ATSC Standard: A/321:2026-04 Amendment No. 1, "Bootstrap Clarification"

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Revision History

Version	Date
Amendment approved	11 June 2026

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1. OVERVIEW

1.1 Definition

An Amendment is generated to document an enhancement, an addition or a deletion of functionality to previously agreed technical provisions in an existing ATSC document. Amendments shall be published as attachments to the original ATSC document. Distribution by ATSC of existing documents shall include any approved Amendments.

1.2 Scope

This document defines and clarifies the required usage of the bootstrap to remove ambiguity when heterogeneous physical-layer waveforms are time-multiplexed within a single RF channel. Specifically, it prevents misinterpretation that frames carrying non-ATSC 3.0 physical-layer waveforms may omit bootstrap transmission. This amendment clarifies that each frame, regardless of the post-bootstrap physical-layer waveform type, shall begin with a bootstrap, and clarifies understanding for bootstrap usage in time-multiplexed operation with multiple signal types. This amendment is in response to New Project Proposal N-093r0, "Clarification of Bootstrap Usage with all physical layer waveforms".

1.3 Rationale for Changes

The bootstrap is a fundamental element of ATSC 3.0, providing a universal entry point regardless of the underlying physical layer waveform. Ambiguity regarding bootstrap usage for non-ATSC 3.0 physical layer waveforms may lead to implementations that cause interoperability issues. This amendment will resolve such ambiguity through explicit clarification, ensuring consistent interpretation while preserving technical integrity of existing standards.

Clear definition of bootstrap usage is essential to ensure physical layer configuration, interoperability, receiver behavior, and backward compatibility across current and future ATSC systems. This clarification will be intended to prevent divergent implementations that could fragment the receiver ecosystem, particularly when introducing non-ATSC 3.0 physical layer waveforms alongside existing ATSC 3.0 services. It also will help ensure that receivers can reliably detect, identify, and appropriately process or ignore frames employing different physical layer technologies.

1.4 Compatibility Considerations

No changes are made to modulation, coding, framing, or signaling mechanisms previously defined in A/321.

2. LIST OF CHANGES

Change instructions are given below in *italics*. Unless otherwise noted, inserted text, tables, and drawings are shown in blue; deletions of existing text are shown in ~~red~~. The text "[ref]" indicates that a cross reference to a cited referenced document should be inserted.

2.1 Change Instructions

Add the following reference to Section 2.2, "Informative References".

[3] ATSC: "ATSC Standard: Physical Layer Protocol," Doc. A/322:2026-04, ATSC, Washington, DC, 14 April 2026.

Add the following acronyms to Section 3.3, "Acronyms, Abbreviations and Mathematical Operators".

APLF – Alternative Physical Layer Frame
BSP – Baseband Sample Period

Add the following terms to Section 3.4, "Terms".

Alternative Physical Layer Frame – A Physical Layer Frame that is of one of two or more different types of Physical Layer Frames that alternate within an emission, using Bootstraps as defined herein to introduce each such Physical Layer Frame. Alternative Physical Layer Frame adds to the original structure the construct that has been referenced colloquially by the industry as "Evolutionary Frames," "Future Extension Frames," and the like.

Baseband Sampling Rate – The frequency at which a baseband signal is converted into digital samples.

Baseband Sample Period – The time interval between two consecutive baseband samples, defined as the reciprocal of the Baseband Sampling Rate.

Modify Section 1.1, Introduction and Background,".

1.1 Introduction and Background

Broadcasters anticipate providing multiple wireless-based services, in addition to just broadcast television, in the future. Such services may be time-multiplexed together within a single RF channel. As a result, there exists a need to indicate, at a low level, the type or form of a signal that is being transmitted during a particular time period, so that a receiver can discover and identify the signal, which in turn indicates how to receive the services that are available via that signal.

To enable such discovery, a bootstrap signal ~~can be used~~ is required. This comparatively short signal precedes, in time, a longer transmitted signal that carries some form of data. New signal types, at least some of which have likely not yet even been conceived, could also be provided by a broadcaster and identified within a transmitted waveform through the use of a bootstrap signal associated with each particular time-multiplexed signal. Some future signal types indicated by a particular bootstrap signal may even be outside the scope of ~~the~~ ATSC.

The bootstrap provides a universal entry point into a broadcast waveform for all signal types conveyed in the RF channel. The bootstrap employs a fixed configuration (e.g., sampling rate, signal bandwidth, subcarrier spacing, time-domain structure) known to all receiver devices and carries information to enable processing and decoding the signal associated with a detected bootstrap. This capability ensures that broadcast spectrum can be adapted to carry new signal types that are preceded by the universal entry point provided by the bootstrap, for public interest to continue to be served in the future.

