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양방향 CEC 기능을 갖는 무선 고화질 이미지 전송 시스템의 설계

Design of Wireless HD Image Transmission System with Bidirectional CEC Function

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요 약 오늘날에는 모바일 스마트 기기를 많이 사용해본 소비자들이 무선 연결 방식과 같은 보다 편리하고 스마트한 가정용 전자기기의 연결성을 기대하고 있기 때문에 기존의 전기선을 다른 지능적인 연결방법으로 대체하는 것이 필요하다. 이 연구에서는 양방향 CEC 제어 구조를 새롭게 제안하여 밀리미터 밴드 이미지 전송 시스템에서 제어능력을 단방향에서 양방향으로 확장하는 것을 목적으로 하는데, 이는 2자유도 제어 능력이 HDMI 인터페이스 시스템에서 보다 지능적인 편리성을 제공하기 때문이다. 실험연구를 통해 1080p 풀 HD 이미지 스트림에 대해서 3.0 Gbps의 전송 성능 결과를 보여 지능적 2 DOF CEC 인터페이스를 보유한 밀리미터 밴드의 진보된 이미지 전송 솔루션으로서 제안된 시스템의 유용성을 보인다.

Abstract Nowadays it is necessary to replace electrical wires with another intelligent connection method because the consumers, who have much experience with mobile smart devices, are expecting easier and smarter connectivity in their home electronics such as wireless linking. In this paper a bidirectional CEC control scheme is newly proposed to expand the controllability from one to two way in a millimeter band image transmission system because two degree of freedom controllability presents more intelligent convenience in HDMI interface systems. Experimental study shows the feasibility of the proposed system as an advanced image transmission solution in millimeter band including an intelligent 2 DOF CEC interface with the performance result of 3.0 Gbps transmission band for 1080p full-HD image steaming.

Key Words : Wireless transmission, High density image resolution, Consumer electronics control.

Ⅰ. Introduction

As audio and video electronics market is moving to high density(HD) resolution, it is necessary to replace electrical wires with another intelligent connection method because consumers, who have much experience with mobile smart devices, are expecting easier and smarter connectivity in their home electronics such as wireless linking. In Fig. 1, a conventional method is illustrated on the connection of HD source devices to HD sinks in the link, in which HD source devices are blue-ray DVD players, set-top systems supporting HD and HD camcorders while HD sink devices are full HD digital TVs, PMPs supporting HDMI and so on. To replace the hard-wired linking method with wireless solutions, the solutions should support the wide band

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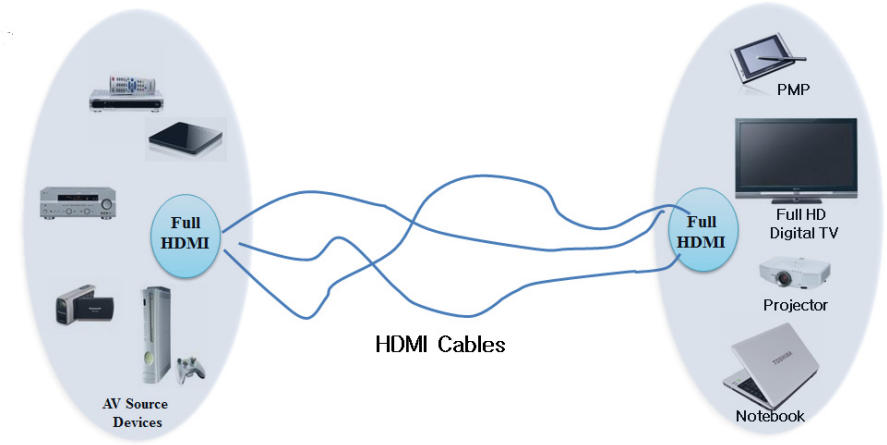

그림 1. HD 소스와 싱크 기기를 연결하기 위한 기존의 방법
Fig. 1. Conventional method to link HD source and sink devices

