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To Analyze the Aftermath of using Hybrid RF/FSO Link Over FSO Link under Various Turbulence of Atmosphere

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***Abstract*— The palatable conditions are followed by both FSO and RF and for that they are considered to be one of the main connections in the field of networking system of communication correspondence systems though the two works efficiently as indicated by there individuality. The constraints for there use are turned out to be there limited states of different crumbling that would result as a effect of different parameters that termed as fading and among them the climatic conditions turns to be the most effective highlights among rest of all others. For conquering the limitations of the model utilized by fso connections, we have utilized the Hybrid FSO/RF model which contains the rf link also with fso as a connection. The linked up connection of both rf and fso link prompts the developed model into system .we contemplated the effects of fading over the FSO connection and after that we are to infer the shut structure expression of BER utilizing OOK plot and as a result the signal is to be demonstrated by utilizing gamma-gamma dispersion channel. The framework precision could only be maintained by analyzing the entirety of its misalignment parameters in terms of BER and outage probability. Whereas, the 16-QAM modulator is to be used for RF connect utilizing Rician channel conveyance parameters for model. Accordingly with the use of both links in the model the crossover system of these connections is made referred to be as the half breed or hybrid FSO/RF interface by utilizing switching techniques. Presently we dealing with the execution of the cross breed FSO/RF interface.**

Keywords—OOK , BER, 16-QAM, Outage Probability, Cross breed FSO/RF

I. INTRODUCTION

The free space optics have accomplished a markable remain in the remote correspondence organizes when contrasted with radio recurrence. In spite of the fact that the way rf and mm joins are additionally viewed as one of the significant frameworks in remote systems administration. It is very conceivable to access the networking system by means of sending voice and video through ease and it is due to haste data distribution and dependable over the mm wave network. FSO have obtained the augmented worry in the field of remote correspondence by getting further developed scope of data transmission with the expanded limit when contrasted with RF link connection. The remote system those are reliant on RF and mm wave gives the information rate as 10Mbps (one to many) to different estimations of 100Mbps (balanced). Though these systems have its very own limit conditions that it may confront disappointment because of blockage of the range or aggravations brought about by other approved band groups.

Subsequently, so as to come over the confinements we could plan a system as a combination of both the connecting links and could have the better execution of framework is referred to be as mixture FSO/RF with better results. The switching is conceivable way between them that leads the formation of hybrid FSO/RF connect. It comprises of two sorts of systems in it i.e Hard and Soft systems stated in [11]. In hard switching system, the FSO works as a dynamic one like we could say that by default it only works whereas RF is considered as a substitute link for system. The working procedure of it is like that when the conditions are in the support of FSO connect then this connection will perform and RF go about as an inactive one. while on the off chance that the circumstance get turned around, at that point FSO falls flat and around then RF connection will be dynamic and come into the work. The switching system in which both the connections performing in the meantime that is known to be as soft switching presented in [12]. The utilization of this connection could totally lessen the side effects caused over the fso interface and improves the execution of the connection in the hybrid model. By the utilization of this switching technique in our procedure, this is working more efficiently and demonstrated valuable over the system region. In the field of WCN the FSO is viewed as finest organized connect. It furnishes us the permit unfenced with higher information rate and data transmission at an exceptionally ease rate. The rest are stated in [1],[2]

The framework increasingly solid due to switching technique and yet it has its very own confinements. The framework disintegrate through different effects like affectability towards atmosphere and weather conditions, smog, pointing blunders and so forth. The transmission in fso is considered to be piogant and results as the predominant factor of pointing errors. Along these path this atmospheric disturbance lessens the efficiency of the system and results in terms of disappointment of the framework. The requirement of the ideal system with the insignificant misfortune rate drives us to the development of the half breed system of both FSO and RF connect. With the assistance of this system we could avoid the odds of framework disappointment. After knowing the turbulence of atmosphere with smog totally dependable over the variations in reflective index. These variations prompts colossal varieties in the power, the signal of light and effect

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the execution of connection. In this we could examine, the FSO interface execution is finished by utilizing connected pathloss with the misaligned fading of network. Furthermore, it works with OOK modulatio(on-off keying) scheme and have the received signals over varieties by Gamma-Gamma disseminations.

