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Implementation of the Local Extender Device for Wireless Video Transmission based mmWave

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Abstract

Establishment and focus: The frequency band to be used for 5G service is 3.5GHz or 28GHz, which is a higher frequency band than the existing frequency band. Therefore, it is necessary to secure a wide bandwidth for high transmission speed while avoiding interference with existing frequencies. 5G is expected to solve the problem by densely constructing a base station, a repeater, a small cell and the like compared to 4G (LTE). Therefore, it is possible to design a short-range expansion device based on image generation technology, communication circuit design technology, and UHD 4K wireless image transmission and reception ICT technology.

System: In this paper, we implemented a near wave expander for mmWave based wireless video transmission in 5G environment. To this end, the transmitter and receiver modules were fixed at a straight line distance of 50m or longer, and an L / E system was installed in the middle. In addition, the UHD-class ultra-high definition image of the transmitting side is extended to the wireless image transmission / reception distance by constructing an L / E system capable of real-time wireless display on the end-stage monitor after passing through the L / E system. 5G is a global new industry creation technology that connects everything beyond mobile communication (voice and data) between people and triggers digital innovation in the industry. Through this, it is possible to apply the expander of the transmission function of 50m or more wireless image based on the 60GHz frequency bandwidth.

Keywords: *Local Extender, mmWave, Indoor Communications, Wireless Video Transmission, 5G.*

1. Introduction

The frequency band to be used for 5G service is 3.5 GHz or 28 GHz. This uses a much higher frequency band than the frequency bands currently used in 4G (eg, 850 MHz and 1.8 GHz). In 3G, 4G, radio and broadcast frequencies, frequencies are already allocated for many communication services. 5G mobile communication is emerging as the core infrastructure technology of the 4th Industrial Revolution[1,2]. There is also increasing interest and importance in 5G. Next-generation communication technologies that process large amounts of data in real time are essential to increasing data traffic, explosive device connections, and smart cities and factories. Major countries and IT-related companies around the world are conducting a lot of research and development for early construction of 5G wireless communication networks and preemptive

technology. In other words, if they do not preoccupy the 5G market, they are unlikely to gain an edge in the "future-growth industry" sector related to the fourth industrial revolution[3,4]. As a result, it is urgent to develop a new system of UHD-based technology in which wireless communication technology and ergonomic design technology converge. Recently, users (including unmet needs) have shifted their perception to the level at which they consume value. In addition, in 3G, smartphones were born, and in 4G, smartphones have been utilized[5]. Now, 5G is the time to research and develop new innovative devices or systems such as the Internet of Things and artificial intelligence.

Therefore, it is necessary to secure a wide bandwidth for high transmission speed while avoiding interference with existing frequencies. In addition, an unlicensed high frequency band must be allocated and introduced. However, mmWave has a high speed while having a high straightness, but has a problem in indoor / outdoor use such as short wavelength and short diffraction angle so as not to penetrate a building[6,7].

As a result, 5G will be able to solve the problem by densely constructing a base station, a repeater, a small cell and the like compared to 4G (LTE)[8,9]. Therefore, in this paper, we designed and implemented a short-range expansion device for wireless video based on image generation technology, communication circuit design technology and UHD 4K wireless video transmission / reception ICT technology. To this end, As shown in figure 1, a short distance expander is installed between the wireless image transmitting apparatus and the receiving apparatus to implement a system for transmitting wireless images in an indoor space of 50m or more.

