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Comprehensive Review of Space Wave Optical Link

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Abstract- Optical wireless communications offer a viable alternative to radio frequency communication for rural and urban where high performance links are needed. This paper presents a review of the most significant issues related to optical communication technology, which will enable the realization of future high performance and cost-effective optical wireless systems. Several possible configurations for optical wireless systems, modulation, and multi-access techniques are presented as well as their advantages and limitations discussed.

Keywords: Optical linking, Modulation techniques, multi-plexing techniques.

1. INTRODUCTION

1.1 WIRELESS OPTICAL LINK

The advancement of inexpensive opto-electronic devices, such as LEDs and LDs, p-intrinsic-n (PIN) photo-diodes and avalanche photo-diodes (APDs) and various optical components, has resulted in the improvement of these systems. Indoor, rural or small optical wireless systems have been used in many applications in the past few years, ranging from simple remote controls in home to more complex wireless local area networks. Many other applications are envisaged for the future, including data networking in the indoor environment and the delivery of broadband multimedia services to mobile users within such an environment together with general connectivity to base networks.
Several companies have introduced data communication products using optical wireless technology and many other computer communication products are entering the market. The source output passes through an optical system (typically has telescope and optical diplexer) into the free space (propagation medium). The received signal also comes through the optical system and passes along the optical signal detectors (PIN diodes/APDs) and thereafter to signal processing electronics. The wavelength band from 780nm to 950nm is the best choice for indoor or rural optical wireless systems. The higher wavelength can be used for longer wavelengths. For small area optical wireless system uses IR technology in which links are based on intensity modulation and direct detection (IM/DD) of the optical carrier. Intensity modulation is performed by varying the drive current of LED or LD (direct modulation). Direct detection is performed by PIN photo-diodes or APDs which produce an electric current proportional to the incident optical power. For small area say rural part optical wireless transmitter, LDs are preferable over LEDs because they have higher optical power outputs, broader modulation bandwidth and linear electrical to optical signal conversion characteristics. Linearity in signal conversion is particularly important when sophisticated modulation schemes such as multi-subcarrier modulation or multilevel signalling are used. But due to safety reasons (eye safety) laser diode cannot be used directly for the indoor IR systems, where radiation can enter a human eye quite easily. LDs are highly directional radiation sources and can deliver very high power within a small area on the retina thereby resulting in permanent blindness.

1.2 TRANSMITTER

For indoor optical wireless transmitter, LDs are preferable over LEDs because they have higher optical power outputs, broader modulation bandwidths and linear electrical to optical signal conversion characteristics. LDs are highly directional radiation sources and can deliver very high power within a small area on the retina thereby resulting in permanent blindness. On the other hand, LEDs are large-area emitters and thus can be operated safely at relatively higher powers. They are also less expensive and more reliable. Consequently, LEDs are the preferred light source for most indoor applications. To compensate for the lower powers, array of LEDs can be used. However, LEDs cannot be used beyond 100 Mbps due to the limitations imposed by the mechanism by which they emit light, whereas LDs can be used for transmission at bit rates of the order of a few Gbps.

1.3 PROPAGATION MEDIUM

Like any wireless system, the link power budget for an optical wireless system is strongly dependent on atmospheric loss along the path of the propagation. Since indoor atmosphere is free of environmental degradation such as mist, fog, particulate matter, clouds etc. indoor optical wireless systems encounter only free space loss and signal fading.

1.4 DESIGN CHALLENGES

For achieving high electrical signal to noise ratio (SNR) is the single biggest problem facing the designer of an infrared system. The difficulty arises due to two reasons. Firstly, the SNR of an IM/DD system depends upon the square of the average power of the received optical signal. This implies that one should transmit at relatively higher power levels, even though available transmitter power may be limited due to considerations of eye safety regulations [16] and power consumption. It also implies that one should design the system to minimize path loss, and employ a receiver having a large light-collection area. Secondly, in many environments there exists intense ambient infrared noise, which introduces white shot noise and low-frequency cycle stationary noise into the receiver. Besides ambient noise, the bandwidth of wireless infrared systems is also limited due to inter-symbol interference produced by the multipath dispersion of the optical channel.