The conditions of weather and turbulences over atmosphere are stated to be the major reason behind the loss in the system in the FSO connect. For overcoming the loss in the received signal the decrease the effects the hybrid FSO/RF interface is liked and applied. The outage probability and BER are parameters that are utilized to check the execution of the system. The total dependency of parameters results into distribution and leads to the mistakes in pointing errors in the framework. The weather conditions effectiveness could be controlled by utilizing pointing mistakes and that will be helpful for the system. So by utilizing the half and half FSO/RF interface we can see the execution of the framework that couldn't bound the system and it very well may be used in intense disturbances over atmosphere with no failure.

II. SYSTEM MODEL

A. FSO CHANNEL MODEL

The system requires IM/DD with OOK modulatn as an essential part of this system. As per this channel, AWGN having distributive fading 'g', at that point received signal is presented by r2. It is defined as (1).

$$r2 = ge2 + n2 \quad (1)$$

In above expression the mean value of n2 is zero and variance is σ2 n. The standardized fading channel is presented in the form of given expression in (2).

$$g = gl2 * ga2 * gp \quad (2)$$

The g terms in above expression is presenting the elements of the attenuation which are to be considered in a mid of the misalignment. Due to this it is easy to obtain the misfortunes or losses that happened in framework. The system has these with them as a result of this the rate of being influenced by turbulence increments because of this as it were.

FADING EFFECTS

The WC contains fading as a variation in the attenuation of a transmitted signal towards collector with the loads of different resources. These resources include different factors like geographical positions, time, rf recurrence ranges etc. It could likely be expressed in the form of arbitrarily performed procedure. Just the correspondence channels need to confront the proportions of Fading. The fading in FSO requires different parameters to it and among them pointing erors, air misfortune, barometrical choppiness and last with the first one is joined model of channel. Due to these parameters only the charge of disappointment happened in the connection. The various effects are presented here.

- Pointing Errors
- Atmospheric Loss
- Atmospheric Turbulence
- Combined Channel

Among these pointing errors plays a vital role in the section as it only becomes a major cause for the loss occurred at the receiver section signal. This is clearly stated in [3],[4]

B. RF CHANNEL MODEL

The utilization of 16-QAM and transmission(LOS) is feasible for good outcomes at recipient side. The r1 is presented in the form of signal output in the form as (3)

$$r_1 = \sqrt{g_{l1}} g_{\alpha 1} e_1 = n_1 \quad (3)$$

The various terms of g like gα1 and gl1 presents the fading coefficient and then the loss of the way. The pathloss to be represented in terms of 60Hz in (4).

$$g_{l1}[dB] = G_T + G_R - 20log_{10}(\frac{4\pi L}{\lambda_{RF}}) - \alpha_x L - \alpha_{rain} L \quad (4)$$

The parameters of RF interface can be utilized as Rician dispersion by the use of Rice parameter presented in the form of K as recommended in [15]. The Rayleigh distribution have K is exactly equal to zero which is responsible for having the largest effect of fading. In this way if the esteemed for is more prominent than it brings down the fading effect to framework as AWGN. Among some of them the rice parameter is considered to be one of the significant factor for this conveyance. It can be easily presented. It makes us ascertain the qualities all around obviously in form of given expression (5).

$$f_{RF}(g_{\alpha 1}) = 2(K+1)g_{\alpha 1}(-K-(K+1)g_{\alpha 1}^2) \times I_0(2g_{\alpha 1}\sqrt{K(K+1)}) \quad (5)$$

Above I(0) is displayed as the zeroth order modified Bessel Function that of first kind as it were in [5]. The SNR of RF in terms of instantaneous receiver could be presented as normal SNR.

III. THE OUTAGE PROBABILITY

The communication wirelessly involves the outage probability as a significant factor. It is characterized in terms of probability of the state when the SNR falls beneath a specific edge of nature's service and the connection winds up unfit to transmit information stated in [6]. This segment contains the detailed study of various characterstics such as outage probability for both rf and fso links so afterwards it leads for the deduction of it in case of hybrid rf/fso .