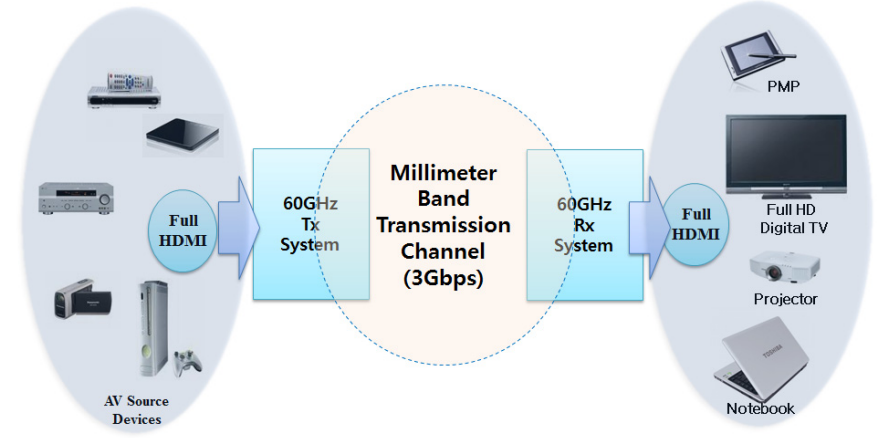

그림 2. HD 소스 기기와 싱크 기기를 밀리미터 밴드 기술을 이용하여 연결하는 무선 방법
Fig. 2. Wireless method to link HD source and sink devices in millimeter band technology

transmission function to cover full-HD image resolution streaming. Though there are many well-known wireless methods such as RF, UWB and wireless internet, the appropriate connection method should be chosen in considering the performance levels in image quality and transmission bandwidth.

In low level image transmission, it is adequate to use UWB transmission technology, which has 480M bps in the transmission performance in sending images to remote receiving systems. However, some difficulties appear when this technology being applied to a HD image stream transmission because the transmission capacity is not enough to handle the data amount of the HD resolution image streaming. While wireless LAN has a long-range feature, the transmission performance is still within 600Mbps and this technology is also unsuitable to the HD image transmission because at least 3 Gbps is needed to guarantee HD image transmission for 1080p level image resolution in 60Hz image update rate. To make UWB and wireless LAN useful for HD image transmission, an adequate image compression technique should be applied in transmitting

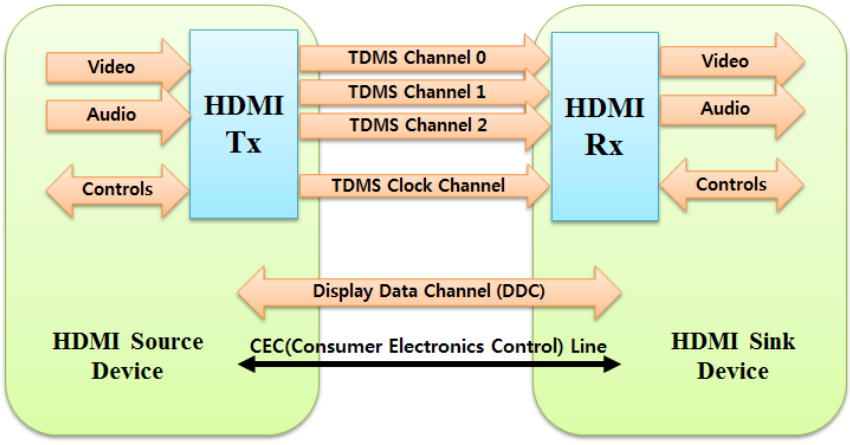

그림 3. HDMI 인터페이스를 통한 HDMI 기기의 연결 다이어그램
Fig. 3. Connection diagram of HDMI device through HDMI interface

