ATSC 3.0 Diversity Receiver Trials

Sungjun Ahn, *Member, IEEE,* Bo-mi Lim, *Member, IEEE,* Sunhyoung Kwon, *Member, IEEE,* Sung-Ik Park, *Fellow, IEEE*

***Abstract*—This paper identifies the practical gain of diversity receivers by introducing the broadcast field trials conducted in South Korea. The presented results are primarily on the on-vehicle reception of ATSC 3.0 services and were obtained in an operating commercial network. Through the technical review in the first part, it is emphasized that multi-antenna diversity brings a significant reliability gain to mobile broadcasting delivering HD content. This paper also presents original field results that verify the diversity gain in distributing ultra-HD services.**

***Index Terms*—Multi-antenna diversity, mobile broadcasting, field trial, receiver-on-vehicle.**

I. Introduction

ONE featured use case of ATSC 3.0, the 2nd generation terrestrial broadcasting standard, is mobile broadcasting. The physical layer of ATSC 3.0 has accordingly adopted ultra-robust transmission modes that can cope with severe signal conditions. As infotainment has recently arisen as essential in the automotive industry, television-in-vehicle has become a great interest of media broadcasters, so that it lets ATSC 3.0 become more attractive. However, still, a featured knowledge in this field is that the users moving at very high speed are prone to lose the service signal due to the mobility-caused effects, such as Doppler spread [1].

A diversity receiver exploiting multiple receive antennas is a promising solution to this mobile-vulnerability issue [1], [2]. This solution is seen as impactful because it readily allows expanding the broadcasters' market toward the automotive industry. From this motivation, several studies have reported the feasibility of diversity receivers on broadcasting-over-vehicles, particularly on top of the ATSC 3.0 systems [3]-[6]. This paper comprehensively identifies the mobile coverage gain of diversity receivers in the real world. Focused on the field trials in South Korea, the results in [4] are first summarized, and the sequel test results are subsequently introduced as an original work.

II. Diversity Receiver Mounted on Vehicle

It is a feasible idea to implant multi-antenna diversity into the vehicle-type broadcasting receivers. Terrestrial broadcasting typically exploits UHF or VHF bands, whose wavelengths are longer than that of cellular carriers. For instance, the 700 MHz UHF signal has 42.9 cm wavelength. For this reason, in contrast to the cellular handheld terminals, the broadcasting sector has suffered from a problem with employing multiple co-located receive antennas in the mobile terminal. However, in case of vehicle-mounted receivers, it is possible to acquire sufficient inter-antenna distance to avoid undesired coupling.

A. Receiver Structure: Signal Combining

This physical capability allows the diversity receiver being a solution for the high-speed reception issue in mobile-oriented broadcast media. To this end, a prototype product of ATSC 3.0 diversity receiver has been developed to perform MRC over the input branches [3]-[6]. The diversity receiver performs a weighted summation across the signals received at each antenna branch to feed it into the demodulator. For this procedure, down-converted, post-ADC signals were used. According to the presented implementation, up to four-antenna combining is supported. If a branch signal is lost, the corresponding branch was dropped from signal combining.

III. Field Trials and Results

A. Test Environment

The diversity receiver trials took place in Seoul and the surrounding metropolitan area within the Gyeonggi Province. In the service area of interest, more than ten coordinated towers operate to form an SFN [7]. To be emphasized, every trial was conducted in the commercial broadcaster's ATSC 3.0 network currently operating for service. The experiments used 768 MHz UHF channel for transmission.

The measurements were performed in a customized test vehicle equipped with an ATSC 3.0-specific measurement platform. For the diversity reception, 0 dBi isotropic antennas were installed on the rooftop of the vehicle, where sufficient isolation was secured by guaranteeing the distance of more than a half of signal wavelength between every pair of antennas.

B. Previous Results: Mobile HD

We first discuss the results reported in [4], which the HD video services were of interest. The experiment evaluated the reduction of required field strength subject to the ESR5 criterion of ITU-R. The service signal was modulated under 8k-FFT and held 1.6 Mbps capacity. Within the expected service area, driving through a predetermined urban route, the test vehicle recorded the physical layer error rate and field strength simultaneously with the GPS location data.

From the resultant data presented in Fig. 1, it was demonstrated that 4-antenna diversity can advantage the on-vehicle reception by reducing the field strength requirement by 13 dB compared to the single-antenna reception.