A. FSO Link

The parameter could easily be defined with the help of the threshold value in dB for FSO link stated in [8],[9]. The equation presented here would easily reflect its output value in terms of various terms as presented in (6).

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$$F(\gamma_{thFSO}) = \int_0^{\gamma_{thFSO}} f_{\gamma_{FSO}}(\gamma_{FSO}) d\gamma_{FSO} \quad (6)$$

After simplifying the equation (6) we get the output in terms of the huge expression that is represented as (7) in terms presented in [7]

$$P_{out}^{FSO}(\gamma_{thFSO}) = \frac{2^{\alpha+\beta-3}\phi^2}{\pi\Gamma(\alpha)\Gamma(\beta)} \times G_{3,7}^{6,1}[(\frac{\alpha\beta\gamma}{4})^2 \frac{\gamma_{thFSO}}{\gamma_{FSO}} |^{1,\frac{\phi^2+1}{2},\frac{\phi^2+2}{2}}_{\frac{\phi^2}{2},\frac{\phi^2+1}{2},\frac{\alpha}{2},\frac{\alpha+1}{2},\frac{\beta}{2},\frac{\beta+1}{2},0}] \quad (7)$$

Thus, this is considered to be final expression to plot and presents the exact required output in terms of using the gamma-distribution model from [1]. Thus in (7) the use of Meijer G-function leads using [14]

B. RF Link

For this link we have SNR value in its average that falls for certain values of the system and as a result it is expressed in the form of expression (8) stated as [10]

$$P_{out}^{RF}(\gamma_{thRF}) = 1 - Q_1(\sqrt{2K}, \sqrt{\frac{2(K+1)\gamma_{thRF}}{\gamma_{RF}}}) \quad (8)$$

C. Hybrid RF/FSO Link

The combination of both the links results in terms of equations and forms the better performance system model with better outage probability stated in [13].

$$P_{out}^{hybrid} = P_{out}^{FSO}(\gamma_{thFSO}) \times P_{out}^{RF}(\gamma_{thRF}) \quad (9)$$

Thus, it results in the detailed expression as presented in the expression below marked as (10)

$$P_{out}^{hybrid} = \frac{2^{\alpha+\beta-3}\phi^2}{\pi\Gamma(\alpha)\Gamma(\beta)} \times G_{3,7}^{6,1}[(\frac{\alpha\beta\gamma}{4})^2 \frac{\gamma_{thFSO}}{\gamma_{FSO}} |^{1,\frac{\phi^2+1}{2},\frac{\phi^2+2}{2}}_{\frac{\phi^2}{2},\frac{\phi^2+1}{2},\frac{\alpha}{2},\frac{\alpha+1}{2},\frac{\beta}{2},\frac{\beta+1}{2},0}] \times 1 - Q_1(\sqrt{2K}, \sqrt{\frac{2(K+1)\gamma_{thRF}}{\gamma_{RF}}}) \quad (10)$$

IV. BIT ERROR RATE

This area contains the shut structure expression for the BER of the FSO interface for a mixed fading and OOK tweak. At that point, the BER for the RF channel can be presented over Rician fading and 16-QAM modulator. Besides this the articulation can be presented in the form of BER of the hybrid FSO/RF framework for hard exchanging.

A. FSO Link

The PDF expression for BER of fso can be expressed in the (11) with the consideration of Marcum Q-function

$$P_b = \int_0^{\infty} P_e f_h(h) dh \quad (11)$$

Here Pe can be presented in the given form

$$P_e = Q(\sqrt{\frac{\gamma_{FSO}}{2}}) \quad (12)$$

The final expression for BER can be presented in the form here as (13)

$$P_b(\gamma_{FSO}) = \frac{2^{\alpha+\beta-4}\phi^2}{\pi^{\frac{3}{2}}\Gamma(\alpha)\Gamma(\beta)} \times G_{7,4}^{2,6}[\frac{4\gamma_{FSO}}{(\alpha\beta\zeta)^2} |^{\frac{1-\phi^2}{2},\frac{2-\phi^2}{2},\frac{1-\alpha}{2},\frac{2-\alpha}{2},\frac{1-\beta}{2},\frac{2-\beta}{2},1}_{0,\frac{1}{2},\frac{-\phi^2}{2},\frac{1-\phi^2}{2}}] \quad (13)$$

