Mobile and Forensics (MF)
Vol. 3, No. 2, September 2021, pp. 48-57
P-ISSN: 2656-6257, E-ISSN: 2714-6685, DOI: http://dx.doi.org/10.12928/mf.v3i2.5390

DESIGN AND ANALYSIS OF 5G TELEMEDICINE SYSTEMS

[1]Lalit Chettri, [2] Rabindranath Bera
[1,2] Department of Electronics and Communication Engineering, Sikkim Manipal University, India
e-mail: lalitelectricalengineer@gmail.com*, rbera50@gmail.com
*Correspondence email

Abstract

Recently, remote health care is one of the serious issues to look after. Due to lack of technological advancement, the services in heath have been degrading. This work details about design of 5G Wireless communication systems and further it is implemented in telemedicine systems. As 5G deals with FBMC as a selected waveform and this has been chosen because it has the higher spectrum allocation capability and better interference rejection as compared to that of other multicarrier techniques. The main motivation to jump into 5G technologies is because of more connected devices and it can allocate the underutilized spectrum to the secondary user verifying the certain policies. As these telemedicine systems is one of the most needed 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 work details about transmission of patient's vital sign, image and video and analysis which are most essential components in future Telemedicine systems.

Keywords: 5G, Telemedicine, Wireless Communication, Technology, Health

INTRODUCTION

Telemedicine is a wireless system which uses information and advance communication technology [1]. In these systems, remote hospitals can be considered as the transmitter section and one of the specialist hospitals can be considered as the receiver section [2]. A healthcare system can be made efficient with advance wireless and network technologies called 5G technology [3]. The main motto of telemedicine system is to implement expert based remote health care services in places like Sikkim and other north eastern states which lack with proper transportation facilities. In such systems, the patient vital sign is extracted using different sensors and further it is transmitted through 5G communication link and the same data is received at the major hospitals which act as a receiver section. The proposed telemedicine systems use developed 5G wireless systems considering filter FBMC as a waveform for signal generation [4]. The main reason in choosing FBMC as a carrier because it has lesser peak to average power ratio (PAPR) compared to other multicarrier techniques [5]. As we have seen that the existing multicarrier uses one filter per multiple subcarriers but the future waveform technologies use individual filter for single subcarrier called as polyphase filter bank, which results in less inter symbol interference. 5G wireless telemedicine system transmits the Patient vital sign such as ECG [6], temperature [7], blood pressure [8], blood oxygenation [9] and still images [10]. 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 [11].

METHODS

A. Design of 5G Transmitters

Offset OQAM Quadrature Amplitude Modulation, Poly phase network and OQAM post processing have been used to design a 5G Transmitter by employing a QAM mapping

Received September 2, 2021; Revised September 17, 2021; Accepted September 28, 2021

with sample offset of M/2 components in phase (I) and quadrature (q) of complex signal [12]. Offset is the half time shift of the sub per sub carrier.

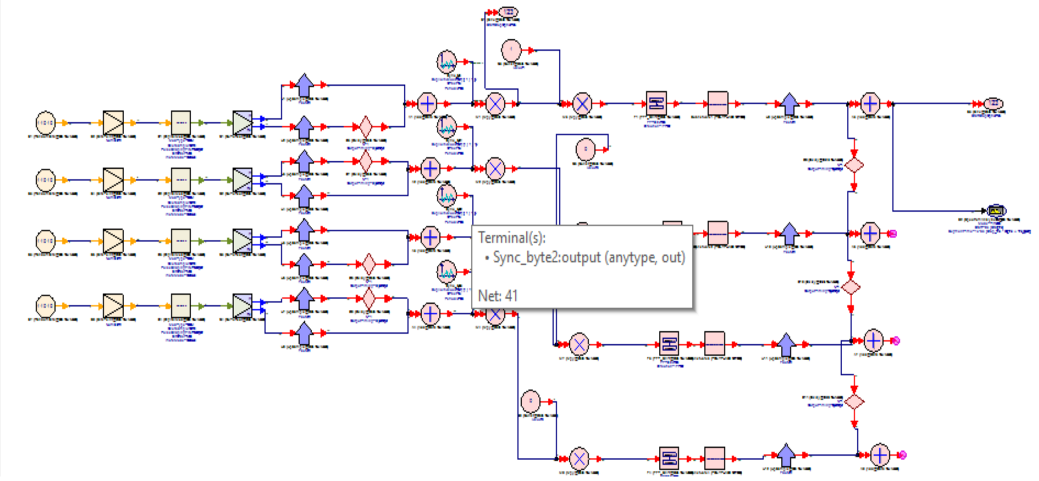

Fig. 1. Design of 5G Transmitter [13].