HD image stream and this will induce motion blurs which are the degenerate factors in received HD images. This is the motivation to increase the operating frequency up to the millimeter wave bandwidth range in 60 GHz. Transmission in this high bandwidth does not need any compression technique in sending HD image stream because its transmission capacity is being estimated to at least 3 Gbps. Furthermore, it also supports CEC(Consumer Electronics Control) channel, which is a kind of data communication in lower bandwidth to control other devices intelligently. To utilize 60GHz band channels effectively, the policies for frequency allocations in millimeter band have beenn suggested in [1]-[4]. While OFDM(Orthogonal Frequency Division Multiplexing) is one of the 4-th generation communication methods, the noise reduction technique is an important issue in this method. Tomba analyzed the effect of Wiener phase noise in OFDM systems in [5], and Wu and Bar-Ness proposed a phase noise suppression algorithm for OFDM-based WLANs in [6]. Meanwhile CEC technology is a key feature in consumer electronics for wireless communication. A control scheme was proposed in [7], in which connected devices could be hierarchically controlled in a HDMI-CEC configuration, and the CEC was implemented as a firmware in an MCU for HDMI 1.3A CEC specification in [8].

II. Problem Statement

High density multimedia interface(HDMI) is extensively used to connect HD source and sink devices as illustrated in Fig. 3. The purpose of the interface is to transform the audio, video and control signals of input ports in HDMI source devices to corresponding digital signals to digitally link remote HDMI sink devices. There are transition minimized differential signaling(TMDS) and TDMS clock channel, which include the segmented HD image stream information according to a certain timing signal in the HDMI interface. While the TDMS signals are dedicated to HD image transfer, another data channel is prepared for the communication of HDMI devices such as display data channel(DDC). Especially the consumer electronics control(CEC) is also prepared to control the sink devices digitally by the source devices in CEC network configuration. An example of CEC network configuration is illustrated in Fg. 4. There are a DVD system, a set-top system, an A/V receiver directly connected to a digital TV and another VHS system in the example and it is assumed that all the devices have HDMI interfaces. By the HDMI interfaces, the CEC network is automatically configured in a hierarchical system and the appropriate network address is designated to each HDMI device as illustrated in Fg. 4.

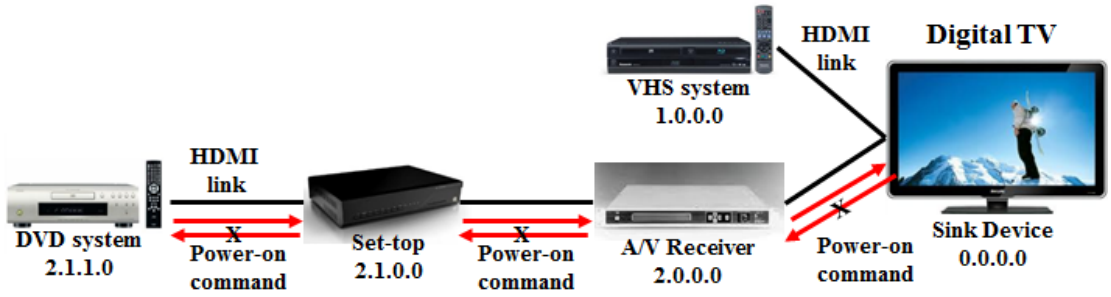

그림 4. 다수의 HDMI 기기에 대한 기존 CEC 네트워크 연결 다이어그램
Fig. 4. Conventional CEC network connection diagram of multiple HDMI devices

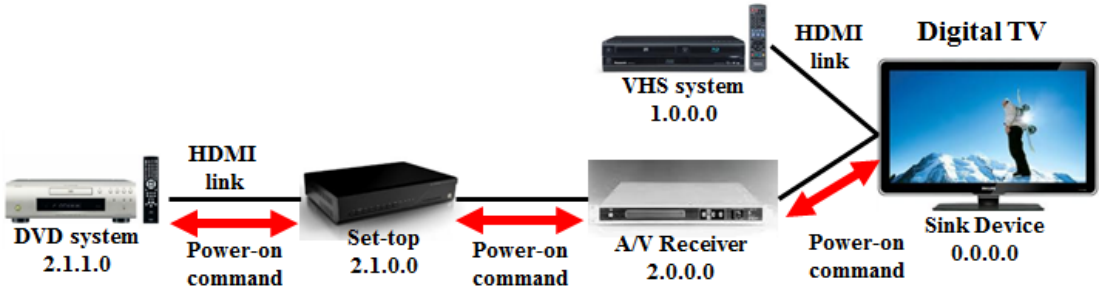

그림 5. 양방향 CEC기능에 대한 HDMI 네트워크 연결 다이어그램
Fig. 5. HDMI network connection diagram for the bidirectional CEC function

