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Implementation of 5G in Guided and Unguided Optical Communication System with Cellular Frequency Bands

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ABSTRACT

Optical wireless communication is the budding technology of fifth generation communication networking systems. It is an emerging platform to interconnect the domestic appliance together with a strong optical backbone network. However for a very long distance communication over 500 to 1000 km optical fiber is irreplaceable. The speed of the data communication is higher in free space optical communication without amplifying the received signal at the receiver side. The microwave optical communication frequency ranges from 3GHz to 30 GHz. Millimeter wave optical communication with 5G network is under progress. In this paper, the speed of communication used is 50 Gbps. The different channels optical wireless communication (OWC), free space Optical communication (FSO) and optical wired cables are considered with 5G speed. The Quality factor and maximum distance of transmission with suitable transmitter power is achieved via respective channels.

KEYWORDS: *Free Space optical communication, 5G, Optical wireless channels, Bit Error Rate, Quality factor*

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INTRODUCTION

The transmission of light via different channels undergoes several losses. The transmitter and the receiver design have to be in line of sight for better reception of the information signals. In fiber optical cable channel, the attenuation is lesser since the medium is conserved. However in free space optical communication, there is a chance of attenuation effect at the channel. One of the major channel noises is atmospheric noises which are caused due to rain, fog, smoke and snow. This may be prevented by proper alignment of the signal towers and using fiber grating techniques to avoid atmospheric effects. In this paper, maximum attenuation of 10 dB/km is considered which falls in the category of severe to mild attenuation category. Cellular architecture with 5G network enables the user to uplink and downlink of data in fraction of seconds. The data rate of 5G network ranges from 3Gbps to 100 Gbps. The technology associated with the design depends upon the frequency, data rate and channel losses. The major difference with previous works in optical wireless communication has reduced user capacity. With the advent of 5G, maximum users can be able to get connected in the network anytime and anywhere. The block diagram Fig.1 shows general optical communication.

HIGH SPEED FREQUENCY BANDS

A. Optical wireless communication with 5G in C, S and E spectrum bands

The frequency range of C band is between 5.9 to 6.4 GHz for uplink and 3.7 to 4GHz for downlink. The wavelength range of 1550nm C band is considered in this work. The signals are generated from the pseudorandom signal bit generator with 50 Gbps speed. The distance between the transmitter and the receiver covers over 200kms. The same parameters are implemented for S band of wavelength 1625nm and E band of wavelength 1310nm [1]. Fig.2 shows the design of OWC channel with 5G.

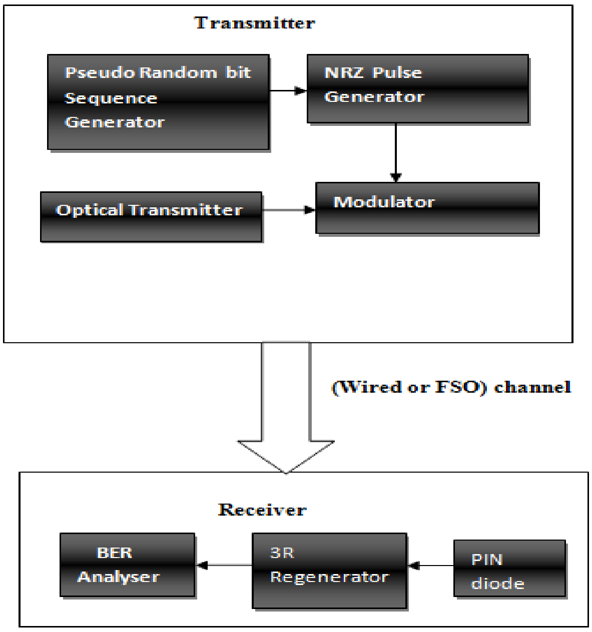


Fig.1. Block Diagram of communication systems

B. Free Space optical communication with 5G in C, S and E spectrum bands

The major difference between FSO and OWC as optical wireless communication uses unguided light rays as carriers. Free space optical communication uses guided light signal as carriers. The frequency range of S, C and E band is analyzed with suitable parameters. The power range of the transmission is 30 dB. After the signal generation from pseudorandom signal generator, the guided light rays are modulated and passed through the channel [2]. It provides good Quality factor for a distance over 1km for end users. Fig.3 shows the FSO channel with 5G speed.