Modify Section 4.1, "Features," as follows.

4.1 Features

The bootstrap provides a universal entry point into a digital transmission signal. It employs a fixed configuration (e.g., sampling rate, signal bandwidth, subcarrier spacing, time domain structure) known to all receiver devices.

Figure 4.1 shows an overview of the general structure of a physical layer frame, the bootstrap signal, and the bootstrap position relative to the post-bootstrap waveform (i.e., the remainder of the frame). The bootstrap consists of a number of symbols, beginning with a synchronization symbol positioned at the start of each frame period to enable signal discovery, coarse synchronization, frequency offset estimation, and initial channel estimation. The remainder of the bootstrap contains sufficient control signaling to permit the reception and decoding of the remainder of the frame to begin.

Only the bootstrap structure and contents are specified within the present document.

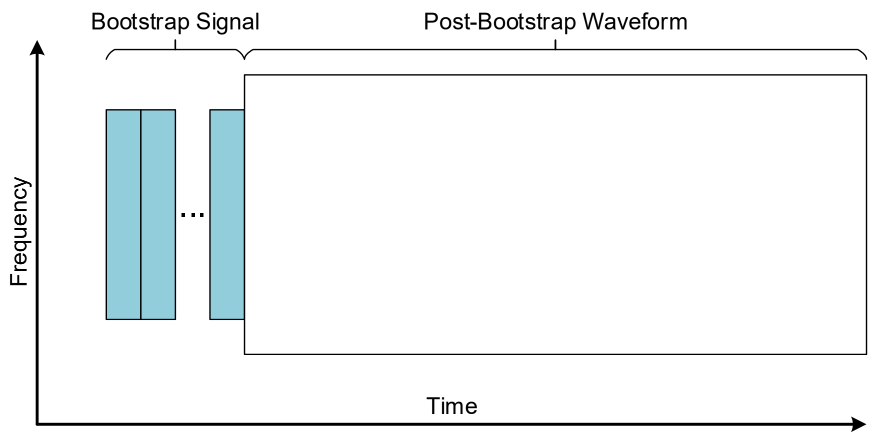

Figure 4.1 General physical layer frame and bootstrap structure.

The structure in Figure 4.1 applies to all signal types, time multiplexed based on this Standard. For all physical layer waveforms present in the RF channel (including physical layer signal types defined by standards organizations other than ATSC), each physical layer frame shall begin with a bootstrap. The start of the bootstrap for the next physical layer frame shall immediately follow the end of the current frame's post-bootstrap waveform. Any gap between adjacent frames shall not exceed the longer of the Baseband Sample Periods of the two frames.

Modify Section 4.2, "Central Concepts," as follows:

4.2 Central Concepts

The bootstrap design exhibits flexibility via the following core concepts.

- **Versioning:** The bootstrap version is expressed in text as a major version number (decimal digit) followed by a period and a minor version number (decimal digit), e.g., bootstrap version 0.0. The major version and minor version are referenced in code as bootstrap_major_version and bootstrap_minor_version, respectively. A Zadoff-Chu (ZC) root and a pseudo-noise (PN) sequence seed are used for generating the base encoding sequence for bootstrap symbol contents. A major version number (corresponding to a particular signal type) is signaled via selection of the ZC root. A minor version (within a particular major version) is signaled via appropriate selection of the PN sequence seed. The syntax and semantics of signaling fields within the bootstrap are specified within the Standard(s) to which the major and minor versions refer.

- **Scalability:** The number of bits signaled per bootstrap symbol is defined, up to a specified maximum, for a particular major/minor version. The maximum number of bits per symbol is

$$N_{bps} = \lfloor \log_2 (N_{FFT}/CyclicShiftTol) \rfloor,$$

where $\lfloor X \rfloor$ is the greatest integer less than or equal to X (Floor function).

N_{bps} affects the cyclic shift tolerance, and is specified in the Standard(s) for the particular version. The number of signaling bits per symbol can be increased up to the specified maximum as a backward-compatible change when incrementing the minor version within the same major version.

- **Extensibility:** The bootstrap signal duration is extensible in whole symbol periods, with each new symbol carrying up to N_{bps} additional signaling bits. Bootstrap signal termination is signaled by a final symbol having 180° phase inversion relative to the preceding symbol.
- A bootstrap containing undefined signaling information (such as the use of reserved values) is expected to be discarded by the receiver.
- **Universal Accommodation**: A bootstrap prefix identifies the signal type (i.e., physical layer technology) applied to the associated post-bootstrap waveform when multiple signal types are time-multiplexed. A receiver is expected to discard frames when the bootstrap versions of those frames indicate signal type(s) unsupported by the receiver.

