무선 HD 비디오 전송 시스템용 스마트 HDMI 스위치의 설계

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요 약

이 연구에서는 스마트 HDMI 스위치를 제안하는데, HDMI 플러그를 물리적으로 빼고 다시 꺼는 일이 없는 상태에서 새로이 형성되는 비디오 스트림을 감지해서 자동적으로 전송 경로를 해당 포트로 전환해 주는 것이 주된 내용이다. 더 나아가 제안하는 시스템은 밀리미터 밴드 기술을 기반으로 진보된 무선 비디오 전송 구조 안에서 설계되었다. 하드웨어 실험을 통해서 제안된 시스템이 스마트 포트 전환 기능을 포함하는 가운데 풀 HD 비디오 전송 성능을 갖는 것을 보임으로써 그 유용성을 확인하였다.

주제어 : 고해상도, 비디오 신호 전송, 무선 링크, HDMI 스위치

Design of the Smart HDMI Switch for Wireless HD Video Transmission System

Won Kim†

ABSTRACT

In this study a smart HDMI switch is proposed to detect newly formed video stream and automatically change the transfer path to the corresponding port without pulling the HDMI plug and putting it again in the desired port manually and physically. Furthermore the proposed switch is designed in the advanced wireless video transmission scheme based on millimeter band technology. The proposed system shows its feasibility by the hardware experiment in the full-HD video transmission performance including the function of the smart port change.

Keywords : High-definition, Video Signal Transmission, Wireless Link, HDMI Switch

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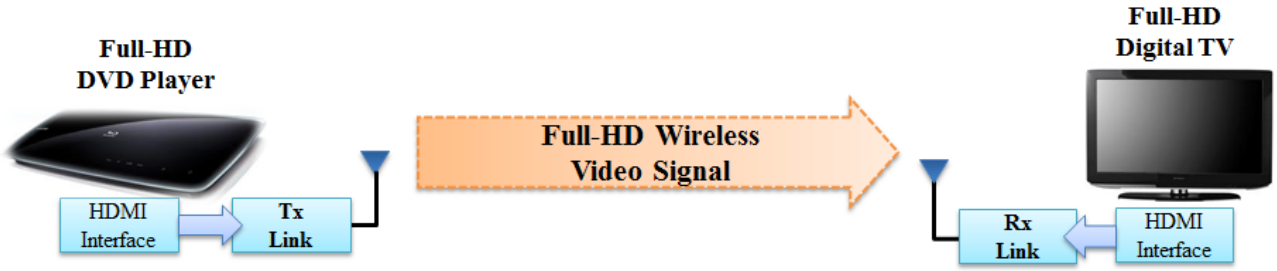
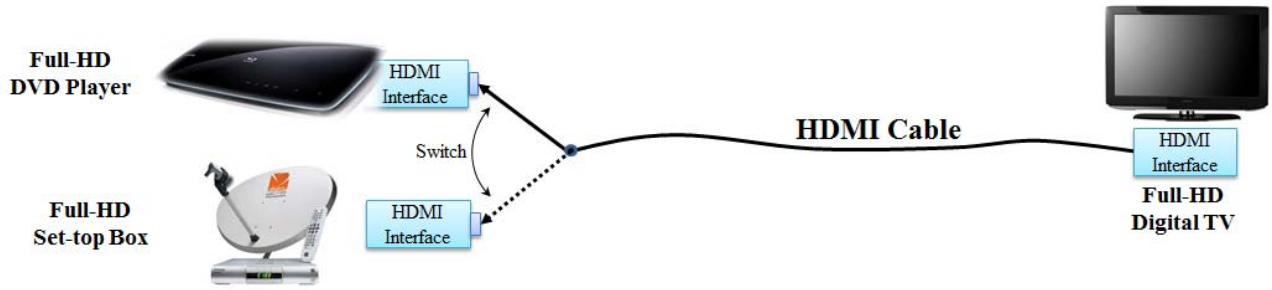
1. Introduction

