International Journal of Innovations in Research
ISSN: 3048-9369 (Online)

Indoor Optical Wireless Communication using Pencil Beam and BER Calculation by using K-L Method

Deepali Choudhary
Assistant Professor, Department of Electronics and Instrumentation Engineering
Shri Govindram Seksaria Institute of Technology and Science, Indore, Madhya Pradesh, India
Email id: choudharydeepali11@gmail.com

DOI: https://doi.org/10.5281/zenodo.20473574

Abstract
Free Space optical wireless communication offered ultra high capacity using optical pencil beam to per individual device. By using this we are tuning the beam wavelength as 2D steering takes place, crossed grating pair also plays vital role in this process. This system is a part of indoor communication and so designed that angular steering of 2D beams takes place over an area approximately 2.5 meters and was achieved by wavelength tuning at a wavelength of 1550nm. System experiment by using Karhunen-Loeve method for DPSK without saddle point have shown the BER is 10^{-5} *shows the optical communication at a wavelength of 850nm i.e. near infrared region.*

Keywords: *Indoor Optical communication, diffractive optical beam steering, diffraction grating, Pencil Radiating antenna (PRA), Angular magnification.*

1. Introduction:

It has been noted in the last few years, mutual growth takes place in indoor and outdoor application of wireless communication which is making our communication less costly. As we can see in wired networks or say wired communication cost goes high because of maintenance and reconfiguration of wired networks but in case of wireless communication it is economical and flexible alternative to wired networks. In optical communication system, we reply on the optical beam to send our message to receiver in free space or wirelessly by using certain range of wavelength in infrared to ultraviolet including visible light spectrum. A European Union funded project known as OMEGA has developed Gigabit home access network, as infrared optical wireless provides high speed indoor communication. Due to the limited coverage area and spreading of light which implies that limited data rate in VLC (Visible light Communication), multiple directive beams are used, each individually pinpointing at a device and providing high capacity optical path to it. Each PRA provides capacity around 10Gbps per beam as it emits a multiple optical pencil beams. For connecting each PRA point-to-point link is used to the Central Communication Control (CCC), in which tunable laser source is present, which emits a wavelength that is tunable. By using of an optical cross connect (OXC) and fiber optical network, routes the optical signal and this optical signal is confined into the pencil beam. A PRA that is a passive 2D diffractive module is coupled so that light source of tunable wavelength via optical fiber network. CCC, Central Communication Controller is an autonomic network management and controller, which locates and trace the mobile devices (MD), performs a controlling operation on the OXC and the wavelength accordingly. CCC includes a signal-transparent optical cross-connect. The invention further includes a fiber optic network, where the wavelength-tunable light source is coupled to the fiber optic network, a pencil-radiating antenna (PRA), where the PRA comprises a passive 2-dimensional diffractive module, where the PRA is coupled to the fiber optic network, where the PRA coupled so that light source of tunable wavelength via optical fiber network, where the signal-transparent optical cross-connect routes the optical data signal to the PRA, where the optical data signal is transmitted through a confined optical pencil beam, where the PRA deflects the confined optical pencil beam in 2 angular dimensions as a function of a wavelength of the confined optical pencil beam, where the deflected optical pencil beam is disposed for communication with an opto-electronic communication device, and a radio return channel, where the radio return channel carries a data signal from the opto-electronic communication device to the CCC and in case the optical signal is not established carries a lack-of-connection communication between the opto-electronic communication device and the CCC. The RF spectrum has a band in the range of 60GHz, which has to be picking up the radio signal by a PRA. Basically at PRA our information is carried out on optical fiber network by using technique called Radio over Fiber. Inside this PRA, we placed passive diffracting gratings which steers a beam in 2D by varying its wavelength. We can see it in Fig. 2, different elements having different diffractive power as in two, one having low and second having high.

CCC is an interference-free communication system. CCC includes a signal-transparent optical cross-connect and fiber optic network, a pencil-radiating antenna (PRA) that is a passive 2-dimensional diffractive module is coupled so that light source of tunable wavelength via optical fiber network, the cross-connect routes the optical data signal to the PRA, the optical data signal is transmitted through a confined optical pencil beam, the PRA deflects the pencil beam in 2 angular dimensions as a function of a wavelength of the pencil beam, the deflected pencil beam is disposed for communication with an opto-electronic communication device, and a radio return channel that provides upstream communication from the communication device to the CCC includes a lack-of-connection communication between the communication device and the CCC.

