Simulation and Implementation Prototype of Digital Video Broadcasting by Software Defined

Nabiha Ben Abid† and Chokri Souani2††,

†Université de Monastir, Faculté des Sciences de Monastir, Laboratoire de Micro-électronique et Instrumentation, Av. de l'Environnement 5000 Monastir, Tunisia
†† Université de Sousse, Institut Supérieur des Sciences Appliquées et de Technologie de Sousse, 4003, Sousse, Tunisia

Abstract
This research tries to answer the problem of interconnecting several vehicles in real time with the lowest cost. This led to exploit existing technologies. Currently, the field of wireless communications has undergone great evolution. Thus, major challenges however need to be addressed to offer a secure and reliable exchange. Therefore, the paradigm of software-defined radio or "Software Defined Radio (SDR)" emerged, the goal of which is to transport the constraints of signals (RF) from the analogue world to the digital world configured by software in clearer and simpler difficulties to manage. This approach in the vision of the problem has led to study the possibility of realizing a wireless communication prototype based on a software radio solution aiming to transmit audio visual data between the concerned elements, in an efficient and effective manner and at low cost. In this case, it is necessary to analyse and study the performance of the system as a function of quality service parameters (QoS) such as constellation plot, bit error rate (BER) and spectral density of power using BPSK and QPSK modulation techniques in the GNU radio environment. With a view to the realization of this project, our mission has been successfully performed which involve sending a video from a source to a destination via an SDR transmitter / receiver based on GMSK modulation on an open platform source called GNU Radio and Universal Software Radio Peripheral

Key words:
SDR, GMSK, Streaming video, H.264, BER, Modulation, GNU Radio

1. Introduction

According to the report of the World Health Organization (WHO) [1], road accidents will become by 2030, the seventh cause of death in the world. Nearly 1.3 million people die each year from this scourge. To deal with this problem, the contribution of the automobile industry becomes essential. This is what has aroused the interest of researchers and automobile manufacturers in equipping vehicles with intelligent systems for better management of road traffic. With the rapid growth of bandwidth-intensive applications, which mainly affect video, the axis of intelligent transport systems has attracted a lot of interest. The problem of data transfer between a transmitter and a receiver has led to the proposal of new wireless communication methodologies. The architectures of traditional radio transmission systems present certain challenges, including security, reliability, availability, portability and cost. Thus, to cope with these constraints, in-depth research is carried out and compared to the architectures that have prevailed for nearly a century [2].

As a result, in order to meet today's challenges and enable wireless multimedia applications, a new wireless communication system must be designed. Finding the best modulation technique that will work is also essential [3]. More systematic structures may be used to manage these types of signal processing. It's possible that new hardware will be installed as part of the upgrades. The most successful approach to this issue is to use SDR, a rapidly emerging technology of reconfigurable hardware that is more versatile and cost effective [4]. SDR is an intelligent wireless communication device that is aware of its surroundings and employs the understanding-by-building technique to respond to statistical variations in the input, with the aim of ensuring accurate communication and effective radio spectrum use [5]. It is a technological concept [6], defined as a configurable wireless communication system that has made it possible to replace technological hardware constraints into software constraints, easier to solve and less expensive. The GNU Radio software [7] is free and open source software that contains signal processing blocks. Communication applications using GNU Radio are designed with the blocks

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included in this software. These signal processing blocks are created using the C++ programming language. The Python language, on the other hand, connects these blocks to create flowcharts. For the SDR, it manages various forms of signal processing [8].

USRP devices that allow sending and receiving radio frequency signals within a certain frequency range are among such equipment. USRP devices allowed personal computers to become high-bandwidth SDR systems. The NI USRP-2920 having transmit and receive frequency range of 50MHz-2.2GHz along with GNU Radio software. It is a software programmable hardware transceiver which allows rapidly designing and implementing powerful SDR systems [9].

GMSK is a typical modulation technique used in wireless applications. The findings of this research reveal that GMSK is capable of reliably transmitting real-time video data [10]. The pulses of GMSK are formed by combining MSK with a sinusoidal pulse and applying a Gaussian filter. A Gaussian-shaped impulse response filter produces a signal with low side lobes and a wider main lobe. Because it uses a Gaussian filter for pulse shaping, this modulation is known as GMSK modulation. The relationship between the pre-modulation filter bandwidth B and the bit period T determines the device's bandwidth. The Gaussian filter response is given by equation (1). Figure 1 shows a Gaussian filter with a standard Gaussian distribution for the impulse response. for different values of BT=0.5, 0.3 [11].

