

# Design for The Indoor Visible Light Communication Application System Based on LED Visible Light

Wenyu Lian<sup>1,2</sup>, Jia Liu<sup>1,2</sup>, Shigang Cui<sup>1,2</sup>, Lin He<sup>1,2</sup>, Yunxi Zhang<sup>1,2, a</sup>

<sup>1</sup>Tianjin Key Laboratory of Information Sensing and Intelligent Control, Tianjin University of Technology and Education, Tianjin 300222, P.R.China

<sup>2</sup>School of Automation and Electrical Engineering, Tianjin University of Technology and Education, Tianjin 300222, P.R.China.

**Abstract.** This paper designs an indoor visible light communication application system based on LED. The system can modulate the original signal one or more times, move to a specific frequency band, transmit on the power line, in the LED terminal use this module to decode, restore the Ethernet signals. This design is applicable to the simplicity of the LED visible light communication applications, which provide the premise and guarantee for the construction of smart home network.

**Keywords.** LED; visible light communication; Ethernet signal; smart home network

## 1 Introduction

Visible light communications technology is a new type of wireless communication developing rapidly in the past ten years, through the increase in public infrastructure lighting auxiliary function of data transmission, combining communication with indoor lighting Light source, can build indoor Visible Light wireless communication network, information from the server to the client's wireless transmission [1]. Due to visible light is closely related to daily life, office, family, and many of the public equipment is visible light, such as office lights, road lights, the square of the display screen, etc, so the indoor visible light communication technology can meet the users of mobile communication network of wide coverage, high link quality requirements, for indoor users with the convenience of data services anytime and anywhere. At the same time, the indoor visible light communication technology using visible light transmission medium which can ensure the security of mobile communication network, including network data security and user safety and health, the user information privacy protection, avoid malicious intercepted by other users, even for a long time in the mobile communication network, will not affect their health.

At present, the main mode of transmission for wireless communication system is radio frequency communication. Compared with the radio frequency communication technology, indoor visible light communication technology has many advantages:

First of all, indoor visible light communication technology can provide a large number of potential

available bandwidth, and the bandwidth is not limited, so it does not need to obtain the authorization of the management agency [2]. On the contrary, the use of radio frequency band, especially the widespread use of mainstream products is lower than that of the 30GHz band, the electromagnetic wave spectrum is a limited resource, the frequency of strict control by the authorities, leading to the use and maintenance is expensive.

Secondly, indoor visible light communication does not exist electromagnetic radiation [3], is not susceptible to external electromagnetic interference, which can be widely used in sensitive to electromagnetic interference, even to eliminate electromagnetic interference on special occasions [4], such as hospitals, aircraft, gas station and chemical factory, etc. On the contrary, the penetration of radio frequency signals is likely to cause interference between electronic devices, so the areas sensitive to electromagnetic waves are limited to mobile devices.

Thirdly, the indoor visible light communication technology has built a higher network security [5], the technology using the transmission media is visible light cannot penetrate walls and other obstructions in limiting transmission of users within visual range, which means that the transmission of network information is confined to one room (assuming no windows or transparent transmission medium, even if some words can be used to remove the physical block), such as to effectively avoid the transmission of information by malicious interception, ensure the security of the information.

Finally, the indoor visible light communication technology supports the rapid construction of wireless networks, which can facilitate the establishment of

\* Corresponding author: [zyunx2004@mail.nankai.edu.cn](mailto:zyunx2004@mail.nankai.edu.cn)

flexible temporary network and communication links, reduce the use and maintenance costs of network [6]. Radio frequency signals such as subways and tunnels cover blind areas, and if radio frequency communication is used, high cost is required to establish base stations and pay expensive maintenance costs. Indoor visible light communication technology can use its indoor lighting source as base station, combined with power line communication, to provide users with convenient indoor wireless communication services.

Visible light communication technology is a new type of communication developed with lighting support high speed switch [7], can effectively alleviate the current problem of the shortage of radio frequency communication band, provides a new method for short distance wireless communication [8,9]. Indoor visible light communication can meet the requirements of users for security, stability, speediness and environmental protection of communication links, and provides a new broadband access mode for indoor wireless communication networks. The application of visible light communication technology based lighting in the next generation wireless communication technology is feasible, is an alternative construction of indoor wireless communication system, is an effective complement to the existing wireless radio frequency communication technology.