2. Optical beam steered indoor communication:

As shown in fig.1, in a building optical communication steered communication system is installed so that each room contains PRA. Each PRA has a capacity of close to 10Gbps per beam and is operating the same in multiple beams. All the PRAs are connected with CCC by point to point fiber link. By laser diodes we can tune the beam wavelength and by Optical Cross Connect (OXC) we can manage the traffic as per demand with PRAs installed in different rooms. To provide automation to our network we are having intelligent tracking system to track the user location or Mobile Devices (MD) and OXC to set the required wavelength of the beam.

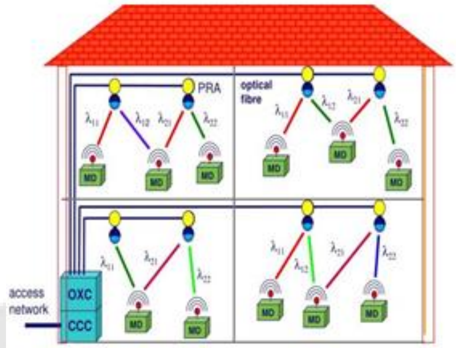

Fig. 1: Free space indoor optical communication by pencil beam

In this system we are using Machine Learning Technique to gather information related to user, user characteristics and also the beam steering process. MD to CCC is the upstream path where links are in the band of 57GHz to 64GHz are expected to be picked by the PRA and carried the signal over our fiber network. In the PRA, pair of diffraction grating provides steering to beam in 2D by varying its wavelength. Pair of diffraction grating or module contains two cross connect diffractive elements of low and high diffractive powers for beam wavelength variation. This will actually help us to steer the beam accordingly to the requirement.

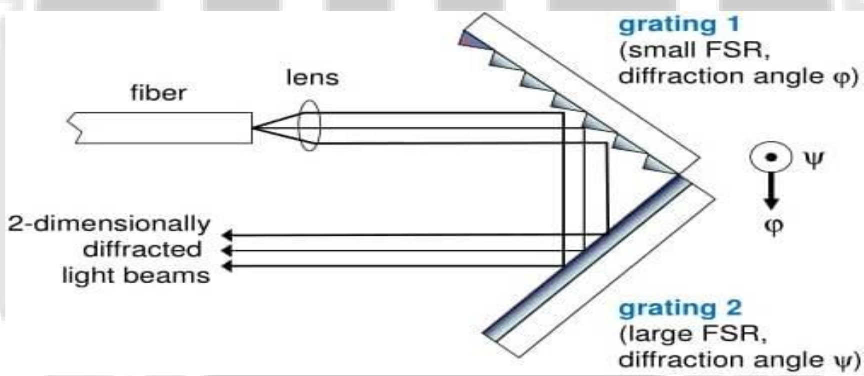

Fig. 2: Beam steering by a pair of crossed grating

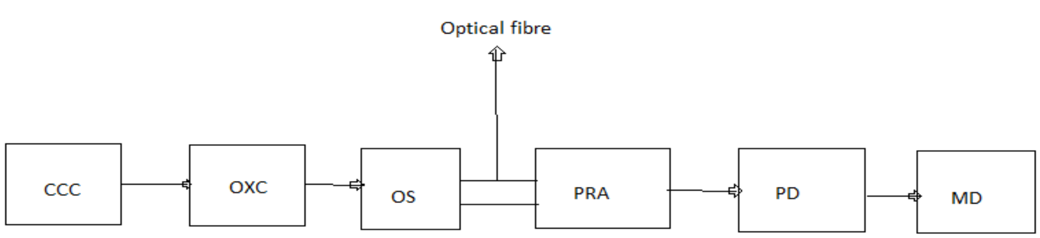

Fig. 3: Block diagram of components

In this system, wavelength of beam is the control to channel of 2D steering of beams which is embedded in this system and by this we are avoiding separate control channel. Also by this we are relaxing network management in this system. All the tunable networks are guided jointly by CCC which is connected to each PRA by using OXC. To enhance the capacity of the device we are placing multiple laser diodes in CCC which is mapped in accordance with the demand to the PRA, requires service or in need of service delivery. As we know fiber is the backbone of this system that's why we are using single mode and multimode fiber as silica or plastic fiber. As compared to single mode, multimode can carry higher light powers and the main reason as it is best to support pencil beams to radiate in free space from the PRAs. To provide right direction to right signal towards marked PRA cross-connect of each wavelength plays an important role.

In DPSK, binary information is feuded between two elements and for this additional carrier is not required to synchronize. Now this information is encoded with the help of PSK modulation and generating the DPSK signal in which one previous bit is used to define the shift in phase for the next arrival bit.