The Separation process is known as synthesis filter banks. Operation by implementing the network phase used in FBMC after iFFT [14]. This block is used to reduce ICI and ISI. QAM symbol half-period time offset(T/2). Fig. 1 Shows the design of a 5G transmitter. The software that has been used to design the entire model called System Vue 2013.01. The input signal used here is a random bit, which is converted to an integer. The value of the bit becomes an integer which corresponds to changes because the Bit model also changes to an integer. to generate a digitally modulated signal in the baseband using a Digital Modulation model, including basic modulation. 16QAM is chosen as the modulation scheme here. The oversampling ratio used is 16. The sample rate with the input signal and the timing signal at the output is related to the model set sample rate. The sample rate used is 1.6e+007 Hz. To convert complex input values into real and imaginary output values using the CxToRect Model. This model reads one sample from the input and writes one sample to each output. For two successive sub-channels, e.g., m and m+1, the real part of the QAM symbol in the sub-channel applies an offset, while the imaginary part of the QAM symbol applies m-1. CxToRect passes the incoming signal from the multiplier where the RIR filter and delay block are passed by the real signal. In the delayed block, the incoming signal will apply the delay unit. The transmitter side involves multiplying theta (ɵ) and beta (β). Here using theta values 1,j,1,j,1,j... for even and j,1,j,1,j,1.... for odd. For operation using a set of digital filters used in the poly phase. The set of three FIR filter kit is designed using a polyphase filter. The overlap factor is used when one input IFFT and one carrier modulation applies element data. The out-band rejection (interference) will be low and the spectral efficiency will be high when we increase the k factor. The individual filter is used to allocate each sub operator. Here the size of the iFFT is M with a sampling frequency of 1 with M carriers; therefore, the carrier frequency is 1/M [15].

B. Design of 5G Receiver

The proposed method is shown in Fig. 2. The set point is the reference signal. The tuning method is a coefficient diagram. The nonlinear model is the Maglev System. The output is object position. The difference between the set point and feedback is error. The controller is integral state feedback.

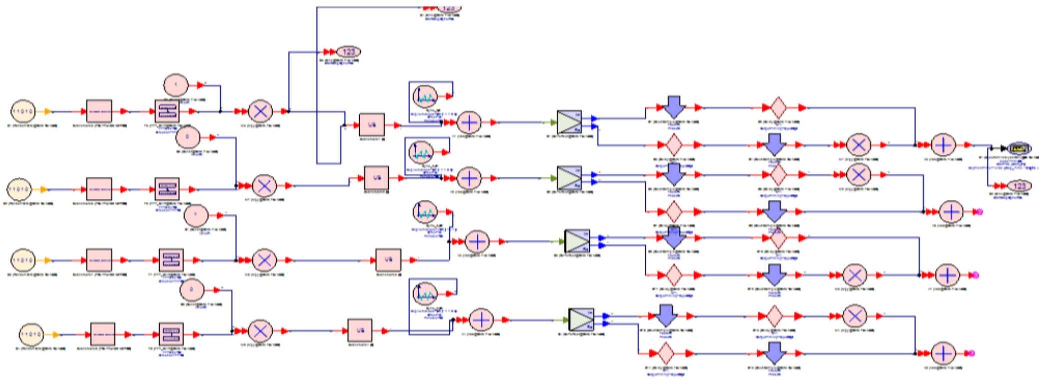

Fig. 2. Design of 5G Receiver

The transmitter uses digital bits with sub channel processing and IFFT as a demodulator. The value of betas is the same as the transmitter value. Sub channel mapping design receiver. A three-tap FIR filter was used to model sub-channel equalization. Operators will overlap at some point. Therefore, to solve this problem use an equalizer. Least Mean Squares (LMS) algorithm model used for implementing real arithmetic adaptive filter (FIR or IIR). Minimize errors in the desired signal and filter the output based on the Least Squares (LS) criteria using the LS Algorithm.