1.5 EYE SAFETY

This consideration puts limit on the amount of optical power that should be emitted by the transmitter, thus limiting the coverage of an optical wireless system. Both indoor and outdoor optical wireless systems can pose a hazard if LDs are operated at high power. The eye safety standards are set by International Electro-technical Commission (IEC), where LDs are classified based on their total emitted power into Class 1, 2, 3A and 3B. They dictate that all transmitters must be Class 1 eye safe under all conditions and launch power must not exceed 0.5 mW for the systems employing lasers.

2.MODULATION TECHNIQUES

In optical wireless communications, modulation takes place in two stages. First the transmitted information is coded as waveforms and then these waveforms modulate signal intensity (amplitude) of emitted infrared light. In practice direct amplitude modulation by the message is not preferred, because optical wireless links suffer from extensive amplitude fluctuations. Several modulation and detection schemes have been considered for use in optical wireless systems in the past. Most common schemes suitable for indoor optical wireless are the RZ, NRZ, SAW-UP/SAW-DOWN.

2.1 Optical Multiplexing Techniques:

Optical multiplexing techniques can be divided into two techniques; Wavelength-division Multiple Access (WDMA) and Space-Division Multiple Access (SDMA).

2.1.1 WDMA

In this technique, each transmitter transmits at different infrared wavelengths using narrow-band emitters such as LDs. The receiver has a band pass optical filter that extracts the wanted infrared wavelengths before the detection process. The transmitter may be tuneable so that it can transmit at different wavelengths (e.g. tuneable LDs); however, such transmitters are currently expensive and need complex techniques to accurately tune them to a certain wavelength.

2.1.2 SDMA

This technique makes use of an angle diversity receiver to receive signals from different directions. For example, a hub may be capable of establishing a direct line-of-sight with several portable transceivers. This hub can use an angle diversity receiver to reduce co-channel interference between channels in the same cell.

3.OPTICAL WIRELESS NETWORKS

Traditionally communication connectivity for offices and commercial buildings is achieved using hard wires consisting of coax, twisted pairs or fibre-optic cables. This type of connectivity is expensive and troublesome to install, maintain and especially, change. In office data communications, where the ratio of workers to data terminals or personal computers (PCs) is rapidly approaching one to one, local area networks (LANs) are very difficult to manage. Beyond costs, performance of connectivity itself is a factor. Unshielded twisted pair (UTP) wiring supports the 10 Mbps speeds which is adequate for existing LANs, but may not support the high speed, reliable data transport needed in coming years. In addition to limited speed, problems such as cross talk, impedance matching, signal degradation, and data security are often thorny problems for network planners. Clearly, a less expensive and yet a high performance wireless alternative i.e. wireless LAN which is functionally compatible with existing systems, is badly needed for in-building communications. A wireless LAN can be implemented as an extension to, or as an alternative for, a wired LAN. A wireless LAN uses electromagnetic waves to communicate information from one point to another without relying on any physical connection. Hence, users can access shared information without looking for a place to plug in, and network managers can set up or augment networks without installing or moving wires. The market for wireless LAN products is growing rapidly due to the flexibility and mobility of wireless LANs that make them both effective extensions and attractive alternatives to wired networks.

4.Optical Wireless LAN Technology

Wireless LANs traditionally use radio or microwave techniques; however the radio spectrum is a scarce resource and the pressure to be economic is ever increasing. Allocated channels are therefore usually narrow band which means that broadband wireless transmission for densely populated buildings is not possible. Optical wireless, on the other hand, uses IR technology and supports the required mobility within buildings. It is intrinsically broadband, and by operating in the infrared (850 nm), low cost LED/lasers and silicon photo-diodes can be used. In addition, since the radiated signals are completely contained within the room in which the system is operating, security is intrinsically better than either radio or microwave wireless systems.

5.CONCLUSION:

The requirement of portable information terminals in work and living environment of future is expected to accelerate the introduction of high capacity wireless systems. Such portable terminals should have access to all the services that will be available on wired networks. Unlike their wired counterparts, portable devices are subject to severe limitations on power consumption, size, and weight. This paper has provided a review of the main issues associated with the physical layer of a wireless infrared communications system. It has highlighted the significant problems of high ambient light levels and restrictions on transmit power and discussed some of the techniques for mitigating these effects.

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