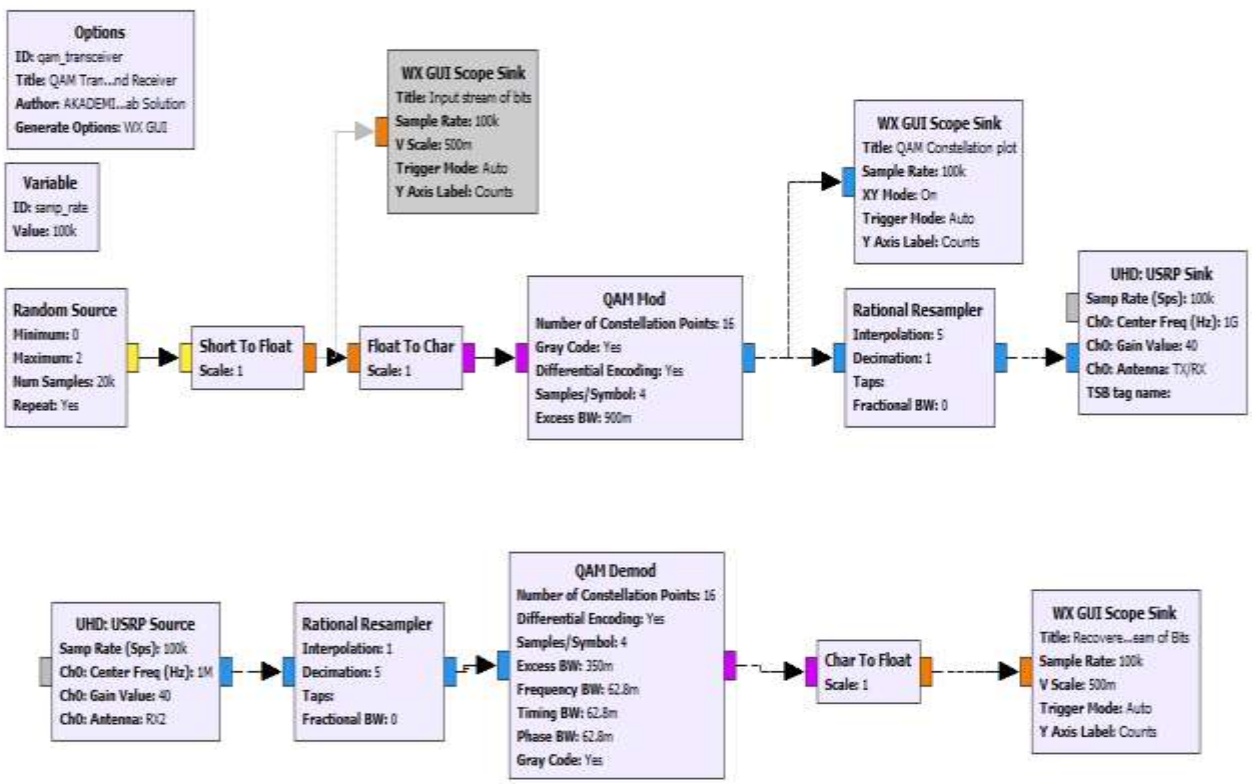
Frequency modulation is widely used for FM radio broadcasting. It is also used in telemetry, radar, seismic prospecting, and monitoring newborns for seizures via EEG, two-way radio systems, music synthesis, magnetic tape-recording systems and some video-transmission systems. In radio transmission, an advantage of frequency modulation is that it has a larger signal-to-noise ratio and therefore rejects radio frequency interference better than an equal power amplitude modulation (AM) signal. For this reason, most music is broadcast over FM radio.