C. Design and Analysis of 5G Wireless Communication Link

5G communication transmitters, receivers and channels used to design 5G wireless communication systems [16]. Millimeter wave and have higher performance and are less sensitive to RF interference such as phase, boost, and non-linear power boosters, all of these used in 5G. Due to the high directivity of mm-wave transmission, mm-wave channels are relatively flat, and the distribution of a single solution is simpler than that required for future wireless systems [17]. 5G wireless communication system is shows in Fig. 3. The simulated transmitter and receiver models are used to develop the model. FBMC as a waveform used in 5G wireless communication. Compared to OFDM, FBMC offers additional benefits [18]. The FBMC waveform reduces the cyclic prefix which results in the better interference rejection and increases spectral efficiency [17][19][20]. As we know that, the communication systems are characterized by interference such as noise and this parameter is considered for designing. Initially the input is in 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 results of 5G wireless communication system.

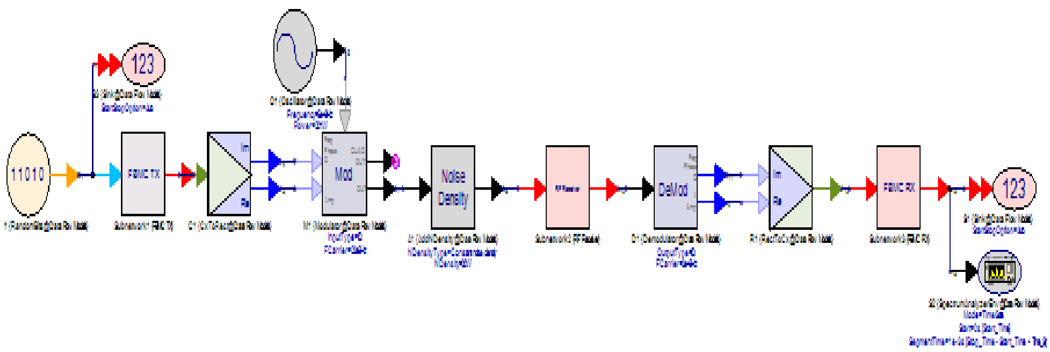

Fig. 3. Design of 5G Wireless Communication Systems [21].

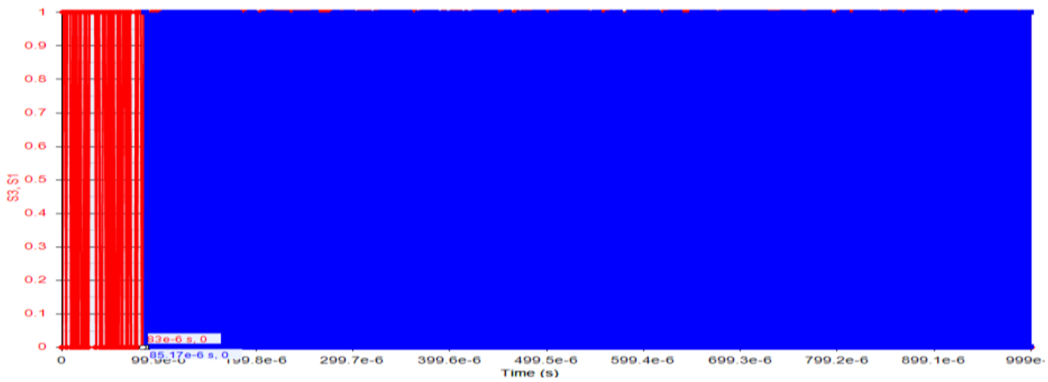

Fig. 4. Times Domain Signal of 5G Wireless Communication Systems.