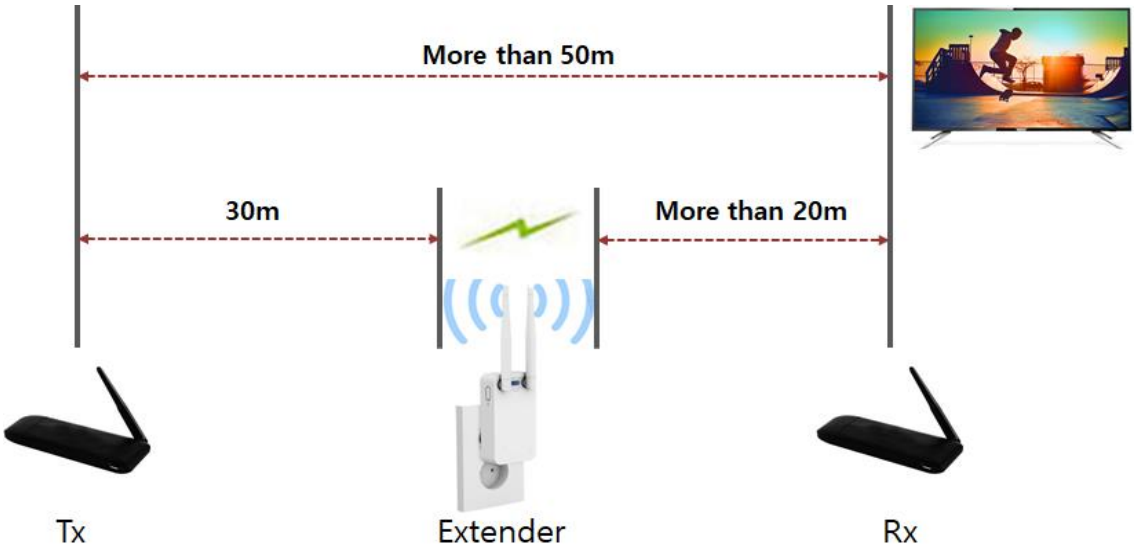

Figure 1. Local extender application system concept

2. Technology Trends

2.1 Domestic technology trend

The official name of 5G is IMT-2020, which has technical features such as ultra-fast 20 times faster than existing 4G, ultra low delay with 10 times shorter communication delay, and super connection with 10 times more connected devices. Giga Wifi means Wifi that supports speeds of 1Gbps and above. It is a wireless replacement technology for HDMI cable in high speed video transmission between devices. Low Power Wide Area Network (LPWAN) is a mobile communication network for Internet of Things devices[10]. The technology has the advantages of longer battery life of more than 10 years, wide coverage with tens of kilometers, and

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low installation cost. In addition, network slicing is a technology that provides a dedicated network specialized for each service for various services having different characteristics by making a logically separated network on a physically one network[11]. Massive MIMO (Multi Input Multi Output) is a technology that transmits large-capacity data at high speed by using a multi-input / output technology that uses dozens of antennas to improve the capacity of a base station and a repeater.

The Extender technology proposed in this paper is an extension of the repeater. Repeater compensates for signal distortion and amplifies and recovers lost signal during transmission. That is, it is a device used to connect a network circuit and bidirectional forwarding of physical signals between two network nodes. The general level of communication service technology in Korea is high. However, the technology level of base stations, repeaters, expanders, and small cell network equipment is low. The repeater was developed to solve the dead zone in the radio shade area, thanks to the growth of the smartphone market. It is a device that maintains the same as the original data by installing in a local area where radio wave demand is not high, such as subway and high-rise buildings, where radio waves cannot reach. Korea provides the world's best network service based on high speed internet[12]. Table 1 shows the country's technology level in the mobile communication and network sectors in the 2018 ICT technology level survey report.

Table 1. Initial international telecommunication and network technology levels

Field	Top Tech. Country	Technology Level(%)				
		US	Korea	Europe	China	Japan
Mobile communication	US	100	92.3	94.0	93.1	90.7
Network	US	100	81.1	89.9	85.2	86.3

2.2 Overseas technology trend

Overseas, related network equipment such as base stations and repeaters have recently emerged as a key issue in the US and China trade wars. In the United States, China is leading the world's high-tech industry, including 5G, through “Manufacturing 2050”, which is a strong commitment to check. In a White House speech, President Trump stressed that 5G racing is a race that the United States must win and cannot allow other countries to outpace the United States. China acknowledged the mistake that its competitiveness in wireless communication technology was falling behind in choosing 3G and 4G routes. In order not to repeat this, 5G international standards are very active in securing related technologies. Japan is conducting a public-private 5G comprehensive demonstration test led by the Ministry of Internal Affairs and Communications. In line with the Tokyo Olympics in 2020, the company is conducting R & D with the aim of commercializing 5G technology[11,13].

One of the most important direct and indirect techniques of Extender proposed and designed in this paper is small cell. Small cell proposed to increase the network capacity of mobile communication network and to cover the shadow area. It is defined as a low-power radio base station using licensed frequency bands that emerged as a new technology along with 5G base stations and repeater networks. Small cell is evolving and developing as a core component of next generation mobile network that brings new revenue opportunities through realization of wired and wireless convergence service.