B. RF Link

In case of this link the expression for BER could be with the various sub variables such as presented here in (14) expression

$$P_b(\gamma_{RF}) = a + b - 2\sqrt{\frac{c}{\pi}}(a+2b)I_1 + \frac{4bc}{\phi}I_2 \quad (14)$$

Thus, the values for particular variables are expressed in terms of the expression as (15) and (16)

$$I_1 = exp(-K)\sqrt{\frac{\gamma_{RF}}{(1+K+c\gamma_{RF})}} \sum_{m=0}^{\infty} \frac{K^m\Gamma(m+\frac{3}{2})}{(m!)^2} \times \frac{(1+K)^m}{1+K+c\gamma_{RF}} \quad (15)$$

$$I_2 = \frac{\gamma_{RF}exp(-K)}{(1+K+2c\gamma_{RF})} \sum_{m=0}^{\infty} (\frac{1+K}{1+K+2c\gamma_{RF}})^j \quad (16)$$

This expression we have variables that could easily be mentioned in [1].

C. Hybrid RF/FSO Link

The combined value of fso and rf results in terms of hybrid rf/fso and in this way if we consider the expression here we have it as

$$P_b^{Hybrid} = P_b^{RF}(\gamma_{RF}) \times P_b^{FSO}(\gamma_{FSO} \quad (17)$$

$$Pr(average\gamma_{FSO} < \gamma_{thFSO}.average\gamma_{RF} > \gamma_{thRF}) = Pr(average\gamma_{FSO} < \gamma_{thFSO}) Pr(average\gamma_{RF} > \gamma_{thRF}) \quad (18)$$

The final BER expression for the hybrid network is presented here in terms of expression as (19)

$$P_b^{hard} = \frac{(1 - P_{out}^{FSO}(\gamma_{thFSO}))P_b(average\gamma_{FSO}) + P_{out}^{FSO}(\gamma_{thFSO})(1 - P_{out}^{RF}\gamma(thRF))P_b(average\gamma_{RF})}{1 - P_{out}^{FSO}(\gamma_{thFSO})P_{out}^{RF}(\gamma_{thRF})} \quad (19)$$

V. SIMULATION RESULTS

This segment of the paper contains the simulation result for each of the links separately except the rf link. Being the active link the fso link has to play a major role that will be totally effecting the results of the system. Here various graphs in the form of figures are obtained that results in terms of outage probability and BER parameter .

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TABLE I

FSO parameters for linking

FSO		
Parameters	Symbols	Value
Laser wavelength	γ_{FSO}	1550 nm
Modulation	s	OOK
Beam Divergence Angle	θ	2 mrad
Receiver Diameter	D	20 cm
Data Rate	R	1Gbits/s
Displacement Standard Deviation	σ_s	0.07 m
Receiver Aperture Radius	R_0	0.062 m

TABLE II

RF linking Parameters

RF		
Parameters	Symbols	Value
Modulation	-	16-QAM
Bandwidth	B	250MHz
Transmitter Antenna Gain	G_T	44 dBi
Receiver Antenna Gain	G_R	44 dBi
Data Rate	-	100 Mps

The Fig.1 states several effects of fading over the outage probability basically in terms of the errors in case of fso link that results in this form pointing. Among this we have another factor in consideration that is turbulence conditions over atmosphere which results in terms of α and β parameters. Here different conditions for turbulence are preferred like moderate and strong due to which we have variation in α and β value. For moderate α=2.296 & β=1.822 and for strong α= 2.064 and β=1.342. The threshold value for FSO as well as RF in terms of SNR is 6dB. Thus, here we could determine that increment in atmospheric disturbance strength and pointing errors sternness results in increase of outage probability. The ϕ parameter is inversely related with the pointing error ratio. As a result the outage probability increases with the reduction of ϕ from 6 to 1.2.