$$r(t) = \frac{1}{2}\left[erfc\left(\pi\sqrt{\frac{2}{log2}}\,BT_b\left(\frac{t}{T_b}-\frac{1}{2}\right)\right) - erfc\left(\pi\sqrt{\frac{2}{log2}}\,BT_b\left(\frac{t}{T_b}+\frac{1}{2}\right)\right)\right]\ldots \quad (1)$$

It's worth noting that when BT_b drops; the frequency shaping pulse's temporal spread grows. GMSK modulation was chosen for video transmission because it balances spectral power and low spurious radiation complexity, lowering the chance of neighboring channel interference [12]

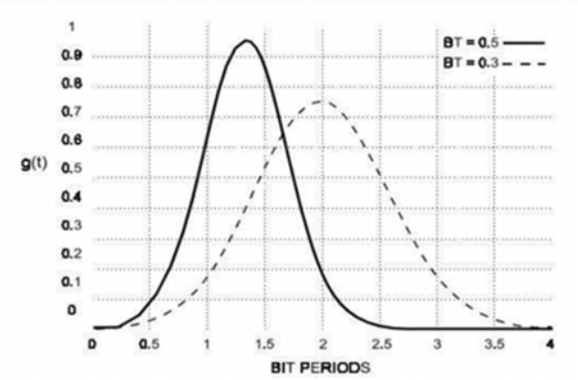

Fig. 1 Gaussian response filter with various BT_b values

Compressing digital video is very important in wireless communication applications. Video compression, transferring medical videos, 3D medical images with low bandwidth. It is used in many fields such as transferring in networks [13]. Video compression performance comes to the fore when transferring high-quality videos on low-bandwidth networks. In this study, the H.264 standard was used to compress the raw video obtained through the Gstreamer library. H.264 works by dividing a video image into small and variable-sized macro blocks and transferring the motion information seen between these blocks. In this study, in order to evaluate the performance of the H.264 standard and to learn the bitrate of the data to be transferred, the values given in Table 1 were obtained by comparing the data obtained by compressing the raw video taken from an external camera and the video taken from the same camera with the H.264 standard.

GStreamer is a library designed using the C programming language, which allows the processing of the acquired video data. This software supports MP3, Ogg/Vorbis, AVL, MPEG-1/2, QuickTime, H.264 and many other multimedia formats and allows many signal processing applications on files with these formats. GStreamer basically contains structures called elements and by combining these structures, structures called Pipelines are obtained. Element structures allow simple manipulation of media, such as capturing, playing, scaling, compressing, etc. Elements are connected one after another and if the input and output data types of successive element structures are not compatible, Pipeline is not generated and GStreamer generates an error. In this study, the compressed and scaled real-time video to be input to the GNU Radio software on the transmitter side was obtained through a pipeline created using GStreamer.

Table 1: H.264 or MPEG2 video compression performance

	Video Information		
	Resolution	***Frame rates***	***Binary bits***
Raw Video	1280x720 pixels	25 frames/s	928 Kbits/s
MPEG2 OR H.264 Video	1280x720 pixels	25 frames/s	128 Kbits/s

With this Pipeline, a real-time image was taken from the source file on the transmitter side, scaled to 1280 × 720 resolution and 25 frames/s, converted to H.264 format and broadcast. Once the pipeline is created, proceed to the step of generating the GNU Radio flowchart.
Our research was conducted as part of a project to provide high-resolution video transmission between vehicles, as well as meaningful information transfer and the elimination of distortions that occur during analog video signal transmission between two vehicles. The GStreamer library, the GMSK modulation technology, GNU Radio software, and USRP B210 devices were used to transmit high-resolution, real-time video wirelessly. On the reception side, a laptop computer is used, while on the transmitter side, an NI-USRP device is employed. With GNU Radio software, the NI USRP-2920 has a transmit and receive frequency range of 50 MHz to 2.2 GHz.

However, interference, noise and multiple fades wreak havoc on a reliable communication system. The bit error rate has its own importance in the quality of service (QoS). It is not very convenient to run the performance of the system, so to make it easier there is a platform where we can perform multiple modulation schemes. The SDR platform is much more convenient to use. The output of various modulation techniques such as BPSK, QPSK, QAM, PAM, GMSK and OFDM has been studied and analyzed in this field using various parameters such as constellation diagram, spectral density, and channel capacity power efficiency and bit error rate on various platforms, like Matlab/Simulink and GNU radio [14].

