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Estimation of Channel characteristics of milli meter wave communication using propagation channel models

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Abstract: The paper describes the application of channel simulation with respect to statistical dependency on Saleh Valenzuela model, Geometry based Stochastic Channel model. The bit error rate is calculated for all the channel models using different modelling method under different channel scenario. The Bit Error Rate is calculated for the frequency of 28 GHz. The estimation of Bit Error Rate is necessary for legitimate exegeses of the model and, consequently, for relevant system design & channel characterization. The SV model and Geometry based stochastic channel model have been simulated using MATLAB software and calculated the parameters for milli meter wave communication such as Bit Error Rate for 1 dB to 30 dB signal to noise ratio. For SV channel model the BER with and without LDPC CRC is 0.00013250 & 0.00026700 for minimum SNR and 0.00011425 & 0.00023525for maximum SNR for indoor Scenario whereas for outdoor scenario the respective values are 0.00013300 & 0.00028375 and 0.00011800 & 0.00025825. For Geometry based stochastic channel model the BER with and without LDPC CRC is 0.00013400 & 0.00028475 for minimum SNR and 0.00011900 & 0.00025000 for maximum SNR for indoor Scenario whereas for outdoor scenario the respective values are 0.00013325 & 0.00028725 and 0.00011725 & 0.00026600.

Keywords: Millimeter wave (mmWave), SV Model, Log distance model, Geometry based stochastic channel model, Bit Error rate, Path loss, LOS probability.

1. Introduction

In indoor wideband (WB) wireless transmission systems, with stochastic characteristics regarding the resolvable multipath components' (MPCs) arrival delays and amplitudes are described by the widely used and well-recognized Saleh–Valenzuela (SV) model. It simulates MPC arrivals in clusters, where Poisson processes are assumed to control in cluster arrivals and MPC arrivals in every cluster. When the SV model was first presented, WB systems with several hundred MHz of bandwidth or less were the focus. Subsequently, measurements of ultra-wideband (UWB) channels were discovered to suit the SV model as well. It is discovered that, in IEEE 802.15.3a model is very useful in personal area network. Afterwards, a modified version of the SV model was presented and utilized in the IEEE 802.15.4a concept for wireless PANs operating at low data rates. In order to parameterize the models for various scenarios, including homes, offices, industries, and outdoor spaces, extensive measurement campaigns were carried out. Models are independent on Line-of-sight (LOS) and non-line-of-sight (NLOS) parameters with situations for every scenario (except for outdoor scenario). The tests were carried out for large range of distances, and for the wide range of frequency, the satisfactory results were found [7]. Saleh and Valenzuela investigated the propagation of in office structure with the help of radar pulses a 10 ns width at 1.5 GHz frequency and discovered that multipath components i.e. MPCs for the clusters. Statistical channel model based on cluster is used for predicting the power of cluster and the proposed model is depends upon the path based exponentially decreasing cluster function. It also predict cluster entry time and the sub path entry time inside every cluster with respect to the instant time. Each cluster's sub path arrival time and cluster arrival time followed a Poisson distribution. When a wireless channel's small-scale fading mean and autocorrelation are displacement invariant, it is considered wide-sense stationary (WSS). This happens when the channel has a lot of propagation paths because the complex summing of those paths averages out any features unique to a particular displacement. Microwave channel is called as WSS due to extensive measurement campaigns, its inherent richness in diffracted paths, the use of omnidirectional antennas by 1G to 4G systems to detection of paths in all the directions and the bandwidths have narrow and add up all paths over extended periods of samples [1]. The older outdoor NYUSIM channel models' mathematical basis, this study suggests a unified statistical channel model for sub-Terahertz and millimeter wave frequencies inside buildings. A indoor channel simulator built that can simulate signal bandwidth, antenna beamwidth, and random sub-THz and millimeter-wave carrier frequency up to 150 GHz in 3-D in multiple input, multiple output (MIMO), directional, and omnidirectional