3. Result and Discussion:

The Karhunen–Loeve theorem is explaining linear combination between orthogonal functions, fourier functions in bounded intervals. This theorem actually transforms and also termed as Hoteling Transform and Eigen vector transform. The technique used in this theorem is relevant with PCA known as Principal Component Analysis which is commonly used in Image Processing, Data Analysis etc. It is used for performance evaluation. The following modulation techniques are used for evaluating BER by using the K-L method.

3.1 DPSK: DPSK is a fast and stable modulation format for optical communication. Ask signal was found to be very sensitive to the dispersion in the fiber which limits the error free transmission to only few km, longer transmission is possible for DPSK. The DPSK method avoids the necessity of the synchronizing circuits at the receiver.

$$E_b N_o = 10^{\frac{SNR}{10}} \times \frac{C}{0.1 S_b \lambda^2} \quad (1)$$

Where, SNR range is the 2-13, C is the velocity of light that is $3*10^8$, S_b is the symbol rate, λ is the optical wavelength which is 1550nm & eq (1) is also written in db in eq (2).

$$E_b\ N_o(\text{dB}) = 10*\log10(E_b N_o) \quad (2)$$

The curve between the BER and the $E_b N_o$ is shown in Fig. 4.

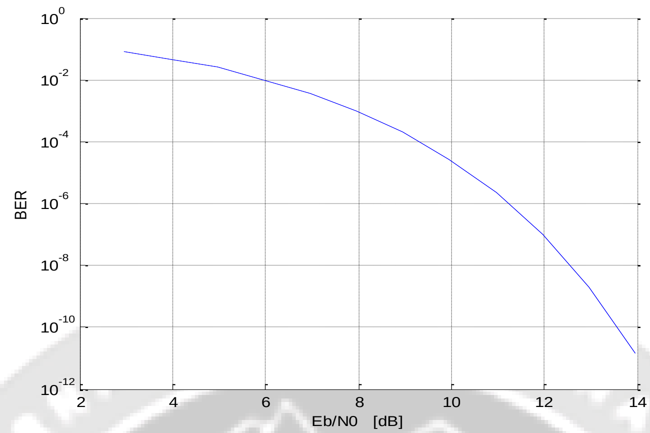

Fig. 4: Curve between the BER and $E_b N_o$

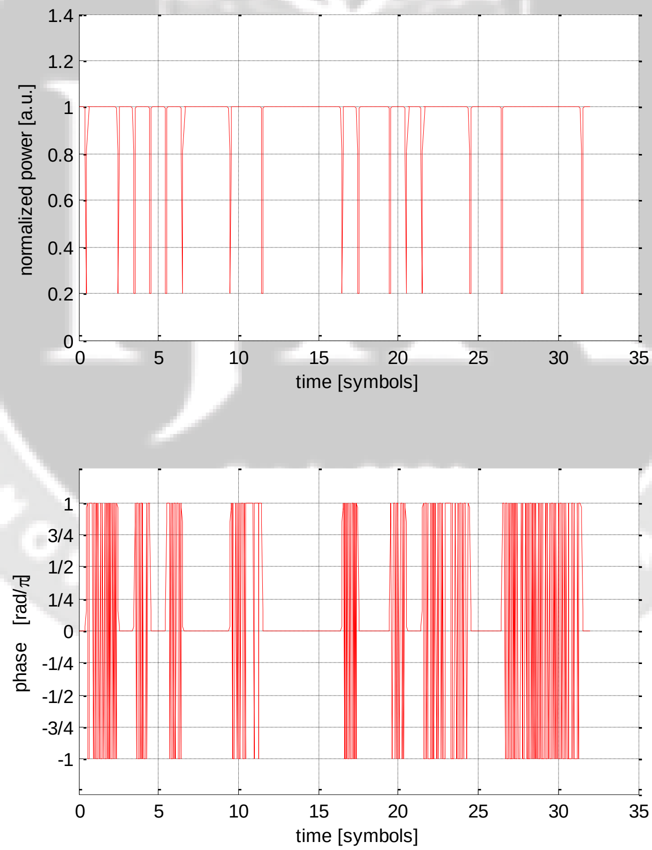

Fig. 5: Phase and Power versus symbols

4. Conclusion and Future Work:

To obtain ultra high capacity wireless communication in free space we used 2D steered pencil beam in which we do variation as per terminal or user requirement. This system contains pair of diffraction module having passive elements by means of this we steered beams in free space. It is possible to tune the beam wavelength in infrared range around 1500nm. In this system we also discussed different types of grating modules orders to enhance our capacity. By using angular magnification lens system we achieve practical FOV which introduce some propagating factors for broadening of beams. Secondly for improving efficiency, reduced the diffraction order by which Angular dispersion is reduced. Fig. 6 shows the basic block diagram of Angular magnification used in system network in this way.

