Features and Applications of ATSC 3.0 Transmitter Identification (TxID)

Bo-mi Lim, Sunhyoung Kwon, Sungjun Ahn, Sung-Ik Park, and Namho Hur

Abstract—**Transmitter identification (TxID) is uniquely assigned to each transmitter to identify and control the transmitters in Advanced Television Systems Committee (ATSC) 3.0 broadcast networks, especially on a single frequency network (SFN). A transmitter also generates the TxID signal in addition to the ATSC 3.0 host signal but combines them, resulting in interfering with each other. This paper summarizes the TxID technique in ATSC 3.0 physical layer standard, including the detection performance, influences on the host ATSC 3.0 signal, and applications.**

Index Terms—**ATSC 3.0, TxID, transmitter identification, SFN**

I. INTRODUCTION

BY adopting orthogonal frequency division multiplexing (OFDM) for the second digital broadcast, the broadcasters can actively apply a single frequency network (SFN) under insufficient frequency bands. To construct a more efficient SFN, the Advanced Television Systems Committee (ATSC) 3.0 standard supports the centralized transmitter control system based on the broadcast gateway and transmitter identification (TxID) [1]-[3]. TxID is a unique value to identify each transmitter in the nationwide broadcast area. Also, transmitters generate TxID signals to differentiate signals from which transmitters come on the receiver side. This paper briefly introduces the TxID technique in ATSC 3.0 and considers the detection performance of the TxID signal in addition to applications.

II. TRANSMITTER IDENTIFICATION (TxID)

A. Features

TxID is a unique value between 0 to 8191 to identify the individual transmitter in ATSC 3.0 broadcast coverage areas. Therefore, a broadcast gateway controls the emission time, carrier offset, and the multiple input single input (MISO) filter of each transmitter in addition to passing common broadcast streams. Transmitters can generate the TxID signal depending on their own TxID values apart from the ATSC 3.0 signal, as shown in Fig. 1. As a result, the receiver can separate the received signals that appear as a superposition of transmit signals from multiple transmitters like multipath delayed fading channel and analyze their relative delays and amplitudes. The transmitter generates the unique binary Gold sequence with a length of 8192 depending on the assigned
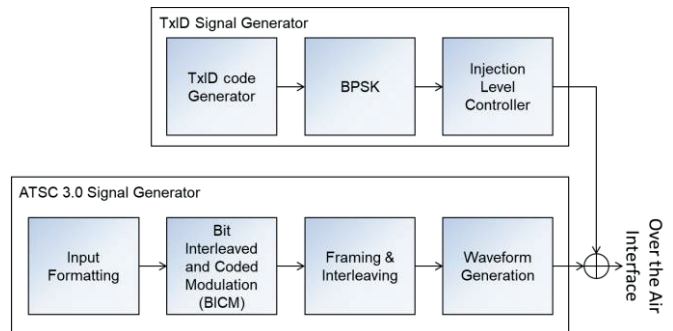

Fig. 1. Block diagram of ATSC 3.0 transmitter employing channel bonding.

TxID value and modulates the sequence as binary phase shift keying (BPSK). The modulated signal is time-synchronously injected on the first preamble symbol of the ATSC 3.0 host signal with 9 to 45 dB lower power. Therefore, two signals interfere with each other.

While the TxID is much lower than the ATSC 3.0 preamble signal, it can be detectable due to enough processing gain resulting from a direct sequence spread spectrum (DSSS) with an 8192 symbol length. The theoretical processing gain of the TxID signal is about 39 dB [4]. In addition, as the TxID signal is always aligned with the first preamble symbol, it is repeatedly injected according to the size of fast Fourier transform (FFT). For example, in the case of 32K FFT size, the TxID signal is continuously delivered four times. Therefore, the processing gain increases by 3 dB when the FFT size doubles. In [4], the authors dealt with the detection performance of the TxID signals and proposed the detection schemes. Since the TxID signal is the same over the transmission period, the detection performance may enhance after ensemble averages of receiver signals. Also, removing the preamble signal from the received signal significantly improves the reception performance.

