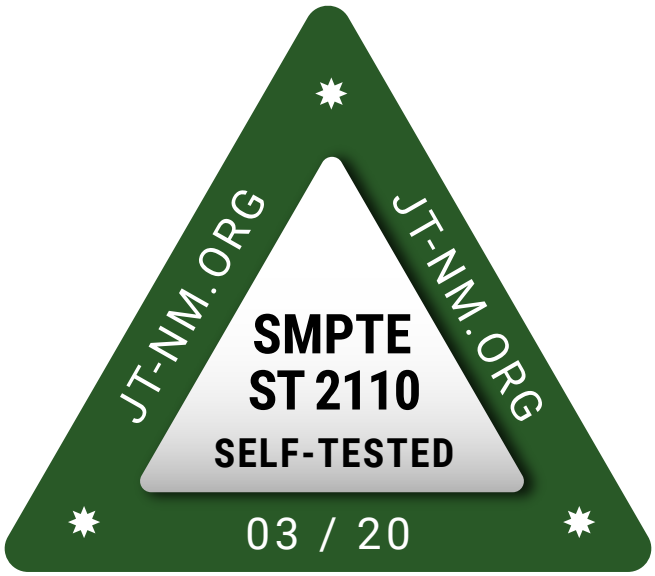
JT-NM Tested March 2020
SMPTE ST 2110 Media Nodes
Results Catalog



“JT-NM Tested Program March 2020” SMPTE ST 2110 Test Plan v.1.4

Due to the COVID-19 crisis, the face-to-face stage of the testing was canceled. The test plan was adapted post-factum to reflect the changes made to the program.

Self-Tested Results

For the first time, this catalog includes Self-Tested results, and, for vendors who submitted their own test results, JT-NM has created a Self-Tested badge. The JT-NM was unable to hold a planned face-to-face meeting in March of 2020 where vendor-submitted tests could be validated. We decided to modify our program so that vendors who self-tested their products in accordance with the JT-NM Tested test plans could submit their results for publication in this catalog. JT-NM is responsible for the development and publication of the test plans. Vendors are solely responsible for any representations they have made in the self-tested results they have submitted; JT-NM is simply reprinting the submitted results in this catalog.

JT-NM Tested Results

For NMOS Controllers, the JT-NM Test Team was able to independently validate the vendor submitted test results using a Virtual Private Network and a lab at CBC/Radio Canada. In the case of these controller tests, the JT-NM is responsible for development and publication of the controller test plan, and also for validating vendor results included in this catalog.

Changelog to v.1.3

- **The test plan was adapted to reflect the changes made due to the cancellation of the face-to-face stage of the testing**

Changelog to v.1.2

- **Sections 5_TX, 6_TX, 6_RX, test 6.5** - errors corrected in channel count and packet times

Changelog to v.1.1

- **Section 4_TX** - amended
- **Test 4.5** - added and numbering amended

Changelog to v.1.0

- **SDPoker** - link updated
- **Wireshark ST 2110 dissectors** - links updated
- **General statements and terms** - amended
- **Tests 2.5, 2.6, 2.7** - editorial corrections

Changelog to “JT-NM Tested August 2019 Program” Test Plan v.1.3

- Initial release. This document may undergo substantial changes ahead of the final version.
- It is recommended that participants of previous JT-NM Tested events carefully familiarize themselves with the new revision of the test plan
- Editorial corrections and ambiguities resolution throughout the text
- SMPTE ST 2110-31 tests added
- SMPTE ST 2110-40 and ST 2022-7 tests numbering updated
- Video formats throughout the document are changed to 59.94 frame rate
- General statements and terms amended
- Section 2 - Some tests amended, PTP GM failover behavior tests added and tests numeration updated
- Section 5_TX tests - amended, DSCP values check added
- All essence RX tests - amended, RTP payload ID acceptance check added
- Test 7.1. - Recommended DID/SDIDs values are provided
- Section 8 - amended

Abstract and motivation behind the program

The JT-NM Tested program offers documented insight into how vendor equipment conforms to specific SMPTE standards and AMWA NMOS specifications.
Vendors who meet the testing criteria will have the opportunity to display badges and to make public statements about their participation. JT-NM will publish the JT-NM Tested Catalog listing vendor results along with a detailed test plan.
In a major change to the program, vendors will conduct self-testing prior to a face-to-face event where JT-NM validates the results.
It is important to note that the JT-NM Tested program is not a certification program; rather it is a snapshot in time of how vendor equipment conforms to key parts of SMPTE standards and AMWA NMOS specifications.