If the digital TV is power-off state in initial state, the TV power-on command is delivered through the CEC network when a user press the play-button in the DVD system in the example and finally the digital TV will be automatically turned on by the CEC function interactively. This is the explanation on the CEC function and network, but the direction is still the only way. The other direction is not available because the original CEC has been designed on the assumption that the command is delivered on the direction of from source to sink. This is the motivation to propose the bidirectional CEC to include the other directional controllability from sink to source as illustrated in Fig. 5. It is obvious that the another degree of freedom is needed for more intelligent CEC when considering the case that the DVD player is automatically tuned off by the CEC command from the digital TV when a user is pressing the power-off button on the TV in the example of Fig. 5.

Ⅲ. Design of Wireless HD Image Transmission System with Bidirectional CEC Function

Design objective in this research is illustrated in Fig. 6. The final goal is to design a new wireless transmission system which delivers full-HD digital image streams from AV source devices to the corresponding sink including the bidirectional CEC function. It is obvious that the wireless transmission system is comprised of 60GHz transmitting(Tx) and receiving(Rx) systems because at least 3 Gbps performance is needed to guarantee HD image transmission with 1080p level image resolution in 60Hz image update rate.

The design concept of the millimeter band transmitting system with bidirectional CEC function is illustrated in Fig. 7. HDMI input signals consisting of TMDS(Time Minimized Difference Signals), control

