Study on Recent Trends and Future Challenges in FSO Communication System

[1]B. Reuben, [2]B. Prakash Ayyappan
[1]*Assistant Professor, Department of ECE, Sri Bharathi Engineering College for Women, Kaikkurichi, Pudukkottai-622 303*
[2]*Associate Professor, Department of EEE, Sri Bharathi Engineering College for Women, Kaikkurichi, Pudukkottai-622 303*

Abstract- ***In recent period of communication there is a necessity of structures with high capability and bandwidth. This is done by means of the non-fiber optics based gadget recognized as free space optical communication device. These systems which are reliant upon optics in free area, does no longer require any license for its operation. Free space optical (FSO) wi-fi communication has emerged as a possible generation for bridging the distance in current excessive date charge fiber network and as a temporary backbone for swiftly deployable mobile wi-fi communication infrastructure. Free space optical communication gives the capacity to ship massive amount of data security over slight distances without the fee of laying fiber optic cable. The era is useful in which the physical connection of the transmitter and receiver locations is hard. These sturdy structures which establish communication links by way of transmitting laser beams immediately through the surroundings, have matured to the point that mass produced fashions are now to be had. FSO device offers many functions among them being the low-begin up and operational fee, fast improvement and excessive fiber-like bandwidth. In this paper first component introduces the FSO device, its advantages, and risks its packages. Second part informs about the demanding situations which a FSO system faces while running. The demanding situations faced with the aid of FSO device is atmospheric attenuation. The atmospheric attenuation is caused by the fog, smog, rain, smoke, hen flap and many others.***

Keywords-Free space optics (FSO), WDM, Atmospheric turbulences, Line of sight, Beam divergence

I. INTRODUCTION

A. FSO Communication - An Overview

The improvement of wi-fi communications be dealt with as one of the most noteworthy phenomena in the past of technology. Free space optical (FSO) communication is a main region to investigate and researcher supply emphasis in this technology because of numerous advantages. This type of wi-fi optical communication generation makes use of fantastically narrow beam to transmit records from one factor to the other one. This LOS (line of sight) era gives advantages to each telecommunication customers and providers. It provides a excessive the most as much as several Gbps, has most noteworthy radio frequency interferences, requires no licensing, gives a especially secured communication hyperlink due to the usage of a very narrow beam angle, and offers an cheaper, speedy and smooth deployment whilst compared to the fiber optic installation.[1]. Wireless devices and technology have come to be pervasive plenty extra hastily than absolutely everyone could have imagined thirty years ago and they will hold to be a key element of cutting-edge society for the foreseeable future. Optical communication structures provide the very best to be had provider frequencies and for that reason the quickest facts costs feasible these days [2]. FSO is designed to be a lower value opportunity to traditional fiber-optic cable-based communication links. The maximum mature era used in FSO equipment relies on low price semiconductor lasers or LED's operating inside the near infrared at wavelengths of 785 nm or 850 nm. In the beyond few years, structures running at 1550 nm have also been developed. At first the companies of those structures claimed that the 1550 nm wavelength had higher propagation characteristics in intense climate than the 785 nm wavelengths [3]. With similarly analysis and research, those claims were withdrawn. Now there are claims that even longer wavelengths close to 10 microns will remedy the FSO hyperlink availability issues related to severe climate. Hype

approximately such magic wavelengths for FSO is each a disservice to the buyers who will lose the money they're making an investment based totally on exaggerated claims, and to the relaxation of the FSO industry which should be developing realistic expectations for the capability of its equipment [4]. In the weather conditions which usually reason the highest attenuation for FSO structures, namely coastal fog and coffee clouds, 10 microns offers no propagation gain over shorter wavelengths [5].