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3. Local Extender Design

In this paper, we designed and implemented a short-range expansion device for wireless video based on image generation technology, communication circuit design technology and UHD 4K wireless video transmission / reception ICT technology. To this end, a short distance expander is installed between the wireless image transmitting apparatus and the receiving apparatus to implement a system for transmitting wireless images in an indoor space of 50m or more. Finally, for the real-time transmission of wireless images over a distance of 50m or more indoors, the following technologies need to be developed and applied.

① 4K UHD-class wireless video transmission and reception circuit design and operation implementation technology

② Local Extender wireless video transmission / reception operation technology

③ Beamforming wireless video communication operation realization technology

④ Wireless video transmission speed 3Gbps operation realization technology

⑤ Low temperature heat radiation temperature operation technology

⑥ Wireless video transmission and reception (low) delay time operation

First, 4K UHD wireless video transmission / reception technology transmits 25G level signal and wireless module including 4 module VCSEL / VCSEL driver and wireless module to focus 4 array VCSEL light source into 4 array fiber optical. Manual alignment is possible with an optical module with 4 channel VCSEL / VCSEL driver. The four-channel optical transmitter module uses a flip chip bonder in the submount with the alignment mark. In addition, the submount including the H-shaped lens manually mounted using vision can be manually aligned to the guide pin and the guide hole. FPCB, drive board and evaluation board capable of transmitting 25G VCSEL signals are implemented through I2C communication. Lenses of the H type do not need to align the focal length separately since the focal length is already determined by the H shape. Since only active alignment of 4-channel fiber arrays is performed, the process is simple and easy to align, enabling mass production. Figure 2 shows the design of 4 channel optical module for 4K UHD wireless video transmission and reception.

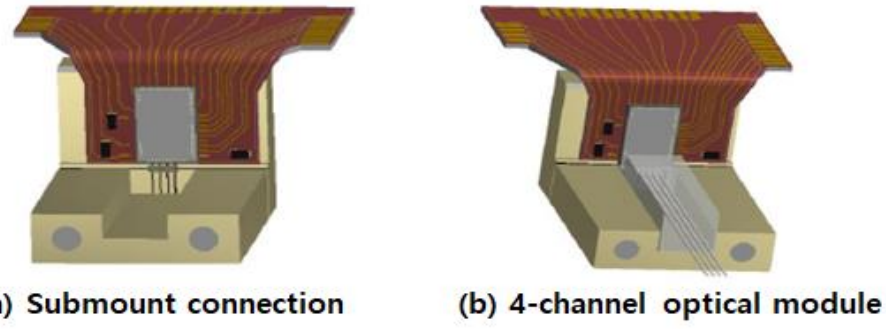

Figure 2. 4K UHD wireless video optical module

Secondly, the core of Local Extender technology is about ultra-high speed wireless relay system for millimeter wave band. In other words, it means a 60GHz ultra-high speed video transmission technology based on the millimeter wave frequency band. It is a technology that transmits HDMI high-definition video input signal at transmission speed of 4Gbps in 60GHz band. This provides a wireless communication function of various receiving means when performing high performance, uncompressed,

lossless wireless video transmission and reception. In addition, it is a core technology of the ultra-high speed wireless relay system for the millimeter wave band to relay the multimedia data efficiently to the on-state receiving means.

Third, beamforming is wireless image communication implementation technology. It is a technology that radiates / receives only in a specific direction when a radio wave is desired from an antenna, and generates a radio beam by multiple antennas (or array antennas) to have directivity. It is a technology having the concept of a smart antenna that the base station antenna always faces the radio wave emission direction toward the caller. Spatial filtering is performed to increase the directivity in the desired direction, and spatial multiplexing is performed by enabling spatial multiplexing. In the FDD scheme in which transmit / receive frequencies are separated, even if downlink beamforming is performed based on feedback of downlink propagation state information, there is no guarantee that uplinks having different frequencies achieve the same beamforming. In the case of the TDD scheme in which the transmission and reception signals share the same frequency band, beamforming is performed by analyzing the state of the uplink radio signal received from the base station. Figure 3 shows that beamforming technology is more efficient at LTE-TDD and at higher frequencies than LTE-FDD.

