Design And Implementation of 5G Wireless Telemedicine Systems

Lalit Chettri
Sikkim Manipal University
India
lalitelectricalengineer@gmail.com

ABSTRACT: *Recently, remote healthcare systems have received increasing attention in the last decade, explaining the need for e-health care. This paper deals with the design of 5G Wireless communication systems and further it is implemented in telemedicine systems. As 5G deals with FBMC as a physical layer and this has been chosen because it has the higher spectral efficiency and better interference rejection as compared to that of other multicarrier techniques. Initially OFDM was the first choice in wireless communication but due to the use of cyclic prefix it has the high PAPR which is less suitable in 5G systems. The main motivation to jump into 5G technologies is that it has more connected devices and it the ability to allocate the underutilized spectrum to the secondary user verifying the certain policies. As these telemedicine systems is the most promising technologies in health care especially in remote places and 5G systems has higher data rate where the health specialist can receive the patient status at less time and act as per the condition. This paper details about the transmission of patient vital sign, image and video and analysis which are most essential components in future Telemedicine systems.*

Keywords: 5G Wireless, Telemedicine, FBMC, Offset, Polyphase, Filter Bank, Synchronization, Vital Signs, Equalization.

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1. Introduction

Telemedicine is the wireless systems which uses information and communication technology. In these systems the remote hospitals can be considered as the transmitter section and one of the specialist hospitals can be considered as the receiver section. A healthcare system can be made reliable with the advances in wireless and network technologies called 5G technology. The aim of this telemedicine system is to provide expert-based healthcare to under staffed remote sites through future telecommunication (wireless communications) and information technologies. The main telemedicine system components in includes bio signal sensors, processing units, data communication networks, and medical service center. The bio signal sensors are responsible for acquiring the physiological data (patient's vital signs) and transmitting it to the signal processing unit. At the next stage, sensor layer of every remote monitoring system is typically connected to the processing device for signal acquisition, processing, analysis, and formatting data to be sent to the 5G communication channel. Also recent advances in wireless and network technologies make it possible to develop a wireless telemedicine system which offers an effective means of bringing healthcare services to patients with less time consumption and transmission efficiency. The proposed telemedicine systems uses developed 5G wireless systems considering filter bank multicarrier (FBMC) as a carrier waveform. The main reason in choosing FBMC is that it has lesser peak to average power (PAPR) compared to other multicarrier techniques. The main advantage of using FBMC is that it has less bit error rate (BER). As we have seen that the existing multicarrier uses one filter per multiple subcarrier but the future waveform technologies uses individual filter for single subcarrier called as polyphase filter bank, which results in less inter symbol interference. 5G wireless telemedicine deals with the transmission of Patient vital sign such as ECG, temperature, Blood Pressure, blood oxygenation and still images. Video conferencing is one of the major trends in telemedicine system and all the parameters in telemedicine has been designed and successfully implemented in 5G wireless communication system.

2. Design of 5G Transmitter

The 5G transmitter is designed using Offset Quadrature Amplitude Modulation (OQAM) preprocessing, Poly phase network and OQAM post processing It uses QAM mapping followed by the application of offset of M/2 samples in time domain between the in phase (I) and quadrature (q) components of complex signal. The term offset refers to the time shift of half of the sub channel per sub carrier. The resulting OQAM mapper enables an efficient reduction of Inter carrier interference (ICI) and inters symbol interference (ISI). The separation process is known as synthesis filter banks. FBMC applies a filtering operation through the introduction of a poly phase network after IFFT. This block also reduces ICI and ISI. In this sense the real to complex conversion decreases the sample rate. A time offset of half a QAM symbol period (T/2) is applied to either the real part or the imaginary part of the QAM symbol. Figure 1. shows the design of 5G transmitter.