The TxID signal also interferes with the ATSC 3.0 preamble signal. As the injection level gets larger, the TxID signal can be easily detected without an advanced detection algorithm, but the preamble deteriorates more. Therefore, there is a trade-off between the detection performance of the TxID signal and the preamble signal. In [5] and [6], the impact of the TxID signal on the preamble detection is considered both theoretically and practically with respect to the injection levels of the TxID signal and the protection modes of Layer 1 (L1) signaling data, L1-Basic and L1-Detail, conveyed in the preamble symbol. Protection modes

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

144

1 and 2, generally used in ATSC 3.0 broadcasting system, are less influenced by the TxID signal. Therefore, the TxID signal might be provided all the time, not just when the broadcasters build their broadcast networks.

B. Applications

TxID signal enriches the broadcast service coverage, avoiding the deep nulls caused by multiple transmitting signals simultaneously arriving on the receiver side. In Seoul metropolitan areas [7], [8] and Jeju areas [9], the broadcasters examined the coverage areas with poor reception performance and enough signal strength based on the TxID signal analysis. By adjusting transmit time delays among transmitters, the reception performance might be improved. Even more, TxID signals enable channel modeling under a rich scattered fading environment [10]. By decoding TxID, the receiver can recognize which broadcast service areas it belongs to, so the broadcaster can provide the local service application like a geo-targeted advertisement.

III. Conclusion

This paper considered the TxID technique in the ATSC 3.0 physical layer standard. Though the TxID signal may interfere with the host ATSC 3.0 signal, it serves processing gain. It enables the broadcaster to manage the broadcast network in a centralized way, orchestrate transmitters, and provide localization services.

References

[1] ATSC Standard: A/322, Physical Layer Protocol, document A/322:2023, Advanced Television System Committee, Washington, DC, USA, March 2023.

[2] ATSC Standard: A/324, Scheduler/Studio to Transmitter Link, document A/324:2023, Advanced Television System Committee, Washington, DC, USA, March 2023.

[3] S.-I. Park *et al.,* "ATSC 3.0 Transmitter Identification Signals and Applications," *IEEE Trans. Broadcast.*, vol. 63, no. 1, pp. 240-249, March 2017.

[4] S. Kwon *et al.,* "Detection Schemes for ATSC 3.0 Transmitter Identification in Single Frequency Network," *IEEE Trans. Broadcast.*, vol. 66, no. 2, pp. 229-240, June 2020.

[5] B.-m. Lim *et al., "*Laboratory Test Analysis of TxID Impact into ATSC 3.0 Preamble," *2018 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB)*, Valencia, Spain, June 2018, pp. 1-3.

[6] B.-m. Lim *et al.,* "Performance Evaluation of ATSC 3.0 Preamble for TxID Signal-Injected Use Cases," *2022 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB)*, Bilbao, Spain, June 2022, pp. 1-5.

[7] J. Lee *et al*., "Transmitter Identification Signal Detection Algorithm for ATSC 3.0 Single Frequency Networks," *IEEE Trans. Broadcast.*, vol. 66, no. 3, pp. 737-743, Sep. 2020.

[8] S. Jeon *et al*., "Field Trial Results for ATSC 3.0 TxID Transmission and Detection in Single Frequency Network of Seoul," *2018 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB)*, Valencia, Spain, 2018, pp. 1-4.

[9] B. Lim *et al*., "Field Evaluation of Transmit Diversity Code Filter Sets in ATSC 3.0 Single Frequency Networks," *IEEE Trans. Broadcast.*, vol. 68, no. 1, pp. 191-201, March 2022.

[10] S. Ahn *et al*., "Characterization and Modeling of UHF Wireless Channel in Terrestrial SFN Environments: Urban Fading Profiles," in *IEEE Transactions on Broadcasting*, vol. 68, no. 4, pp. 803-818, Dec. 2022.