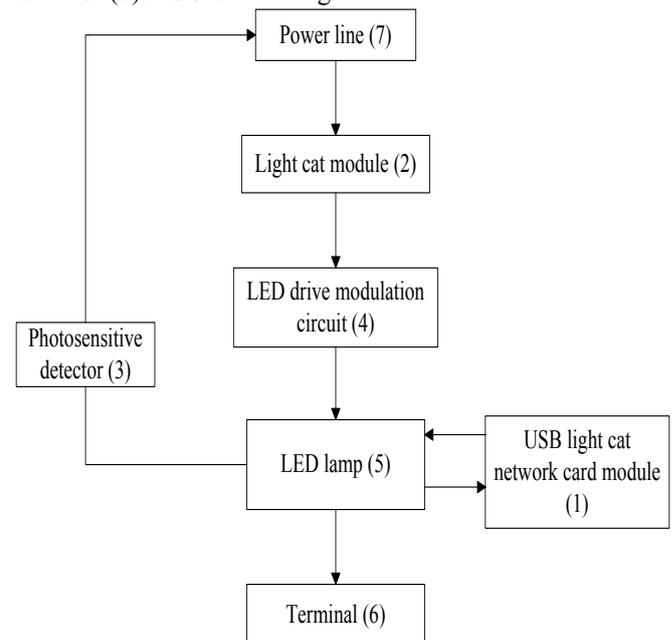
Based on this, this paper researches the key technology of the application of visible light communication system under indoor channel environments, in order to apply simple LED visible light communication, in indoor applications without re laying of cables, the design of a indoor visible light communication system based on the LED will be one or more original signal modulation, moving to the specific frequency band for transmission on power line. At the end of the LED lamp, this module is used to decode and restore the Ethernet signal.

## 2 Overall Design Scheme

The utility model is based on the USB light cat network card module and the light cat module, and establishes a smart home hardware and software integration system of a wireless local area network based on visible light communication, so as to build an intelligent home network. The main research and development of portable visible light communication interface module, can be directly embedded in all kinds of electrical appliances and network access equipment, realize low cost and high rate of local area network (LAN) networking technologies, household appliances can be used to realize intelligent.

Indoor visible light communication based on LED application systems, including USB light cat network card module (1), its characteristic is that the USB light cat network card module (1) connected to the light cat module (2), and the light cat module (2) connected to the photosensitive detector (3), and the photosensitive detector (3) connected to the LED drive modulation circuit (4), and the LED drive modulation circuit (4)

connected to the LED lamp (5), and connected to the terminal (6). As shown in Fig. 1.



**Fig. 1.** A block diagram of an indoor visible light communication application system based on LED

(1)USB light cat network card module; (2) light cat module; (3) photosensitive detector; (4) LED drive modulation circuit; (5) LED lamp; (6) terminal.

## 3 Key Technology Research

### 3.1 Design of USB Light Cat Network Card Module

This design carries on the LED modulation signal to receive, and send it to the PC machine, and carries on the PC signal similarly by the LED modulation way to the LED lamp. Realize full duplex data transmission of LED visible light communication. The design scheme adopts the USB network card chip AX88772B produced by Taiwan AsiaInfo Engineering Department, and the light cat module is still used in ML6652 chip.

AX88772B is a highly integrated high-performance and low-power USB 2.0 10/100M fast Ethernet control chip, can increase the low cost, small package, plug and play fast Ethernet networking characteristics for all kinds of applications, can be used for desktop computer, notebook computer, ultra portable computer, the bracket / port replicator / dock, game machine, intelligent home furnishing and any of the USB interface of embedded devices. This chip is made up of USB to Ethernet bridge, voltage regulator, crystal oscillator and PLL, SRAM, memory arbitrator, Ethernet MAC, Ethernet PHY, general input and output circuit and interface. AX88772B is used to connect the USB host side and conform to the USB 1.1/2.0 standard USB port, support the 10/100M Ethernet functionality based on the IEEE802.3 and IEEE802.3u specification and built-in network packet buffer SRAM, and integrated of

10/100M Ethernet PHY, thus simplifies the system design.

AX88772B can cooperate contains a USB Host microcontrollers, support twisted pair cable or through a fiber optic PECL interface to connect the external 100BASE-FX optical transceiver module, the ability to provide embedded system Ethernet connection, network data transceiver and remote control. AX88772B has the following characteristics:

(1) USB 2 turns RMII, supports HomePNA and Homeplug PHY.

(2) On the USB interface, the AX88772B integrates the USB 2.0 transceiver and serial interface engine, which conforms to the USB 1.1/2.0 specification; Support USB full speed and high speed mode, power drive capability, support bus power supply mode and self powered mode; Support 4~6 programmable USB bus endpoints; Support isolated power saving mode, automatically remove the USB host when it detects the removal of the network line; With unique burst transmission mechanism, it can make the cover transmission on USB bus more efficient.

(3) AX88772B has advanced power management function which can effectively reduce power consumption.

(4) Support dynamic power management to save power consumption under no load or light load; Support for AutoDetach power saving mode, which will automatically remove the USB host when the network line is detected.

(5) Universal extended media interface. AX88772B optional RMII interface to support the MAC working mode, for connecting AX88772B external 100Base-FM or Homeplug PHY; Optional Reverse-RMII interface to support the PHY working mode, support MAC-to-MAC seamless connection.

(6) Extremely low power sleep mode that supports waiting for network events to wake up.