Acknowledgment

This Test Plan was prepared by an expert group within the Joint Task Force on Networked Media (JT-NM) with key contributions from: Alun Fryer (Ross Video), Andrew Bonney (BBC R&D), Andy Rayner (Nevion), Bill McLaughlin (EEG), Claudio Becker-Foss (DirectOut GmbH), Ievgen Kostiukevych (EBU), Jack Douglass (PacketStorm Communications, Inc.), Jean Lapierre (Matrox), John Mailhot (Imagine Communications), Leigh Whitcomb (Imagine Communications), Mike Overton (Tektronix/Telestream), Mike Waidson (Tektronix/Telestream), Pedro Ferreira (Bisect), Peter Brightwell (BBC R&D), Robert Welch (Arista Networks), Serge Grondin (Grass Valley), Sonja Langhans (IRT), Thomas Kernen (Mellanox Technologies) and Willem Vermost (EBU).

Applicable Standards and versions

- **SMPTE ST 2059-1:2015 -** Generation and Alignment of Interface Signals to the SMPTE Epoch
- **SMPTE ST 2059-2:2015 -** SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications
- **SMPTE ST 2110-10:2017 -** Professional Media over Managed IP Networks: System Timing and Definitions
- **SMPTE ST 2110-20:2017 -** Professional Media over Managed IP Networks: Uncompressed Active Video
- **SMPTE ST 2110-21:2017 -** Professional Media over Managed IP Networks: Traffic Shaping and Delivery Timing for Video
- **SMPTE ST 2110-30:2017 -** Professional Media over Managed IP Networks: PCM Digital Audio
- **SMPTE ST 2110-31:2018 -** Professional Media over Managed IP Networks: AES3 Transparent Transport

- **SMPTE ST 2110-40:2018 -** Professional Media over Managed IP Networks: SMPTE ST 291-1 Ancillary Data
- **SMPTE ST 2022-7:2019** - Seamless Protection Switching of SMPTE ST 2022 IP Datagrams
- Internet Engineering Task Force (IETF) **RFC 3376** Internet Group Management Protocol, Version 3 https://www.ietf.org/rfc/rfc3376.txt
- **JT-NM TR-1001-1:2018** http://www.jt-nm.org/documents/JT-NM_TR-1001-1:2018_v1.0.pdf
- **AES67-2018 -** AES standard for audio applications of networks - High-performance streaming audio-over-IP interoperability

Equipment used during testing

The equipment lists were adapted to reflect the changes made to the program because of cancellation of the face-to-face event.

The following equipment was selected by the JT-NM Tested Experts Group to support the "JT-NM Tested" event. In a number of cases, other vendor's equipment would have worked equally well. To preserve the integrity of the testing environment, the team needed to choose one set of support equipment. The listing of a company below should not be taken to indicate that this is the only equipment that could have performed the tasks required. Note also that support equipment was *not* "JT-NM Tested" unless it is specifically listed in the test results matrix, and that no special status is awarded by the JT-NM to these companies other than to note that the JT-NM appreciates their support. Except for the JT-NM face-to-face events, it is never expected that the same test and measurement, network, PTP or reference equipment is used for self-testing or independent testing.

Test and measurement equipment and software used during the event (the list was changed because of cancellation of the face-to-face event)

- EBU Live IP Software Toolkit (EBU LIST)
  - https://tech.ebu.ch/list
- SDPoker
  - https://github.com/AMWA-TV/sdpoker
  - ○ Note: The latest 'master' version of this fork is used as opposed to the original Streampunk repository in order to benefit from recent additions and bug fixes.

