Proposed Increased Data Rate of RF Watermark Modulation in A/110

In ATSC A/110, an RF watermark was specified for transmitter identification and channel impulse response measurements in a single-frequency network environment. A/110 also provided for the modulation of the RF watermark, enabling its use for data transmission, radio location finding, and a variety of other applications. The RF watermark consists of four consecutive binary sequences (16-bit Kasami sequences – together termed the TxID sequence), the total length of which equals the ATSC field length; see Figure 1(a). The modulation of the RF watermark specified in A/110 is phase modulation of an entire TxID sequence, synchronized to the 8-VSB data fields, resulting in transmission of 1 bit of data per ATSC field and yielding a data rate of 41.3 bits/sec.

The BER performance of the existing A/110 watermark data transmission is presented in the right curve of Figure 2. One can see that the BER curve is VERY robust. For a watermark injection level 36 dB below the DTV signal, which has absolutely no impact on DTV reception, the BER is 1E-15. This means 769,000 years per transmission error! The proposed amendment to A/110 would relax the watermark data robustness by a small amount in exchange for a higher data rate.

The proposed modulation parameters would allow phase alternation of each 16-bit Kasami sequence, as shown in Figure 1(b), rather than of the entire TxID sequence. Since each TxID sequence consists of four 16-bit Kasami sequences, the data rate for the proposal is four times that of the existing standard, i.e., 165.2 bits/sec.

The BER performance of the proposed system is shown in the leftmost curve in Figure 2. At a watermark injection level 33 dB below the DTV signal (again, having no impact to DTV reception), the BER is still 1E-8, or 7 days per error.

Another option is phase modulation of two Kasami sequences together, as shown in Figure 1(c). This choice would result in a data rate of 2 x 41.3 = 82.6 bits/sec, or 2 bits per ATSC field. The corresponding BER performance, as shown in the middle curve of Figure 2, is 3 dB more robust than the 4-bits per field approach, and 3 dB less robust than the existing standard.

The proposed modification has following advantages:

1. The data rate would be two or four times that of the existing standard, while retaining tremendous robustness.
2. There would be no impact on the RF watermark functionality.
3. There would be a very minor change in the transmitter implementation (no hardware changes).
4. The data transmission would be very robust and could be received by a mobile terminal.
5. The data would be much more robust than the DTV signal. In places where there was no DTV reception, watermark data still could be reliably received. The RF watermark could become a good candidate for Emergency Alert System (EAS) applications.
6. The RF watermark signal could be used for indoor radio location finding since the robust data transmission capacity could be used to transmit a time reference signal. (Note: the U.S. and Canadian governments are searching for terrestrial complements to, or substitutes for, the GPS system in the event that it should be compromised.)
7. Although the RF watermark in A/110 originally was developed for Distributed Transmission applications, the proposed system was designed so that it also could be applied to conventional, single-transmitter systems.

As shown in Figure 2, three different modes of data transmission are possible, with different data rates and robustness. By permitting selection of the RF watermark phase independently for each Kasami

sequence, any of the three modes can be obtained through proper coding of the data. To enable the widest range of applications of the data carried on the RF watermark, no constraint should be applied in A/110 to the data formatting. Consequently, subsections that previously provided a very limited scheme for data coding and formatting are proposed to be removed, with no substitution made.