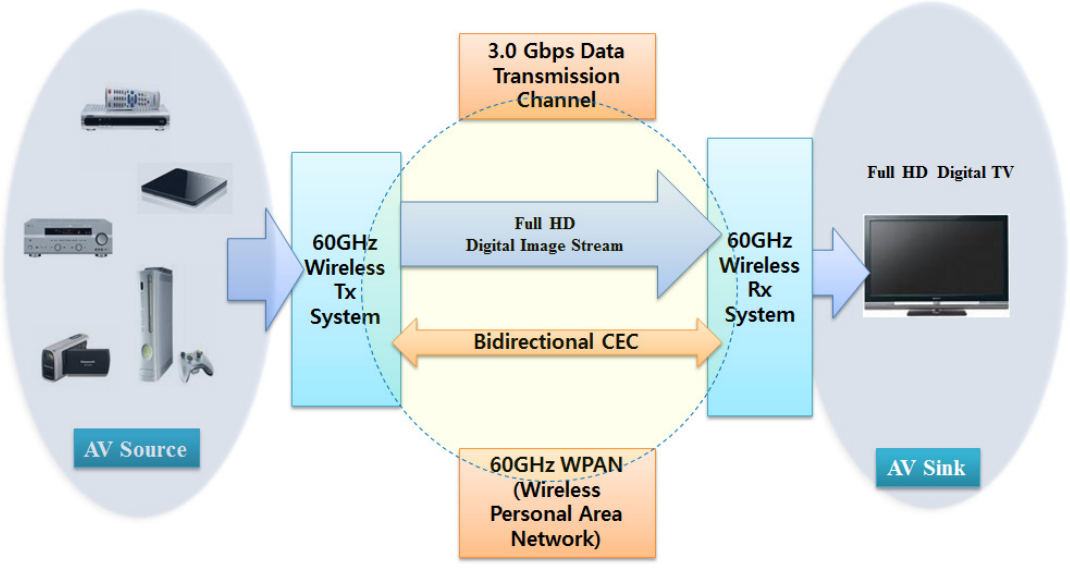

그림 6. 제안하는 시스템의 설계 목표
Fig. 6. Design object of the proposed system

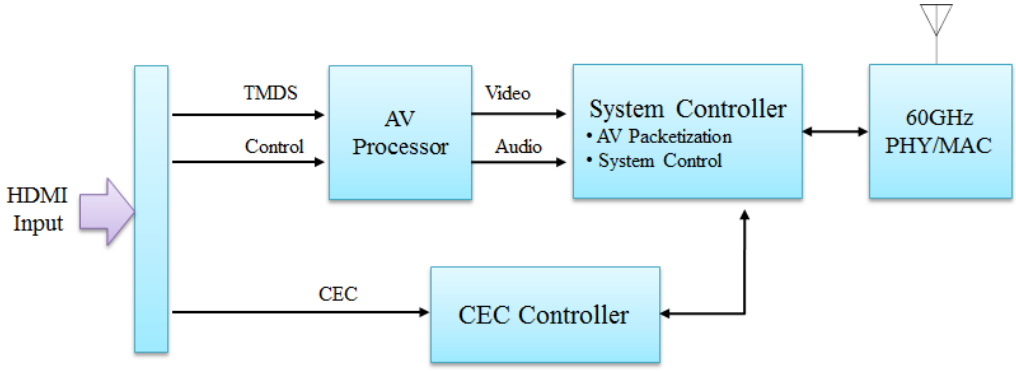

그림 7. 양방향 CEC 기능을 가진 밀리미터 밴드 송신 시스템의 설계
Fig. 7. Design of the millimeter band transmitting system with bidirectional CEC function

and CEC signals are transferred to an AV(Audio Video) processor, which processes these input signals to construct video and audio signals. System controller converts the video and audio signals to AV data packets by the packetization process including the control signals such as system control and CEC control signals. Finally the PHY/MAC in 60GHz receives these data signals and converts them to corresponding physical electromagnetic waves to send them into air.

Meanwhile the structure of the proposed wireless receiving system for HD image transmission is illustrated in Fig. 8. In the figure, it is easily understood that the signal transfer direction is totally reverse relative to the transmitting system. Air data are catched at the PHY/MAC in 60GHz and the system controller constructs the video and audio signals by the AV packetization process including the control signals such as system control and CEC control signals. Finally, AV processor handles the data signals to construct corresponding HDMI output signals for sink

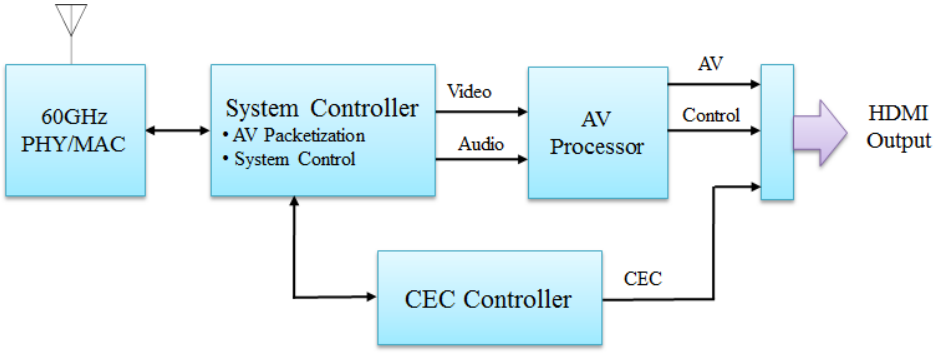

그림 8. 양방향 CEC 기능을 가진 밀리미터 밴드 수신 시스템의 설계
Fig. 8. Design of the millimeter band receiving system with bidirectional CEC function

devices. As mentioned earlier, the CEC is one of the data communication channels in lower bandwidth to control other devices with CEC interface. By integrating the proposed wireless transmitting and receiving systems explained earlier, the entire system is easily constructed for a wireless HD image transmission link.