"Wireless optical Communication" (WOC) is the technology that uses optical service to switch statistics from one point to any other via an unguided channel which perhaps an atmosphere or free space. WOC is considered as a next frontier for excessive speed broadband connection because it offers extremely excessive bandwidth, ease of deployment, unlicensed spectrum allocation, decreased power intake (~half of RF), decreased size (~1/10 the diameter of RF antenna) and improved channel protection [1]. It can be labeled into two wide categories, particularly indoor and outside wireless s optical communications. Indoor WOC makes use of IR or visible light for communicating inside a constructing in which the possibility of setting up a physical stressed connection is bulky[2]–[9]. Indoor WOC is categorized into four everyday system configurations i.e., directed line-of-sight (LOS), non-directed LOS, diffused and tracked. Outdoor WOC is additionally termed as free space optical (FSO) communication. The FSO communication structures are in addition categorized into terrestrial l and area optical hyperlinks that encompass constructing-to-constructing, floor-to-satellite tv for pc, satellite tv for pc-to-floor, satellite-to-satellite, satellite-to-airborne platforms (unmanned aerial cars (UAVs) or balloons), [10]–[12] and so forth. Fig. 1 illustrates the classification of WOC device.

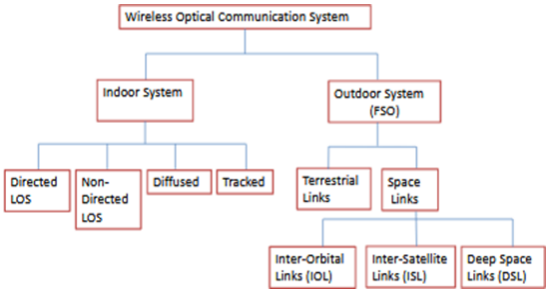

Fig 1. Classification of WOC device

The FSO communication affords LOS communication owing to its slender transmit beam width and works in visible and IR spectrum. The primary principle of FSO transmission is similar to fiber optic verbal exchange except that unlike fiber transmission, in this case the modulated statistics is transmitted through unguided channel rather of guided optical fiber. The initial paintings on FSO communication started out almost50 years again for protection and area applications where US military used to ship telegraph signal from one point to some other using sunlight powered gadgets. In year 1876, Alexander Graham Bell verified his first wireless telephone system [13], [14] by way of converting sound waves to electrical phone alerts and transmitted the voice signal over few feets using daylight as service. The device become referred to as "photograph-phone" as it changed into the world's first wireless telephone system. Commercially available FSO equipments offer a whole lot higher information costs ranging from 10Mbps to ten Gbps [24], [25]. FSO hyperlink has been demonstrated in laboratory as much as 80 Gbps with average BER of10−6withoutforward blunders correction (FEC) coding [26]. Many optical companies like Light Pointe in San Diego, fSONA in Canada, Cable Free Wireless Excellence in UK, Air Fiber in California etc., provide huge variety of wireless optical routers, optical wireless bridges, hybrid wireless bridges, switches etc., that can assist organization connectivity, remaining mile get right of entry to, HDTV broadcast link with nearly 100% reliability in unfavorable weather conditions.

B. Advantages of FSO Communication over RF Communication

FSO communication system gives numerous advantages over RF device. The major difference among FSO and RF communication arises from the large difference in the wavelength. For FSO machine, below clean climate situations (visibility > 10 miles), the atmospheric transmission window lies in the close to infrared wavelength range between 700 nm to 1600 nm. The transmission window for RF machine lies between 30 mm to 3 m. Therefore, RF wavelength is thousands of times larger than optical wavelength. This excessive ratio of wavelength ends in a few thrilling variations among the two structures as given below:

(i) Huge modulation bandwidth:

It is a properly known reality that boom in carrier frequency will increase the statistics wearing capacity of a communication system. In RF and microwave verbal exchange systems, the allowable bandwidth can be up to 20% of the carrier frequency. In optical verbal exchange, even if the bandwidth is taken to be 1% of provider frequency (≈1016Hz), the allowable bandwidth will be one hundred THz. This makes the usable bandwidth at an optical frequency in the order of THz which is almost105times that of ordinary RF provider [27].

(ii) Narrow beam divergence:

Narrow beam divergence: The beam divergence is proportional to λ/DR, where λ is the carrier wavelength and DR the aperture diameter. Thus, the beam unfold provided by means of the optical provider is narrower than that of RF service. This ends in growth in the intensity of sign at the receiver for a given transmitted power.