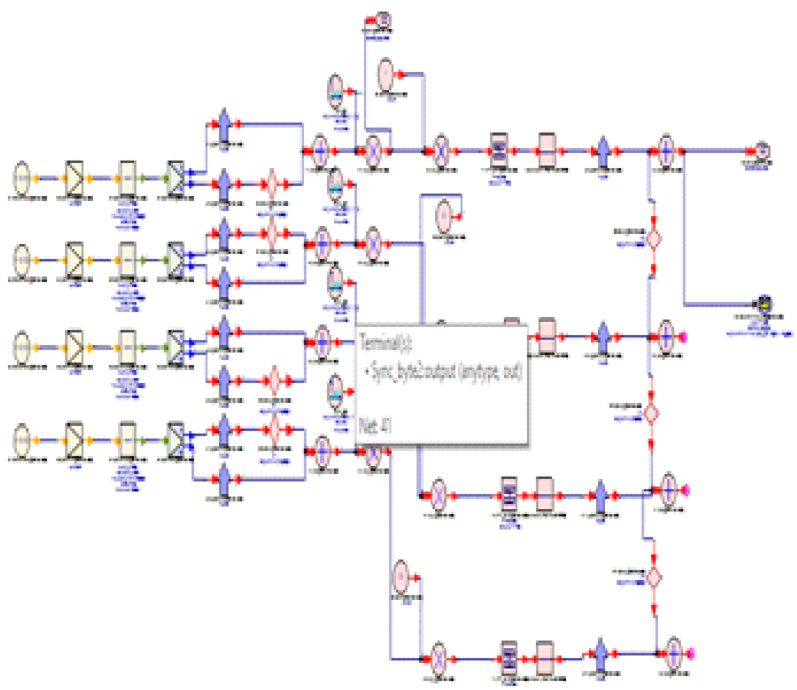

Figure 1. Design of 5G Transmitter

The entire model is designed using the software called Systemvue 2013.01. Here I have used random bits as the input signal, which is then converted to the integer. The Bits to integer converter model converts the bits value into its corresponding integer. Digital Modulation model can be used to generate digital modulation signal on baseband, including the basic modulation schemes. The modulation scheme selected here is 16 QAM. The oversampling ratio used is 16. The Set Sample Rate model associates the sample rate with its input signal and creates a timed signal at its output. Here the sample rate provided is 1.6e+007 Hz. The CxToRect model converts input complex values to output real and imaginary values. This model reads one sample from the input and writes one sample to each of the output. For two successive sub-channels, say m and m+1, the offset are applied to the real part of the QAM symbol in sub-channel, while m-1 is applied to the imaginary part of the QAM symbol. Incoming signal from the multiplier is passed through CxToRect where real signal is passed through FIR filter and also through delay block. In delay block unit delay is applied to the incoming signal. The transmitter side involves the multiplication of theta (θ) and the beta (â). Here the value of theta we have used 1,j,1,j,1,j…… for even and j,1,j,1,j,1….for the odd. Here the poly phase filtering using the set of digital filters has been considered. The polyphase filter is design using the setoff three FIR filters. Data element is applied to one input of the IFFT and it modulates one carrier. It uses overlapping factor of k and modulates 2k-1 carriers. As we go on increasing k factor then the out of band rejection (interference) will be low and the spectral efficiency will be high. Each sub carrier is allocated with individual filters. Here iFFT size is M with sampling frequency is 1 with M carrier; therefore carrier frequency is 1/M.

3. Design of 5G Receiver

5G receiver makes the use of analysis filter bank which recombines the signal which is separated in transmitter section. It also uses, OQAM post-processing, which performs two operations: First operation is multiplication by è pattern that is followed by the operation of taking the real part. Second operation is real to complex conversion, in which two successive real valued symbols form a complex valued. In this sense the real to complex conversion decreases the sample rate. The receiver section involves the IFFT operation. The sub channel equalizer is considered in this section for time and frequency synchronization and the better interference rejection. Fig 2 shows the design of 5G receiver.

