APPLICATION OF VISIBLE LIGHT COMMUNICATION TECHNOLOGY IN DIGITAL OPERATING ROOM

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ABSTRACT

Visible Light Communication (VLC) is a wireless communication technology that uses visible light for illumination and communication at same time. Compared with the conventional wireless communication technology with radio channels, VLC transceiver units can be integrated with the existing lighting system. VLC system has advantages such as energy saving, easy deployment, no radio interference, electromagnetic compatibility and so on. It also has the disadvantages of being easily blocked by moving object, interrupted and interfered by sunlight. Finding the right application scenario for visible light communication has always been a challenge.

With the technology progress of medical digitization, traditional hospitals and are transforming into digital hospitals. More and more medical devices with wireless communication capabilities are being deployed, and more wearable devices are used in patients' body, such as pacemaker. Serious electromagnetic interference problem should be considered to affect medical safety. In this project, VLC technology is used in the digital operating room to reduce electromagnetic interference as an application experiment.

Keywords: Visible Light Communication, interference, transceiver, application experiment , ElectroMagnetic Compatibility

1. INTRODUCTION

Visible Light Communication (VLC) refers to communication method that directly transmits optical signals in the air by using Light in the visible band as information carrier. VLC technology is green and low-carbon, and can realize nearly zero energy consumption. It can also effectively avoid electromagnetic signal leakage and other weaknesses of radio communication, and quickly build an anti-interference and anti-interception safe information space. The idea is not new. On June 3, 1880, Alexander Graham Bell transmitted the first wireless telephone message on his newly invented "photophone," a device that allowed for the transmission of sound on a beam of light [1].

In the 21st century, with popularity of Light Emitting Diode (LED), VLC rises again and the technology is reinvented with new breakthroughs. LED can support faster switching on and off than traditional fluorescent and incandescent bulbs. By adding microchips to ordinary LED lights, they can be made to flash at extremely fast speeds and send data. As long as the overhead light is shining, it is theoretically easy to transfer data information, access the Internet, make voice and video calls, or adjust the switch of Internet of Things devices, and with the ultra-high transmission rate, the application experience is far better than WiFi and 4G networks. In the future, VLC will interact with WiFi, cellular networks (3G/4G/5G) and other communication technologies (such as zigbee and wsn), bringing innovative applications and value experience to the Internet of Things, smart city (home), aviation, navigation, subway, high-speed rail, indoor navigation, underground operations and other fields[2][3]. Visible light communications can be interfered with by sunlight and be blocked by objects, which physically limits the application range of VLC. The operating room is a good scene for VLC applications naturally. Furthermore, VLC can solve the Electro Magnetic Compatibility problem in the digital operating room.

Electro Magnetic Compatibility (EMC) defined as "the ability of equipment and systems to function properly in their electromagnetic environment without causing intolerable electromagnetic disturbance to anything in the environment." This definition has two meanings. First, the equipment should be able to work normally in a certain electromagnetic environment, a certain electromagnetic immunity (EMS). Secondly, the electromagnetic disturbance generated by the device itself should not have too much influence on other electronic products, namely electromagnetic disturbance (EMI).

EMC is not only related to the safety and reliability of the product itself, but also related to the protection of electromagnetic environment. Therefore, meeting EMC requirements is also a very important condition for products to enter digital operating room. With the progress of technology, more and more electronic equipment and medical equipment is miniaturization and wireless. Wearable devices and implantable medical devices, such as pacemakers, are used for the patients in digital operating room, rehabilitation centre and elderly care community. The density of electronic equipment is becoming higher and higher, with the requirement for EMC becomes more and more serious. The earth's EM environmental background noise is shown below, in Fig1.