(iii) Less power and mass requirement:

For a given transmitter power level, the optical intensity is more at the receiver due to its narrow beam divergence. Thus, the a smaller wavelength of optical carrier permits the FSO designer to come up with a system that has smaller antenna than RF system to achieve the same gain (antenna gain scales inversely proportional to the square of operating wavelength). The typical size for the optical system is 0.3 m vs 1.5 m for the spacecraft antenna

C. Choice of wavelength in FSO communication

Wavelength choice in FSO communication is very important design parameter as it impacts link performance and detector sensitivity of the system. Since antenna gain is inversely percentage to operating wavelength, consequently, it is greater useful to operate at decrease wavelengths. However, higher wavelengths provide better hyperlink quality and lower pointing prompted sign fades [32]. Therefore, careful optimization of running wavelength in the design of FSO hyperlink allows in achieving higher performance. The choice of wavelength strongly depends on atmospheric effects, attenuation and heritage noise strength. Further, the availability of transmitter and receiver additives, eye safety guidelines and fee deeply affects the choice of wavelength in FSO design procedure. The International Commission on Illumination [33] has classified optical radiations into 3 classes: IR-A (700nm to 1400 nm), IR-B (1400 nm to 3000 nm) and IR-C(3000 nm to 1 mm). It can sub- categorized into (i) near-infrared (NIR) starting from 750 nm to 1450 nm is a low attenuation window and especially used for fiber optics, (ii) brief- infrared (SIR) ranging from 1400 nm to 3000 nm out of which 1530nm to 1560 nm is a dominant spectral range for long distance communication, (iii) mid- infrared (MIR) ranging from 3000nm to 8000 nm is used in army programs for guiding missiles, (iv) lengthy-infrared (LIR) ranging from 8000 nm to15μm is used in thermal imaging.

II.DEVELOPMENT OF FSO TECHNOLOGY

Optical communication in numerous bureaucracies, were used for thousands of years. The historical Greeks used a coded alphabetic gadget of signaling with torches. In the current era, wireless solar telegraphs referred to as heliographs have been developed, using coded alerts to talk with their recipients. On June 3, 1880, Bell performed the sector's first wireless smart phone transmission between buildings, a few 213 meters (700 toes) aside. The invention of lasers within the Nineteen Sixties revolutionized free space optics. Military organizations were particularly fascinated and boosted their improvement. In 2008, MRV Communications delivered a free-space optics (FSO)-based system with a records rate of 10GB/s initially claiming a distance of two km at excessive availability. This equipment is no longer available; before quit-of-life, the product's useful distance become modified all the way down to 350m. In 2013, the employer MOSTCOM started to serially produce a new wireless communication device that also had a records price of 10GB/s in addition to an advanced variety of up to two. Five km, Recent advances in FSO era have opened up mainstream communications makes use of, from quick-term solutions for brief distance network bridges to an attractive and possible alternative for service carriers to deliver the promise of all-optical networks. As an optical generation, FSO is a natural extension of the metro optical community middle, bringing fee-

powerful, dependable and fast optical ability to the network's edge.

III.WORKING PRINCIPLE

FSO-hyperlinks are majorly motivated by way of climate conditions. For that motive, a few tremendous traits of the environment need to be elaborated previous to describing the optical wi-fi structures in more detail. The lowest a part of the surroundings up to ten km above the Earth's surface is referred to as the troposphere or the weather sphere. It has a varying refraction index, that is dependent on the peak above the Earth's floor. Normally the refraction index decrease with the peak, but at climate inversion conditions there's a special courting. Atmospheric situations degrade laser communications via the environment in approaches. First, the atmosphere acts as a variable attenuator among the transmitting and receiving terminals. Second, a loose area laser hyperlink is subjected to scintillations. Attenuation is extra within the foggy days and less at the time of thin fog. Moreover the haze also consequences the transmission because the medium is air. Rain does not affect the signal at a great deal extent because the drop length aren't corresponding to laser wavelength.

IV.FSO ARCHITECTURES

FSO era has tested itself in different programs, in particular those requiring a tactical, point-to-factor link. FSO's finest fulfillment up to now has come from the LAN/campus connectivity market. Such applications should consist of a link among a newsroom and a broadcasting station, or a committed link among two high-traffic nodes in a massive building complicated. Thus, to maintain great of provider for a particular patron, the space from that purchaser's area to the nearest hub may also need to be shortened.