The FBMC model transmitter is represented by red waveform, while the receiver is represented by blue waveform. In the above results the receiver is almost identical to the transmitter, as it is delayed with the time of 100 µs. Since it is a wireless communication system which consists of transmitter and receiver. The transmission line is accompanied by noise, jamming and other inferences that separate these two models. According to the simulation results, the receiver fully receives the transmitter part which transmits the among of data, which means that compared to the existing OFDM technology the system has lower interference and this proves that the most efficient multicarrier technique for future wireless communication technology (5G technology) is FBMC.

D. Design and Analysis of 5G Wireless Telemedicine Systems

The developed telemedicine systems use 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 [22]. Individual sensors are used to acquire the patient vital sig, processed and transmitted using 5G wireless communication systems.

1. ECG in 5G Wireless Communication Systems

The 0.5-100 Hz bandwidth limits the ECG signal. The FIR filter is used to filter out power line interference on the ECG signal, with a tap equal to 1*8. Fig. 4 shows design of ECG signal processing blocks. The ECG can be designed using the various digital signal processing, here sine wave is used as an input and given the gain of 5, followed by the FIR filter then the up sampling is given by a factor 2 followed by the amplifier [23]. Initially the input is analog is nature then the ADC block is used to convert the analog signal to digital. Fig. 5, Fig. 6, and Fig. 7 shows transmission of ECG using 5G wireless communication systems and its results respectively.

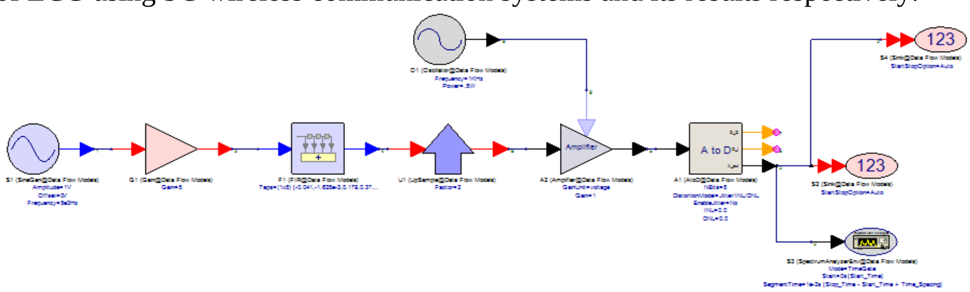

Fig. 5. Design of ECG Signal Processing Blocks.

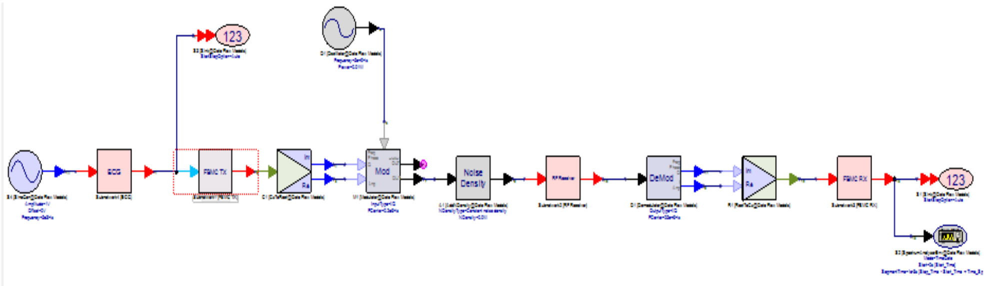

Fig. 6. Transmission of ECG Using 5G Wireless Communication Systems.

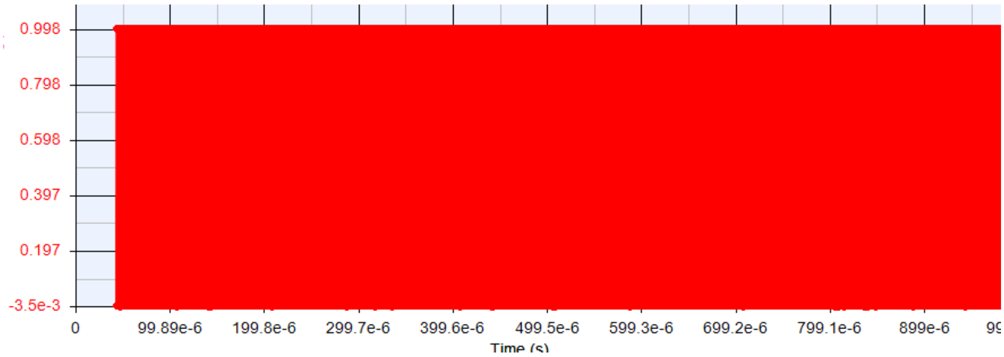

Fig. 7. Time Domain Signal of ECG IN 5G Systems.

