Test of UHD/HD Integrated MATV Functions in real environment

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Abstract **This paper presents the test results of UHD/HD integrated MATV functions in real environment. In Korea, terrestrial broadcasters simulcast the same content programs in UHDTV and HDTV. In the near future, HDTV services will be terminated and replaced by UHDTV services. It may results in a problem of HDTVs in households to be useless. To solve this problem, a new UHD/HD integrated MATV system is developed to deliver ATSC 1.0 HDTV signals as well as ATSC 3.0 UHDTV signals for apartment complexes. For this, tests of the developed UHD/HD integrated MATV functions are performed. Through the tests, its functions are verified in real environment.**

***Index Terms*—UHD/HD integrated MATV, Fuction test, ATSC 3.0 UHDTV, ATSC 1.0 HDTV**

I. Introduction

In Korea, terrestrial UHDTV has been launched since 2017 for Seoul metropolitan area and six metropolitan cities[1]. The coverage of Korean UHDTV will be extended to nationwide by 2023. Currently, HDTV and UHDTV simulcast the same contents and the discussions regarding the shutdown of ATSC 1.0-based HD broadcasting are scheduled to start in 2027. In Korea, about 60% of Koreans live in apartments and watch terrestrial TV via MATV (master antenna television). Many apartments installed HDTV MATV system and deliver HDTV services to households. As the HDTV services are expected to be terminated and replaced by UHDTV services in the near future, it is unable for the exisiting HDTV sets to watch UHDTV services, and they may not be used anymore. It makes a problem for households with HDTV-sets and want to use them. To solve this problem, UHD/HD iMATV (integrated MATV) system was developed to deliver UHDTV and HDTV services through MATV cable lines[2],[3].

In this paper, we present the test results of UHD/HD iMATV functions in real environment. For the test, we selected seven apartment complexes in Korea nationwide and installed UHD/HD iMATV systems.

II. Overview of UHD/HD integrated MATV system

A. Functional structure of UHD/HD iMATV system

UHD/HD iMATV system receives an On-Air UHDTV signal from a broadband UHF antenna installed on the top of an apartment and distributes the received UHDTV signal to the households via MATV cable lines[2],[3]. The functional diagram of UHD/HD iMATV system is shown in Fig. 1. UHDTV broadcasting uses ATSC 3.0 system in Korea, and HDTV broadcasting uses ATSC 1.0 system. Considering the Korean terrestrial TV systems, UHD/HD iMATV outputs both ATSC 3.0 UHDTV signal and ATSC 1.0 HDTV signal simultaneously, as shown in Fig. 1.

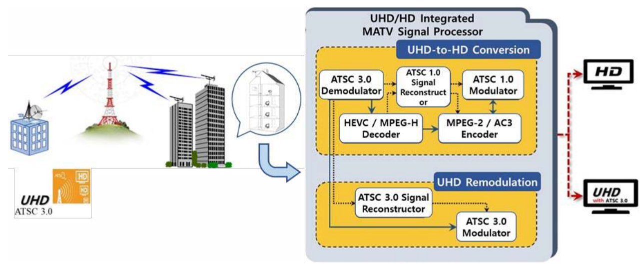


Fig. 1. Structure of UHD/HD iMATV system

B. UHDTV services and its frequency allocation in Korea

In Korea, there are four UHDTV services such as KBS1 on channel 52(698~704MHz, f_C=701MHz), Local broadcasters on channel 53(704~710MHz, f_C=707MHz), MBC on channel 55(698~704MHz, f_C=765MHz), and KBS2 on channel 56(765~771MHz, f_C=768MHz). EBS, the educational broadcasting station, received channel 54(753~759MHz, f_C=756MHz) for its UHDTV services but does not start UHDTV services yet. The UHDTV networks are configured in a single frequency network (SFN) using one frequency band for each broadcaster to cover nationwide UHDTV services.