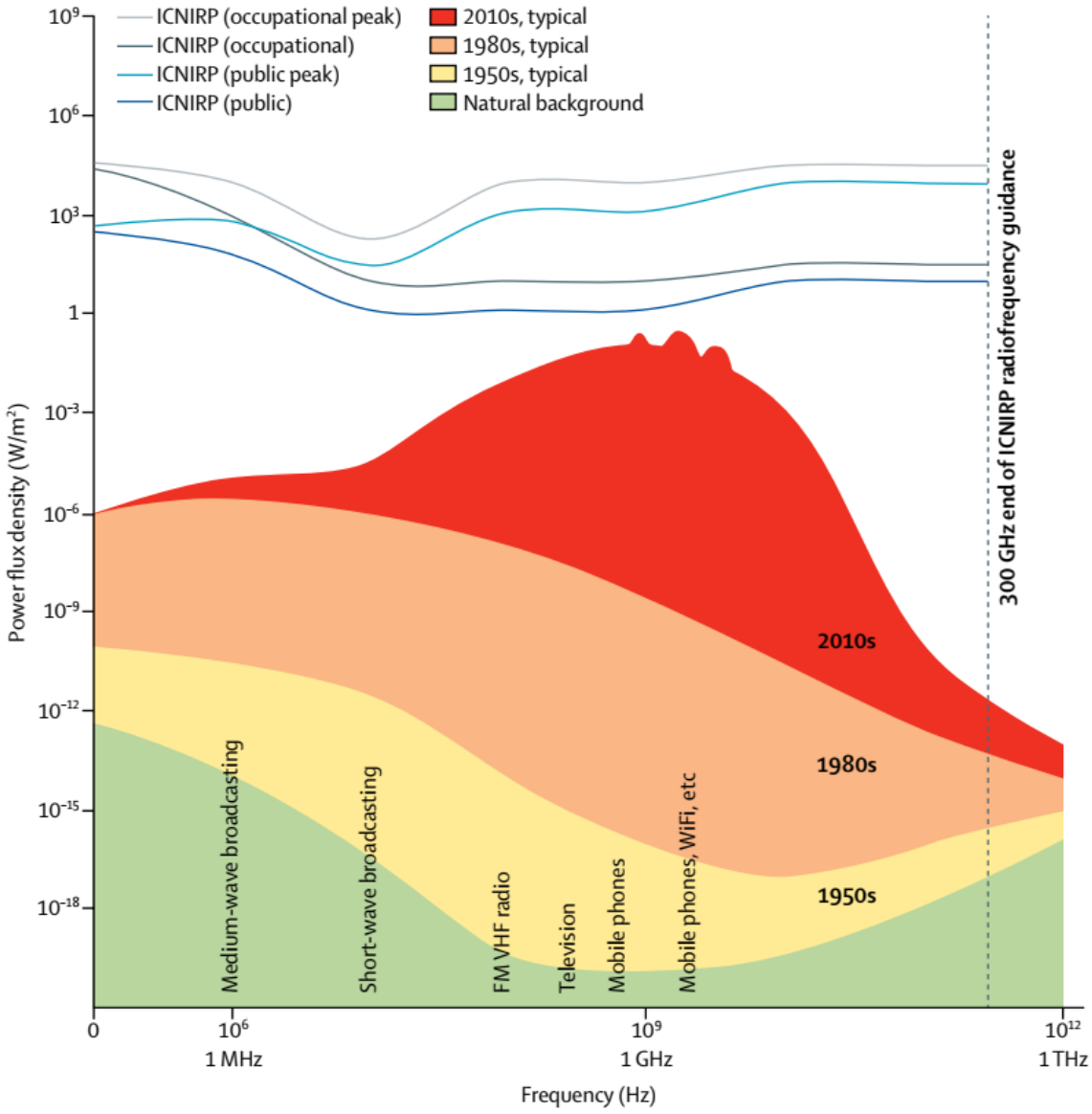

Fig1. Level of background EM noise [4]

As shown in the figure above, we can see that the increase of electronic equipment causes the change of spectrum utilization and spectrum noise. The appearance of VLC makes it possible to develop an innovative method to solve the problem of EMC in digital operating room.

With the architectural design of hospital and digital operating room, it is found that hospital operating room meet VLC requirement, no daylight and only artificial light. Therefore, in the research work of this paper, the possibility of using VLC in digital operating room to solve EMC problem is preliminary experimented and evaluated in a real world.

2. METHOD

The operating room always uses artificial lighting system and is a good place for VLC usage without interference of sunlight. With the increase of digital equipment, digital operating rooms are plagued by more and more radios interference. This situation will affect the safety of surgery and the patient's healthy with pacemaker and other important equipment inside the body. In the experiment, the project team with both electronic engineering ability and medical license, deploys VLC system in a real digital operating room and verified the effectiveness of VLC in operation.

The application experiment consists of two tasks:

- Verify the digital operating room environment can support video-level VLC applications. The light source in the operating room will not interfere with the video transmission of the VLC system.
- Verify the multi-emission source technology can be used to ensure that the VLC senders (8 in the experiment) would not be completely blocked by the body of the doctor and nurse during the operation. At least one transmitter of VLC system can work to maintain the communication functions.

For task one, shadow less operating lamp is modified as VLC receiving unit (Signal receiving module), the core receiving and control module of VLC system. Shadow less operating lamp, as the lighting source in the operating room, can theoretically produce a full range of transceiver without dead angle and solve the problem of visible light interruption caused by shading. The system is shown in Fig2. The sender of VLC video system is integrated with shadow less operating lamp.

Fig2. VLC video transmission system used in the digital operation room

For task two, in the operating room, eight potential device deployment points install the VLC sender (Signal transmitting module) module. In one hour simulated operation, the interference of doctors and nurses with VLC system at different locations was simulated. Experiment data are collected comprehensively as in Fig 3.

Fig3. Eight potential device deployment points to verify the VLC video transmission continues in the digital operation room

3. RESULT

The application of the VLC technology in the digital operating room achieved preliminary results. The experiment proved that it was feasible to carry out two-way data transmission through the multi-transmitting point method in the actual operation when shadow less operating lamp are used as the arbiter control. The communication would not be interrupted or interfered by the movements of doctors and nurses.

4. CONCLUSIONS

The experiment of VLC technology in the digital operating room proved that VLC can be well applied in the digital operating room, especially relying on shadow less operating lamp as the base station. VLC is a potential way to reduce electromagnetic interference, maintain the safety of patients' implantable electronic devices, and improve the security of communications in digital operating rooms and medical environments. Particularly, shadow less operating lamp is the natural VLC centre in the operating room.

5. FUTURE WORKS

The current combination method of the VLC system and shadow less lamp is unacceptable in the real operating room. Cooperation with the manufacturers of medical devices is needed to develop a customized shadow less lamps that support VLC which will meet the requirements of aseptic treatment in the operating room.

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