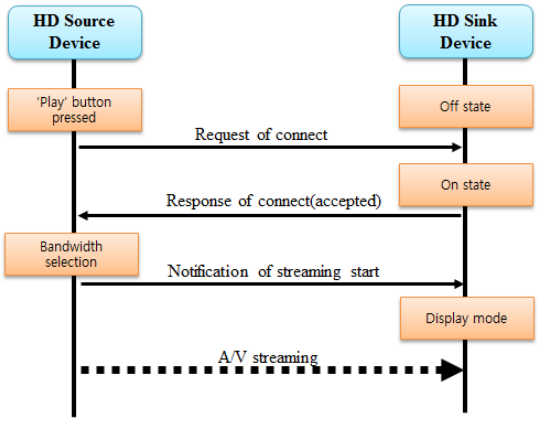

그림 9. 소스에서 싱크 기기로의 상태 다이어그램
Fig. 9. State diagram of the direction from a source device to a sink

In the proposed system, there is a CEC controller in which the bidirectional CEC control firmware are embedded. In Fig. 9 a state diagram is illustrated to explain the CEC control scheme from a source device to a sink device. In this example, the source is a DVD player and the sink is a digital TV. When the play-button is pressed in the DVD system, the request of connection is transferred to the HDMI interface of the TV and finally will turn on the TV automatically to make A/V streaming between the two systems.

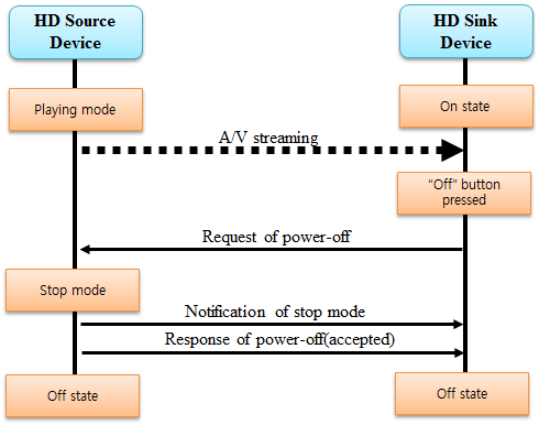

그림 10. 싱크에서 소스 기기로의 상태 다이어그램
Fig. 10. State diagram of the direction from a sink device to a source

The other direction of control is illustrated in Fig. 10, in which the A/V streaming is assumed to be already maintained in initial state. If the off-button on the TV is pressed, the request of power-off is delivered to the source, the DVD, through the CEC data channel, and finally the DVD will prepare to turn off its power. This two-way control scheme makes users to control their HD image devices at any terminal points such as sources or sinks.

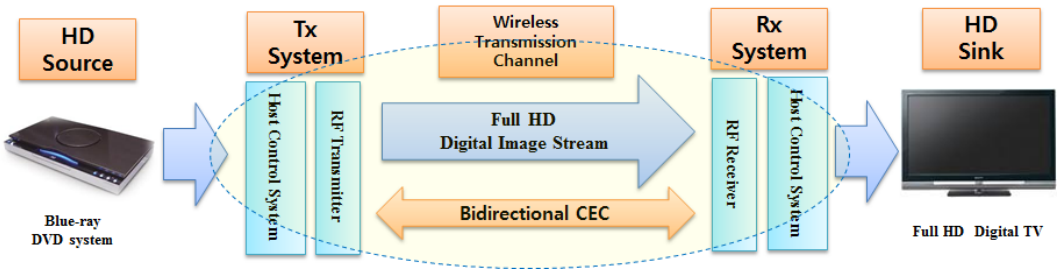

그림 11. 제안하는 무선 전송 시스템의 개념적 구성도
Fig. 11. Conceptual configuration of the proposed wireless transmission system