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channel. Future designs of transceivers, beamforming, and air interfaces for Sixth Generation and beyond will be directed by the provided statistical channel model and simulator. [2]. An iterative reflection coefficients configuration approach is proposed with the channel spatial correlation functions (CFs) in this channel model. This method maximizes the ergodic channel capacity by utilizing statistical channel state information. Through simulations, the effects of the Intelligent Reflecting surface spatial positions and Intelligent Reflecting Surface elements count on the ergodic channel capacity are examined. A helpful recommendation for real-world deployment is that the IRS should be positioned close to the transmitter side or the reception side in order to maximize the ergodic channel capacity [3]. In order to meet the demands of a 1000-fold increase in data rate, millimeter wave (mmWave) and large multiple-input multiple-output (MIMO) technologies were proposed as critical technologies for the physical layer of fifth-generation (5G) wireless communication. An effective way to address the current spectrum deficit is to use mmWave frequencies, which provide a vast quantity of spectrum range varies from 30 GHz to 300 GHz. Gigabits of data per second, can be easily achieved with the huge bandwidth. Increased channel capacity can thus be achieved by taking advantage of increased spectrum resources. While this is going on, large MIMO allows one to get around the significant route loss that high frequency introduces [4]. In this article another spatial model is proposed for milli meter wave indoor scenario. It is founded that comprehensive 28 GHz and 140 GHz radio propagation measurements that were done in an indoor office setting between 2014 and 2020. The number of collected channel statistics show the temporal clusters follows a Poisson distribution for both LOS and NLOS settings at 28 GHz and 140 GHz, whereas sub paths follows exponential distribution which are present inside the each cluster. Throughout the last few decades, this modeling technique has been widely applied. Rappaport carried out 1.3 GHz propagation experiments in factories and demonstrated that, in open-plan buildings factories with reflecting objects dispersed around different workspace, MPCs arrived singly as opposed to in clusters. Beginning in the early 1990s, additional mmWave indoor channel measurements and modeling projects were carried out, the bulk of which were carried out at 60 GHz. Standard publications like 3GPP TR 38.901 and IEEE 802.11 ad/ay provided channel models which will work up to 100 GHz for interior framework like homes, offices, shopping centres, and factories. The proposed system is operated at very high frequency range i. e. 28 GHz. The milli meter wave frequency band lies between 30 GHz to 300 GHz and bandwidth of 250 GHz. IEEE 802.11 ad/ay channel models had adopts a double-directional Channel Impulse Response for 60 GHz frequency with twin polarizations depends upon complementary ray-tracing simulations and field measurements. 3GPP TR 38.901 presents uniform geometry dependant based channel model for both indoor & outdoor scenarios for 0.5 to 100 GHz frequency band. Depending on the situation, several large-scale parameters (Delay Spread, Angular Spread, Rician K factor, and shadow fading (SF)) are needed for the channel formation process. As long as objects are randomly situated in the environment, the SV model can adequately describe stochastic environment in terms of different amplitudes, different phases, and arrival time delays of MPCs in WB propagation channels, as demonstrated by observations reported in numerous previous studies. This paper presents a thorough explanation of the physical basis for the model's structure, demonstrating that when randomly distributed "super scatters " and/or scatters clusters are present in the propagation environment, the double-Poisson MPC cluster arrivals provides a reasonable estimate of the behaviour of the channel. In event where UWB channels are used with the SV model, the physical reason has been re-examined. The individual MPC distortion becomes substantial at large relative bandwidths, and hence requires explicit modeling; otherwise it is possible to utilize the complex baseband equivalent notation. Since spatial resolution falls within the size of the dominant scattering objects, it is no longer