Our work is divided into three sections: first, we describe our system's methods and materials; second, we discussed two basic techniques, BPSK and QPSK, and evaluated their performance parameters such as constellation diagram, Bit Error Rate (BER), and PSD using GNU Radio over USRP; third, we explain the simulations, results, and interpretation of the development of a GMSK transmitter and receiver; and finally, we present the conclusion.

2. Methodology

The main goal of this project is to establish a configuration for broadcasting a digital video (DVB) stream via the USRP device, which is a video compression/transmission method. Figure 2 shows the block diagram system of our research.

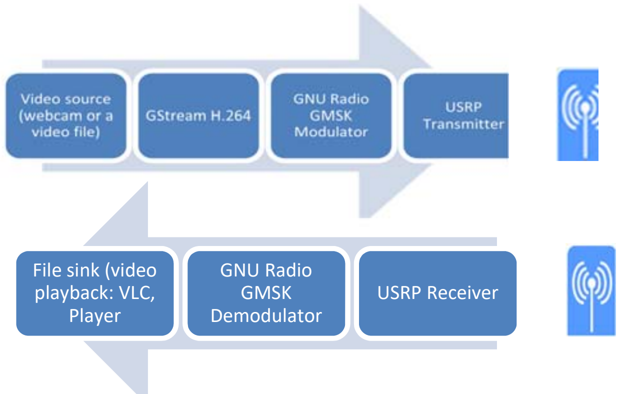

Fig. 2 Block diagram system

First and foremost, it requires an efficient technique to play the source video, including the recorded files, and stream them to the other end of the destination. Gstreamer receives the video feed, scales it to a specified bitrate, encodes it in MPEG, and sends it to the GNU Radio software. GNU Radio conducts essential data transfer operations on the digital data it receives, such as encoding and modulation, and transfers the resulting data to the USRP device via the USB interface. The data is delivered wirelessly to the receiving side by the USRP device, which elevates the data it receives to high frequencies and distributes it wirelessly through the air. VLC Player is used on the receiver side to play the data obtained by reversing the processes on the transmitter side. The video was streamed and encoded using VLC Media Player.

In general, always we find interference and noise problems in most communication systems which affect a reliable and robust system. Here, the GMSK system is implemented using GNU Radio and its performance under different modulation techniques; we have discussed about two basic techniques BPSK & QPSK and evaluated their parameters like constellation plot, BER, and PSD using GNU radio. We also looked at the GNU radio, how it is used, and how the simulation of diverse methodologies is done on a single platform. Figure 3 shows the block diagram for this step.

Simple operations, filtering, modulation / demodulation, and many other functions are covered by GNU radio's existing blocks. To construct a real-world interface, UHD (USRP hardware driver) blocks and audio blocks are employed. UHD blocks are added to the flow graphs to use the USRP to broadcast or receive signals from wireless media.

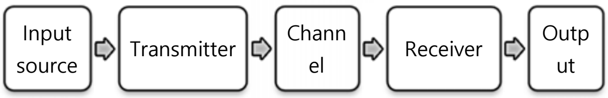

Fig. 3 Block diagram of digital communication

In the block diagram, the input source block is the very first block. This block's input can be in any format, including text, images, music, and video. The output of this input source block is sent on to the transmitter block, which is the next block. A transmitter, often known as a radio transmitter, is an electronic device that uses an antenna to emit radio waves. A radio frequency alternating current is generated by the transmitter itself and applied to the antenna. The antenna emits radio waves when it is energized by this alternating current. Typically, the term "transmitter" refers to equipment that generates radio waves for communication purposes. Then a channel is used to transport an information signal, such as a binary digital flux, from one or more emitters to one or more receivers. A channel's ability to transmit data is often measured in Hz or bits per second. A radio receiver is an electrical device that receives radio waves and translates the information delivered by them into a usable form in radio communications. It is used in conjunction with an antenna. The antenna picks up radio waves (electromagnetic waves) and converts them to small alternating currents, which are then applied to the receiver, which extracts the needed data. The receiver employs electronic filters to distinguish the desired radio frequency signal from all other signals picked up by the antenna, an electronic amplifier to boost the signal's power for further processing, and lastly demodulation to extract the desired information.

In this paper, we have implemented only two techniques within the simulation environment. The techniques are: Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK), in digital modulation techniques binary phase shift keying is one of the simplest forms of techniques, one of two phases is transmitted by the carrier which is modulated by binary symbols "1" and "0" and for each hard bit duration T [15]. BPSK takes the highest noise level; therefore the demodulator makes an incorrect decision.

$$BPSK = A_C \cos(2\pi f_C + \pi), \quad m(t)=1 \tag{2}$$

$$BPSK = A_C \cos 2\pi f_C \quad , \; m(t)=0 \tag{3}$$

Where $m(t)$ the binary information to be is transmitted which is worth either '0' or '1'.

