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Proposed Standard: Corrigendum No. 1 to ATSC A/110 (Synchronization Standard for Distributed Transmission)

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The Following Changes are Specified:

Replace Section 6.4 with:

6.4 Transmitter Timing Control Data

In order to enable multiple transmitters in a single frequency network to be set to transmit their signals in specific time relationships to one another, it is necessary to provide a time reference to all transmitters and to offset some or all of them in time by amounts determined by the network design. While such timing adjustments could be made on a fixed basis, in far-flung networks, it can be quite helpful to have means to adjust the timing of transmission remotely. Thus, provision is made in the Distributed Transmission Packet to carry timing control information individually to each of the transmitters in a network.

The transmitter timing control function operates by sending two time reference values to all transmitters and a third time value to each transmitter individually. The two time reference values sent to all transmitters are a Synchronization Time Stamp (STS) and a Maximum Delay (MD) value. The third time value is an Offset Delay (OD) that is specific to each transmitter. The Emission time for each transmitter is the combination of STS, MD, and OD. The timing is dependent upon a common time reference (such as GPS time) being available to each of the nodes in the network, including the Distributed Transmission Adapter and each of the transmitters. The relationships between the various elements of the transmitter timing control data are shown in Figure 6.5.

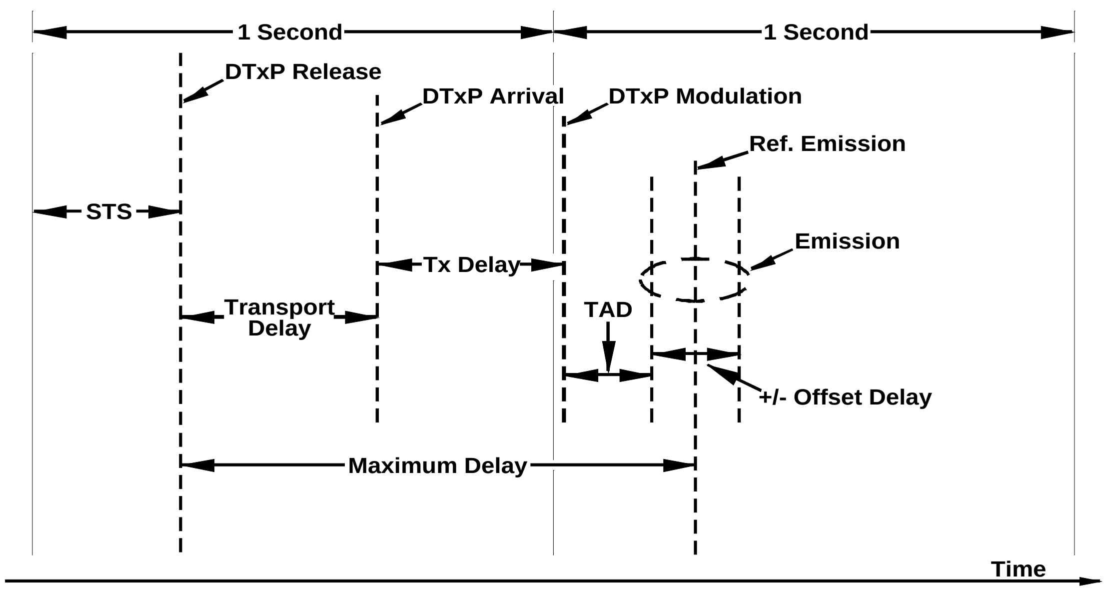

Figure 6.5 Transmitter timing control relationships.

6.4.1 Synchronization Time Stamp (STS)

The Synchronization Time Stamp (STS) information shall be carried in the synchronization_time_stamp field and shall be the number of 100 ns time intervals between the leading edge of the last 1 second clock tick of the common time reference and the occurrence in the MPEG-2 Transport Stream of the first bit of the MPEG-2 packet sync byte in the header of the Distributed Transmission Packet at the output of the Distributed Transmission Adapter (see Section 8).