possible to assume that the fading per resolvable MPC in Rayleigh for high bandwidths. This introduces correlation among MPCs which reflects upon similar object. The other vital difference among WB channel and UWB channels is the overlapping of spatial variation scales for small scale fading and access large arrival delays. Stated otherwise, non-correlated samples of the fading in amplitudes or even to get average out the influence of fading while adjusting for the additional arriving delays and by extension the fading statistics. Thus the statistics of MPC arrival delays and fading amplitudes are difficult to extract in the WB channel. The wireless standards for 3GPP and various channel model is given for frequency band from 0.5 GHz to 100 GHz [5]. In Millimeter-wave (mmWave) channel modelling suppose that channel is Wide Sense Stationary without using any measured-based evidence, despite the fact that 5G systems operating in that region use pencil beam antennas and have ultra-wide bandwidths, and channels is intrinsically sparse because of weak diffraction. A recent measurement experiment did, in fact, demonstrate that the 60 GHz channel can be non-WSS at specific beam widths; henceforth the campaign took into account one measured channel and a specific range of beam widths and bandwidths. Using 60 GHz channel sounder, it is possible to measure eighty eight channels in 3indoore and 2 outdoor situations for a thorough investigation. By continuously adjusting the beamwidth and bandwidth crossover points can be identify. Geometry-based stochastic channel modeling is vital and famous modelling techniques because of its adaptability. By using the fundamental rules of wave propagation, a geometry-based stochastic channel model i.e. GBSM is obtained with the help of preset stochastic distribution of successful scatterers. The regular-shaped GBSMs represented as (RS-GBSMs) are thoroughly explained in the paper. Additionally, it presents RS-GBSM for traditional cellular system before describing recent developments in RS-GBSMs for (V2V) i.e. vehicle-to-vehicle communication systems. Since the purpose of using IS-GBSMs is to replicate physical reality, adjustments must be made to the placement and features of the efficient scatterers of RS-GBSMs. This paper relates how gemoetry based stochastic channel models are used for high speed railway. The proposed system is simulated at frequency of 2.4 GHz [6]. A novel idea derived from meta materials is the intelligent reflecting surface (IRS), which allows programmable passive reflecting elements to accomplish beamforming. This gadget, which has gained more and more attention, enables the engineering of the wireless communication environment. Now a days linked channel models are used widely channel modelling leaving out Intelligent reflecting surface. This paper uses an IRS-assisted wireless communication system and a GBSM. The model is computationally simple and has a certain degree of accuracy. Specifically, it records the relationships between sub channels linked to various IRS aspects, which are generally overlooked in existing studies. Flexible beamforming can also help to lessen interference. Therefore, using spatial multiplexing gain as a means of achieving higher channel capacity is an additional avenue. All those methods, nevertheless, are limited to transmitter and receiver design. Conversely, the wireless channels should be adjusted; they should not be modified. Base station (BS) coverage in 5G and beyond may be significantly less than in 4G systems because of the higher frequencies that will be employed in these systems. The interaction between the transceivers and the wireless propagation conditions becomes more complex as a result of the requirement for additional BSs. In these kinds of scenarios, it would be ideal if the wireless environments, or channels, could be "engineered" through active control. The localization system of IR ultra wide band nodes in indoor scenario is proposed for reduction of signal to noise ratio [8]. The behaviour of path gain and power delay profile of Saleh and Valenzuela foe ultra wide band channel is mentioned in this research article for 60 GHz frequency [9]. For calculating the fading characteristics and measuring the channel delay the article estimate the RMS delay spread for indoor environment [10]. The statistical multipath model for indoor scenario is used for calculating delay spread for 1.5 GHz frequency [11].