From the simulation result of ECG block, the three waves P Wave, QRS Wave T wave are identical with their own characteristics. From the above simulation block it is clear that the ECG signal has been clearly transmitted with the delay of about 50µ sec which is very less time difference between the transmitting and receiving.

2. Temperature/Blood Pressure/Blood Oxygenation in 5G Wireless Communication Systems

As per the health expertise the temperature, pressure and the blood oxygenation are determined by the numerical values. Various types of temperature sensors are used to extract these vital signs and then it is processed using various modern digital signal processing technologies [24]. Normally the temperature of a healthy person is about 37-degree C, and it can change according to the environmental conditions. Medically measuring the body is very important, because changes in body temperature can signal the presence of disease. Oxygen saturation in the body, which is related to the heart rate when blood is pumped from the heart to other parts of the human body is measured by (SpO2) and Heart Rate.SpO2 or pulse oximetry [8][9]. For simulation purpose the normal human temperature i.e., 37 degrees centigrade has be utilized. Fig Fig. 8 shows these vital signs in 5G wireless communication systems.

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

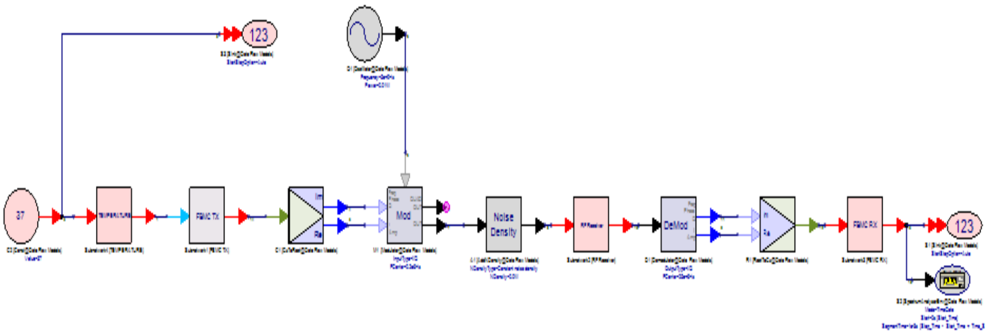

Fig. 8. Patients Vital Sign in 5G Wireless Communication Systems.

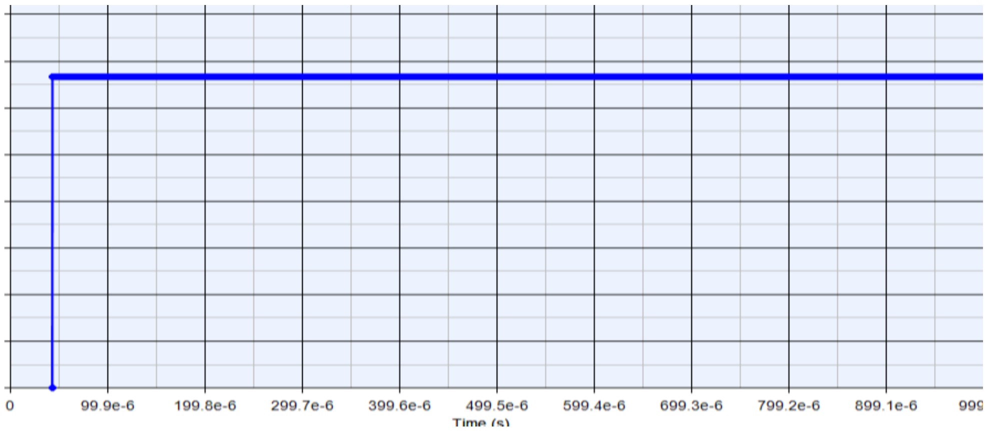

Fig. 9. Patients Vital Sign in 5G Wireless Communication Systems by time

From the simulation results, it clearly states 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 50µ sec.