When remembering the developing news on the HDTV(High Definition TV) technology about 10 years ago, it was doubtful to have the sophisticated consumer electronics really in home at that time. However the technological prophecy has turned to be real situation while seeing the fact that most of conventional cathode-ray tube type televisions have been replaced with digital HD(High Definition) televisions in many houses nowadays. Wireless solutions are adapted to connect the devices each other in air rather than through electrical wires as illustrated in Fig. 1. In the figure, it is found that a Tx link, the transmitting device, has the function of sending video streams into air while the corresponding Rx link, the receiving device, which catches the video signal in air and transforms the signal into video frames for digital TVs. Though there are many well-known wireless methods such as RF, UWB(Ultra Wide Band) and wireless internet, the appropriate connection method should be chosen in considering the performance levels in image quality and transmission bandwidth.

To make UWB and wireless LAN(Local Area Network) useful for HD image transmission, an adequate image compression technique should be applied in transmitting 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 been 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 WLAN(Wireless Local Area Network)s 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(High Definition Multimedia Interface)-CEC configuration, and the CEC was implemented as a firmware in an MCU(Main Control Unit) for HDMI 1.3A CEC specification in [8].



<Fig. 1> Flexible method to link consumer electronic devices with wireless HDMI interfaces



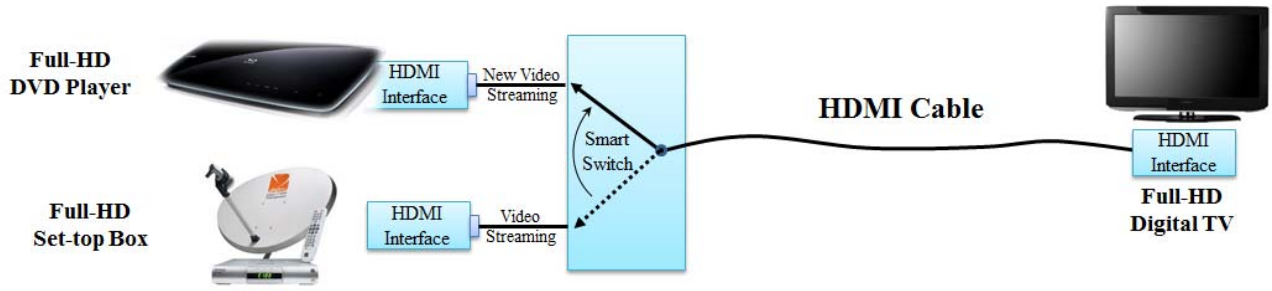
<Fig. 2> Connection topology for the case of multiple HD source devices