We consider QPSK as our next modulation scheme. In this modulation scheme, there will be two information bits for each symbol duration during transmission by one of the four possible carrier phases (0. 90. 180. 270), the carrier phase is modulated. By the binary symbols "00", "01", "10", "11" [16]. The advantage of QPSK over BPSK is that for the same bandwidth and same the binary rate, we can achieve the data rate twice.

$$\emptyset_1 = \sqrt{\frac{2}{T}} \cos(2\pi f_c t), \quad 0 < t \leq T \tag{4}$$

$$\emptyset_2 = \sqrt{\frac{2}{T}} \sin(2\pi f_c t), \quad 0 < t \leq T \tag{5}$$

- *Constellation diagram*

A constellation diagram is a depiction of a signal that has been modified using a digital modulation algorithm such as quadrature amplitude modulation or phase shift keying. At symbol sampling instants, it presents the signal as a two-dimensional X-Y plane scattered diagram in the complex plane. It shows the various symbols that may be picked by a given modulation scheme as points in the complex plane in a more abstract manner. The type of interference and distortion in a signal can be identified using measure constellation diagrams.

- *Bit Error Rate*

Finally, we analyzed the questionnaires data and based on the findings, some results and recommendations are suggested. The next section shows the results of the companies' survey.

- *Power Spectral Density (PSD)*

The frequency response of a random or periodic signal is called power spectral density. It shows how average power is distributed as a function of frequency. The PSD is deterministic, and it is time independent for some types of random signals

3. Simulation, Results and Interpretation

In this study, two different designs of GNU Radio flowcharts were performed. First, we performed modulation technique simulation to find the performance of our video stream system based on GMSK modulation under GNU Radio. We use a stored video file as the source. We try to play this video sent by the transmitter and check the QoS parameters (constellation diagram, BER, and PSD)

To smooth the graphics, we started with the constellation diagram modulation graph in Figure 4 which contains a source file block .ts goes to the Packet encoder at a 2 symbol per samples and one bit per symbol then we move on to the block GMSK mod (complex) which is characterized by 2 samples per symbol, then 2 for the constant parameter in the constant multiply block, finally a QT block Gui constellation Sink displays the constellation diagram for BPSK.

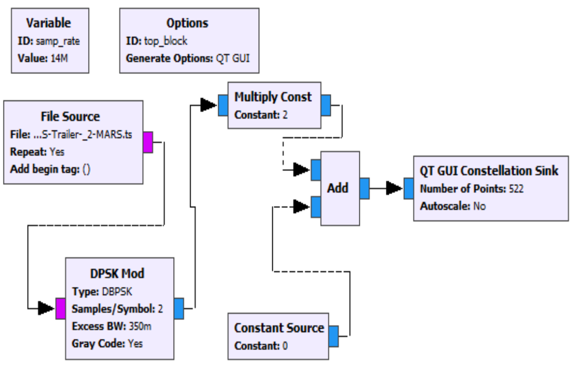

Fig. 4 BPSK Constellation flow graph

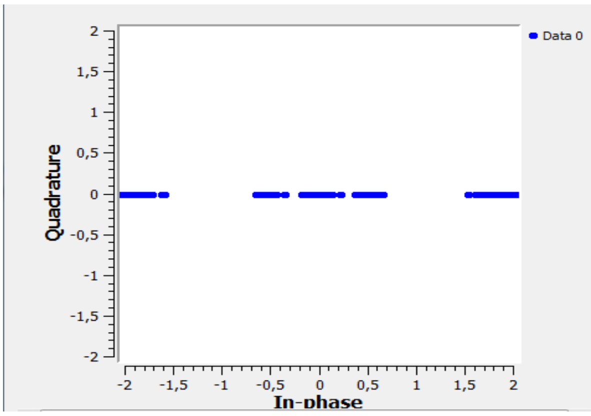

Fig. 5 BPSK Constellation Diagram.

In the QPSK modulation, we added the most important block in this simulation which is the DQPSK type DPSK MOD block characterized by two samples per symbol and we added to this block a Gaussian type noise source to display a constellation diagram correct QPSK modulation.