The block diagram comprise of transmitter, channel and receiver. In transmitter input bit stream is encoded by (a, b) with the help of LDPC encoder, where a bits are the input and b bits are the output. The output bits of the LDPC encoder is passed through the OFDM modulator. OFDM modulator performs various operation likes carrier modulation, applying Fourier transform. The output of the OFDM modulation is passed through channel where AWGN noise is added to the signal. OFDM demodulation uses FFT operation to extract the original transmitted signal from a carrier signal. The equalizer is used to reduce the inter symbol interference and allows to recover the original signal. The QAM modulation and demodulation is used to achieve high levels of spectrum usage efficiency.

Wireless communication system has fading to multipath nature of propagation of signal in the environment of wireless communication. Channel can be modelled as

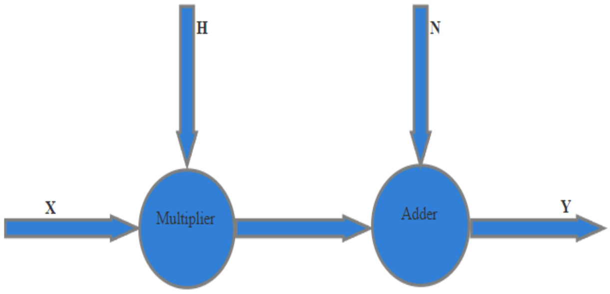

Fig1: Basic Channel Model

X=Transmitted Signal, H= Fading Coefficient, N=Noise, Y=Received Signal

$\mathrm{Y = HX + N}$

$\mathrm{H = a \times e^{j\emptyset}}$

where 'a' represents fading coefficient amplitude and

$'\emptyset'$ represents fading coefficient phase

$\mathrm{Received\ Power} = |\mathrm{H}|^2 \times \mathrm{P}$

P Represents Transmitted power

$\mathrm{H = a \times e^{\Phi}}$

$|\mathrm{H}| = \mathrm{a}$

$\mathrm{Received\ Power} = |\mathrm{a}|^2 \times \mathrm{P}$

$\mathrm{Received\ or\ Fading\ SNR} = (\mathrm{a^2 P})/\sigma^2$

$\mathrm{Received\ or\ Fading\ SNR} = \mathrm{a^2 \times SNR}$

BER of OFDM system

$= 0.5 \times (1 - \mathrm{sqrt}((\mathrm{L/N \times SNR})/(2 + \mathrm{L/N \times SNR}))$

2. Methodology

Fig2: Use of Channel in Wireless communication system

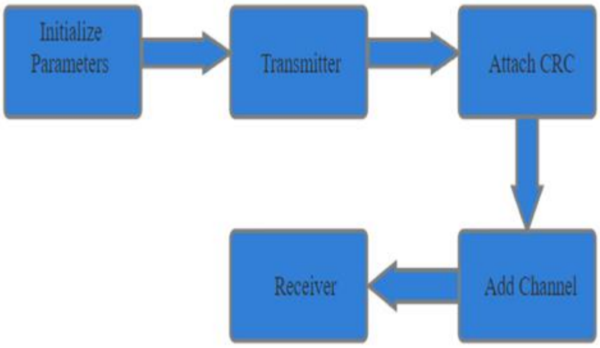

Table1.Simulation Settings for Bit Error Rate

Parameter	Specification
Length of Sequence	1000 bits
Frequency	28GHz
QAM Size	64
Noise	AWGN
Channel	Rayleigh
Digital Transmission Type	OFDM