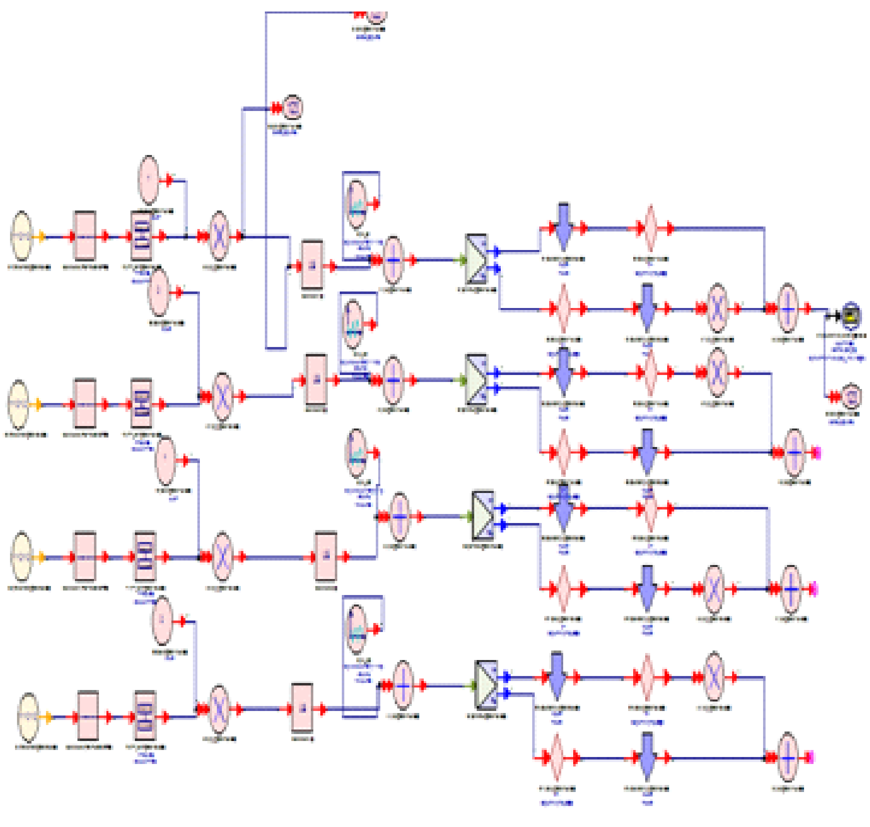

Figure 2. Design of 5G Receiver

For the transmitter section I have used the digital bits followed by the sub channel processing and the IFFT. Here it acts as the demodulator. Here also the value of beta is same as that of transmitter. The receiver is modeled with the sub channel equalization. The sub channel is modeled using the three tap FIR filter. The carrier will overlap at some instant of time. Hence this equalizer overcomes these problems. This model implements a real arithmetic adaptive filter (FIR or IIR) using the Least Mean Squares (LMS) algorithm. The LMS algorithm tries to minimize the error between the desired signal and the output of the filter based on the Least Squares (LS) criterion. Sub channel equalization can cope up with the variation in time and frequency and the phase and amplitude distortions.

3. Design And Implementation of 5G Wireless Communication Systems

The 5G wireless communications is designed using the developed 5G transmitter, receiver and the communication channel. 5G uses the millimeter wave and has higher performance and is less sensitive to RF impairments such as phase noise and power amplifier nonlinearities. Because of the high directivity of the mm wave transmission, the mm wave channel is relatively flat and the equalization of a single carrier solution may be simpler than what is required for a future wireless systems. Fig 3 shows the design of 5G wireless communications systems.