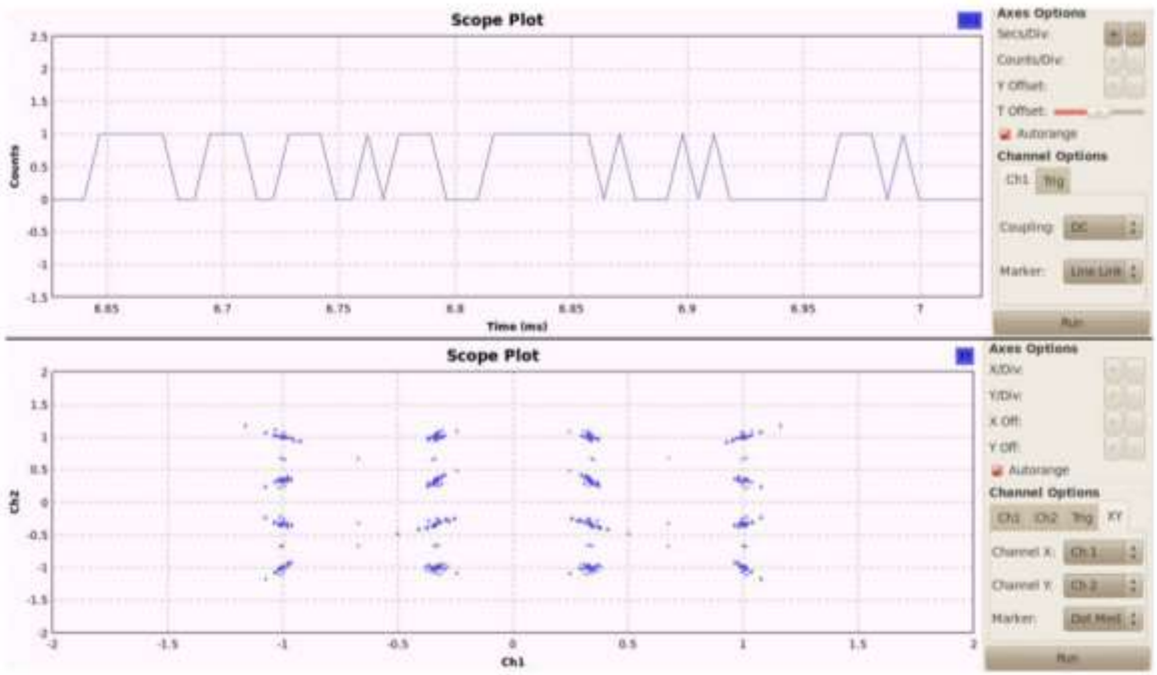


3. Practical Applications of SDR using Modulation Techniques

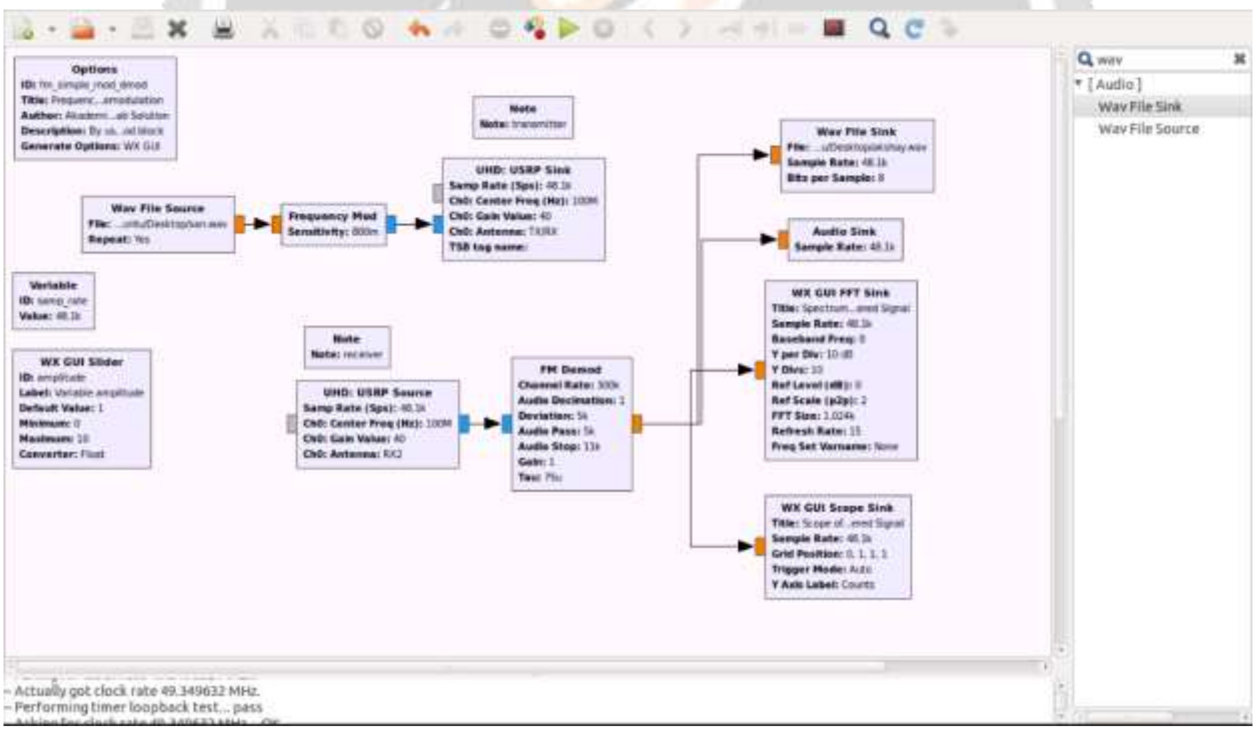
SDR is used to implement various applications such as transmitting audio files by FM modulation, text file by GMSK modulation, so in this section we are going to see some of the SDR applications and modulations.