6.4.2 Maximum Delay (MD)

The Maximum Delay (MD) information shall be carried in the maximum_delay field and shall be a value that is set as a system parameter so as to assure that the output times of all transmitters in the network will be delayed sufficiently to account for the longest delay in the distribution path to any transmitter plus the delay of the transmitter itself and its antenna system. It shall be measured in 100 ns time intervals and shall take a value between a lower and an upper bound such that, when MD is added to the Offset Delay (OD) plus the delay time of the transmitter and antenna system, the total neither falls below 0x000001 nor exceeds 0x98967F (i.e., the total falls within the range between one count and one count less than 1 second). Nominal lower and upper bound values of MD of 0x008064 and 0x98161C, respectively, can be considered usable without further calculations. In unusual situations in which it is necessary to more closely approach the limiting values, care should be used to calculate the total of all delays so that the limits of one count more than zero and of one count less than one second are not exceeded under any circumstances of system operation. The values given are sufficient to allow for distribution systems using satellite transponders to reach transmitters in a network.

6.4.3 Offset Delay (OD)

The Offset Delay (OD) information shall be carried in the transmitter_time_offset fields and shall be a value that is set as a parameter for each transmitter so as to allow adjustment of the emission timing of transmitters with respect to one another. It shall be measured in 100 ns time intervals and shall take a value between –32,768 and 32,767 (i.e., from –3.2768 ms to 3.2767 ms). The OD for each transmitter shall be compensated for the Transmitter and Antenna Delay (TAD) of that transmitter, which value shall include the total delay from the input to the Data Randomizer (see Figure 9.1), at which point the transmitter output timing shall be measured and controlled, to the output of the antenna. TAD shall equal the time from the entry of the first bit of a Cadence Sync word into the Data Randomizer to the appearance at the antenna output of the leading edge (zero crossing of the +5 to –5 transition) of the segment sync of the corresponding Data Frame Sync data segment (i.e., the segment sync that occurs at the start of the corresponding Data Frame Sync data segment).[1] The TAD compensation shall be performed through a calculation carried out by the transmitter, subtracting TAD from OD, using a fixed value of TAD determined for that transmitter. The total spread between emission times of transmitters in a

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[1] Beyond the Data Randomizer, the data processing path does not have a constant delay. Insertion of field and frame sync data segments, insertion of error-correction data, and the process of interleaving cause the instantaneous time delay through the data processing blocks to vary as a function of position in a data frame. The TAD value establishes a delay reference for a particular point in a data frame – the start of cadence sync and the corresponding start of the data frame sync data segment – which is used to time-align all transmitters at their outputs, even though they may have different data and signal processing delays.

network thus can be up to 6.5535 ms (possibly limited by any differences in transmitter and antenna system delays).

6.4.4 DTxP Modulation and Reference Emission Times

The DTxP Modulation time for each transmitter shall be the time of arrival at the input of the Data Randomizer of the first bit of the MPEG-2 packet sync byte in the header of the Distributed Transmission Packet.[2] The Reference Emission time shall occur at a time equal to the sum of the Synchronization Time Stamp value plus the Maximum Delay value (STS + MD) carried in the DTxP. Each transmitter in a network shall use that Reference Emission time plus the Offset Delay (OD) for that transmitter, minus that transmitter's TAD value, to determine its required DTxP Modulation time value. A transmitter's Emission time shall equal its DTxP Modulation time plus its TAD value. When the calculated Emission time exceeds 1 second (0x989680), 1 second shall be subtracted from the Emission time value to find the Emission time relative to the leading edge of the most recent 1-second clock tick of the common time reference.

6.4.5 Determining Transmitter Delay

A transmitter may determine the delay required (Tx Delay in Figure 6.5) between its reception from the transport system of any given Distributed Transmission Packet and input of that packet to the Data Randomizer by measuring, in 100 ns time intervals, the time from the leading edge of the last 1 second tick of the common time reference to the time at which it receives the first bit of the MPEG-2 packet sync word in the header of the Distributed Transmission Packet (DTxP Arrival). The Emission time for that transmitter minus the time of DTxP Arrival minus the TAD value yields the delay time (Tx Delay) required, in 100 ns time intervals, from the point at which DTxP Arrival is measured to the input of the Data Randomizer.

[2] Although the Data Randomizer does not affect the sync byte (which is eventually replaced by segment sync), this point in the signal path is used as the reference point for determining TAD. Not only is this a suitable conceptual reference, it is also a point where delay may be easily physically measured by system implementers with a logic analyzer or an oscilloscope. The delay from MPEG sync input at this point to emergence of the corresponding segment sync is the delay value for the modulator block. Addition of this value to the delay in the RF circuits, mask filter, transmission line, and other system elements yields the TAD value.