Add a new Section 6.2 as follows:

6.2 Bootstrap Signaling for Major Version One (1)

This section and its subsections apply when bootstrap_major_version = 1.

The ZC sequence root (q), as specified in Section 5.2.1, shall be 197 when bootstrap_major_version = 1.

6.2.1 Signaling Minor Versions for Major Version One (1)

This subsection specifies how to signal minor versions when bootstrap_major_version = 1. The number of symbols (N_S) in the bootstrap symbol set shall be greater than or equal to four (including the initial synchronization symbol) for all minor versions.

The initial register state of the pseudo-noise sequence generator for a given bootstrap minor version within bootstrap_major_version = 1 shall be set to a value from Table 6.6 to signal the corresponding bootstrap_minor_version that is in use.

Table 6.1 Initial Register State (pseudo-noise seed) of the Pseudo-Noise Sequence Generator for each respective bootstrap_minor_version

$r_{init} = \{r_{l-1}, \dots, r_0\}$		
Bootstrap Minor Version	**Binary**	**Hexadecimal**
0	1111 0001 0001 0000	0xF110
1	0011 1101 0010 0001	0x3D21
2	1110 0101 0101 0000	0xE550
3	1011 1101 0100 1001	0xBD49
4	0010 0011 1100 1111	0x23CF
5	0000 1011 0101 0000	0x0B50
6	0011 1101 0011 1100	0x3D3C
7	1010 0010 0001 0110	0xA216

6.2.1.1 Minor Version 0 Constraints and Signaling

When the value of r_{init} is set to 0xF110, indicating bootstrap_minor_version = 0, the same constraints, signaling syntax, and meanings as specified in Section 6.1.1.1 shall apply, with minor semantic changes as specified below:

ea_wake_up_1 – Bit 1 of emergency alert wake up field. Bit semantics are defined by the document(s) establishing the corresponding receiver capability set (e.g., [2]).

system_bandwidth – Signals the nominal system bandwidth used for the post-bootstrap portion of the current physical layer frame. Values: 00 = 6 MHz, 01 = 7 MHz, 10 = 8 MHz, 11 = Greater than 8 MHz. Each nominal system bandwidth value may equivalently indicate the actual system bandwidth of the post-bootstrap portion, as defined by the document(s) establishing the corresponding receiver capability set. For example, the following value mapping can be used: 00 = 5.4 MHz, 01 = 6.3 MHz, 10 = 7.2 MHz, 11 = Greater than 7.2 MHz.

ea_wake_up_2 – Bit 2 of emergency alert wake up field. Bit semantics are defined by the document(s) establishing the corresponding receiver capability set (e.g., [2]).

bsr_coefficient – Sample Rate Post-Bootstrap (of the current physical Layer frame) = $(N + 10) \times 0.384$ MHz. N is the signaled value and shall be in the range from 0 to 86, inclusive. Values of 87 to 127 are reserved.

preamble_structure – This field establishes the capability to signal the structure of one or more RF symbols following the last bootstrap symbol. It is provided to enable such signaling by use of values defined by another Standard.

> Note: This Standard does not constrain the contents of this field. This field may therefore be interpreted according to the Standard that specifies the post-bootstrap portion of the signal. For example, this field may indicate the configuration of a channel acquisition signal (CAS): Bandwidth, cyclic prefix length option, and frequency-domain placement (centered, upper-aligned, lower-aligned). As another example, this field may indicate the preamble signal configuration defined in [3].

Change the numbering of Section 6.2 into Section 6.3 and modify as follows:

~~6.2~~6.3 Future Major Versions

This section lists the Zadoff-Chu root (q) values that are permitted to be used to indicate future bootstrap_major_version values. The Zadoff-Chu root (q) values within the ranges 0 .. 136, 138 .. 196, and 198 .. 1498 shall be Reserved.

Add Section 7 as follows:

7 MULTIPLEXING OF DIFFERENT SIGNAL TYPES WITH BOOTSTRAP PREFIXING

7.1 General Description

The bootstrap is defined to provide a universal entry point for receivers by enabling identification of the signal type applicable to the waveform that immediately follows it. A signal type herein denotes the format of the post-bootstrap waveform, corresponding to a digital transmission technology or a combination of technology pieces, with ATSC 3.0 specified in [3] as one example. This Section describes how multiple signal types can be multiplexed within a single RF channel by time-division multiplexing and specifies the relationship between bootstrap versioning and identification of the signal type associated with each time-multiplexed frame interval.

Such multiplexing derives from the non-backward-compatible extensibility mechanism described in Section 3.5. The signal type associated with a physical layer frame is identified by the bootstrap prefixed to that frame, specifically by the bootstrap major and minor version value pair. The bootstrap-enabled identification in this Standard accommodates a broad range of digital transmission technologies: A signal type may be specified either within ATSC standards or by documents defined by other organizations.