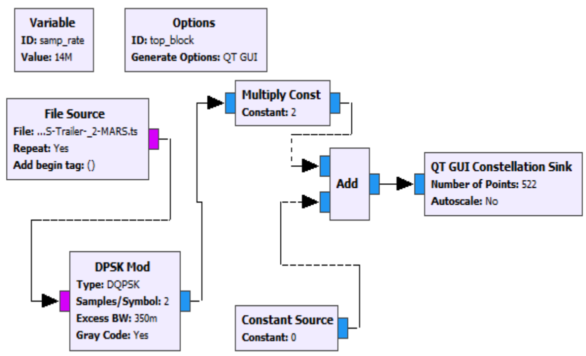

Fig. 6 QPSK Constellation flow graph

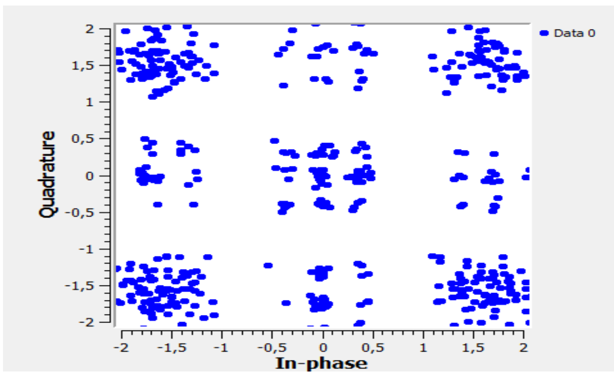

Fig. 7 QPSK Constellation diagram.

The implementation of QPSK on GNU radio is shown in the diagram above (Figure 6). The simulated output of the constellation diagram for QPSK is shown in Figure 6. Because of the noise effect, the simulated outcome is warped. To represent four separate input symbols, the phase shift of the wave can be any of the four values π/4, 3π/4, 5π/4 or 7π/4. (00, 01, 10 and 11).

When using digital transmission, the percentage of bits containing errors divided by the total amount of bits transmitted, received, or processed over a specific period of time is called BER. Typically, the rate is stated as 10 to the negative power. The digital equivalent of signal-to-noise ratio in an analog system is BER. We started with the error bit binary phase modulation graph in Figure 8 which contains a file source block of type .ts at a sample rate value of 14 MHz and then move on to the error rate block of type .ts. Bit Error Rate which is characterized by a bit per symbol, finally a Wx Gui Number Sink block displays the error rate percentage 0.4419% with variable_static_text = 0.0 and EBN0 = 10.0 in db.

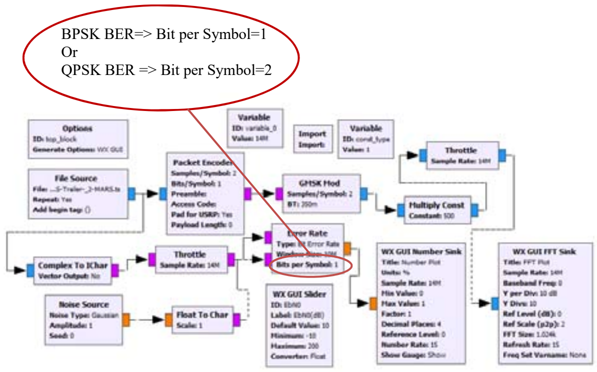

Fig. 8 BER BPSK flow graph

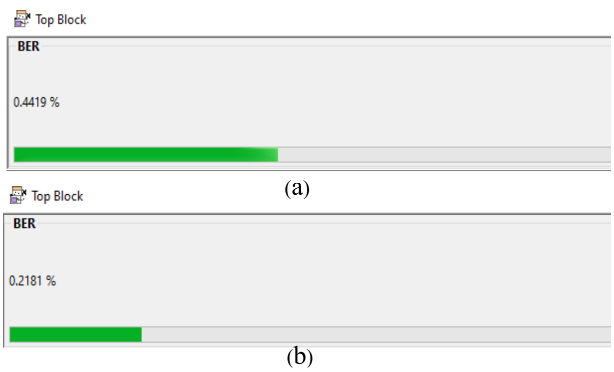

Fig. 9 (a) BPSK BER output (Bits per Symbol=1), (b) QPSK BER output (Bits per Symbol=2).

Same as QPSK BER except that the difference is at bits per symbol equal to 2 instead of 1, Figure 9(b) is the simulated output of the BER percentage for QPSK equal to 0.2181%.

From the simulations of figure 8 we can say that the BPSK system is double that of the QPSK system, the selection of digital modulation system is mainly affected by the variable Bits per Symbol in the Error Rate block. Three key criteria influence the choosing of a digital modulation system: Efficiency of bandwidth at the receiver, Error performance is defined as the likelihood of making a bit error as a function of signal-to-noise ratio, Equipment complexity.