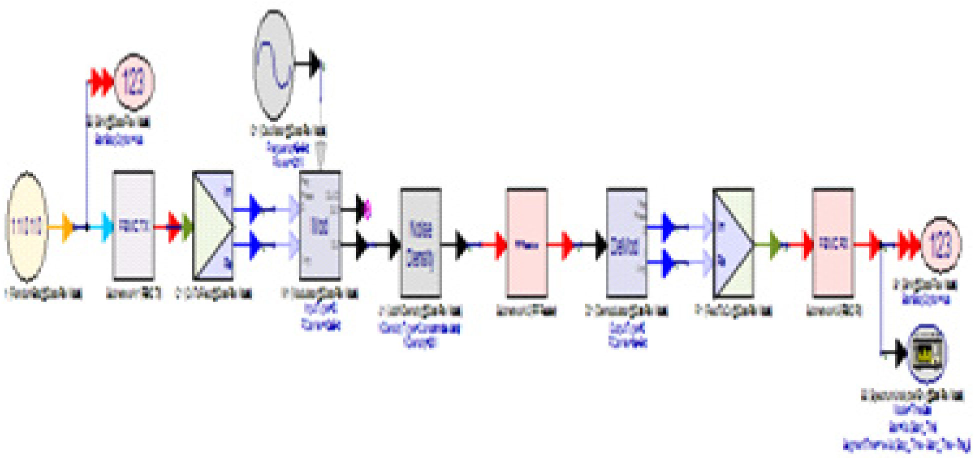

Figure 3. Design of 5G Wireless Communication Systems

The above model is designed using the simulated transmitter and receiver model. 5G wireless communication uses the FBMC as a waveform. It offers additional benefits as compared to OFDM. The regular CP is replaced by null symbols where null symbols are appended at the end of a group of symbols. The first additional advantage of NCP SC over a regular CP method (OFDM included) is that the null portion enables a built in guard period for switching of RF beams without destroying the CP property. As we know that the communication systems is characterized by the interference such as noise and this parameter is considered for designing. Initially the input is in the form of baseband signal and furthers it is converted into RF signal because the mm wave wireless communication uses the RF signals. Fig 4 shows the results of 5G wireless communication system.

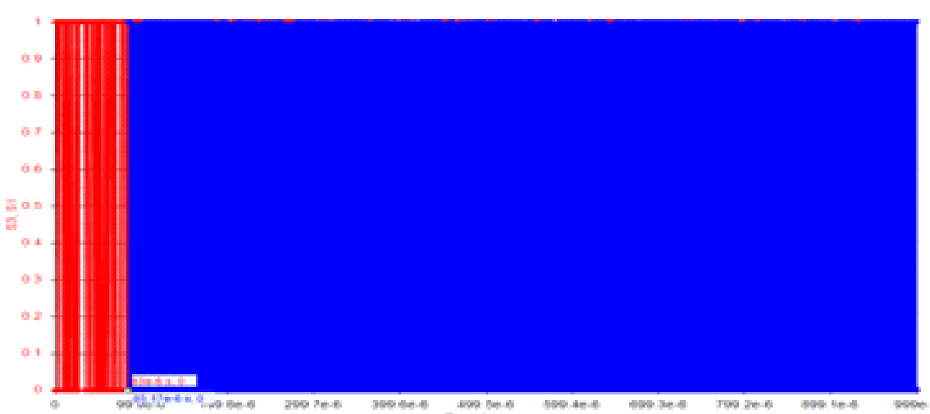

Figure 4. Time Domain Signal Of 5G Wireless Communication Systems

Here the red waveform represents the transmitter of FBMC model whereas blue represents the receiver section. In the above results the receiver is delayed with the time of 100is, which is almost identical to the transmitter. Since it is wireless communication system which consists of transmitter and receiver. Both these models are separated by a transmission channel which is accompanied by a noise, jamming and other interferences. As per the simulation results this model the amount of data transmitted from the transmitter section is fully received at the receiver, which means the system has lesser interference as compared to existing OFDM technology and proves that it is the most efficient multicarrier technique for future wireless communication technology, i.e. 5G Technology.