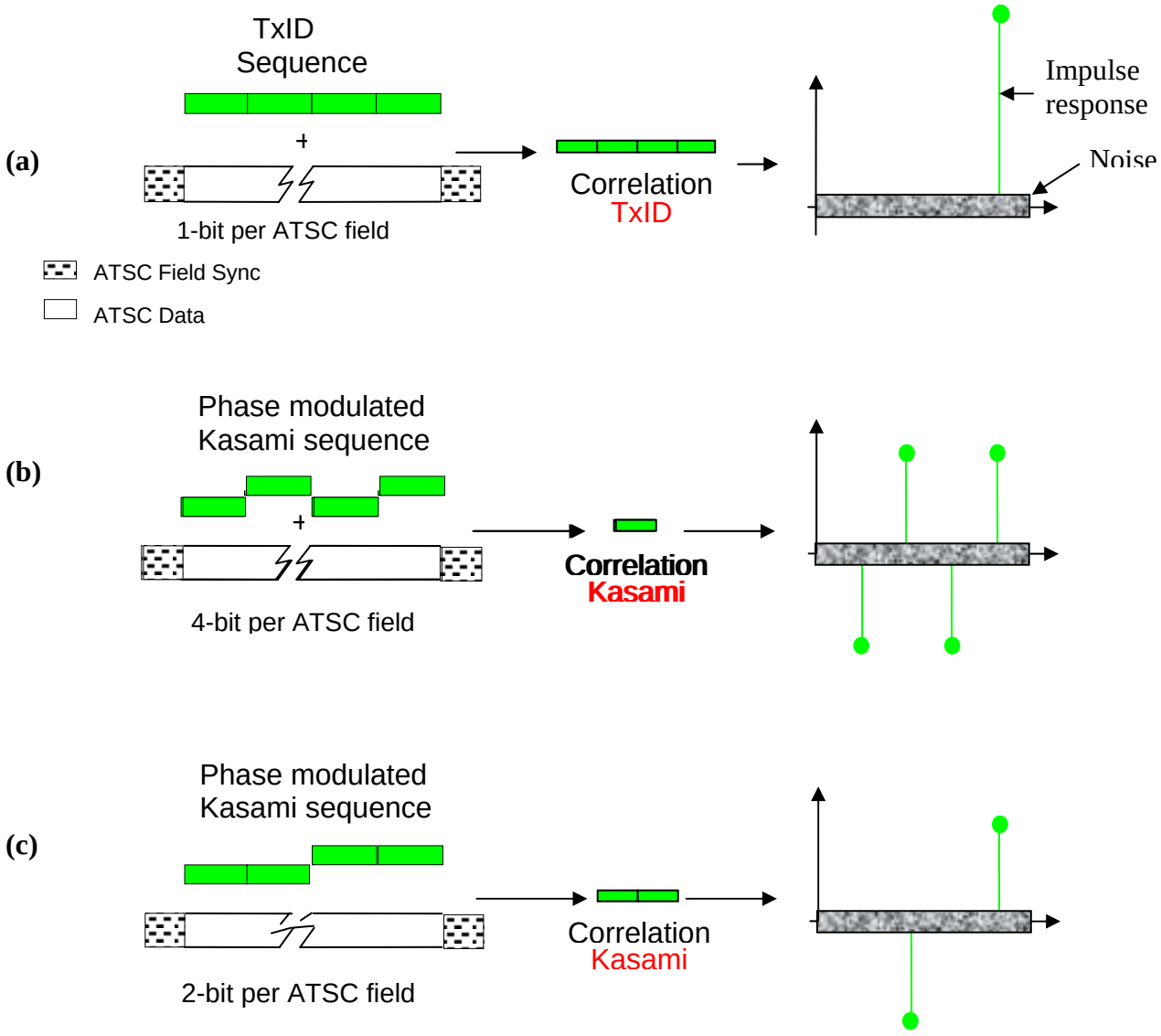

Figure 1. (a) A/110 RF watermark data transmission system (1 bit per 8-VSB field);
(b) Proposed data transmission system with 4 bits per 8-VSB field;
(c) Proposed data transmission system with 2 bits per 8-VSB field.

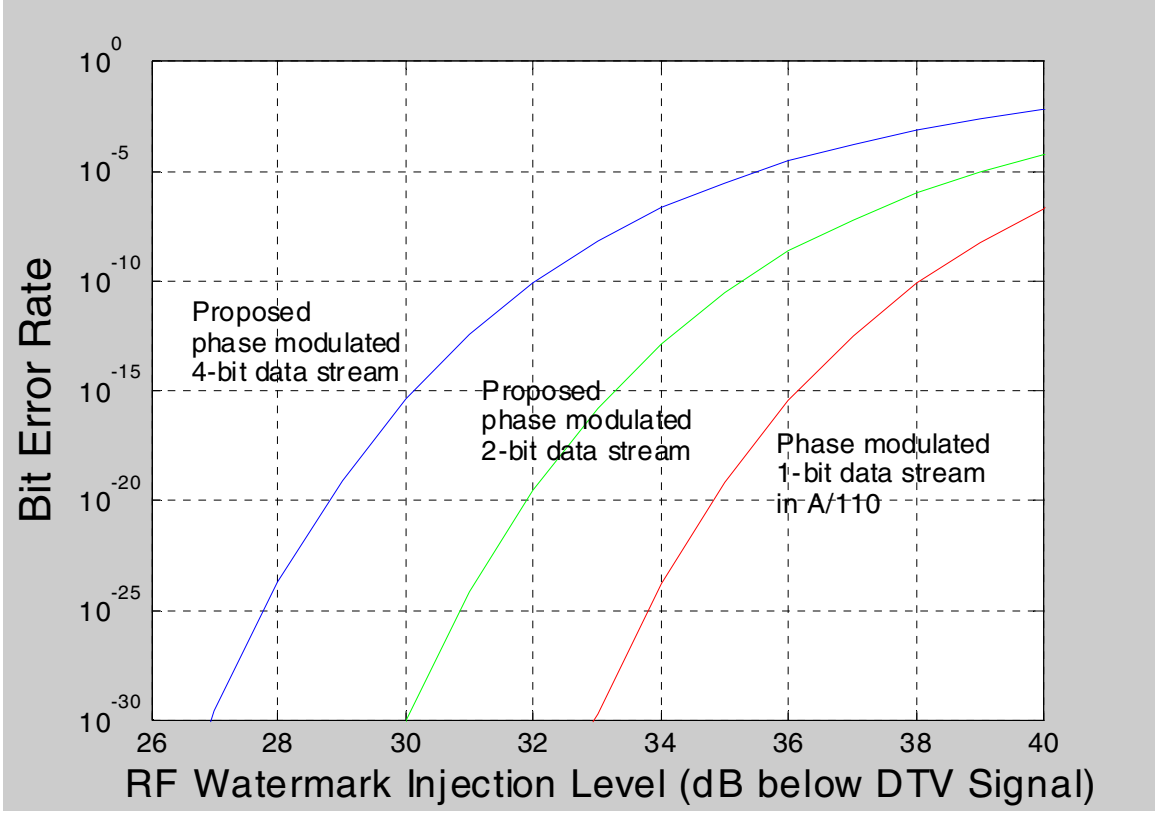

Figure 2. BER performance vs. watermark injection level for different watermark data transmission systems