The most recent implementation is based on BPSK's Power Spectral Density. Power Spectral Density (PSD) is a metric for signal strength that is used to calculate the signal's power by evaluating the PSD's area. When considering filtering in a communication system, this parameter is critical. Figures 10 and 11 show the performance of PSD for the BPSK approach in the GNU radio environment.

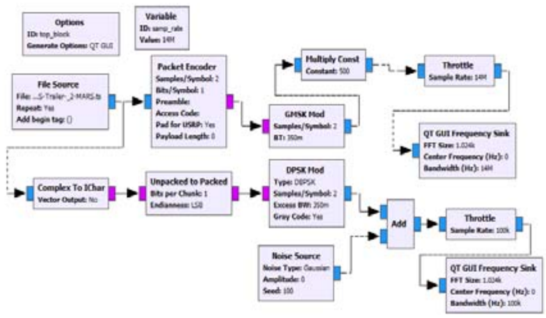

Fig. 9 PSD BPSK flow graph

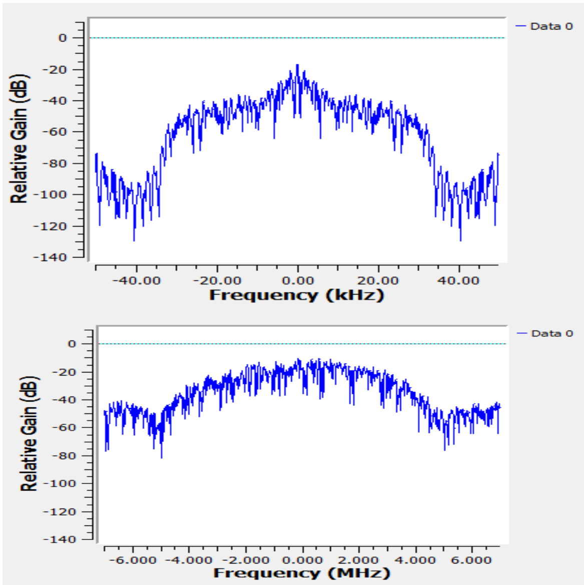

Fig. 10 PSD BPSK Output.

Now we move on to the second part of our article which discussed the implementation of a GMSK modulation in gnu radio. First, we performed a video streaming simulation based on GMSK modulation under GNU Radio. The source is a video file that has been saved. We try to play the video that was sent by the transmitter and see if we can recreate it on the receiver. This must be done in simulator mode, without using USRP, and simply cycling through the transmitter and receiver this implemented configuration is shown in Figure 8 through this simulation, we passed the stream successfully. After that, we ran a second test with the identical parameters as the first, but this time we added the NI-USRP 2920 device, which had to be incorporated into the image, and we deleted the looping. The same device, USRP, is used to implement both the receiver and transmitter sides the video is thus transmitted successfully but with a quality less than the 1st test and a delay time obtained during video transmission. The GNU Radio flowcharts are shown in Figures 10 and 11. In both configuration cases, VLC Media Player, which serves as the new video source, can be used to create a live video source. GStreamer is a multimedia framework. The specification of GMSK Based Real Time Video Transmission on SDR Platform using GNU radio is reported in Table 2.

Table 2: Specification of GMSK Modulation

Parameters	Values
Sample rate	14 MHz
The BT	350 m
Samples per symbol rate	2
SNR	50
IP address (UDP)	127.0.0.0
Port (UDP)	1.234 K
Destination IP address	127.0.0.1
Destination port	5.008 K
Center frequency	88 MHz

3.1 Simulator Mode without USRP

In the first phase, we use a saved video file as the source. We try to play the video that was sent by the transmitter and see if we can recreate it on the receiver.

This has to be done in simulator mode without using USRP and just by looping back the transmitter and receiver. This implemented configuration is shown in Figure 12. The system input is a pre–recorded video file in .TS format that is processed by the GNU Radio software. This video sent by the transmitter was played on the receiver to check if the latter recovers the original signal sent. This was done in simulator mode without using USRP. This test was done to ensure a reliable implementation and solid debugging when we bring USRP into the picture. When transcoding the media, in this case a .TS video file, we reduced the audio and video bitrate. The role of the GRC session is to modulate and demodulate the incoming signal and sends the baseband audiovisual data which will be recovered by the VLC on output through the UDP protocol on the IP address and the assigned port. The video was streamed to the PC local host over the IP-based network; the mainly used data transfer protocol is UDP transport protocol

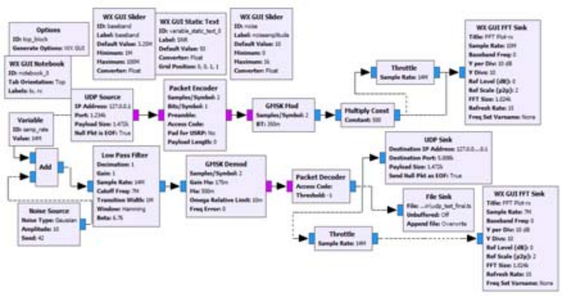

Fig. 12 Flow graph of a simulator mode GMSK modulation.