4. Design of Implementation of 5G Wireless Telemedicine Systems

The developed telemedicine systems uses the 5G transmitter in the remote hospitals and the receiver at the major hospitals where the patient health status is received and it is diagnosed and monitored as per the requirements. This telemedicine system uses the patient vital sign such as ECG, temperature, blood pressure, blood oxygenation still images and videos. Individual sensors is used to acquire the patient vital sig, processed and transmitted using 5G wireless communication systems.

4.1 ECG In 5G Wireless Communication Systems

An ECG is a bioelectric signal which records the heart's electrical activity versus time. The electrocardiogram is obtained by measuring electrical potential between two points of the body using specific conditioning circuit. The ECG signals are restricted in bandwidth of 0.5–100 Hz. The power line interference in the ECG signal is filtered by using FIR filter with taps equal to 1*8. Fig 4 shows the design of ECG signal processing blocks.

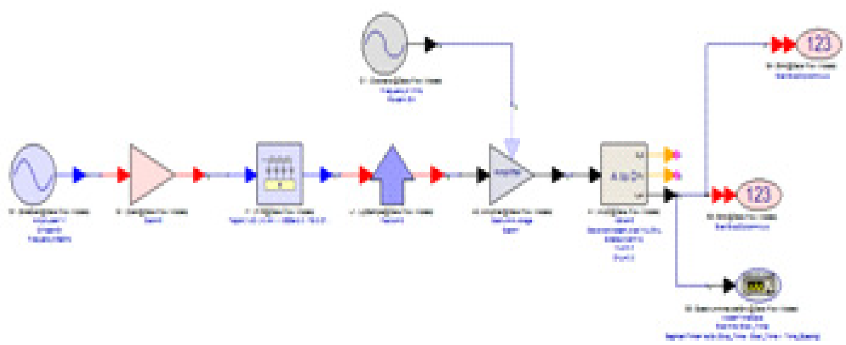

Figure 5. Design of ECG Signal Processing Blocks

The ECG is designed using the various digital signal processing, here I have given the gain of 5, followed by the FIR filter then the upsampling is given by a factor of 2 followed by the amplifier. Initially the input is analog is nature then the ADC block is used to convert the analog signal to digital. Fig 6 and 7 shows the transmission of ECG using 5G wireless communication systems and its results respectively.