3.1 Implementation of QAM

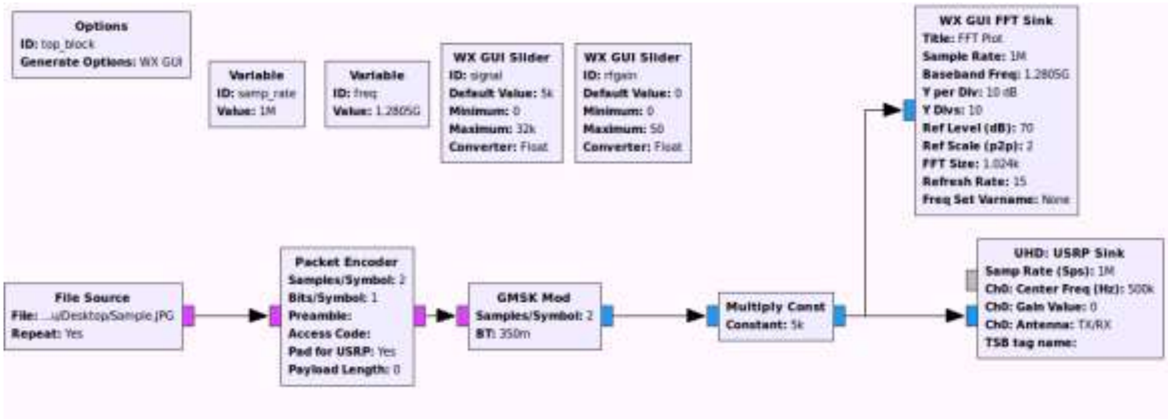


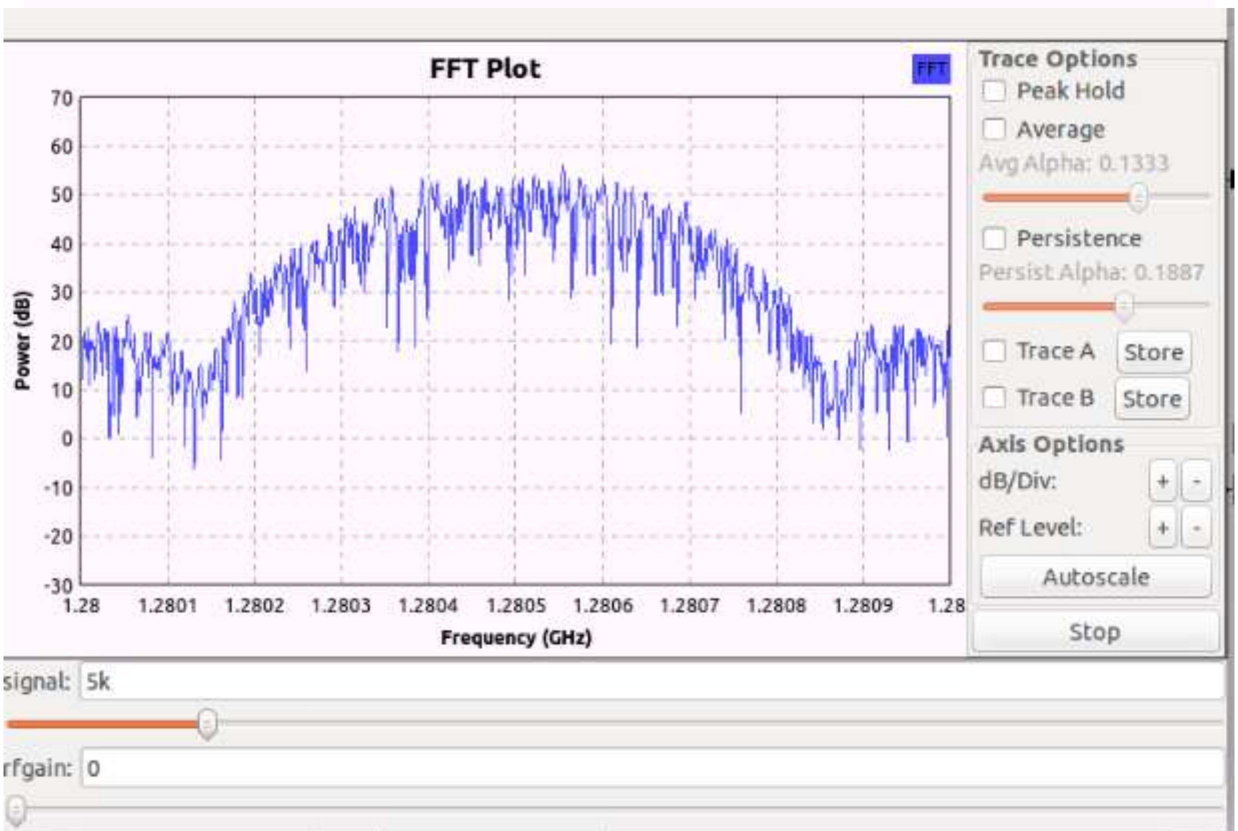


3.2 Transferring Audio File Using Frequency Modulation



3.2 Transferring Image or Text file Using GMSK





4. CONCLUSIONS

SDR is powerful tool whenever it comes to transmission of data wirelessly. In todays world wireless technology is crowded with lot of transmission standards and also the number of users is increasing day by day. So by using SDR we can provide solution to this problem by using various modulation techniques and future technologies such as **Cognitive Radio** (CR). SDR allows us easy implementation of modulation and demodulation schemes.

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