In simulator mode, we were able to send and receive a video file with a loop from transmitter to receiver using GMSK modulation. As a result, the first test was successful. Figures 13 and 14 show the spectrum result of the transmitted video as well as the received video. The video file is saved to a file and successfully streamed to the VLC receiver over the GNU radio. This flow chart for GNU Radio shows how to get from one network port to another. VLC player handles encoding, mixing, and transcoding.

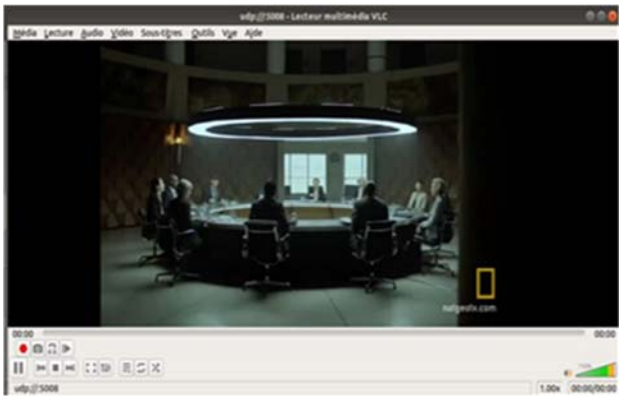

Fig. 11 Successful video reception

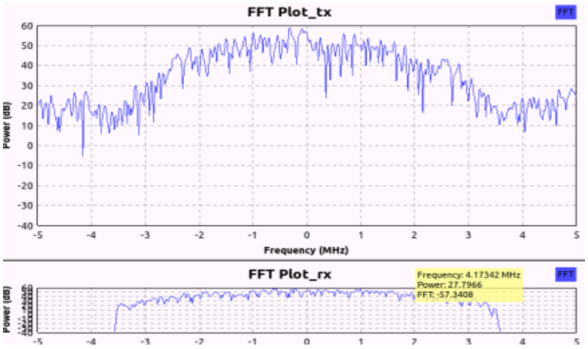

Fig. 12 GMSK Modulation Spectrum

In the GNU radio streaming block diagram, there are two primary parameters that must be modified. The sampling rate is the most significant feature of GNU radio. The number specifies the block diagram's maximum available sample rate and restricts the bit rate to half of the sample rate. The sampling rate should be double that of the highest rate of information. To demonstrate Shannon's theory, the stream's maximum video bitrate must be less than half the sample rate. In our example, the filter cutoff frequency was set at 7 MHz after research and testing, and the variable sample rate was set at 14 MHz, where the value is twice or equal to the cutoff frequency. The noise or SNR variable to assess the impact of noise for transmission was set at 50 in our case.

3.2 Simulator Mode with NI-USRP

NI-USRP 2920 hardware will be introduced in the implementation image (Figure 15): The modulated source file is transmitted using a USRP transmitter. The transmitted signal is received by the receiving USRP and demodulated by the GNU Radio then played on the VLC Player.

this test bench, the signal is processed using the USRP device connected to the computer. Initially, the transmission is carried out at a predefined frequency fixed at 88 MHz

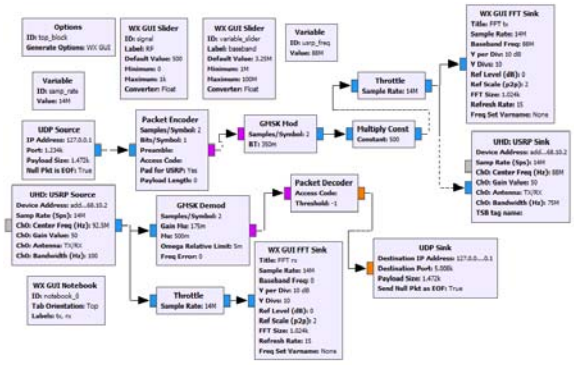

Fig. 13 Diffusion graph with USRP.

After making this implementation, it can be concluded that the behavior of the signal is transmitted successfully, but with more errors and interference, this was expected. Figures 16 and 17 represent the shape of the frequency spectrum of the signal.