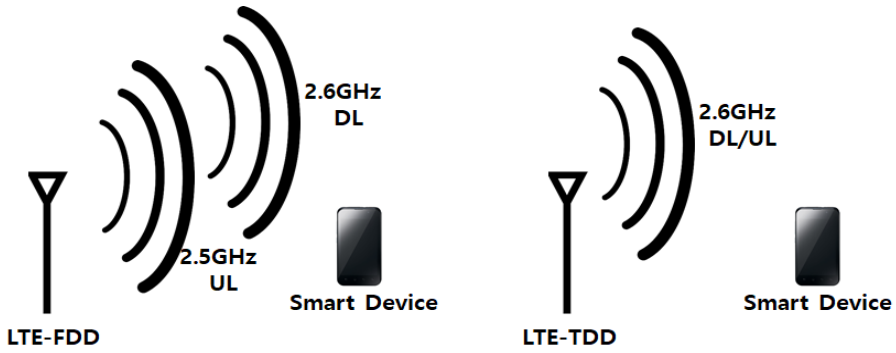

Figure 3. Beamforming and LTE-FDD/TDD

Fourth, the present invention relates to a wireless video transmission rate 3Gbps operation. Compared with traditional Wi-Fi, the biggest feature of mmWave band communication is the high speed, short-range communication. First, ultra-high speed means that by using a wide bandwidth of 9GHz, it is possible to achieve multi-Gbps communication, which was not possible with conventional Wi-Fi. Considering that Wi-Fi is latest 802.11n technology can achieve only a few hundred Mbps, these ultra-fast transfer rates are a new application. In order to transmit full HD high quality video, only 3Gbps data rate is required. When using existing Wi-Fi solutions, video data must be compressed and sent to about 20: 1. The compression of such images causes loss of detail images due to the compression itself. In addition, the video delay caused by the compression / decompression process and the bit error compression caused during transmission have been spread to adjacent video frames. As a result, full HD uncompressed transmission technology using the mmWave band is required.

Another feature of the mmWave band is near-field communication. In general, the transmission loss in the air is proportional to the square of the propagation distance and the square of the center frequency. That is, even at the same distance, the 60GHz (mmWave) signal attenuates about 144 times more than the 5GHz (Wi-Fi) signal. Thus, unlike Wi-Fi, which emits radio waves in all directions and has a reach of about 30m, all transmit power must be collected and aimed at the target device (beam

formation), but the reach is also limited to within 10m. Therefore, the IEEE classifies mmWave technology as WPAN, wireless personal area network technology, while 5GHz is classified as WLAN, wireless local area network technology. As a result, mmWave communication has less reach than 10m, and since the signal is directed toward the target device, there is much less room for interference. In addition, since the beam is formed only to the target device that is needed, and the power is collected and transmitted, the transmission energy efficiency (J/bit) is relatively higher than that of Wi-Fi that radiates power over the entire range. If the beams do not overlap with each other, even if data is transmitted simultaneously in the same room and on the same frequency channel, no interference occurs.

Fifth, the technology related to low temperature heat radiation temperature operation. Low thermal stabilization of electronic devices has limited parameters, so there are not many solutions. After all, if the power consumption of the parts can't be lowered, it is necessary to take measures to lower the temperature of the parts. To do this, three methods are applied. First, increase the effective heat dissipation area. Second, improve heat transfer rate. Third, lower the ambient temperature. Among the low thermal resistance of electronic devices, the most important thing is the expansion of the heat dissipation area. Increasing the heat dissipation area is less expensive than other measures, such as the installation of a fan, and has many advantages such as noise, dust, power consumption, and fan life. There are many ways to increase the heat dissipation area, but the basic idea is to connect the parts to large objects of the area and heat them. Therefore, the reduction of contact thermal resistance must be realized. As heat sources become smaller and denser, it is important to reduce contact thermal resistance to increase the effective heat dissipation area of components.

In addition, the utilization of Thermal Interface Material (TIM) is important. TIM has various types of products such as heat dissipation sheet, heat dissipation lubricant, heat conductive adhesive, heat dissipation gel and PCM (Phase Change Material). In most of these cases, TIM is made of an insulating material having high flexibility and high thermal conductivity, thereby reducing contact thermal resistance. The liquid phase improves the thermal conductivity of the interstitial fluid by filling the space of the contact portion with the fluid. The use of TIMs should be evaluated from a wide range of aspects, including thermal properties, reliability, stability, manufacturability and safety. Figure 4 shows the reduction of the resistance to heat flow when using the TIM method reduces the heat transfer efficiency from the environment.