C. Fiber optical cable communication with 5G in C, S and E spectrum bands

Optical fiber cable covers maximum of 1km with 5G data rate.. The power range of the design is 30 dB. Modulation is done by Machzehnder modulator and the modulated signal is passed via fiber cable to reach the receiver port. The design is tested with S, C and E bands. It has poor response compared to FSO and OWC. If the distance increases between the receivers say user terminal and the transmitting tower, the Quality factor of optical fiber is decreased. Fig. 4 shows the optical cable channel with 5G speed.

EXPERIMENT AND RESULT

The proposed scheme is simulated with optiwave product Optisystem version 16.1. The Quality factor and the Bit Error Rate is compared for Optical fiber, OWC and FSO. The transmitter aperture diameter is 5cm and receiver aperture diameter is 20cm. The beam divergence is 2mrad and Number of samples per bit is 32768 throughout the simulation.

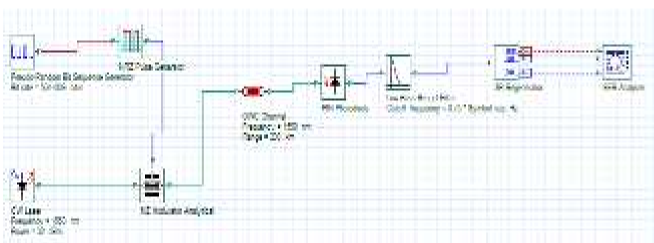


Fig.2. Optical wireless communication Design

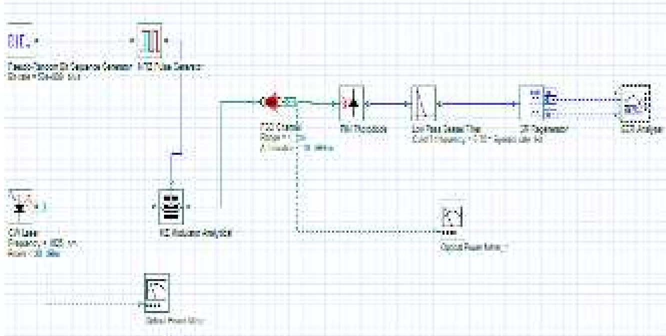


Fig.3. Free space optical channel Design

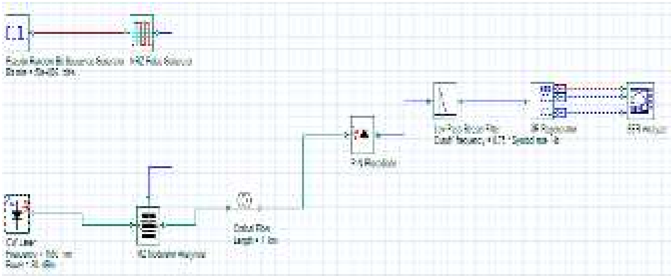


Fig.4. Fiber optical cable communication Design

TABLE -1 Optical wire cable Experiment Result

Channel Type	Max. Q factor	Min BER
S Band (1625 nm)	18.1701	4.43593e-074
C Band (1550 nm)	21.9737	2.56764e-107
E Band (1310 nm)	28.3138	1.15211e-176

Table 1 show the maximum Quality factor and minimum Bit error rate of 5G speed 10Gbps in optical wired cable channel model.