In time-multiplexed operations with multiple signal types, a physical layer frame is referred to as an Alternative Physical Layer Frame (APLF). APLFs are further classified as follows:

- ATSC-native APLF: An APLF that has a signal type specified by ATSC documents.
- Externally-defined APLF: An APLF that has a signal type specified by a document prepared by an organization other than ATSC.

7.2 Frame and Bootstrap Positioning

Each APLF begins with a bootstrap, followed by a post-bootstrap waveform corresponding to the signal type identified by the major and minor version value pairs carried by that bootstrap. Each consecutive APLF is positioned in time so that start of its bootstrap immediately follows the end of the preceding APLF's post-bootstrap waveform. When adjacent APLFs employ different baseband sampling rates, the next APLF's bootstrap occurs within max(T_A, T_B), where T_A and T_B denote the baseband sample periods of the adjacent APLF post-bootstrap waveforms.

The baseband sampling rate of each specific signal type follows specifications provided by related documentations, which specifications are defined outside the scope of this Standard.

Figure 7.1 shows an example of time-multiplexed APLFs incorporating different signal types.

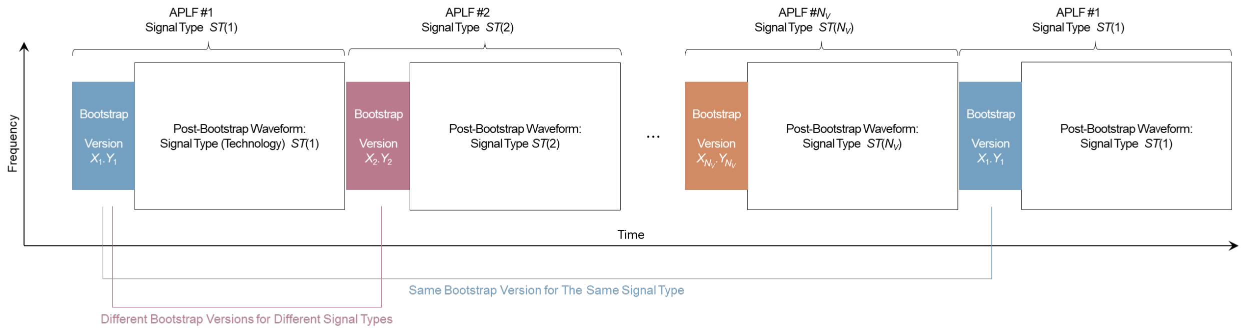

Figure 7.2 Example of time-multiplexed APLFs carrying N_V signal types.

7.3 Identification of Signal Types by Bootstrap Versioning

This section specifies the signal type identification mechanism outlined in Section 4.2, using the versioning structure defined in this Standard. A defined set of major/minor version value pairs is used to identify the signal type associated with each APLF. ATSC 3.0 is identified by Bootstrap version 0.0 (bootstrap_major_version = 0; bootstrap_minor_version = 0) as specified in [3].

Consistent with the extensibility mechanism described in Section 3.5, changes in the major version value correspond to major changes in signal type (e.g., a different underlying digital transmission technology), while changes in the minor version value correspond to evolution, extension, or reconfiguration within the same major signal type.

A bootstrap version allocation table is configured to map each bootstrap version to an APLF signal type identifier. Table 7.1 provides an example using two bootstrap versions defined in Sections 6.1 and 6.2.

Table 7.2 Bootstrap Version Value Allocation Example for APLF Identification (Example Using Two Bootstrap Versions)

bootstrap_major_version Value	bootstrap_minor_version Value	Signal Type of APLF Post-Bootstrap	Notes
0	0	Signal Type A	Note 1
1	0	Signal Type B	

Note 1: The signal type specified in [3] (ATSC 3.0) uses Bootstrap version 0.0 (bootstrap_major_version = 0; bootstrap_minor_version = 0) when employed in an APLF.

Beyond the bootstrap versions 0.0 and 1.0, the constraints and signaling of which are specified in this version of the Standard, the allocation extends to use future major and minor versions. Table 7.2 provides an example.

Table 7.3 Bootstrap Version Value Allocation Example for APLF Identification (Example Using Five Bootstrap Versions)

bootstrap_major_version Value	bootstrap_minor_version Value	Signal Type of APLF Post-Bootstrap	Notes
0	0	Signal Type A	Note 1
1	0	Signal Type B1	
1	1	Signal Type B2	
2	0	Signal Type C	
3	0	Signal Type D	

Note 1: The signal type specified in [3] (ATSC 3.0) uses Bootstrap version 0.0 (bootstrap_major_version = 0; bootstrap_minor_version = 0) when employed in an APLF.

– End of document –