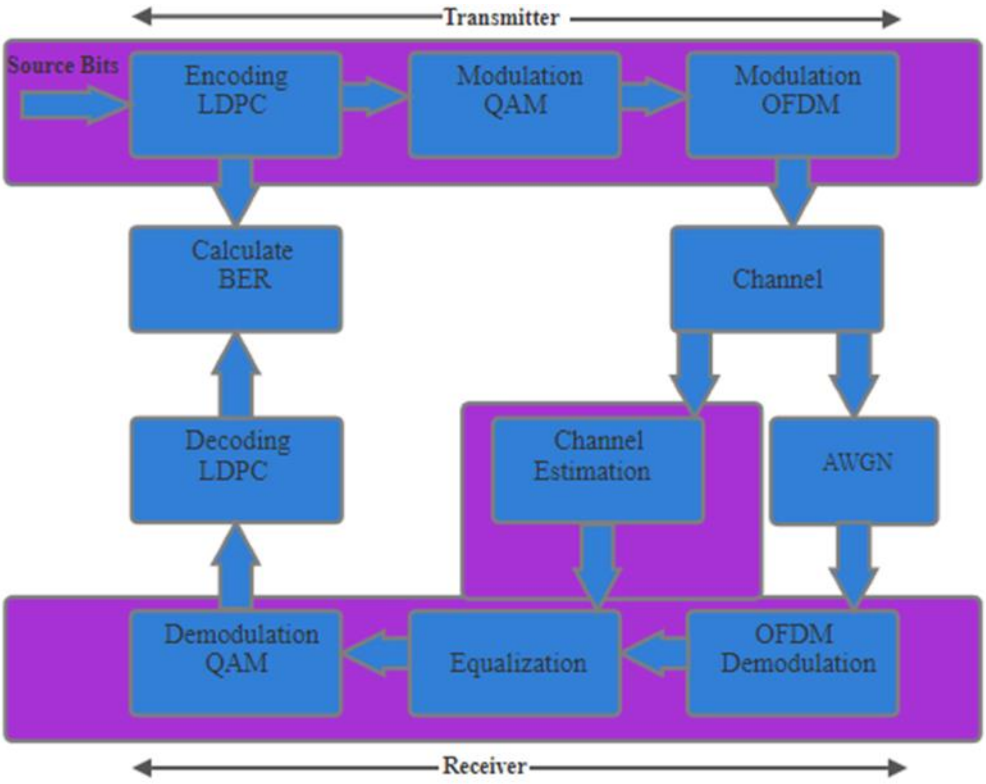

Fig3: Block diagram of the proposed system

3. Simulation & Result

In the figure 4, the Bit Error Rate of Saleh Valenzuela channel model for indoor environment is calculated for signal to noise ratio from 1 to 30 dB and it is found that Bit Error Rate with Cyclic Redundancy Check (CRC) Low Density Parity Check (LDPC) is very much less than Bit Error Rate without Cyclic Redundancy Check (CRC) Low Density Parity Check (LDPC). In the figure 5, the transmitted signal is passed through the channel and the Received signal with CRC LDPC and without CRC LDPC for SV channel model for indoor environment is calculated. In the figure 6, the Bit Error Rate of Saleh Valenzuela channel model for outdoor environment is calculated for signal to noise ratio from 1 to 30 dB and it is found that Bit Error Rate is more in the outdoor environment as compared to indoor environment. In the figure 7, the transmitted signal is passed through the channel and the Received signal with CRC LDPC and without CRC LDPC for SV channel model for outdoor environment is calculated and it is observed that more noise is accumulated in the signal. In the figure 8, the Bit Error Rate of Geometry based stochastic channel model for indoor environment is calculated for signal to noise ratio from 1 to 30 dB and it is found that Bit Error Rate with CRC LDPC is very much less than Bit Error Rate without CRC LDPC. The Bit error rate for the Geometry based stochastic channel model is more as compared to the Saleh Valenzuela channel model. In the figure 9, the transmitted signal is passed through the channel and the Received signal with CRC LDPC and without LDPC for Geometry based stochastic channel model for indoor environment is calculated. In the figure 10, the Bit Error Rate of Geometry based stochastic channel model for outdoor environment is calculated for signal to noise ratio from 1 to 30 dB and it is found that Bit Error Rate is more in the Geometry based stochastic channel model as compared to the Saleh Valenzuela channel model. Figure 11, the transmitted signal is passed through the channel and the Received signal with CRC LDPC and without CRC LDPC for Geometry based stochastic channel model for outdoor environment is calculated.