Test and measurement equipment and software used during the previous face-to-face events:

- *BridgeTech VB440*
  - *https://bridgetech.tv/vb440/*
- *EBU Live IP Software Toolkit (EBU LIST)*
  - *https://tech.ebu.ch/list*

- *Meinberg PTP Track Hound*
  - *https://www.ptptrackhound.com/*
- *Packetstorm CRS, Network Emulator (6XG / 8XG), VIP*
  - *https://packetstorm.com/packetstorm-products/*
- *SDPoker*
  - *https://github.com/AMWA-TV/sdpoker*
  - *Note: The latest ‘master’ version of this fork is used as opposed to the original Streampunk repository in order to benefit from recent additions and bug fixes.*
- *Tektronix PRISM*
  - *https://www.tek.com/prism-media-monitoring-and-analysis-platform*
- *Wireshark (with ST 2110 dissectors)*
  - *https://github.com/NEOAdvancedTechnology/smpte2110-20-dissector*
  - *https://github.com/NEOAdvancedTechnology/smpte2110-40-dissector*

Reference senders and receivers used during the event (the list was changed because of cancellation of the face-to-face event)

- No reference devices were used

Reference senders and receivers used during the previous face-to-face events:

- *DirectOut MONTONE.42*
  - *https://www.directout.eu/en/products/montone42/*
- *Imagine Communications SNP*
  - *https://www.imaginecommunications.com/products/networking-infrastructure/processing/selenio-network-processor*
- *Nevion Virtuoso*
  - *https://nevion.com/products/nevion-virtuoso/*
- *EEG Alta™ IP Video Caption Encoder*
  - *https://eegent.com/products/X6KO3ARIL9X1VEIU/altaTM-ip-video-caption-encoder*
- *Matrox X.mio5 Q25*
  - *https://matrox.com/video/en/products/developer/hardware/xmio5_Q25/*
- *SDI source(s), SDI monitor(s), SDI DA(s), SDI router(s), audio source(s), audio monitor(s)*

Network switches used during the event (the list was changed because of cancellation of the face-to-face event)

- No network switches were used

Network switches used at previous face-to-face events:

- *Arista 7060CX2-32 (EOS Version 4.21.4F)*

    - *https://www.arista.com/assets/data/pdf/Datasheets/7060X_7260X_DS.pdf*
- *Arista 7280SR48-YC6 (EOS Version 4.21.4F)*
    - *https://www.arista.com/assets/data/pdf/Datasheets/7280R-DataSheet.pdf*
- *Arista 7280SR2-48YC6 (EOS Version 4.21.4F)*
    - *https://www.arista.com/assets/data/pdf/Datasheets/7280R-DataSheet.pdf*
- *Arista 7020TR-48 (EOS Version 4.21.4F)*
    - *https://www.arista.com/assets/data/pdf/Datasheets/7020R-48_Datasheet.pdf*

PTP configuration used during the event (the list was changed because of cancellation of the face-to-face event)

- No PTP devices were used

PTP configuration used at previous face-to-face events:
*The PTP Grandmaster(s) used during the event - Tektronix **SPG8000A**.*
*The network switches will be configured in a **Boundary Clock** mode.*
Multicast communication mode for all messages will be used (except for management TLV responses).
The PTP profile details will be provided at the time of testing. The parameters provided will be within the values allowed by SMPTE ST 2059-2:2015.

General statements and terms (the list was adapted because of the cancellation of the face-to-face event)

- This test plan outlines the principles and methods for the IP Media Endpoints testing which are applied for on-site testing at the face-to-face events, but can and should also be applied for self-testing as well as independent testing. Therefore, except for the JT-NM face-to-face events, it is never expected that the same test and measurement, network, PTP or reference equipment is used for self-testing or independent testing.
- Vendors may not change software/firmware once testing has commenced but may adjust settings on their products as necessary during the testing process.
- Throughout the text the term "disruption" is used, It may be applied to baseband signals and/or IP streams.
    - Disruption on a transmitting IP Media Node includes but not limited to:
        - Black lines in the video essence
        - Frozen/dropped frames in the video essence
        - Mutes or pops in the audio essence
        - Distorted or lost symbols in the ancillary essence
        - Discontinuity of RTP sequence numbers

        - Change in RTP timestamps by more than a duration of a video frame/audio frame.
    - A disruption on an IP Rx Media Node includes but not limited to:
        - Black lines in the video essence
        - Frozen/dropped frames in the video essence
        - Mutes or pops in the audio essence
        - Distorted or lost symbols in the ancillary essence
    - A disruption in the baseband signal includes but not limited to:
        - Black lines in the video essence
        - Frozen/dropped frames in the video essence
        - Mutes or pops in the audio essence
        - Distorted or lost symbols in the ancillary data
- The JT-NM Tested team reserves the right to update the "JT-NM Tested Program" Test Plans as required.

Descriptions of the tests

1. General Network Interface Tests

Description: This set of Tests is expected to validate the general network-related functionality of a media device.