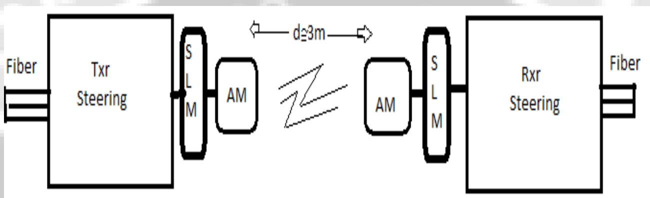

Fig.6: Block Diagram of simple methodology structure

References

- Koonen, C.W. Oh, K. Mekonnen, Z. Cao, E. Tangdiongga, “Ultra-high capacity indoor optical wireless communication using steered pencil beams,” Journal of . Lightwave Technology , vol. 34, pp. 4802-4809, Jun.2016.
- Ton Koonen, Joanne Oh, Ketemaw Mekonnen, Eduward Tangdiongga “ Ultra high capacity indoor optical wireless communication using steered pencil beam, Int. Topical Meeting Microwave Photonics, pp. 418-426, oct. 2015.
- Suchita choudhary, “Optical Wireless Communication –A future perspective for next generation wireless system”, International Journal of Scientific & Engineering Research, Volume 3, Issue 9, pp. 2229-5518, September-2012.
- Dr. Shikha Neema , Beena R.Ballal, “Developments in indoor fibre wireless network”, International Journal of Computer Science & Communication Networks, vol 1(2), pp. 100-104, 2008.
- Weihua Guo, Pietro R. A. Binetti, Chad Althouse, Leif A. Johansson, and Larry A. Coldren, “InP Photonic Integrated Circuit with On-chip Tuneable Laser Source for 2D Optical Beam Steering”, IEEE Conf. pp. 1-3, 2013.
- A.M.J. Koonen, C.W. Oh, E. Tangdiongga, “Reconfigurable free-space optical indoor network using multiple pencil beam steering”, Opto electron comm. Conf. Optical fibre technology, pp.35-38, July 2014.
- K. Van Acoleyen, W. Bogaerts, R. Baets, "Two-Dimensional Dispersive Off-Chip Beam Scanner Fabricated on Silicon-On-Insulator", IEEE vol. 23, no. 17, pp. 1270-1272, sep. 2011.

- D. O’Brien, R. Turnbull, H. Le Minh, G. Faulkner, O. Bouchet, P. Porcon, M. El Tabach, E. Gueutier, M. Wolf, L. Grobe, J. Li, “High Speed Optical Wireless Demonstrators: Conclusions and Future Directions”, Light wave Technology, vol. 30, no. 13, pp. 2181-2187, Jul. 2012.
- Lee S. C.J. *Discrete Multi tone Modulation for short range optical communication*, 2009.
- Ariel Gomez, Crisanto Quintana, Grahame Faulkner, Dominic O’Brien “Challenges in Wide Coverage Indoor Optical Communications Using Fibre -Wireless-Fibre Links for Terabit data rates”, pp. 2501-2517, IEEE 2015.
- John G. Proakis, “Digital Communications”, Fourth Edition, McGraw-Hill, 2001.
- C.W. Oh, F.M. Huijskens, Z. Cao, E. Tangdiongga, A.M.J. Koonen, “Toward multi-Gbps indoor optical wireless multicasting system employing passive diffractive optics”, *Optics Letters*, Vol. 39, No. 9, pp. 2622-2625, May 2014.
- Z. Yaqoob, A.A. Rizvi, N.A. Riza, “Free-space wavelength-multiplexed optical scanner,” Applied Optics, Vol. 40, No. 35, pp. 6425-6438, Dec. 2001.
- John M. Senior, *Optical fiber Communication, principle and practice,* Pearson Education India, third edition, 2008.
- Hany Elgala, Raed Mesleh, Harald Haas, “Indoor optical wireless Communication”, vol. 49, issue 9, pp.56-62, sep.2011.
- http://optilux.sourceforge.net/ optilux doc/ber_kl.
- B. Mikkelsen, C. Rasmussen, P. Mamyshev and F. Liu, "Partial DPSK with excellent tolerance and OSNR sensitivity", Electronics Letters, vol. 42, no. 23, pp. 1363-1364, Nov. 2006.
- P. Serena, A. Orlandini and A. Bononi, "A Parametric-Gain Approach to the Analysis of Single-Channel DPSK/DQPSK Systems With Nonlinear Phase Noise", Journal of Light wave Technology, vol. 24, no. 5, pp. 2026-2037, May 2006.