The LED dimming circuit adopts the MAX3967 chip, MAX3967 is a programmable LED driver that can be used for the highest 270 Mb/s data rate optical transmitter. The circuit includes a high speed current driver with programmable temperature coefficients, a LED pre bias voltage regulator, and a disable function circuit. The circuit accepts the PECL data input and operates at the +2.97V to +5.5V supply voltage. The SFP LED driver can cut the current of up to 100mA into a typical high speed light-emitting diode. With the increase of temperature, the device of the modulation current can be according to the temperature coefficient increases, the temperature coefficient of programmable range: 2500ppm/°C to 12000ppm/°C. The modulation current is set by an external resistor. The pre bias voltage of MAX3967 can be programmed in 400mV to 925mV. The pre bias circuit generates a peaking current to improve the switching speed of the LED. The compensation current output helps maintain a constant supply current and reduces the EMI and power noise generated by the transmit module. The MAX3967 is provided in the form of a bare chip or provided in a 4mm\*4mm 24 pin and a thin QFN package.

### 3.2 Design of Light Cat Module

In this paper, the function of the light cat module is to convert the Ethernet signal (from the power carrier module) into the level signal modulated by LED. This design adopts ML6652 chip. This chip is a low cost / low LED current drive single chip transceiver, which provides double stranded wire and fiber optical Ethernet technology between 10 Mb/s and 100 Mb/s. The device supports 10 Mb/s and 100 Mb/s operating data rates with Auto-Negotiation using 850nm or 1300nm optics. One or two interfaces of fiber optic and double stranded wires can be interfaced to industry standard miniature fiber optic components or Physical Media Dependent (PMD) modules using Positive Emitter Coupled Logic / Low Voltage Positive Emitter Coupled Logic (PECL / LVPECL) compatible modes. ML6652 has the following characteristics:

(1) Fully implement the media interface between optical fiber and twisted pair.

(2) 3.3V low voltage power supply.

(3) Support ISO/IEC802.3, IEEE802.3, and TIA/EIA785 industrial standards.

(4) Six optional working modes: mandatory 10Mb/s, mandatory 100Mb/s, automatic negotiation of non transparent half duplex, automatic negotiation of non transparent full / half duplex, automatic negotiation of transparent 10 / 100Mb/s, non transparent special case.

(5) The control mode is flexible, which can be controlled by hardware and software. The hardware configuration is achieved by setting the level of the pins in the chip; The software control mode is realized by the corresponding bits in the operation control register.

(6) Small 44 pin Tiny Quad Flat Package (TQFP) and Leadless Plastic Chip Carrier (LPCC) / Quad Flat No-lead (QFN) package.

10M/100M light cat module, as shown in Fig 2.

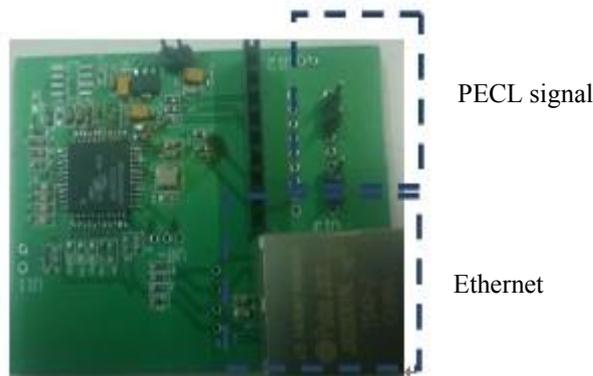


Fig. 2. 10M/100M light cat module.

### 3.3 Design of LED Driver Modulation Circuit

The input of LED driver chip is PECL level, and the output circuit of the photosensitive element is also the PECL level. Through the light cat module, the PECL level can be converted to the Ethernet level. ML6652 chip is used to convert PECL level signal into Ethernet network signal.

The USB card AX88772B and 10M / 100M light cat module ML6652, optical detection and optical emission module integrated in a 5.6 cm \* 2.2 cm of small PCB board, through the USB interface is connected to a computer, to realize the miniaturization of optical communication module, the practical application.

### 3.4 Other Instructions

In the design of this system, the photosensitive detector can receive PECL level signal and convert it to an Ethernet signal. This design uses LED light as the signal source, as long as the light can be obtained where the communication can be carried out, there is no communication blind spots, convenient and quick. Terminal for PC, printer, smart phone and other communication equipment.

Designed based on LED indoor visible light communication application system, can be directly embedded into all kinds of electric equipment and network access equipment, realize low cost and high rate of local area network networking technologies, commonly used household appliances can realize intelligence.

## 4 Conclusion

On the basis of key technology of USB light cat network card module and light cat module, a smart home hardware and software integration system based on visible light communication wireless local area network is established, and the smart home network is constructed. The main research and development of portable visible light communication interface module, can be directly embedded into all kinds of electrical appliances and network access equipment, realize low cost and high rate of local area network networking technologies, commonly used household appliances can realize intelligence.

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