2. Problem statements

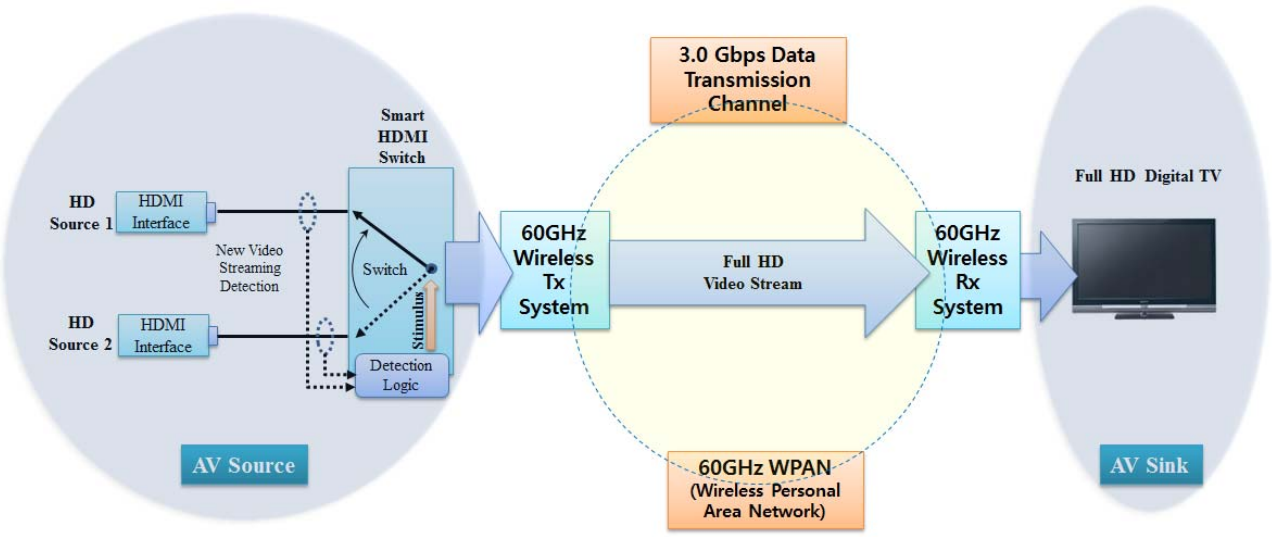
Considering the case of multiple HD source devices to a HD sink device such as a full-HD digital TV, it is necessary to prepare multiple HDMI cables to connect them as illustrated in Fig. 2. The cable is to be manually switched to connect the appropriated source device between the full-HD DVD player or full-HD set-top box in the figure. It is natural to find smarter way to connect the devices while not depending on this kind of physical and manual changing method. Consider the situation that the set-top box is already connected and its video streaming is transferring to the full-HD digital TV, and at this moment the watcher is changing whose mind to connect full-HD DVD player to the digital TV as illustrated in Fig. 3. When the play button is pressed on the DVD player, new video stream is newly formed and starts to be transferred to the digital TV. If a smart switch detects this new video stream and finally changes the transfer path to the DVD player automatically, the watcher can connect the DVD player easily to the TV without pulling the HDMI plug and putting it in the desired port manually and physically. This is the motivation to research the smart HDMI switch in the millimeter band wireless transmission technology. In the previous research in [9], a HDMI switch is designed to transmit two pairs of HDMI video signals over a distance of 10km in CWDM(Coarse Wavelength Division Multiplexing) switching network. However the switch just changes the video port without the smart switching function.

3. Design of the Wireless High Definition Signal Transmission System with a Smart HDMI Switch

Design objective of the proposed system in this research is illustrated in Fig. 4. In the figure, it is easily found that there are a smart