Currently, the UHDTV programs are served in Seoul metropolitan area, 6 metropolitan cities such as Pusan, Daegu, Incheon, Gwangju, Daejeon and Ulsan, and Gangneung, an exceptional city. The UHDTV services of Gangneung is started to broadcast the 2018 Pyeongchang Winter Olympic Games.

III. Selection of test apartment complexes

For the test of UHD/HD iMATV system, seven apartments are selected from the areas with UHDTV services mentioned above. Four apartments are selected from Seoul-metropolitan areas such as Incheon, Yongin, Yangpyeong and Pyeongtaek. One apartment is selected from Pusan, Daegu, and Gangneung, respectively. The local broadcasters of these areas are G1 for Gangneung, KNN for Pusan, TBC for Daegu, SBS and OBS for the Seoul metropolitan area.

For the seven test apartments, the apartment complexes of Yangpyeong, Pusan and Daegu have near LOS(line of sight) channels with a single transmitter. The apartment complex of

Gangneung has a non-LOS channel with a single transmitter. Those of Incheon, Yongin and Pyeongtaek have SFN channel characteristics of two, three, and four transmitters respectively.

A. LOS channel of a received ATSC 3.0 signal

As an example of LOS channel characteristic, the channel profile of the received ATSC 3.0 signal obtained from the Yangpyeong Human-Vil 2 apartment is shown in Fig. 2. It shows a dominant path and small delay spreads. The channel equalizer output shows quite good 256QAM constellations, as shown in Fig. 2 [4].

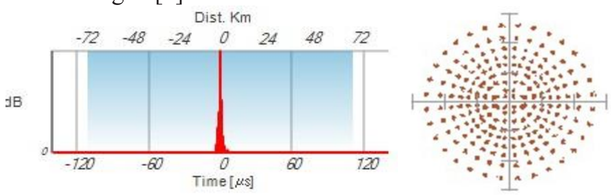


Fig. 2. Received ATSC 3.0 signal characteristic and constellations of a LOS channel in Yangpyeong Human-Vil 2 apartment complex

B. Non-LOS channel of a received ATSC 3.0 signal

The non-LOS channel characteristic is obtained from Gangneung Media-Chon 2 apartment which is obstructed by a high building in the direction of a transmitter in Mt. Gwaebang. The channel profile of the received ATSC 3.0 signal has a dominant path with delay spreads as shown in Fig 3. The delay spreads are resulted from the reflected paths by an obstructing building. The equalizer output signal shows 256QAM constellations but seems not as good as those of the LOS channel, as shown in Fig. 3.

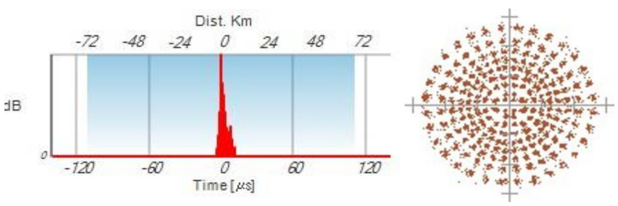


Fig. 3. Received ATSC 3.0 signal characteristic and constellations of a non-LOS channel in Gangneung Media-Chon 2 apartment complex

C. SFN channel of a received ATSC 3.0 signal

As an example of a SFN channel, the received ATSC 3.0 signal of Hyangchon Humancia 2 apartment in Incheon shows a SFN channel characteristic with two signal paths from two transmitters as shown in Fig. 4. It shows quite good 256QAM constellations similar to those of LOS channel, which means the inter-symbol interferences by the two SFN transmitters are compensated by the channel equalizer.

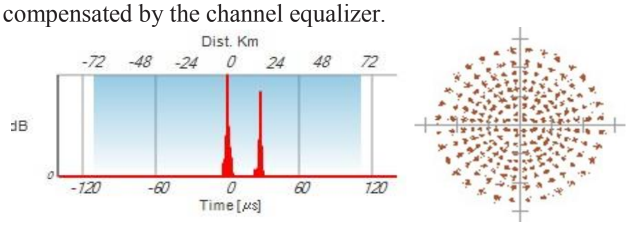


Fig. 4. Received ATSC 3.0 signal characteristic and constellations of a SFN channel in Incheon Hyangchon Humancia 2 apartment complex

IV. TEST OF UHD/HD IMATV IN REAL ENVIRONMENT

For the selected seven test apartments, UHD/HD iMATV system are installed for KBS1, KBS2, MBC, and local broadcasters in the areas of test apartments.