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Sungjun Ahn, Bo-mi Lim, Sunhyoung Kwon, and Sung-Ik Park are with the Media Research Division, Electronics and Telecommunications Research Institute (ETRI), 218 Gajeong-ro, Yuseong-gu, Daejeon, 305-700 South Korea (e-mail: {sjahn, blim_vrossi46, shkwon, psi76}@etri.re.kr).

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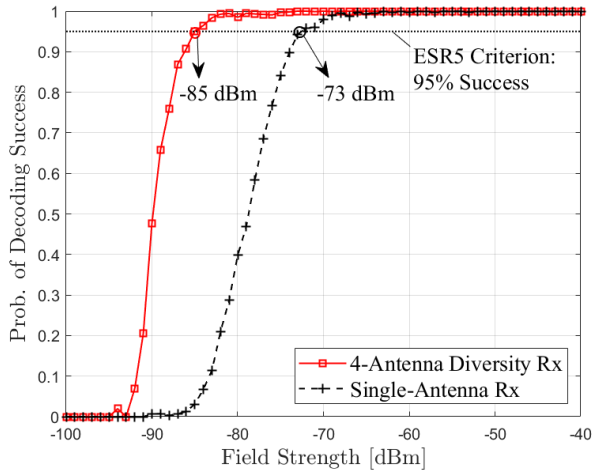

Fig. 1. Field experiment results for mobile HD scenario (reported in [4]): Decoding success probability vs. field strength.

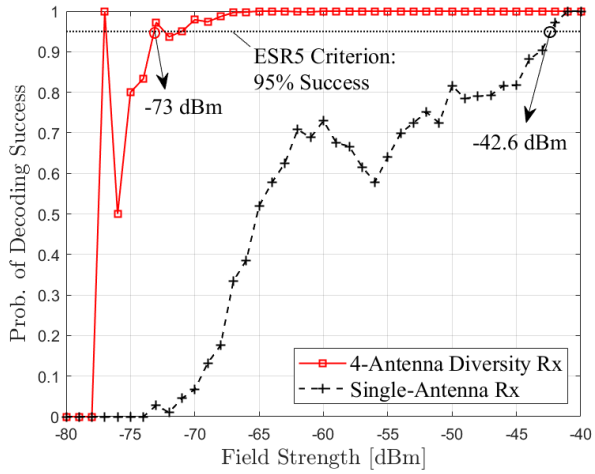

Fig. 2. Field experiment results for UHD reception in vehicle: Decoding success probability vs. field strength.

C. *New Results: UHD Reception on Vehicle*

In addition, the possibility of terrestrial UHDTV in vehicle was newly testified in this work. Particularly, a 16.4 Mbps video content was transmitted for the experiment. To make the system suitable for a mobile scenario, 16k-FFT was applied to reduce inter-carrier interference, different from the previous experiments [3] conducted in 2020.

Fig. 2 shows the ESR5 curve of this UHD trial. The 4-antenna diversity receiver required -73 dBm for ESR5 while the single-antenna receiver was seen to require 20 dB more. In addition, it was also verified that using 4 antennas can allow the receiver to keep under service while driving at 100 km/h.

IV. Conclusion

This paper investigated the practical gain of diversity receivers, specially by introducing the field trials conducted in South Korea. Based on the results obtained in operating networks, the feasibility of multi-antenna diversity was verified for *ATSC 3.0-on-vehicle*. Particularly, significant reliability gains on HD and ultra-HD services were observed, where vehicle-mounted four-antenna reception was compared with the conventional single-antenna reception.

References

[1] S. Ahn *et al*., "Multi-antenna diversity gain in terrestrial broadcasting receivers on vehicles: A coverage probability perspective," *ETRI Journal*, 2021.
[2] S. Ahn *et al*., "ATSC 3.0 for future broadcasting: Features and extensibility," *SET International Journal of Broadcast Engineering*, vol. 6, pp. 21-36, 2020.
[3] S.-I. Park *et al*., "Mobile performance of diversity receiver in ATSC 3.0 system," in *Proc. IEEE BMSB*, Jun. 2020.
[4] S.-I. Park *et al*., "ATSC 3.0 multi-antenna receiver's mobile performance in Seoul and the metropolitan area," in *Proc. IEEE BMSB*, Jun. 2021.
[5] L. Fay, G. Clift, and F. Ansfield, "ATSC 3.0 automotive field tests," Whitepaper.
[6] L. Fay and G. Clift, "ATSC 3.0 file delivery to multiple markets," Whitepaper.
[7] S. Ahn *et al*., "Characterization and modeling of UHF wireless channel in terrestrial SFN environments: Urban fading profiles," to be published in *IEEE Trans. Broadcast*.

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