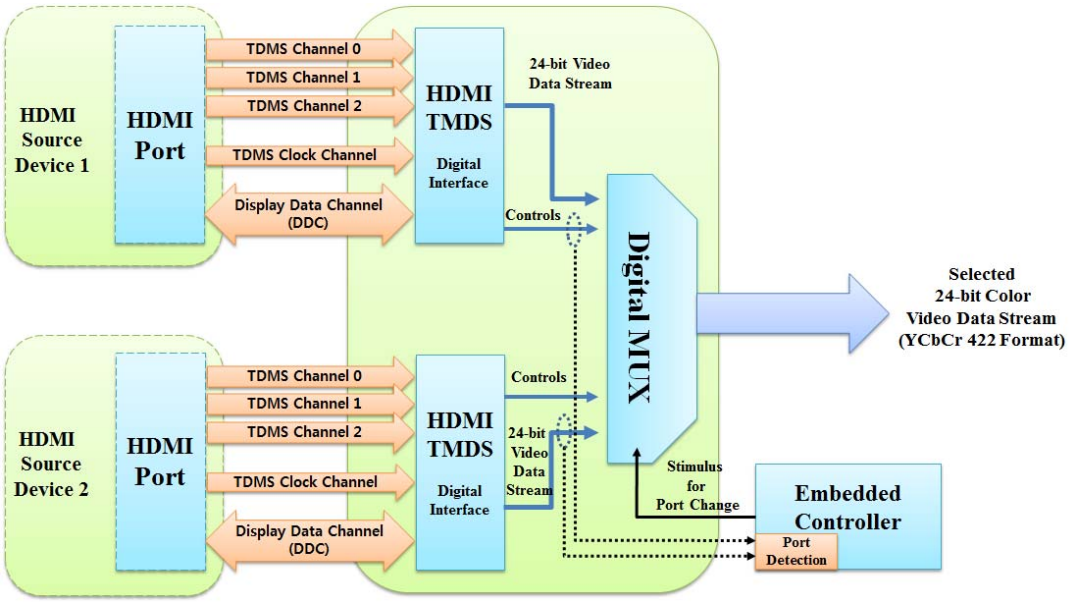


<Fig. 3> Necessity for a smart switch in HDMI interface for the case of multiple HD source devices



<Fig. 4> Design objective of the proposed system

HDMI(High Definition Multimedia Interface) switch, a 60GHz wireless Tx(Transmitting) system and the corresponding 60GHz wireless Rx(Receiving) system. Full-HD video stream is transferred through 3.0 Gbps data transmission channel, a kind of 60GHz WPAN(wireless personal area network), by the pair of a 60GHz wireless Tx and the corresponding 60GHz wireless Rx systems because 60GHz millimeter technology provides the ability of full-HD video transmission. In this research, the core is to design the smart HDMI switch, which automatically detects newly formed video streams and automatically changes the connecting path to the HDMI port including the stream from the current connected HDMI port by stimulating the switch digitally. As mentioned earlier, this smart connectivity gives more convenient way in changing the video path rather than by pulling the HDMI plug and put it in the desired port manually and physically. Futhermore the augmented



<Fig. 5> Structure of the proposed smart HDMI switch

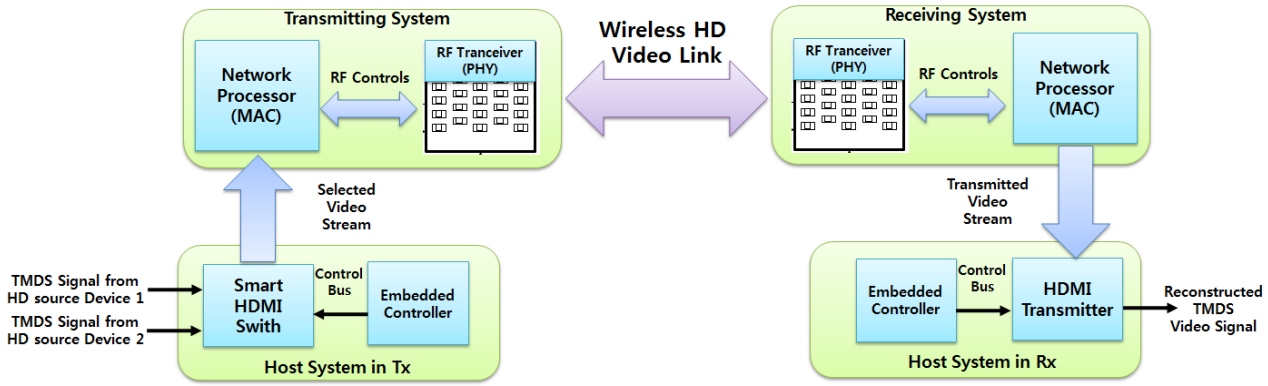
convenience will accelerate the growing speed of the HD consumer electronics market.

The proposed structure of the smart HDMI switch is illustrated in Fig. 5. 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 TMDS(Transition Minimized Differential Signaling) and TDMS clock channel, which include the segmented HD video stream information according to a certain timing signal in the HDMI interface. While the TDMS signals are dedicated to HD video transfer, another data channel is prepared for the communication of HDMI devices such as display data channel(DDC).