As an example, test equipment installed in the apartment of Incheon consists of five UHD/HD iMATV system, a RF combiner, and a monitoring system, as shown in Fig. 5. UHD/HD iMATV system demodulates a received ATSC 3.0 signal and remodulates it into a new ATSC 3.0 signal. Also, it converts ATSC 3.0 UHDTV signal into ATSC 1.0 HDTV signal[3]. The RF combiner has 12 input ports to receive 12 inputs of UHD and HD outputs of six UHD/HD iMATV systems maximally, and outputs one combined signal.

For ATSC 3.0 UHD signal receptions, the legacy HDTV antenna covering UHF low frequencies is replaced by a wideband UHF antenna covering the entire UHF band as shown in Fig 5. The wideband UHF antenna covers 470~862MHz, which includes the frequencies of UHDTV in the high UHF band from 701MHz to 771MHz.

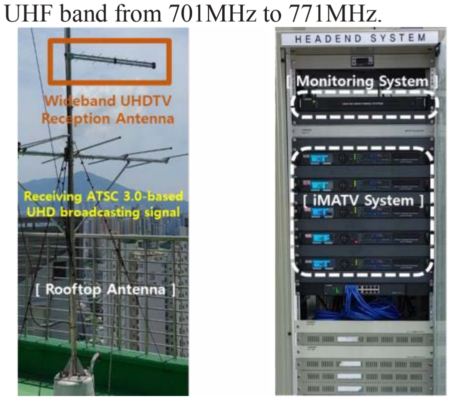


Fig. 5. Test equipment of the apartment in Incheon, a wideband antenna(left) and UHD/HD iMATV system(right)

A. Input and Output of UHD/HD iMATV system

1) *Input of UHD/HD iMATV system*: The input of UHD/HD iMATV system is a received ATSC 3.0 signal. For the apartment in Incheon, a SFN channel of two transmitters is obtained as shown in Fig. 6. The received ATSC 3.0 signal has two PLP(physical layer pipe)s, PLP 1 UHD with 256QAM and PLP 0 HD with 64QAM [4], signal power -34.95dBm and SNR (signal to noise ratio) is 38.5dB.

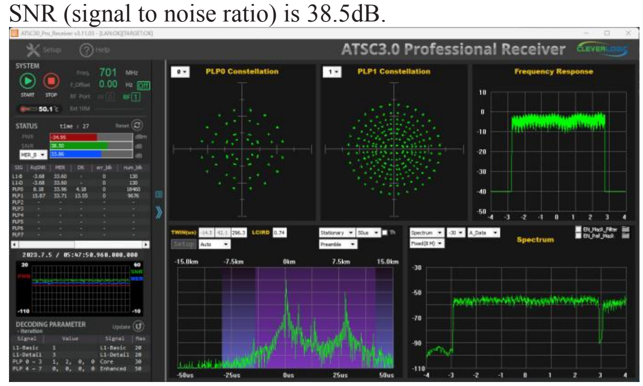


Fig. 6. A received ATSC 3.0 signal of the apartment in Incheon - UHDTV program, SFN channel profile, constellations and frequency spectrum

2) *UHDTV output of UHD/HD iMATV system:* The remodulated ATSC 3.0 UHD output of UHD/HD iMATV system are shown in Fig. 7. The remodulated ATSC 3.0 UHD signal power is -9.88dBm, SNR is 33dB. Two PLPs of UHD 256-QAM constellations and HD 64-QAM constellations are shown clearly. And the channel profile shows single path and a flat frequency spectrum.