Replace Section 11 with:

11. TRANSMITTER TIMING ADJUSTMENT (NORMATIVE)

The timing information sent collectively to all transmitters in a network and sent individually to each transmitter is described in Section 6.4 and Figure 6.5. When a transmitter receives a Distributed Transmission Packet, it shall calculate the time of emission for its signals based upon the timing information sent to it from the Distributed Transmission Adapter.

11.1 Time References and Emission Time Calculations

In order for each transmitter to properly calculate the time of emission for its signals, an appropriate time reference is required, and the emission time of a defined point in the transmitted symbol stream must be measured with respect to that time reference at a known system location. Ideally, the measurement location would be the antenna, and a fixed point in the signal would be measured as it was transmitted from the antenna. But the difficulties of sampling the signal there, combined with the variation in system delay over the period of a data field inherent in the 8-VSB data processing scheme, make other system and signal points preferable. An indirect method is therefore used to determine and control the Emission time.

The time delay from arrival of the Cadence Sync at the input of the conventional 8-VSB data processing subsystem until transmission of the start of the corresponding Data Frame Sync data segment is used to determine the transmitter and antenna system delay (TAD, as described in Section 6.4.3). This provides a constant TAD value that is used in calculations to determine the actual emission time when a different point in the signal is used for the time measurements.

Emission time measurements occur at the input of the conventional 8-VSB data processing subsystem that is defined as the input of the Data Randomizer shown in Figure 9.1. The time of appearance at the measuring point of the start of the MPEG-2 Transport Stream sync word of the DTxP is measured against the 1-second clock ticks of the external precision time reference, and the result is the DTxP Modulation time value. When the TAD value is added to the DTxP Modulation time, the actual Emission time is obtained. The Transmitter Delay (Tx Delay) is automatically adjusted to cause the actual Emission time measured to match the desired Emission time as obtained from the sum of the Synchronization Time Stamp (STS), Maximum Delay (MD), and Offset Delay (OD) values applicable to the particular transmitter.

11.1.1 External Precision Time Reference

The external time reference shall be a source that is available with an accuracy of 50 ns or better at all network locations. The preferred time reference is derived from the Global Positioning System (GPS) satellite navigation system.

11.1.1.1 1 Second Ticks

The one-second ticks of the external time reference shall be used to align the timing of the respective transmitters relative to one another and to the signals from the Distributed Transmission Adapter. In all cases, the leading edges of the one-second ticks shall be used as the time reference points.

11.2 DTxP Modulation Time Alignment

As defined in Section 11.1, the time of DTxP Modulation shall be set according to the information sent to all transmitters and to each individual transmitter, as defined in Section 6.4 and Figure 6.5. A change in the delay between the arrival of data in the Transport Stream and its emission is disruptive to reception because the addition or deletion of symbols is required, thereby breaking the framing structure of the signal. Consequently, transmitters shall not alter their delay times (TX Delay in Figure 6.5) until a change of at least 5 symbols (equal to approximately ½ microsecond) is required. Transmitter settings to allow accumulation of longer required changes in TX Delay before making such changes are expressly permitted.

11.2.1 STS Plus Max Delay Plus Offset Delay

As defined in Section 6.4 and Figure 6.5, the Emission time shall be the sum of the Synchronization Time Stamp (STS) value plus the Maximum Delay (MD) value plus the individual transmitter Offset Delay. To maintain the appropriate Emission time between DTxPs, a transmitter should calculate the difference between DTxP Arrival time and DTxP Modulation time (i.e., the Tx Delay value) required to obtain its Emission time after addition of its TAD value and should apply that value of Tx Delay to all data in the Transport Stream until the next DTxP appears in the stream.

Determination of the TAD value requires calculating the time delay through the transmission system from the input to the conventional portion of the modulator's Data Randomizer, through the upconversion and amplification stages, through the output filters and other RF equipment, through the transmission lines, and to the antenna. Equipment used to automatically adjust the Emission time shall have the capability to accept as an input a value representing the delay in the transmission system from a known point in the system beyond which delay can be measured or calculated for the remainder of the system through the antenna.

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