The video quality in this mode is degraded which is obvious and can be attributed to several factors. This is due to the greater sources of error that the signal can experience during its transmission which can come from several and different elements like the noise introduced by the USRP, and it can also come from Ethernet connection port. Some packet loss due to the inability of spontaneous synchronization between transmitter and receiver frequency. Although there was some packet loss, the degradation in quality was not high enough. Secondly, when the network was unstable or poor quality, there will be a considerable amount of received erroneous packets or packet loss which caused the video not to be played or played slowly.

It can also be said that the data has been successfully transmitted to the receiver. There was an observation delay of 10-20 seconds during transmission of the real-time video signal.

Fig. 14 Successful Stream.

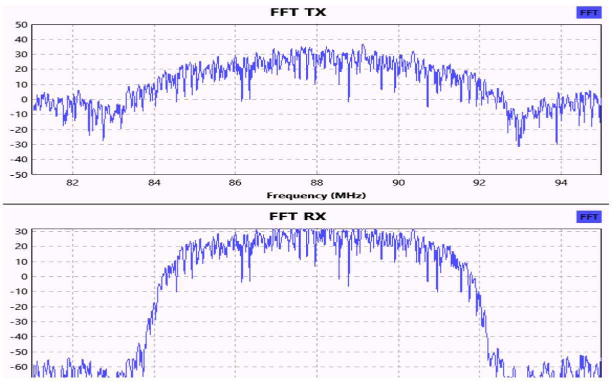

Fig. 15 GMSK Modulation Spectrum With USRP.

Apart from the sample rate and the SNR variable, the center frequency of the USRP device has been changed. The frequency should be as high as the bandwidth of the information signal is installed in the communication band. All other settings should be left at their default values in this configuration. During this experiment, some constraints cannot be ignored among these constraints; the received signal is not reproduced perfectly due to the different sources of disturbance.

Signals can be observed at various points using FFT and scope plots while transmission of video signal. One such signal is shown in figure 16 and 19 the horizontal axis shows the frequency values and the vertical axis shows the signal power value at each frequency in dB (decibel). The maximum signal strength is 30 dB on the transmit side and 33 dB on the receiver side. In the figures, the width of the horizontal axis represents the bandwidth and this value was chosen as 14 MHz in our study.
The first phase of the project was completed successfully, thanks to the experimental arrangement described above. Using GMSK modulation in simulation mode, we were able to send and receive a video file with a boucle of return from the transmitter to the receiver. For the second component, we must maintain a consistent data flow in binary debit for the USRP. To achieve so, we'll use an H.264 encoder, and we'll make sure that the transmission and reception of the video file are both smooth and successful, albeit of mediocre quality.

4. Conclusion

Here in this article the focus is on transmitting the video source using a GMSK modulation scheme, the experiments using GNU radio were performed to see the BER, PSD and Constellation plot for a transmission using BPSK and QPSK modulation scheme and also saw the same for text file transmission and reception through USRP hardware device at 1MHz bandwidth and wider operating frequency range and frequency of higher sampling, the latter proved satisfactory in testing and configuration, and capable of transmitting live video as well as receiving streaming video. The open source GNU radio software is a very powerful platform for implementing real-time video transmission. Real-time video encoding and decoding can be performed significantly with minimal data loss by using H.264 encoder and H.264 decoder. The effectiveness of SDR is demonstrated when changes to the modulation technique are made in software rather than hardware. For video streaming demonstration, we successfully designed a video transmission system using GMSK over real-time SDR based on USRP 2920. The procedure to perform these experiments was discussed and demonstrated in detail with the results. The results obtained show that the estimation of the quality of the radio channel allows the implementation of voice and video image services with SDR radios. This work will help convert any theoretical study into a physically feasible study.

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Nabiha Ben Abid obtained her fundamental degree, her professional master's degree and her research master's degree in electronic systems at the National School of Electronic and Telecommunications in Sfax, Tunisia, in 2011, 2013 and 2015, respectively. Currently, she is preparing her doctorate in Electronics and Microelectronics at the Faculty of Sciences of Monastir. His main research focuses on software defined radio, Video transmission using USRP and SDR, Detection for FMCW Ground Penetrating Radar Using Software Defined Radio

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Chokri Souani is Professor in Electronics and Microelectronics, at Higher Institute of Applied Sciences and Technology Sousse, Tunisia. He is currently team leader in the Microelectronics and Instrumentation Laboratory µEI (LR13ES12). His research interests include Software Defined System, SDR, SD-SoC, MPSoC, Embedded System, Computer Vision, Big Data, IoT, Smart City, Communicant Vehicle & ITS, Small Satellite & Applications.