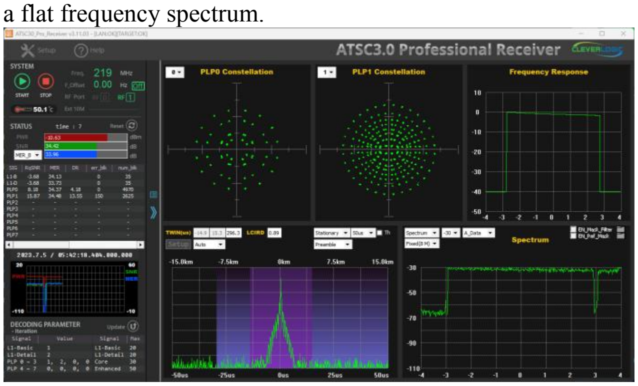
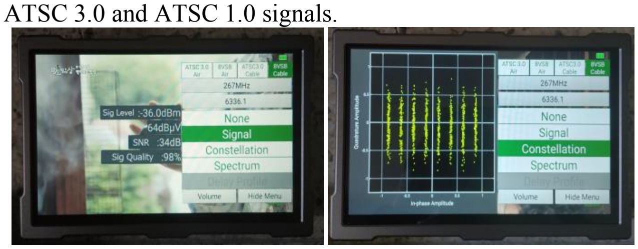


Fig. 7. Remodulated ATSC 3.0 UHD output of iMATV

3) *HDTV output of UHD/HD iMATV system:* The analysis results of the remodulated HD output of UHD/HD iMATV system are shown in Fig. 8. The remodulated HD signal power is -36dBm, 64dBμV, SNR is 34dB, and clear HD 8-VSB constellations are shown [5]. The ATSC 1.0 HD signal is analyzed with "TV Test Analyzer" of Agos, a Korean broadcasting equipment manufacturer, which supports both ATSC 3.0 and ATSC 1.0 signals.



(a) HDTV program and analysis results (b) ATSC 1.0 8-VSB constellations

Fig. 8. Remodulated ATSC 1.0 HD output of iMATV

B. Reception antenna direction optimization

In Korea, ATSC 3.0 UHD broadcasting networks are usually configured in regional SFNs. Consequently the channel characeristics of the received ATSC 3.0 signal influence on the reception of On-Air ATSC 3.0 UHD signal. For the signal reception in SFN, it is better to avoid near 0 dB ghosts which make deep nulls in frequency domain and result noise enhancements during the channel equalization processes.

In our tests, we tried to rotate the reception antenna directions to find an optimal SFN channel characteristic. The channel characteristic before reception antenna rotation is shown in Fig. 9, which has a near 0 dB ghost and may result deep nulls and degrade the reception performances of the receiver. When the reception antenna is rotated, an improved SFN channel characteristic is obtained as shown in Fig. 10, which shows a reduced magnitude of the near 0 dB ghost compared with the channel characteristic before antenna rotation. The MER(modulation error ratio)s of the received ATSC 3.0 signal are improved from 28.78 before antenna rotation to 29.71 after antenna rotation respectively.

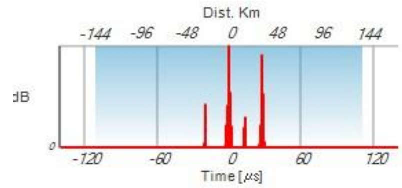


Fig. 9. SFN channel characteristic before the antenna rotation

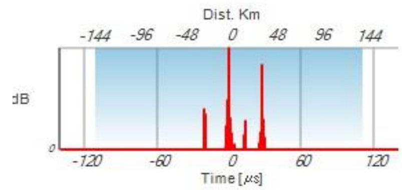


Fig. 10. An improved SFN channel characteristic after the antenna rotation

V. Conclusion

In this paper, we described on the tests of UHD/HD iMATV functions in real environments and presented the test results. Through the tests, the iMATV functions are verified in real environments. In future research, we will analyze the test data and discuss the application of UHD/HD iMATV systems for more apartment complexes.

Acknowledgment

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