First steps:

At the time of testing, Testers will provide the Vendor representative with a set of parameters consisting of:

- A unicast host IPv4 address
- A subnet mask from the range from /8 to /30
- A default gateway IPv4 address

Sets of parameters will be provided for essence interface(s) and for management interface(s) (if an out-of-band management interface is present for the DuT). The Vendor representative will be expected to configure the DuT with the given sets of parameters. If the DuT has no out-of-band management interface(s) and uses inband management via essence interface(s), only a set of parameters for essence interface(s) will be provided and the test 1.1. will be skipped.

1.1. Management Network Interface Test*

*Only applied to devices with out-of-band management interface(s). DHCP variant of this test is part of NMOS/TR-1001-1 testing. If a device does not provide means to display the management IP address assigned by the DHCP - it may be assigned a static address.

Description: Tests the ability of DuT to receive the IPv4 address, subnet mask, and default gateway parameters for a management interface via DHCP. Also tests blocking of ICMP messages and TTL values of ICMP replies. The DuT will be pinged from a host in another subnet. DuT is

expected to reply to ICMP echo requests (ping) coming from another subnet, while properly utilizing a default gateway, and with TTL > 16. This test will not involve a VLAN change and/or IP address change, a demonstration of basic configurability will suffice. The manual configurability of these parameters will also be expected. If the DuT does not support DHCP or does not participate in the NMOS/TR-1001-1 testing, only the manual configurability of these parameters will be expected. The ICMP ping test will be done twice with 2 payloads: 32 and 56 bytes, the DuT is expected to properly reply to both.

Validation method: Console log from a device sending ICMP echo requests is used for validation.

Pass criteria:

- The DuT assumes the parameters assigned via DHCP (if tested), or manually, can be pinged from a host on another subnet. The TTL value of ICMP echo reply to both payload sizes is > 16.

No pass criteria:

- The DuT does not assume the parameters assigned via DHCP (if tested), or manually, or cannot be pinged from a host on another subnet with one or both payload sizes.

1.2. Media Network Interface(s) Test*

* DHCP variant of this test is part of NMOS/TR-1001-1 testing. If a device has inbound management and does not provide means to display the management IP address assigned by the DHCP - it may be assigned a static address.

Description: Tests the ability of DuT to receive the IPv4 address, subnet mask, and default gateway parameters for a media interface(s) via DHCP. Also tests blocking of ICMP messages and TTL values of ICMP replies. The DuT will be pinged from a host in another subnet. DuT is expected to reply to ICMP echo requests (ping) coming from another subnet, while properly utilizing a default gateway, and with TTL > 16. This test will not involve a VLAN change and/or IP address change, a demonstration of basic configurability will suffice. The manual configurability of these parameters will also be expected. If the DuT does not support DHCP or does not participate in the NMOS/TR-1001-1 testing, only the manual configurability of these parameters will be expected.

If a device has ST 2022-7 multiport capabilities - both ports will be tested. The ICMP ping test will be done twice with 2 payloads: 32 and 56 bytes, the DuT is expected to properly reply to both.

Validation method: Console log from a device sending ICMP echo requests is used for validation.

Pass criteria:

- The DuT assumes the parameters assigned via DHCP (if tested), or manually, can be pinged from a host on another subnet. The TTL value of ICMP echo to both payload sizes reply is > 16.

No pass criteria:

- The DuT does not assume the parameters assigned via DHCP (if tested), or manually, or cannot be pinged from a host on another subnet with one or both payload sizes.

2. Media Network Related Tests

Description: This set of Tests validates the basic and advanced behaviors of the DuT related to PTP synchronization and multicast addressing capabilities.

First steps:

At the time of testing, Testers will provide to the Vendor representative sets of parameters consisting of:

- A PTP profile values compliant to SMPTE 2059-2:2015. Any parameter values allowed by the profile may be used.
- A set of multicast addresses.
- Source-specific multicast (SSM) will not be tested.

The Vendor representative will be expected to configure the DuT with the given sets of parameters.

