Studies on the Performance of a Short Haul Optical Link for Broadband Indoor and Outdoor Wireless Communications

Thesis Submitted

by

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ABSTRACT

In today's scenario, communications using electronic wireless systems is the ultimate desirable technology for any type of information transmission between two locations. We feel good and convenient to use Blue tooth or Zigbee type very short distance indoor wireless RF communication links or many other wireless remote control systems in our daily life. Similarly, we are using standard wireless microwave broadband outdoor communications links with repeaters for our PSTN, Internet technologies and other switching networks and systems for long distance transmission of information.

Although we have our standards in the design of hardware systems, as well as we have various systems for communication, but as days passes we find that the global demand for bandwidth continues to accelerate. It is felt that copper/coaxial cables and RF cellular/microwave mobile and Internet technologies with such limitations as limited bandwidth, congested spectrum, security issues, expensive licensing and high cost of installation and accessibility to all, cannot meet the upcoming needs.

A communication system would automatically deny services to its users whenever there is shortage of bandwidth. Similarly, when we plan to transmit broadband signals such as digital real time video, we need high speed broadband transmission networks. But presently we have limited availability of total RF bandwidth resources divided for specific purposes. With time the problems due to shortage of bandwidth has aggravated. We therefore have to depend on development of new generations of wireless communication technology.

Presently, the smart phones are making a pressing demand for much higher bandwidth availability for mobile access. Along with this, the new

concepts of "Internet of Things" and technology for "cloud computing" are gaining popularity. All such new progress and developments in communication technologies will bring lot of change in our society and our day-to-day life. New developments all over the world for breakthrough in technologies via research are very much under way because International Communication Consortium (ICC) agencies are planning to introduce the 5G – the fifth generation technology by 2022. The ultimate plan and objectives are to give the facilities to access any information from anywhere to any other place in this global earth.

In developing the broadband mobile communication technology, the greatest challenge we are facing today is the technology for the "Last Mile" for access to the networks. In order to obtain higher bandwidth in microwave transmission range, we need to shift the carrier frequencies to much higher frequencies such as millimeter wave frequencies in the 30 GHz to 300 GHz bands. The 60 GHz band became attractive to scientists during the last decade and plenty of research have been made and a new technology termed "Microwave Photonics" have emerged where we are able to merge the two technologies (i) microwave and (ii) Photonics technologies to take best of the benefits of their combinations.

Things are also taking new directions because the low cost electronic component technologies for 60GHz operation are not yet been available in the market. Scientists are simultaneously developing an alternative to 60 GHz millimeter wave technology using optical carrier frequencies and total optical technology named as "Optical Wireless Communication" (OWC) Technology.

Knowing the high bandwidth capability of optical wireless systems, scientists for the past decade is trying to use it for applications as the Last Mile wireless solutions of the mobile communication technology. This technology, like the microwave counterpart, is being developed for applications in both indoor and outdoor environments. Thus, ultimately we can have radio-over-fiber in the backbone network for high bandwidth signal transmission over long distance and then this broadband signal at the end can be sent wirelessly to the mobile user using the OWC technology. In future we would have either of the two options for the last mile. The last mile can be (i) millimeter wave system or (ii) optical wireless system or (iii) A Hybrid technology using any of them when needed for optimum operation of communication systems**.**

The available features of OWC are most promising and it can be an alternative to microwave technologies for indoor and outdoor applications. It is observed to offer flexible networking solutions that provide cost-effective, highly secure high-speed license-free wireless broadband connectivity for a number of applications, including voice and data, video and entertainment, enterprise connectivity, disaster recovery, illumination and data communications, surveillance and many others. OWCs also referred to as free-space optical communication systems for outdoor applications and it will play a significant role as a complementary technology to the RF systems in future information superhighways.

The success of optical wireless technology in Inter-satellite links came in easily as the lightwave communication signals pass almost through the vacuum in free space where there is no atmospheric effects present (for GEO at height ~ 36000 km from earth surface) to disturb the propagation of optical wave. But as soon as we try to employ the same technology for high speed data transmission in free space near the surface of the earth, we find that the optical wireless communication link does not work satisfactorily as it was expected. The reason is that the atmospheric outdoor channel is a very complex and dynamic environment that can affect the characteristics of the propagating optical beam, thus resulting in optical losses and turbulence-induced amplitude and phase fluctuation. A number of theoretical models to characterize the statistical nature of the atmospheric channel have been developed during 1960's. Since the atmospheric effect can be weak, moderate or severe due to varying atmospheric turbulence conditions, due to presence of fog, snow, rain, and wind as well as thermally induced fluctuations of refractive index of air.

The requirement of the design of the OWC system for outdoor applications are really very challenging and requires more research in this area. Thus to design efficient outdoor optical wireless communication systems, it is imperative that the dynamic characteristics of the channel are well understood. In our present work we have decided to design and develop laboratory based free space optical communication links for detailed studies of their performances in the indoor and outdoor environments. We have planned also to prepare theoretical models on their practical performances. We have made the planning for procurement of necessary equipments and devices and we present here our findings of theoretical and experimental results.