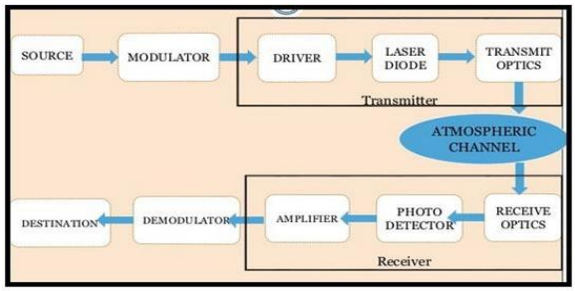

Fig 2. Block diagram of FSO based Communication System [5]

Three principal FSO architectures had been used thus far [4].

Point to factor structure is a dedicated connection that gives higher bandwidth but is less scalable.

Mesh structure may offer redundancy and hig reliability with smooth node addition but restriction distances greater than the other options.

Point to multipoint architecture offers inexpensive connections and enables node addition however on the expanse of decrease bandwidth than the factor to point alternative.

V.ATMOSPHERIC EFFECTS ON FSO LINK

The actual transmission prices are weather structured as the atmospheric attenuation is variable and hard to expect. The link might not paintings nicely in locations in which the ecosystem is stricken by conditions together with fog, hurricane, scintillation and so forth.

FSO and Fog: Fog significantly attenuates visible radiation and it has a comparable impact on the close to infrared wavelengths which are hired within the FSO device (1550nm). Note that the effect of fog at the loose area optical wireless radiation is absolutely analogous to the attenuation and fades suffered by the RF wireless system due to rain fall. Similar to the case of rain attenuation with RF wi-fi fog attenuation isn't a 'showstopper' for FSO (signals block out at the tv during heavy rain) because the optical hyperlink can be engineered such that for a massive fraction of time an appropriate strength is obtained even in presence of heavy fog. FSO optical wireless based communication system may be stronger to yield even greater availabilities [6].

FSO and Scintillation: Atmospheric scintillation may be idea of as converting light intensities in time and space on the aircraft of a receiver detecting the sign from a transmitter at a distance. When the beam is scintillated, photons of light are temporally prompt via pockets of air in random route. This is the identical atmospheric impact what causes stars to appear to twinkle at night time. The obtained sign degree at the detector fluctuates because of thermally brought on adjustments within the index of refraction of the air alongside the transmit direction. The index

modifications purpose the ecosystem to behave like a group of small prisms and lenses that deflect the light beam into and out of the transmit route. The time scale of those fluctuations is ready the time it takes a quantity of air the dimensions of the beam to move throughout the direction and consequently is associated with wind pace. For the case of loose-area optics, which means horizontal direction propagation and therefore stronger scintillation, the distribution tends to be extra exponential. One parameter that is frequently used as a degree of the scintillation strength is the atmospheric structure parameter. This parameter, that is without delay related to wind speed, roughly measures how turbulent the atmosphere is [8]. To conquer the scintillation consequences computerized benefit manipulate mechanism is used and additionally clock recovery phase lock loop time consistent removes the consequences of scintillation and jitter transference.

VI.APPLICATIONS

Education establishments connectivity: Today's l/university campuses are experiencing a triple play traffic (i.e., voice, facts, fax, multimedia traffic) this is overwhelming the typical connections. FSO systems can bridge a couple of homes in corporate and campus networks helping extremely-high speeds without the fee of committed fiber optic connections.

Support or returned quit for cellular systems: The developing quantity of bandwidth-in depth cellular telephone services now requires the deployment of technology including FSO which allow a lot better throughput act as returned cease.

Security: Today's cryptosystems are capable of offer handiest computational safety inside the limitations of conventional computing power and the realization of quantum computer systems could, as an instance, make digital money right away nugatory. Based at the company legal guidelines of physics, quantum cryptography affords a greatly extraordinary solution for encryption and guarantees unconditional safety. Quantum cryptography systems are usually taken into consideration alongside fiber optic infrastructure. FSO hyperlinks offer a flexible opportunity in instances where the fiber optic deployment is luxurious and/or infeasible.

Broadcasting: In broadcasting of live events including sports activities and ceremonies or tv reporting from remote areas and battle zones, indicators from the digital camera (or some of cameras) need to be sent to the broadcasting vehicle that is linked to a vital office through satellite tv for pc uplink. The required top notch transmission between the cameras and the vehicle may be furnished through a FSO hyperlink. FSO hyperlinks are able to fulfilling even the most.