3. Image/Video in 5G Wireless Communication Systems

The sine wave and other digital signal processing blocks are used to design signal processing blocks. By using the ADC block, the input which is originally analog is converted to digital. Digitization translates the signal captured in the physical world, by giving a gain of 5 and FIR filtering is done by tapping 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. Fig. 10 and Fig. 11 shows design of image/video with 5G wireless communication systems and its results.

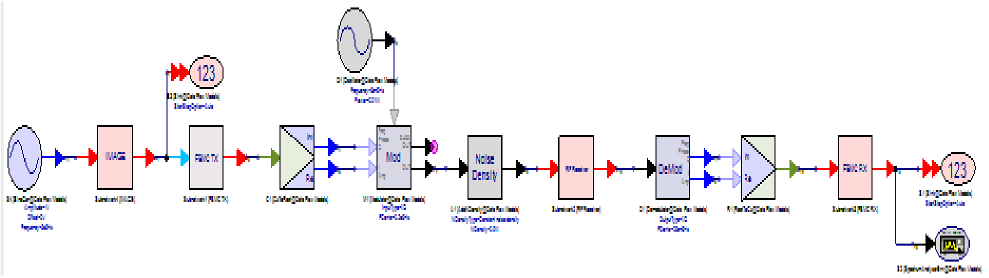

Fig. 10. Image/Video in 5G Wireless Communication Systems.

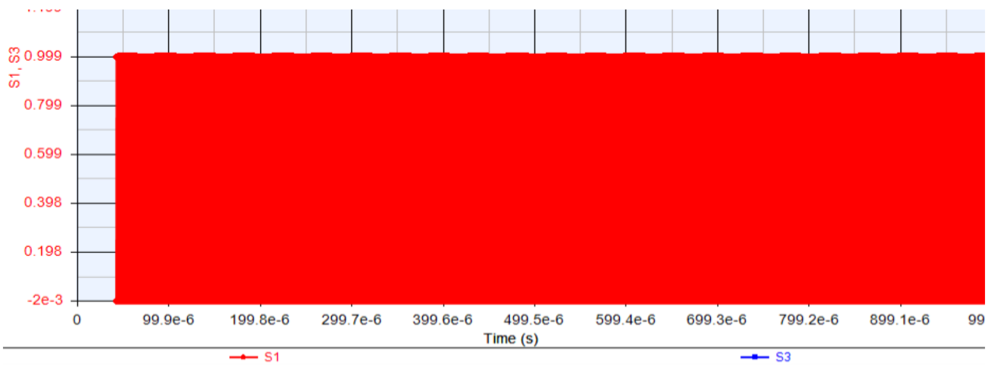

Fig. 11. Image/Video in 5G Wireless Communication Systems by time.

CONCLUSIONS

In this work, the FBMC used for 5G transmitter and receiver has been successfully developed, and also the telemedicine application is proposed to use 5G wireless system. The transmitter section has used OQAM preprocessing and OQAM filter bank. To design the receiving part, a polyphase network of sub-channel processing and OQAM post-processing is used. It employs a multistage filter bank to reduce band rejection. From the results above, the use of a multicarrier bank filter can solve the weakness of OFDM. The filtering operation on a per-subcarrier basis is applied by FBMC to provide off-band spectrum characteristics. An extended poly or IFFT phase network is used for baseband filtering. Different overlap factors (i.e., K factor) are used for filtering to provide different degrees of out-of-band rejection. Further the same designed FBMC waveform is used for developing 5G communication link. In this work all the essential requirements for telemedicine system have been carried out. The same 5G communication link is used to design and transmit patient vital signs and image/video signals. From the simulation results, it can be seen that the data is transmitted with a smaller delay time of about 50μ seconds. This paper describes the overall design of waveform using all the digital signal processing and further it is used in designing both transmitter and receiver of 5G model and further it is deployed in telemedicine application which is the most promising technologies in future wireless telemedicine.