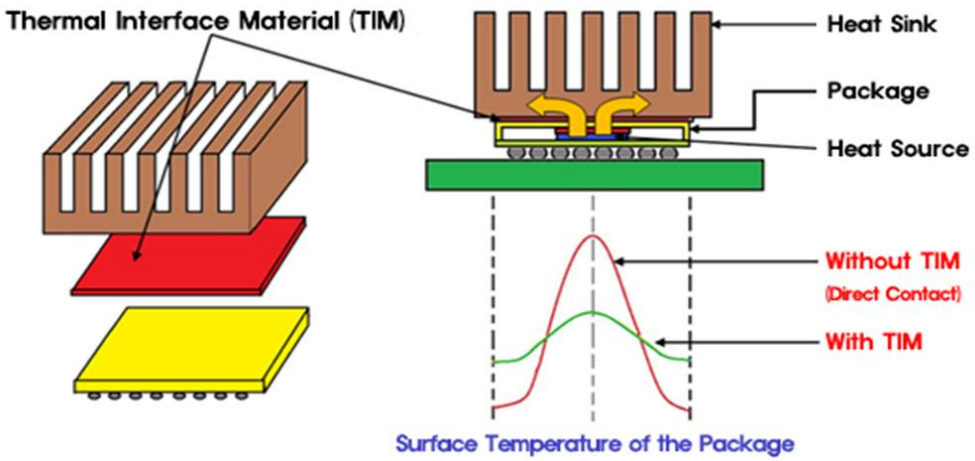

Figure 4. Reduction of the resistance to heat flow

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Finally, the present invention relates to a low latency operation in wireless image transmission and reception. The main traffic is to transmit sporadic low-capacity video information or device-to-device location information to the uplink, and at this time, ultra low delay high reliability requirements must be satisfied. Uplink that sporadically uploads low-capacity data from a multimedia sensor has a non-orthogonal random access channel environment characteristic by asynchronous due to propagation delay time and frequency asynchronous by Doppler effect. The target performance to be optimized in such a system can be defined as the system average frequency efficiency or maximum connectivity that can be obtained while satisfying the required latency and reliability. In order to target efficient performance while satisfying the requirements given from the waveform point of view, low latency must be satisfied. At the same time, it needs to have a low peak-to-average power ratio (PAPR) and a waveform that is robust to asynchronous situations. In order to maximize connectivity efficiency in the multiple access method, a reception method using multiple antennas should be used and a non-orthogonal overlapping channel should be supported. In order to identify multiple users in this non-orthogonal channel environment, time and frequency synchronization errors of each user may be compensated. In addition, there is a need for a synchronization technique and a multiple detection technique with a high detection rate. In the protocol, processing delay caused by performing handshaking for link formation and delay time until resource request, allocation and transmission in case of uplink data generation should be minimized. In this case, it is necessary to ensure reliability that satisfies the service demand performance while preventing collision between frames.

4. Conclusion

In the existing 3G, 4G, radio and broadcasting frequencies, frequencies are already allocated for many communication services. Therefore, to avoid interference with the existing frequency and at the same time to secure a wide bandwidth for a fast transmission rate, the unlicensed high frequency band should be allocated. Accordingly, 5G technology newly emerged in wireless communication. 5G is a technology that can create a global new industry that connects all things beyond the existing human communication (voice and data) and triggers digital innovation of the industry. 5G can solve the problem by densely constructing a base station, a repeater, a small cell and the like compared to 4G (LTE).

In Korea, the world-class technology for manufacturing finished products related to mobile communication, network, and handsets has reached the world level. However, the core source technologies such as RF antenna development (meaning RU / AU, AAU / DAU, etc. as antenna integrated equipment capable of beamforming and MIMO), chipset technology, core components and development technology have lower technological level than the world level. Recently, 5G base station, medium / long range expander, and local extender extension communication technology inside In-Building are recognized as the core source technology (element technology) of 5G mobile communication system, and research and development are in progress.

Therefore, it is necessary to secure a wide bandwidth for high transmission speed while avoiding interference with existing frequencies. In addition, an unlicensed high frequency band must be allocated and introduced. However, mmWave has a high speed while having a high straightness, but has a problem in indoor / outdoor use such as short wavelength and short diffraction angle so as not to penetrate a building. As a result, 5G will be able to solve the problem by densely constructing a base station, a repeater, a small cell and the like compared to 4G (LTE). In this paper, we designed and implemented a short-range expansion device for wireless video based on image generation technology, communication circuit design technology and UHD 4K wireless video transmission / reception ICT

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