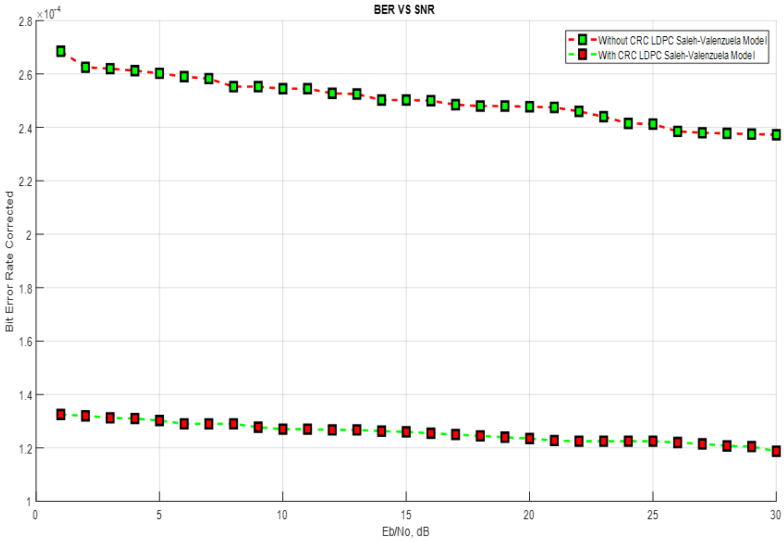

Fig4: Bit error rate plot of SV channel model for indoor environment

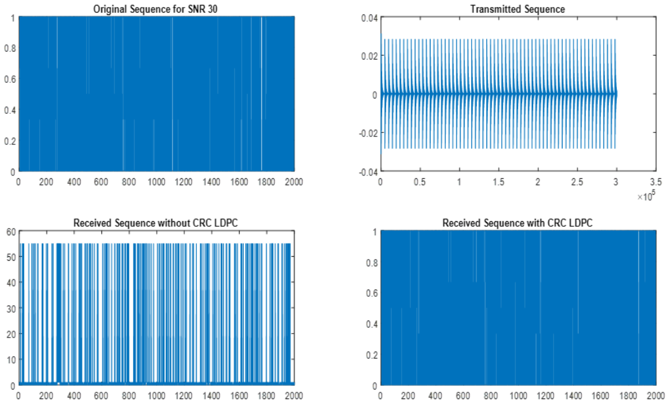

Fig5: Received signal with CRC LDPC and without CRC LDPC for SV channel model for indoor environment