TABLE-2 Free Space optics Experiment Result

Channel Type	Max. Q factor	Min BER
S Band (1625 nm)	108.133	0
C Band (1550 nm)	493.549	0
E Band (1310 nm)	16.2862	6.12951e-060

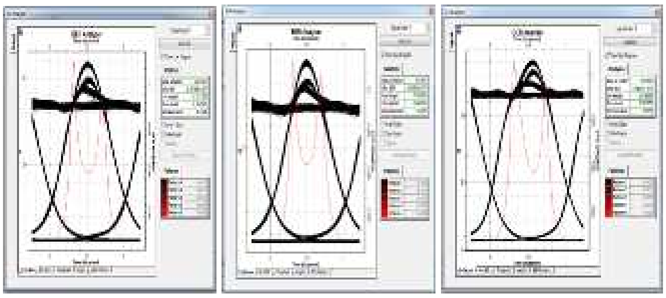
Table 2 show the maximum Quality factor and minimum Bit error rate of 5G speed 10Gbps in free space channel model.

TABLE-3 Optical wireless communications Experiment Result

Channel Type	Max. Q factor	Min BER
S Band (1625 nm)	252.584	0
C Band (1550 nm)	257.818	0
E Band (1310 nm)	326.504	0

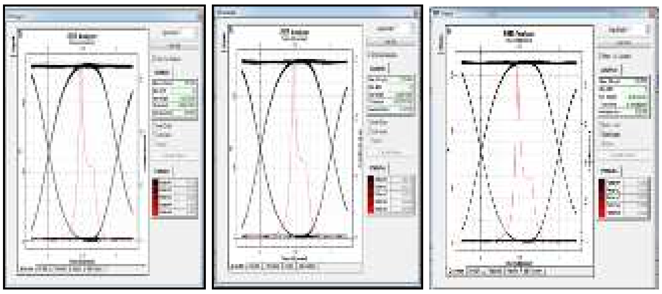
Table 3 show the maximum Quality factor and minimum Bit error rate of 5G speed 10Gbps in optical wireless channel model.

The eye plot of three different channels are simulated and compared. The Distance between the transmitter and receiver determines which channel model has to be used with cost effective and better response of signals [3]. Increasing the Distance increases the attenuation. Attenuation took a major part in FSO with a severe rainy and snow fall atmosphere produces 25 dB/km [7]. In this implementation OWC channel used 0.5 dB/km attenuation and Fiber optical cable has 0.2dB/km.



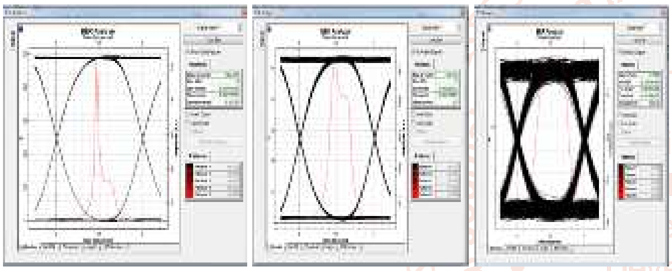
(a) (b) (c)

Fig (a). C band optical fiber Fig (b). S band optical fiber Fig (c). E band optical fiber



(a) (b) (c)

Fig (a). C band wireless channel Fig (b). S band wireless channel Fig (c). E band wireless channel



(a) (b) (c)

Fig (a). C band Free space channel Fig (b). S band Free space channel Fig (c). E band Free space channel

CONCLUSION

By the overall design implementation and analysis, it is concluded that Free space optics has better Quality factor with reduced Bit error rate in C band than its all other frequency Bands. The higher Q factor of C band is 493.549 with negligible BER. The FSO channel in contrast with optical wireless communication channel needs no RF spectrum licensing. For OWC, the Quality factor at the receiver is almost similar in all its frequency spectrum bands. But depending on the usage, the respective Band spectrum has to be selected in OWC channel. For fiber optical cable, E band provides maximum Quality factor of 28.3138 with minimum BER of 1.15211e-176. Maximum distance (200km) is achieved with optical wireless communication channels. Beyond which the signal strength is poor.

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