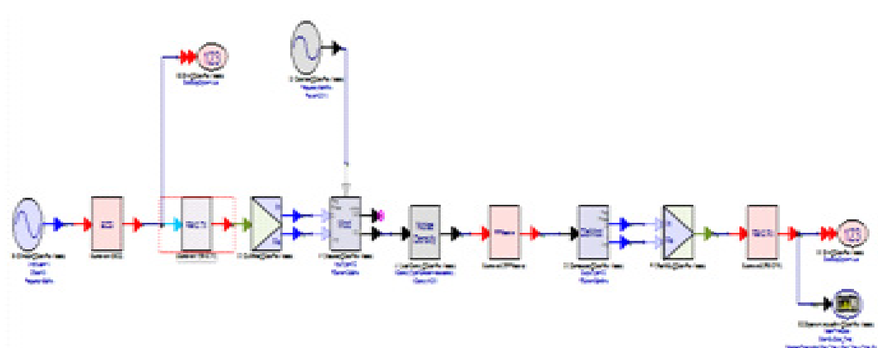

Figure 6. Transmission of ECG Using 5G Wireless Communication Systems

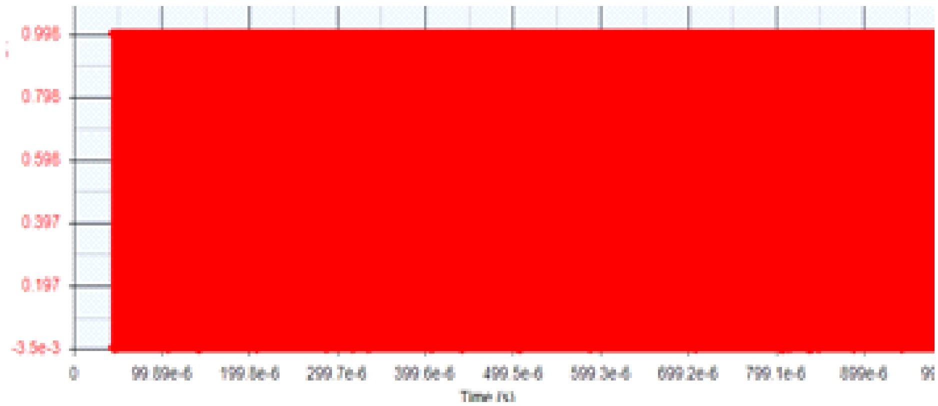

Figure 7. Time Domain Signal of ECG IN 5G Systems

From the simulation result of ECG block block, the three waves P Wave which denotes Artiral Contraction, QRS Wave which denotes Contraction of Ventricles and T Wave represents the Relaxation of Ventricles. From the bove simulation block it is clear that the ECG signl has been clearly transmitted with the delay of about 50μ sec.

4.2 Temperature / Blood Pressure / Blood Oxygenation In 5G Wireless Communication System

As per the health expertise the temperature, pressure and the blood oxygenation is determined by the numerical values. Various types of temperature sensors are used to extract these vital signs and then it is processed using various digital signal processing technologies. The temperature of a healthy person is about 37 degree C; it may slightly or temporarily increase in hot environment or in physical activity; in extreme effort, the increase may be very high. It is of great medical importance to measure body temperature. The reason is that a number of diseases are accompanied by characteristic changes in body temperature. Likewise, the course of certain diseases can be monitored by measuring body temperature, and the efficiency of a treatment initiated can be evaluated by the physician. (SpO2) and Heart Rate.SpO2 or pulse oximetry is the measure of oxygen saturation in the blood, which is related to the heart pulse when the blood is pumped from the heart to other parts of the human body. For simulation purpose I have considered the normal human temperature i.e. 37 degree centigrade. Fig 8 shows these vital signs in 5g wireless communication systems.

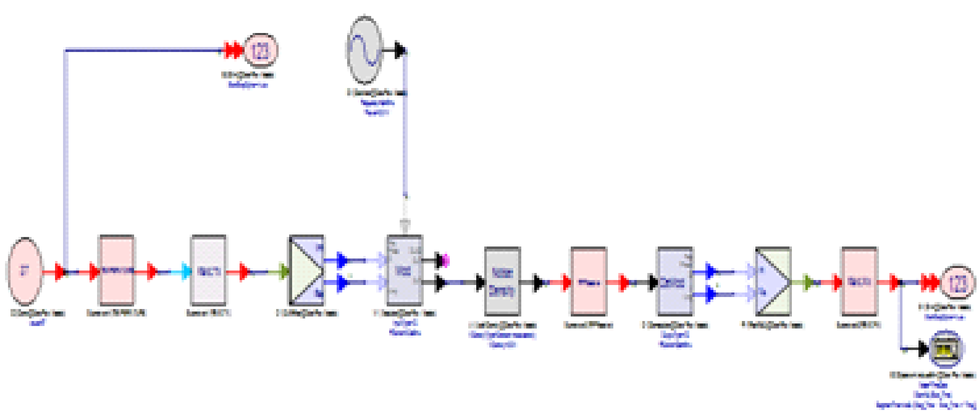

Figure 8. Patients Vital Sign in 5G Wireless Communication Systems

The above model is designed using the same 5G wireless communication. The input given here is constant which represents the patient vital signs. Initially these signals are extracted using the sensors and signals are processed using various digital signal processing and finally it is transmitted through the designed 5G wireless communication model. Fig 9 shows the result of vital signs in 5G wireless communication systems.