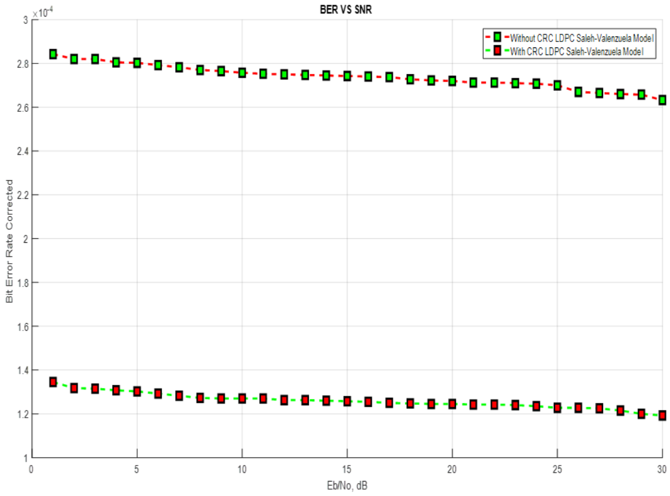

Fig6: Bit error rate plot of SV channel model for outdoor environment

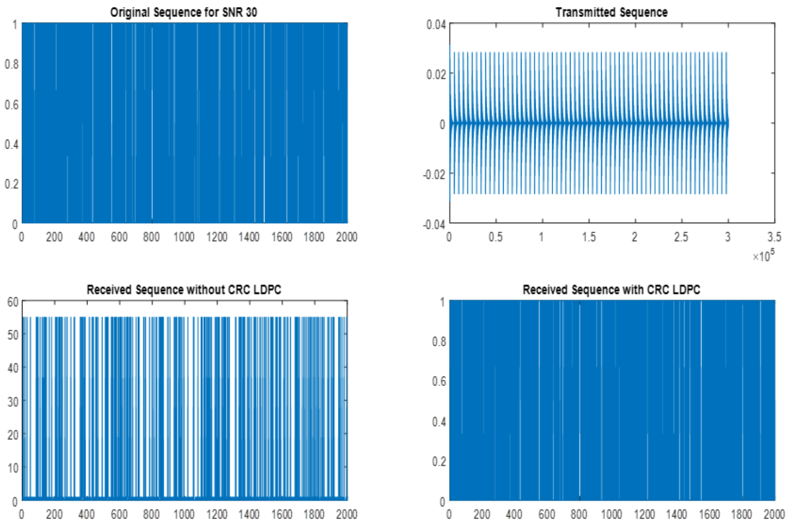

Fig7: Received signal with CRC LDPC and without LDPC of SV channel model for outdoor environment

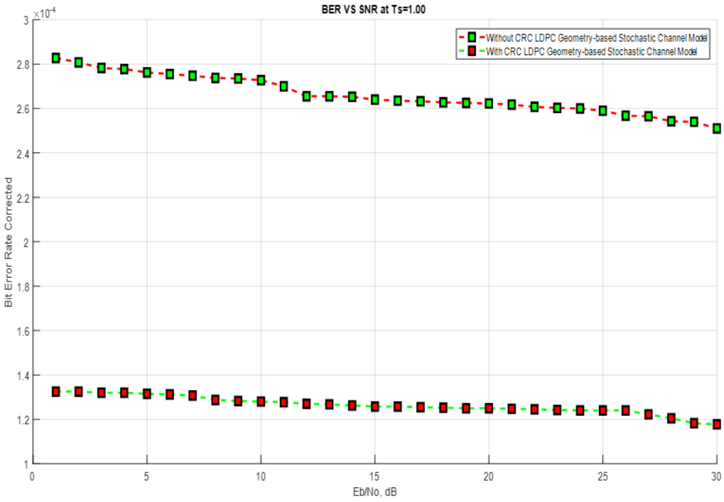

Fig8: Bit error rate plot of Geometry based stochastic channel model for indoor environment

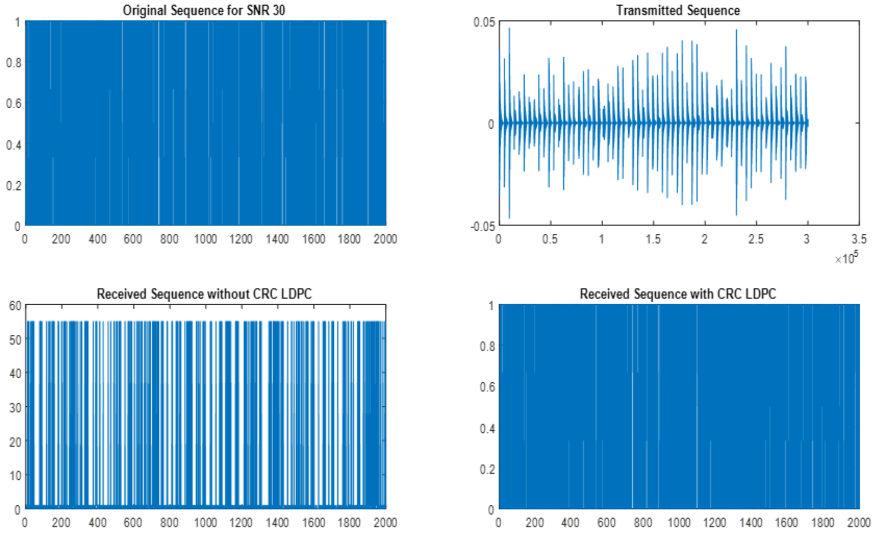

Fig9: Received signal with CRC LDPC and without CRC LDPC of Geometry based stochastic channel model for indoor environment