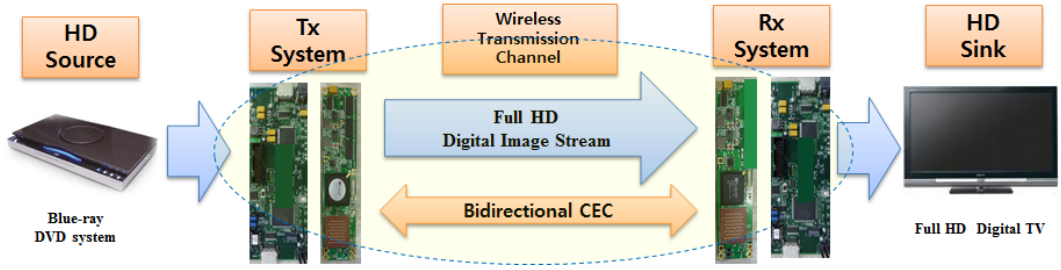

그림 12. 제안하는 무선 전송 시스템의 실험 구성도
Fig. 12. Experimental configuration of the proposed wireless transmission system

By integrating the design results, the overall system is conceptually configured as illustrated in Fig. 11, in which the Tx system is comprised of a host controller and a RF transmitter while Rx system being comprised of another host controller and a RF receiver. The host system processes the HD image signals from a HD source device to make the video, audio and CEC control signals, which are delivered to the RF transmitter to send them into air. On the contrary the RF receiver in the Rx system catches the electromagnetic waves and transforms them into corresponding video, audio and CEC control signals which are delivered to the host system to make the HDMI signals for HD sink devices.

The Tx and Rx systems can make the wireless full-HD image resolution transmission channel including the bidirectional CEC function newly proposed in this research. Consequently the entire system has an ability to transfer the HD image strams from any HD source device(e.g. a blue-ray DVD system) to any HD sink device(e.g. a hull-HD digital TV) as illustrated in Fig. 11.

Ⅳ. Experiments

Finally the millimeter band wireless transmission system is designed to implement the wireless HD image transmission system based on millimeter wave technology in 60 GHz. The system is comprised of the wireless HD image Tx and Rx systems with 3.0 Gbps transmission performance. Won Kim has designed a wireless HD transmission system based on millimeter wave technology for visual surveillance in [9], in which the system has a wireless channel of 2.7 Gbps in its transmission performance. However, frame update rate is just 30 frames a second and image size is not full high density. The performance on the frame update rate and image size should be enhanced to cover full-HD image size. In this research the millimeter band wireless transmission system is designed on the base of the research results in [9] as illustrated in Fig. 12. There are an embedded controller, a HDMI receiver and a HDMI transmitter in the host control system. The HDMI receiver processes the segmented TMDS

data based on the video signal transferred from a HDMI input port to construct corresponding video frames under the control of the embedded controller. The video frames are delivered to the network processor and transformed appropriate electromagnetic signals by he RF tranceiver chip in the transmitting system to send into air as illustrated in Fig. 12. The electromagnetic signals will reach the receiving system through the wireless HD image linking channel and be processed to form video frames under the control of the network processor in the receiving system. The video frames are delivered to the host control system in receiving part and transformed to TMDS signals by the HDMI transmitter chip to be transferred to a HDMI output. In this study the firmware in the millimeter band wireless transmission system is modified to cover full-HD performance. Therefore the performance enhancement is achieved in the aspect of transmission bandwidth, video updating rate and image resolution. The proposed system has 3.0 Gbps in transmission bandwidth, 60 frames/second in video updating rate and supports 1920×1080 image frames(full-HD, 1080p) to cover HD image streams.

V. Conclusion

Nowadays it is necessary to replace the electrical wires with another intelligent connection method because consumers, who have much experience with mobile smart devices, are expecting easier and smarter connectivity in their home electronics such as wireless linking. In this paper a bidirectional CEC control scheme is newly proposed to expand the controllability from one to two way in a millimeter band image transmission system. Experimental results shows the feasibility of the proposed system as an advanced image transmission system in millimeter band with an intelligent CEC interface as summarized in Table 1.

표 1. 제안 시스템의 성능
Table 1. Performance of the proposed system

Evaluation Items	Unit	Previous system in [9]	Proposed system
Directional DOF of CEC	Ways	1	2
Transmission bandwidth	Gbps	2.7	3.0
Video updating rate	Frames/sec	30	60
Image resolution	Pixels2	1280×720	1920×1080
Wireless Transmission Carrier Frequency	GHz	60	

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