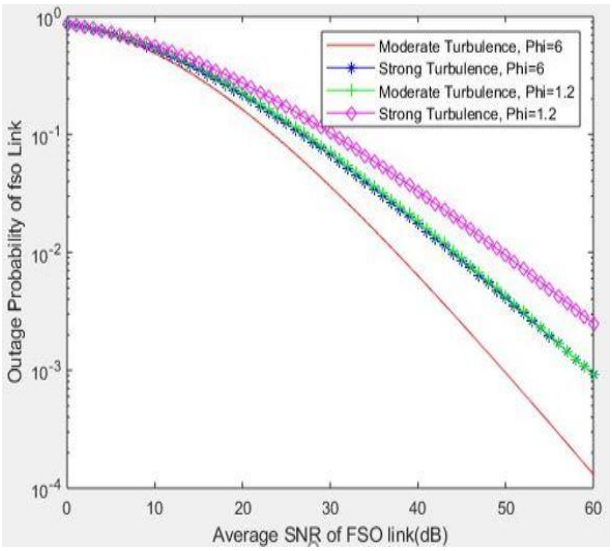

Fig.1 The Outage Probability of FSO link versus average SNR in same link with different variation in ϕ between 1.2 to 6

The Fig.2 states the outage probability for a hybrid rf/fso network which is specially proceeded for the ϕ=1.2 in terms of both moderate and strong network. By seeing the graph output we can depict that the combination of rf link into the network results in better framework performance than only FSO link. The outage probability increases to 0.001 than only 1. Thus, this results into more accuracy of the system due to which the losses occurred in system can be easily inferred. In this way we get better results than only fso link system model. Like here if we consider the SNR as 35 dB for both the cases then we can infer that for moderate turbulence the probability increases with respect to strong turbulence.

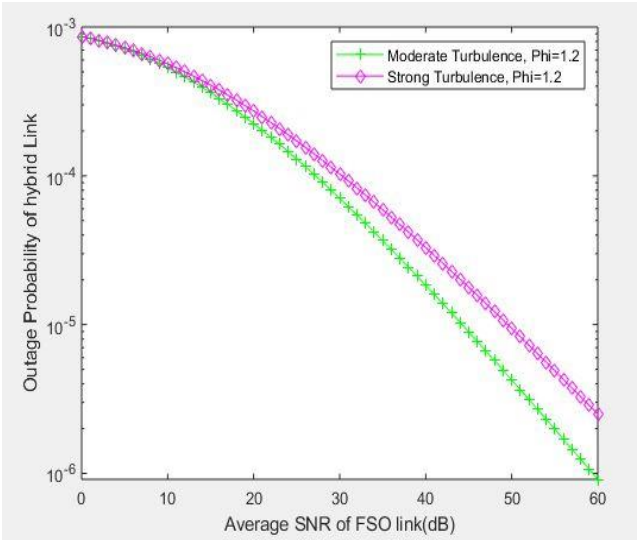

Fig.2 The Outage probability of Hybrid link versus average SNR of FSO link.

Fig.3 presents the bit error rate of FSO with respect to average SNR in terms of different aspects carrying the two different values for ϕ as 1.2 and 6. There are four different conditions to present and among them. The increment in FSO ber we can see by the pointing error effect in strong turbulence. Then in case of moderate the BER decreases with the variation in ϕ value. In this case both increases with the increase in ϕ in terms of BER of fso. As a result we can consider it for the minor cases of misalignment.