Meanwhile the module of HDMI TDMS digital interface reconstructs the video stream, 24-bit color video data in YCbCr 422 format, and the control information included in the DDC channel by integrating TDMS channel data according to the appropriate TDMS clock. In the proposed structure, there is an embedded controller which has the functions of detecting video port and stimulating the digital MUX in the structure to change the connecting path to the HDMI port including newly formed video stream. Finally the overall structure functions to automatically transfer newly formed video stream to the sink HDMI device.

Finally the entire structure is proposed to construct the wireless high-definition signal transmission system with a smart HDMI switch in Fig. 6. In the figure there are a host system in transmitting part, another host system in receiving part and a pair of wireless systems in millimeter technology. In the host system in Tx, it is found that the smart HDMI switch handles TMDS signals from two HD source devices under the control of an embedded system as the way explained earlier. Finally the selected video stream is transferred to the millimeter band wireless transmitting system. The stream is transferred in air to the millimeter band wireless receiving system and the stream is finally converted by the HDMI transmitter in the figure to reconstruct the corresponding TMDS video signal for the HD sink device.

Actually the wireless HD video link is constructed by the pair of the wireless transmitting and receiving systems designed in millimeter technology. In the figure, the transmitting system is comprised of 2 main chips such as a network processor and a RF tranceiver(PHY). In the same figure, it is easily found that the receiving system also consists of the same main chips.

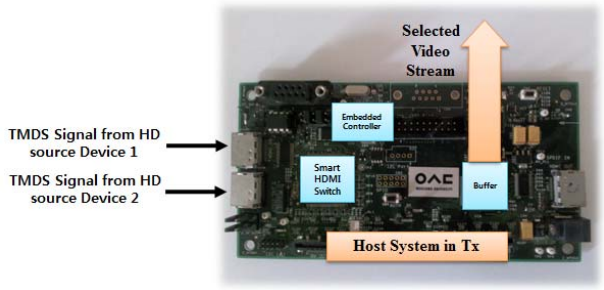


<Fig. 6> Structure of the proposed wireless high-definition signal transmission system

4. Experimental study

Finally the wireless high-definition signal transmission system with a smart HDMI switch proposed earlier is implemented as in a real hardware configuration. Meanwhile Won Kim has designed a wireless HD transmission system based on millimeter wave technology for visual surveillance in [10], 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 as explained earlier. In this research the millimeter band wireless transmission system is designed on the base of the research results in [10]. There are a host system, a transmitting system in Tx part and another host system and a receiving system in Rx part.

The host system in Tx part processes the segmented TMDS data based on the video signal transferred from two HDMI input ports to construct corresponding video frames and automatically select newly formed video stream under the control of the embedded controller. The photograph in Fig. 7 shows the design result of the host system in Tx part, in which there are a smart HDMI switch handling TMDS signals from two HD sources, an embedded controller.



<Fig. 7> Photograph of the host system in Tx

<Table 1> Performance of the proposed system

Evaluation Items	Unit	Previous system in [10]	Proposed system
Multiple ports	Ports	1	2
Availability of automatic port change	Availability	None	Automatic
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	

In this study the firmware in the millimeter band wireless transmission system is modified to cover full-HD performance.

The experimental results on the implemented system are summarized in Table 1. According to the results, the performance enhancement is achieved in the aspect of transmission bandwidth, video updating rate and image resolution than the previous system in [10]. 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. Furthermore the number of port is increased to 2 ports with the automatic port changing ability.

5. Conclusion

Considering the case of multiple HD source devices to a HD sink device such as a full-HD digital TV, it is necessary to prepare multiple HDMI cables to connect them. However if a smart switch detects the new video streaming and finally changes the transfer path to the

port, automatic video path change is available without pulling the HDMI plug and putting it again in the desired port manually and physically. In this study a new scheme in millimeter band is proposed to design the wireless high-definition signal transmission system with a smart HDMI switch and the feasibility is proved by the real hardware implementation.

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