2.1. Basic PTP Configuration Test

Description: The Test validates the basic PTP behavior of the DuT in slave only mode (defaultDS.slaveOnly set to TRUE). A set of PTP-related tests will be executed to test:

- The DuT that has a dedicated network port for PTP (not management and not an essence port) will be expected to expose the IP address configurability as per test 1.2.
- The ability of the DuT to lock to the (Grand)master with freely assignable PTP Domain number and follow the parameters of the PTP profile communicated by a (Grand)master and Master port to which the DuT is connected to: The PTP profile values may be modified in a (Grand)master, the DuT will be expected to re-lock to it. **Validation method:** DuT visual reporting of PTP lock status, a PTP log of the DuT, and/or Wireshark/PTP Track Hound analysis.
- The ability of the DuT to be set in a slave-only mode: the DuT is expected not to assume a (Grand)master role even if there is no (Grand)master present. **Validation method:** by changing the PTP domain setting on the DuT, the flow of valid PTP announce messages is interrupted, DuT visual reporting of PTP lock status, a PTP log of the DuT, or a Wireshark/PTP Track Hound analysis of a PTP communication from a mirrored port of the switch connected to the DuT is used to analyze the behavior of the DuT.
- The ability of the DuT to maintain proper PTP communication according to the parameters communicated by a (Grand)master: the DuT is expected to keep stable lock to PTP and maintain the messages rate communicated by a (Grand)master. **Validation method:** DuT visual reporting of PTP lock status, or a PTP log of the DuT, a Wireshark/PTP Track Hound analysis of a PTP communication from a mirrored port of the switch connected to the DuT.
- The ability of the DuT not to reply to TLV management messages with multicast acknowledgment. **Validation method:** The PTP (Grand)master will be using the defined PTP profile as per SMPTE ST 2059-2 and will be sending the SMPTE TLV management messages once per second. Wireshark will be used to monitor from a mirrored port of the

switch connected to the DuT and to verify that the BC is sending the TLV to the DuT and that the DuT while being locked to PTP, is not responding inappropriately.

Pass criteria:

- The DuT's dedicated PTP port* can be pinged from a host on another subnet. The TTL value of the ICMP echo reply is > 16.
  *Only applicable to DuT that has a dedicated PTP port
- It is possible to freely assign PTP domain parameters into DuT.
- The DuT can lock to the (Grand)master, can maintain a stable lock and maintains PTP communication according to the parameters communicated by a (Grand)master.
- The DuT does not assume a master role if there is no (Grand)master present.
- The DuT does not reply to TLV management messages with multicast acknowledgment.

No pass criteria:

- The DuT's dedicated PTP port* cannot be pinged from a host on another subnet.
  *Only applicable to DuT that has a dedicated PTP port
- It is not possible to freely assign PTP domain parameters into DuT.
- The DuT cannot lock to the (Grand)master, cannot maintain a stable lock or does not maintain PTP communication according to the parameters communicated by a Grandmaster.
- The DuT assumes a (Grand)master role if there is no (Grand)master present.
- The DuT replies to TLV management messages with multicast acknowledgment.

2.2. Manual PTP Configurability Test*

*As this test may be disruptive and/or may require significant network changes, it may be postponed and performed after the rest of the tests are executed. Given the time and resources limitations, this test may be dropped.
If the DuT is designed to automatically adjust itself to the message rates advertised by the PTP master clock, is not exposing this configurability to the end-user and/or is not capable of assuming the PTP (grand)master role, this test may be marked as "not applicable" for this DuT.

Description: The Test validates the manual PTP configurability of the DuT, with a "slave only" mode enabled or disabled (defaultDS.slaveOnly set to TRUE, or FALSE). A multicast and/or a hybrid (also referred to as mixed mode) without negotiation communication modes will be tested. A set of PTP-related tests will be executed to test:

- The DuT that has a dedicated network port for PTP (not management and not an essence port) will be expected to expose the IP address configurability as per test 1.2.
- The ability to freely set PTP profile parameters, including PTP domain number, sync and announce message intervals, timeout intervals, delay request/response rates, priorities 1 and 2 and a communication mode in the DuT: a Vendor representative will be expected to set a given set of PTP parameters into DuT. **Validation method:** DuT visual reporting of PTP lock status, a PTP log of the DuT, and/or Wireshark/PTP Track Hound analysis.
- The ability of the DuT to maintain proper PTP communication according to the parameters set: the DuT is expected to remain locked according to the given PTP profile parameters and to send the number of delay requests that match its configured value. **Validation method:** DuT visual reporting of PTP lock status, or a PTP log of the DuT, a

Wireshark/PTP Track Hound analysis of a PTP communication from a mirrored port of the switch connected to the DuT.