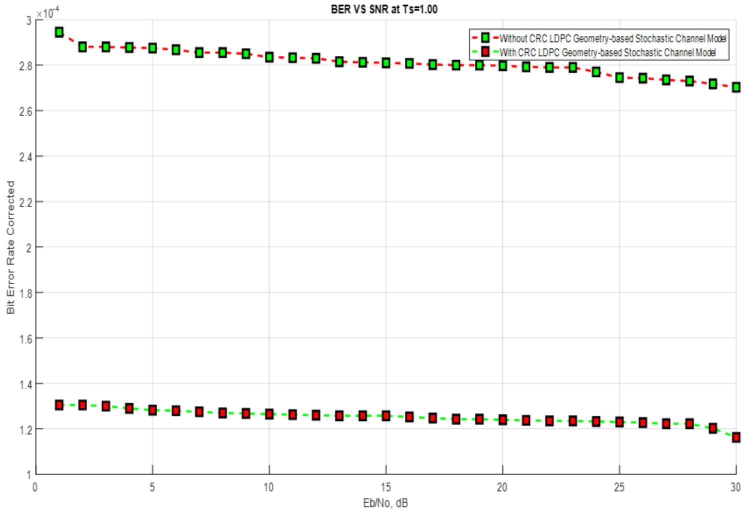

Fig10: Bit error rate plot of Geometry based stochastic channel model for outdoor environment

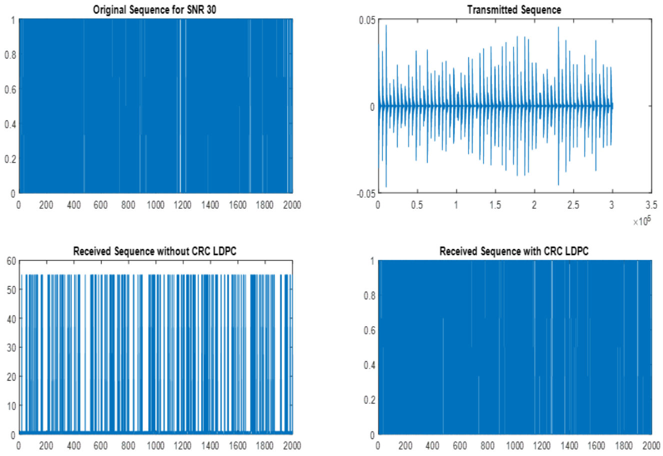

Fig11: Received signal with CRC LDPC and without CRC LDPC Geometry based stochastic channel model for outdoor environment

Table2.Analysis of Bit Error rate

Sr. No.	Model	Environment	SNR (dB)	BER With LDPC CRC	BER Without LDPC CRC
1	SV Model	Indoor	Minimum	0.00013250	0.00026700
2			Maximum	0.00011425	0.00023525
3		Outdoor	Minimum	0.00013300	0.00028375
4			Maximum	0.00011800	0.00025825
5	Geometry based stochastic channel model	Indoor	Minimum	0.00013400	0.00028475
5			Maximum	0.00011900	0.00025000
6		Outdoor	Minimum	0.00013325	0.00028725
7			Maximum	0.00011725	0.00026600

3. Conclusion

It is observed that Saleh Valenzuela channel model is having less Bit Error Rate as compared to the Geometry based stochastic channel model for both indoor and outdoor environment. It can be concluded that SV channel model can be used for milli meter wave communication for high frequency range. To optimize SV model further the Path Loss, Los probability, Spectral Efficiency can be evaluated for milli meter wave communication for high frequency range.

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Appendix

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