VII.CHALLENGES AND FUTURE OF FSO

Free Space Optics (FSO) has become a viable, excessive-bandwidth wi-fi alternative to fiber optic cabling. The primary blessings of FSO over fiber are its fast deployment time and considerable price financial savings. The downside of FSO over fiber is that laser power attenuation thru the environment is variable and tough to predict, seeing that it is weather airports, the link availability as a function of distance can be anticipated for any FSO device. These availability curves provide an excellent indication of the affordable hyperlink distances for FSO structures in a particular geographical vicinity. The vendors and ISPs are every other capability huge user of FSO systems, especially for remaining-mile metro get entry to applications. If FSO structures are to be used in telecommunication programs, they will need to meet plenty higher availability necessities. Carrier-magnificence availability is commonly taken into consideration to be 99.999%. An evaluation of hyperlink budgets and visibility- restricting weather conditions suggests that to fulfill service-magnificence availability, FSO hyperlinks have to normally be less than 140m (there are towns like Phoenix and Las Vegas where this ninety nine.999% distance challenge will increase drastically). This calculation is based on a fifty three dB link price range. This idea is prolonged to the great viable FSO device, which might have a ten W transmitter and a photo counting detector with a sensitivity of one nW. This FSO machine could have a 100 dB link margin, which could best increase the ninety nine.999% link distance to 286 m. A more practical method to extending the high availability variety might be to lower back up the FSO link with a decrease statistics rate radio frequency (RF) hyperlink. This hybrid FSO/RF machine would amplify the 99.999%

hyperlink range to longer distances and open up a miles larger metro/get admission to marketplace to the providers. It is important to recognize that because the hyperlink range will increase, there might be a moderate decrease in standard bandwidth. To display the geographical dependence of FSO performance, the primary map of FSO availabilities contoured over area is need to be presented. This map is step one to growing an attenuation map for predicting FSO overall performance, which will be used in comparable style to the International Telecommunication Union (ITU)/Crane maps for predicting microwave performance.

VIII.CONCLUSIONS

In our survey, we discovered that maximum of the packages of FSO are for short range of communication. The FSO communication system using NRZ line code with 1550 nm as opposed to that of 850 nm running wavelength using APD receiver in special climate situations achieves a super performance so that you can keep an acceptable received sign strength and BER levels. In the rain environment the normal FSO communication device distorts the sign. However with powerful discount in atmospheric turbulences using exclusive modulation strategies the distance may be extended as much as a bigger extent.

REFERENCES

[1] V. W. S. Chan, "Free-space optical communications,"J. LightwaveTech., vol. 24, no. 12, pp. 4750–4762, 2006.

[2] F. R. Gfeller and U. H. Bapst, "Wireless in-house data communicationvia diffuse infrared radiation,"Proc. IEEE, vol. 67, no. 11,pp. 1474–1486, 1979.

[3] A. J. C. Moreira, A. M. Tavares, R. T. Valadas, and A. M.de Oliveira Duarte, "Modulation methods for wireless infrared transmission systems performance under ambient light noise and interference,"Proc. SPIE, Wireless Data Trans., vol. 2601,pp. 226–237, 1995.

[4] A. M. Street, P. N. Stavrinou, D. C. O ' B rien, and D. J. Edward, "Indoor optical wireless systems- A review,"Opt. and Quant. Electr.,vol. 29, pp. 349–378, 1997.

[5] A. P. Tang, J. M. Kahn, and K. P. Ho, "Wireless infrared communication links using multi-beam transmitters and imaging receivers," in Proc. IEEE Int. Conf. on Commun., Dallas, U.S.A., pp. 180–186, 1996

[6] J. B. Carruthers and J. M. Kahn, "Angle diversity for nondirected wireless infrared communication," IEEE Trans. Comm., vol. 48, no. 6, pp. 960–969, 2000.

[7] R. Ramirez-Iniguez and R. J. Green, "Indoor optical wireless communications," in IEE Colloquium on Opt. Wireless Comm., vol. 128, pp. 14/1–14/7, 1999.

[8] D. J. T. Heatley, D. R. Wisely, I. Neild, and P. Cochrane, "Optical Wireless: The story so far,"IEEE Comm. Mag., vol. 36, no. 12,pp. 72–74, 79–82, Dec. 1998.