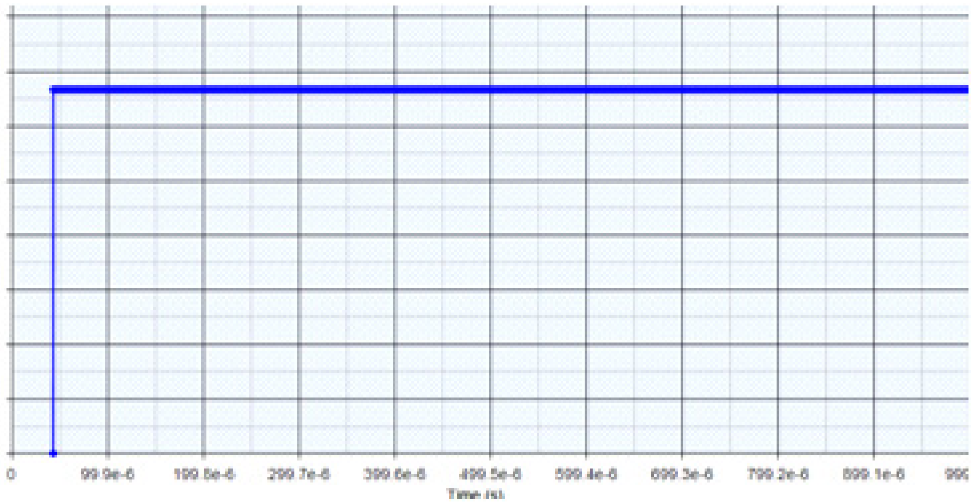

Figure 9. Patient Vital Sign in 5G Wireless Communication Systems

From the above simulation results, it clearly shows that the patient vital signs are transmitted successfully. Since it is a wireless communication system so there will be some delay, the simulation shows that the signal is transmitted with the delay of 50 µ sec.

4.3 Image / Video In 5G Wireless Communication System

The signal processing block is designed using the sine wave and other digital signal processing block. Initially the input is analog in nature, and this analog signal is converted into digital using ADC block. Signals captured from the physical world are translated into digital form by digitization, which involves two processes. A signal is digitized when it is subjected to both sampling and quantization, in either order. When an audio signal is sampled, the single dimension of time is carved into discrete intervals. When an image is sampled, two-dimensional space is partitioned into small, discrete regions. The image/video signals are fully digitalized and transmitted. Initially the signal here is analog in nature. The gain given is 5 and the FIR filtering is done with taps of 1*8. The up sampling is done so as to increase the signal strength for better quality and digitization. The amplifier is used to amplify the analog signals and further it is multiplied with the local oscillator. Amplifier models a nonlinearity including noise figure for use with either baseband or complex envelope signals. The local oscillator has the carrier frequency of 1 kHz and the power of 5W. Oscillator generates an RF (complex envelope) defined by its carrier frequency and with optional thermal noise and phase noise. The phase noise characteristic defined from this list describes a frequency domain specification for phase noise. Here the signal processing block is designed using the sine wave and other digital signal processing block. Initially the input is analog in nature, and this analog signal is converted into digital using ADC block. Fig 10 and 11 shows the design of image/video with 5G wireless communication systems and its results respectively.

