Chapter 29
Visible Light Communication Numerous Applications

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ABSTRACT

Visible light communication (VLC) is a promising research topic that aims at utilizing the visible light spectrum for data communication, which in turn off-loads the heavily utilized wireless radio spectrum. VLC can take advantage of the increased use of light emitting diodes (LED) for lighting purposes in different fields, such as automotive headlights, traffic signals, advertising, aviation, and general lighting. Utilizing solid-state LEDs for lighting purposes not only saves energy but also can be used for data communication since LEDs can be easily modulated by switching the light on and off in frequencies above the human eye perception. This data can be transmitted in addition to the main lighting functionality of these devices. VLC is relatively easy to implement and safe, as it does not have potential side effects like the radio signals. As such, this new technology has a great potential for adoption in several applications. This chapter will briefly introduce the technology and discuss some potential indoors and outdoors applications.

INTRODUCTION

The initial theory of Visible Light Communication (VLC) was founded in the 1880s when Alexander Graham Bell invented the photo-phone which was used to transmit a voice signal using the modulated sunlight. Since the time of Graham Bell, optical communication research has attracted the interest of scholars around the world and has evolved into a new IEEE standard namely the P802.15.7 - Standard

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for Short-Range Wireless Optical Communication (standard, 802.15.7 (2015)). In 2003 at the Nakagawa Laboratory in Keio University, Japan, they have proposed using the Light Emitting Diodes (LEDs) for data transmission.

A major factor that contributes to the evolution of VLC technology is the existing infrastructure. Hence, previously installed facilities, such as LED traffic lights or LED sign boards are readily used. Since the transmitters for VLC are light sources, they function for lighting purposes and illuminate the surrounding environment, hence the radiation power and signal-to-noise ratio (SNR) is high; paving the way for a stable communication link (T. Yamazato, I. H. (2014)).

With respect to the emergence of green communication, VLC is highly energy efficient as it utilizes LEDs. The United States Department of Energy further corroborated the importance of LED technology, as shown in Table 1. There is superiority in terms of power consumption and operating lifetime in LED technology as compared to traditional lighting technology, such as incandescent and fluorescent lighting. This clearly shows the potential of the LED lighting technology to replace all the conventional illumination tools as well as serve as a reliable transmitter for a VLC link (Chung, Y.-Y. T.-Y. (2014)).

Radio Frequency (RF) wireless connectivity has been used for several decades as it allows for indoor and short distance links to be established without any physical connection. However, these solutions remain relatively expensive and have low to medium data rates. RF wireless links require that spectrum licensing fees are paid to federal regulatory bodies and are required to be contained within strict spectral zones. These frequency allocations are determined by local authorities and may vary from country to country, making a standard interface difficult. Since the visible light spectrum is not in the licensed band (400 to 790 THz), licensing fees can be avoided which effectively reduces system cost. In addition, the broadcast nature of the RF link is beneficial for mobile connectivity but this may result in interference between devices located within close proximity. Due to the RF wavelength, it is difficult to contain within boundaries and can impede system performance (Hranilovic, S. (2005)).

Optical radiation in the infrared or visible range is easily contained by opaque boundaries. As a result, interference between adjacent devices can be minimized easily and economically. Additionally, inexpensive LEDs and photodiodes are able to interchangeably work between baseband and transmission frequencies where as high-frequency RF circuit design techniques are required in the RF domain. Free-space optical (FSO) links with an inherent low probability of intercept and anti-jamming characteristics is among the most secure of all wide-area connectivity solutions (Hranilovic, S. (2005)).

Unlike many RF systems that radiate signals in all directions, thus making the signal available to all within the receiving range, FSO transceivers use a highly directional and cone-shaped beam with a dominant line-of-sight (LOS) propagation path. Therefore, interception is extraordinarily difficult and anyone

Table 1. Performance of the conventional and LED lighting technology

Lamp Type	Watts	Lumens	Operating Lifetime
Incandescent	60	900	1000
Compact florescent lamp	15	900	8500
LED (2011)	12.5	800	25000
LED – future(2015)	5.8	800	40000