[9] J. Fernandes, P. A. Watson, and J. Neves, "Wireless LANs: Physical properties of infrared systems vs mmw systems," IEEE Comm. Mag., vol. 32, no. 8, pp. 68–73, Aug. 1994.

[10] Z. Ghassemlooy and W. O. Popoola, Terrestial Free-Space Optical Communications, ch. 17, pp. 356–392. InTech, 2010.

[11] H. T. Yura and W. G. McKinley, "Optical scintillation statistics forIR ground-to-space laser communication systems,"Appl. Opt., vol. 22,no. 21, pp. 3353–3358, Nov. 1983.

[12] V. Sharma and N. Kumar, "Improved analysis of 2.5 Gbps- inter-satellitelink (ISL) in inter-satellite optical wireless communication (ISOWC)system,"Opt. Comm., vol. 286, pp. 99–102, 2014.

[13] D. Hochfelder, "Alexander graham bell," Encylopedia Britannica, 2015.

[14] D. L. Hutt, K. J. Snell, and P. A. Belanger, "Alexander graham bell'sphotophone," Tech. Report: Optic & Photonics News, 1993.

[15] J. Hecht, "Beam: The race to make the laser," Tech. Report: Optics&Photonics News, 2005.

[16] F. Bellinne and D. E. Tonini, "Flight testing and evaluation of airborne multisensor display systems," J. Aircraft, vol. 7, no. 1, pp. 27–31, 1970.

[17] R. Deadrick and W. F. Deckelman, "Laser crosslink subsystem – An overview," inProc. SPIE, Free Space Laser Comm. Tech. IV, vol. 1635, (Los Angeles, CA), pp. 225–235, 1992.

[18] M. Jeganathan, K. E. Wilson, and J. R. Lesh, "Preliminary analysis of fluctuations in the

received uplink-beacon-power data obtained from the GOLD experiments," TDA Progress Report 42-124, Comm. Sys. and Research Sec., pp. 20-32, 1996.

[19] K. E. Wilson, "An overview of the GOLD experiment between the ETS-VI satellite and the table mountain facility," TDA Progress Report42-124, Comm. Sys. and Research Sec., pp. 9-19, 1996.

[20] J. Horwath, M. Knapek, B. Epple, M. Brechtelsbauer, and B. Wilkerson, "Broadband backhaul communication for stratospheric platforms: The stratospheric optical payload experiment (STROPEX),"inProc. SPIE, Free-Space Laser Comm. VI, vol. 6304, (San Diego, California, USA), Sept. 2006.

[21] A. Biswas, D. Boroson, and B. Edwards, "Mars laser communication demonstration: What it would have been,"Proc. SPIE, Free SpaceLaser Comm. Tech. XVIII, vol. 6105, 2006

[22] V. Cazaubiel, G. Planche, V. Chorvalli, L. Hors, B. Roy, E. Giraud,L. Vaillon, F. Carré, and E. Decourbey, "LOLA: A 40,000 km opticallink between an aircraft and a geostationary satellite," inProc. 6thInternational Conf. Space Optics, (Netherlands), Jun. 2006.

[23] Laser communications relay demonstration: The next step in optical communications," Goddard Space Flight Center, (NASA), Tech. Report: Weblink:http://www.nasa.gov/pdf/742122main_ LCRDF actSheet3.pdf

[24] Weblink:http://artolink.com.

[25] Weblink:http://www.fsona.com.

[26] R. M. Sova, J. E. Sluz, D. W. Young, J. J. C., A. Dwivedi, N. M.Demidovich III, J. E. GrJohnaves, M. Northcott, J. Douglass, J. Phillips, D. Don, A. McClarin, and D. Abelson, "80 Gb/s free-space optical communication demonstration between an aerostat and a ground terminal," inProc. SPIE, Free Space Laser Comm. VI, vol. 6304, 2006.

[27] W. D. Williams, M. Collins, D. M. Boroson, J. Lesh, A. Biswas, R. Orr,L. Schuchman, and O. Scott Sands, "RF and optical communications: A comparison of high data rate returns from deep space in the 2020timeframe," Tech. Report: NASA/TM-2007-214459, 2007.