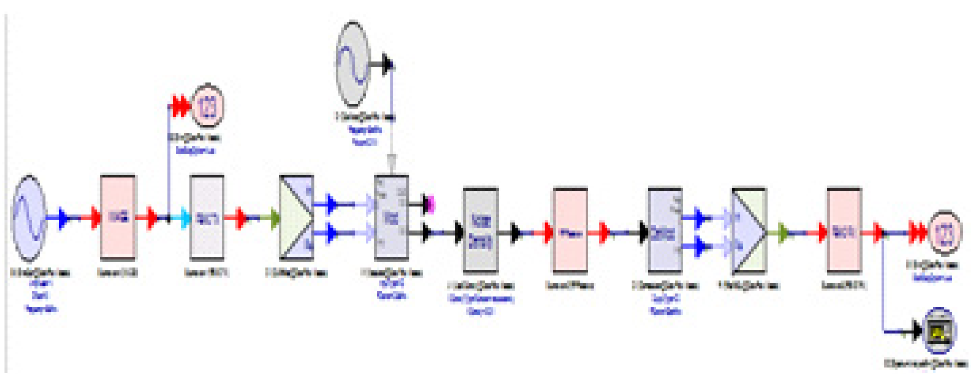

Figure 10. Image/Video in 5G Wireless Communication Systems

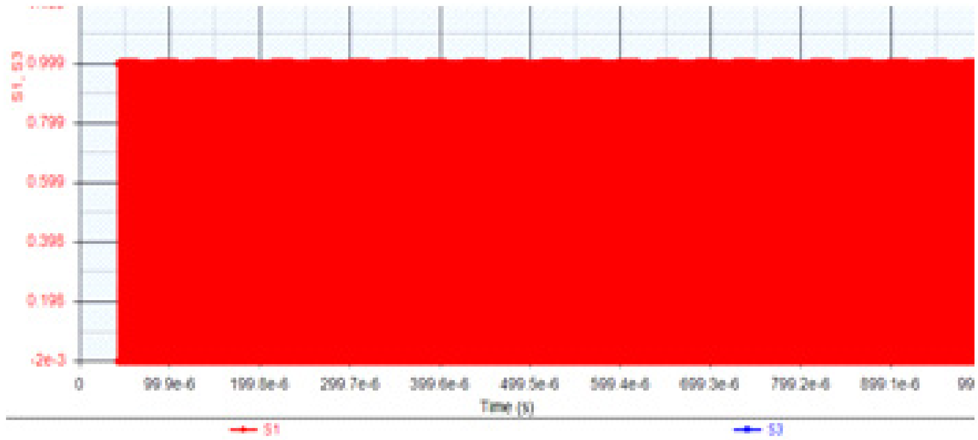

Figure 11. Results of the image/video with 5G wireless communication systems

From the above simulation model I find that the signal is fully transmitted with the delay of 50µsec. The input data here I have used is the digital image/video signal processing block. The simulation shows the analog signal is converted to the digital using the ADC block. The digital image is used a the input for the FBMC block. The data is successfully transmitted and receive at the Receiver of the FBMC model.

5. Conclusion

In this work, I have designed the 5G transmitter and receiver using FBMC and further it is proposed in 5G wireless communication system and the same is used for telemedicine application. At the transmitter section I have used the transform decomposition method, and the OQAM processing and the synthesis filter bank. In receiver section I have used the polyphase network, sub channel processing and the OQAM post processing. In order to reduce the computational complexity we have used multistage filter banks. From the simulation results I can clearly sat that the drawbacks of OFDM are solved by the filter bank multicarrier. FBMC applies filtering on a per-subcarrier basis to provide out of band spectrum characteristics. The baseband filtering is done using either a poly phase network or an extended IFFT. Filtering can use different overlap factors (i.e., K factor) to provide varying levels of out-of-band rejection. Further the same designed 5G wireless communication is used in telemedicine systems and required data are successfully transmitted using the same. Telemedicine system, in which all physiological vital signs are, transmitted to doctors end using 5G networks in emergency case and in normal cases. By this, the cost of using GSM/GPRS network is reduced as only abnormal cases will be transmitted through cellular network. For more improvement in telemedicine systems, many medical algorithms can be developed to help in patient diagnosis and early detection of cardiovascular diseases and real-time analysis of vital signs can be performed in the place where the vital signs are acquired. The latest achievement on a smart phone market provided an opportunity to integrate smart phones in telemedicine systems. For example, android based mobile phones patient monitoring application could be developed which allows doctors to monitor the health. From the simulation results it clearly states that data is transmitted with the lesser delay of about 50µ sec.

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