REFEERENCE

[1] M. Mullen-Fortino, K. L. Rising, J. Duckworth, V. Gwynn, F. D. Sites, and J. E. Hollander, "Presurgical Assessment Using Telemedicine Technology: Impact on Efficiency, Effectiveness, and Patient Experience of Care," *Telemed. E-Health*, vol. 25, no. 2, pp. 137–142, Feb. 2019, doi: 10.1089/tmj.2017.0133.

[2] F. Seker *et al.*, "Clinical results of a new concept of neurothrombectomy coverage at a remote hospital—'drive the doctor,'" *Int. J. Stroke*, vol. 13, no. 7, pp. 696–699, Oct. 2018, doi: 10.1177/1747493018765267.

[3] D. Li, "5G and intelligence medicine—how the next generation of wireless technology will reconstruct healthcare?," *Precis. Clin. Med.*, vol. 2, no. 4, pp. 205–208, Dec. 2019, doi: 10.1093/pcmedi/pbz020.

[4] H. N. Parajuli, H. Shams, L. G. Gonzalez, E. Udvary, C. Renaud, and J. Mitchell, "Experimental demonstration of multi-Gbps multi sub-bands FBMC transmission in mm-wave radio over a fiber system," *Opt. Express*, vol. 26, no. 6, p. 7306, Mar. 2018, doi: 10.1364/OE.26.007306.

[5] A. Kumar and H. Rathore, "Modified DSLM Technique for PAPR Reduction in FBMC System," *Radioelectron. Commun. Syst.*, vol. 62, no. 8, pp. 416–421, Aug. 2019, doi: 10.3103/S0735272719080053.

[6] Y. Zhang, G. Chen, H. Du, X. Yuan, M. Kadoch, and M. Cheriet, "Real-Time Remote Health Monitoring System Driven by 5G MEC-IoT," *Electronics*, vol. 9, no. 11, p. 1753, Oct. 2020, doi: 10.3390/electronics9111753.

[7] D. H. Jin, C. C. Hu, and B. Liu, "Improved sinterability and temperature stability in Zn2+/Ti4+-co-substituted CaAl2O4 ceramics and their 5G antenna applications," *J. Mater. Sci. Mater. Electron.*, vol. 32, no. 13, pp. 18205–18211, Jul. 2021, doi: 10.1007/s10854-021-06362-y.

[8] A. Jacobs, A. E. Schutte, C. Ricci, and M. Pieters, "Plasminogen activator inhibitor-1 activity and the 4G/5G polymorphism are prospectively associated with blood pressure and hypertension status," *J. Hypertens.*, vol. 37, no. 12, pp. 2361–2370, Dec. 2019, doi: 10.1097/HJH.0000000000002204.

[9] K. Venkatachalam, P. Prabu, A. S. Alluhaidan, S. Hubálovský, and P. Trojovský, "Deep Belief Neural Network for 5G Diabetes Monitoring in Big Data on Edge IoT," *Mob. Netw. Appl.*, Jan. 2022, doi: 10.1007/s11036-021-01861-y.

[10] A. M. Lacy *et al.*, "5G-assisted telementored surgery," *Br. J. Surg.*, vol. 106, no. 12, pp. 1576–1579, Oct. 2019, doi: 10.1002/bjs.11364.

[11] M. M. M. Ali and A. Sebak, "Compact Printed Ridge Gap Waveguide Crossover for Future 5G Wireless Communication System," *IEEE Microw. Wirel. Compon. Lett.*, vol. 28, no. 7, pp. 549–551, Jul. 2018, doi: 10.1109/LMWC.2018.2835149.

[12] C. Lele, P. Siohan, and R. Legouable, "2 dB Better Than CP-OFDM with OFDM/OQAM for Preamble-Based Channel Estimation," in *2008 IEEE International Conference on Communications*, Beijing, China, 2008, pp. 1302–1306. doi: 10.1109/ICC.2008.253.