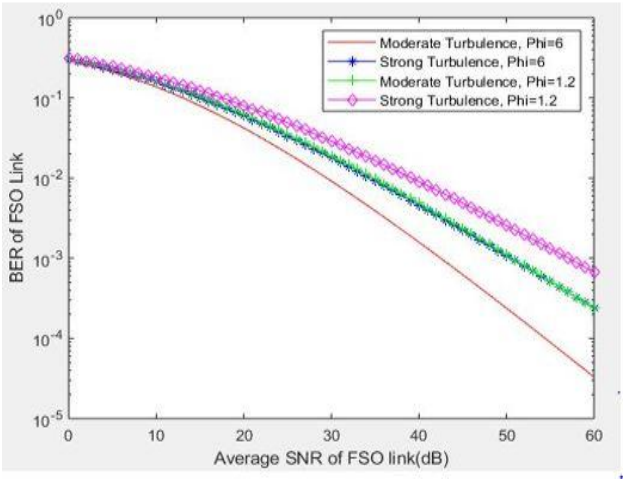

Fig.3 Bit Error Rate of FSO link for again different conditions.

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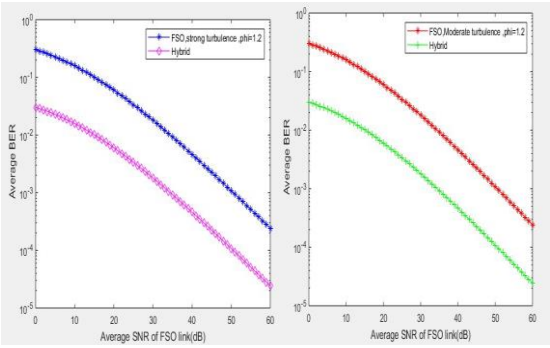
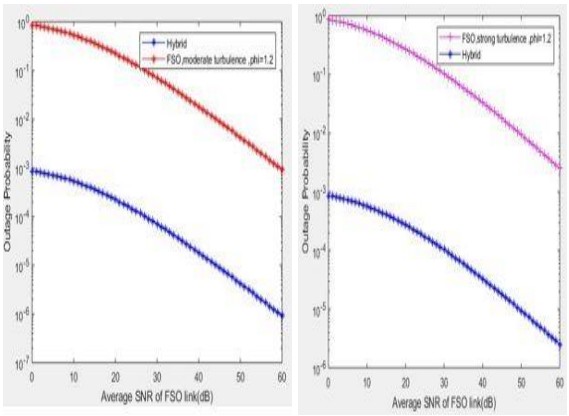
In Fig. 4 the difference between hybrid rf/fso link with FSO link can be seen without any more specifications. Directly we could infer the figure and state its parametric values with its condition over it. As we can see that fso link alone has higher error rate as compared to the hybrid network. So combining both the links results in good performance of the framework then the hybrid is o be considered instead of preferring the fso model. This reduces the signal loss by overcoming the limitations of the network.



(a) (b)

Fig.4 Comparison of hybrid rf/fso link with FSO link where (a) contains strong turbulence and (b) contains moderate turbulence

The Fig.5 depicts the observation of the comparison of network which leads us to except the performance quotient of both the links in terms of outage probability is done. As a result we could notice the performance of links. So the performance for ϕ in different turbulence like strong and moderate. I could determine that the results are better in case of hybrid link as compared to fso link only as presented here.



(a) (b)

Fig.5 Comparison of outage probability for fso and hybrid rf/fso link where (a) have moderate turbulence and (b) have strong turbulence

CONCLUSION

This paper pondered the effects of fading to the FSO link which is reliant on OOK technique of modulation with the RF connect as a consolidated connection so the framework don't confront any disappointment occurred in the system or the data losses that would work at the beneficiary side due to impact of pointing errors that drives the turbulence caused by weather. I got a shut structure articulation for the BER to get the effects which would not lead the framework for disappointment and gives better outcome by defeating the effects of pointing errors in the system. Similarly, we had noticed the effect of mistake over FSO connect organize.I determined that in case of strong turbulence the less fluctuation results in pointing errors that amazingly influence the working of the connection,whereas, in moderate unsettling influence, the aggravation in the connections will execute very effects with the pointing blunders.we looked into for the mixture FSO/RF connect in the consolidated effects.The obtained results exhibit the finding of the FSO interface over the consolidated connection that effects the lead of the hybrid FSO/RF.As a result, we have the low SNR and the hybrid FSO/RF link model network performs more precisely than to FSO alone and may be it could be demonstrated more great as far as execution than just FSO.

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