[13] G. Nikandish, R. B. Staszewski, and A. Zhu, "Breaking the Bandwidth Limit: A Review of Broadband Doherty Power Amplifier Design for 5G," *IEEE Microw. Mag.*, vol. 21, no. 4, pp. 57–75, Apr. 2020, doi: 10.1109/MMM.2019.2963607.

[14] B. Khan and F. J. Velez, "Multicarrier Waveform Candidates for Beyond 5G," in *2020 12th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP)*, Porto, Portugal, Jul. 2020, pp. 1–6. doi: 10.1109/CSNDSP49049.2020.9249568.

[15] Y. Cui, Z. Zhao, and H. Zhang, "An Efficient Filter Banks Based Multicarrier System in Cognitive Radio Networks," vol. 19, no. 4, p. 9, 2010.

[16] B. G. Kim, S. H. Bae, H. Kim, and Y. C. Chung, "RoF-Based Mobile Fronthaul Networks Implemented by Using DML and EML for 5G Wireless Communication Systems," *J. Light. Technol.*, vol. 36, no. 14, pp. 2874–2881, Jul. 2018, doi: 10.1109/JLT.2018.2808294.

[17] B. Farhang-Boroujeny, “Filter Bank Multicarrier Modulation: A Waveform Candidate for 5G and Beyond,” *Adv. Electr. Eng.*, vol. 2014, pp. 1–25, Dec. 2014, doi: 10.1155/2014/482805.
[18] H. Jamal and D. W. Matolak, “Dual-Polarization FBMC for Improved Performance in Wireless Communication Systems,” *IEEE Trans. Veh. Technol.*, vol. 68, no. 1, pp. 349–358, Jan. 2019, doi: 10.1109/TVT.2018.2879573.
[19] M. AlTarayrah and Q. A. Al-Haija, “Adaptive Channel Equalization for FBMC Based on Variable Length Step Size and Mean-Squared Error,” *Int. J. Digit. Inf. Wirel. Commun.*, p. 12, 2013.
[20] T. Ihalainen, T. H. Stitz, and M. Renfors, “Efficient Per-Carrier Channel Equalizer for Filter Bank Based Multicarrier Systems,” in *2005 IEEE International Symposium on Circuits and Systems*, Kobe, Japan, 2005, pp. 3175–3178. doi: 10.1109/ISCAS.2005.1465302.
[21] S. Baig, H. Muhammad Asif, T. Umer, S. Mumtaz, M. Shafiq, and J.-G. Choi, “High Data Rate Discrete Wavelet Transform-Based PLC-VLC Design for 5G Communication Systems,” *IEEE Access*, vol. 6, pp. 52490–52499, 2018, doi: 10.1109/ACCESS.2018.2870138.
[22] M. V. M. Figueredo and J. S. Dias, “Mobile Telemedicine System for Home Care and Patient Monitoring,” in *The 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, San Francisco, CA, USA, 2004, vol. 4, pp. 3387–3390. doi: 10.1109/IEMBS.2004.1403951.
[23] D. Jingwei and J. Wenwen, “Design of Digital Filter on ECG Signal Processing,” in *2015 Fifth International Conference on Instrumentation and Measurement, Computer, Communication and Control (IMCCC)*, Qinhuangdao, China, Sep. 2015, pp. 1272–1275. doi: 10.1109/IMCCC.2015.273.
[24] C. Sha, R. Wang, H. Huang, and L. Sun, “A type of healthcare system based on intelligent wireless sensor networks,” *J. China Univ. Posts Telecommun.*, vol. 17, pp. 30–39, Jul. 2010, doi: 10.1016/S1005-8885(09)60611-7.
[25] M. Abo-Zahhad, S. M. Ahmed, and O. Elnahas, “A Wireless Emergency Telemedicine System for Patients Monitoring and Diagnosis,” *Int. J. Telemed. Appl.*, vol. 2014, pp. 1–11, 2014, doi: 10.1155/2014/380787.
[26] V. Oleshchuk and R. Fensli, “Remote Patient Monitoring Within a Future 5G Infrastructure,” *Wirel. Pers. Commun.*, vol. 57, no. 3, pp. 431–439, Apr. 2011, doi: 10.1007/s11277-010-0078-5.