Pass criteria:

- The DuT's dedicated PTP port* can be pinged from a host on another subnet. The TTL value of the ICMP echo reply is > 16.
  *Only applicable to DuT that has a dedicated PTP port
- It is possible to freely set up PTP profile parameters into DuT.
- The DuT can lock to the (Grand)master, can maintain a stable lock and maintains PTP communication according to the parameters set.

No pass criteria:

- The DuT's dedicated PTP port* cannot be pinged from a host on another subnet.
  *Only applicable to DuT that has a dedicated PTP port
- It is not possible to freely assign PTP profile parameters into DuT.
- The DuT cannot lock to (Grand)master, cannot maintain a stable lock and does not maintain PTP communication according to the parameters set.

2.3. BMCA Master/Slave test*

*This test is applicable to devices capable of assuming a PTP master role.
As this test may be disruptive and/or may require significant network changes, it may be postponed and performed after the rest of the tests are executed. Given the time and resources limitations, this test may be dropped.

Description: The Test validates the PTP behavior of the DuT with a slave only mode disabled (defaultDS.slaveOnly not set to TRUE): The DuT is expected to follow a BMCA process and assume appropriate Master/Slave role. A PTP domain of the DuT is changed and/or priorities 1 and 2 of the (Grand)master and the DuT are changed to trigger the BMCA process. **Validation mode:** DuT visual reporting of PTP lock status, or a PTP log of the DuT, and/or Wireshark/PTP Track Hound analysis of a PTP communication from a mirrored port of the switch connected to the DuT.

Pass criteria: DuT properly follows a BMCA process and assume appropriate Master/Slave role.

No Pass criteria: DuT does not properly follow a BMCA process and/or does not assume an appropriate Master/Slave role.

2.4. One-step/two-step Master lock test*

*As this test may be disruptive and/or may require significant network changes, it may be postponed and performed after the rest of the tests are executed. Given the time and resources limitations, this test may be dropped.

Description: The Test validates the ability of the DuT to lock to the one-step and the two-step (Grand)master: a PTP (Grand)master and/or a switch in BC mode (running as a Master port) will be switched to one-step or two-step clock mode. The DuT is expected to be able to lock to it in both scenarios. **Validation method:** DuT visual reporting of PTP lock status, a PTP log of the DuT, and/or Wireshark/PTP Track Hound analysis.

Pass criteria:

- The DuT can lock to a one-step and two-step (Grand)master.

No Pass criteria:

- The DuT cannot lock to the one-step and two-step (Grand)master.

2.5. RX Device PTP (Grand)master Failover Test with "*a=ts-refclk:ptp=GM-ID"* in a Reference TX SDP

*As this test may be disruptive and/or may require significant network changes, it may be postponed and performed after the rest of the tests are executed. Given the time and resources limitations, this test may be dropped.

Description:** The test validates the receiver's behavior during and after a PTP (Grand)master failover event between 2 equivalent (Grand)masters while receiving a stream from a reference TX device that indicates "a=ts-refclk:ptp=GM-ID" in the SDP object.

**The motivation for this test is that some users report that during PTP GM failover events, disruptions on some Media Nodes have been observed. While not formally in any standard, users have the expectation that a PTP GM failover event shall not cause disruptions on Media Node outputs.

Validation method: PTP awareness is disabled on the switch interface and the DuT is placed into a special PTP testing VLAN. The DuT is then expected to lock to a dedicated PTP testing master clock. This dedicated PTP clock will have the traceable flag set to true in its Announce messages as well as advertised Clock Accuracy of <= 1us (codes 0x020-0x23). The DuT will be expected to receive a stream from the special reference transmitter. The SDP object of that stream will indicate the same reference clock that the DuT is being locked to (a=ts-refclk:ptp=GM-ID). After the stable lock and reception are established, a BMCA between the current master and a backup clock is triggered by changing the Priority 1 value on the master clock thus implying a grandmaster changeover for the DuT and for the reference transmitter. It is a given that the selected reference transmitter does not suffer any disruption during the PTP master change and properly amends the "a=ts-refclk:ptp" field in the SDP object. The Priority 1 value of the original master clock is then reverted back to its original value thus triggering it to take over again as the best master.

It is expected that the DuT does not demonstrate any disruption in the output (baseband or loopback) of the stream being received during both of these changeovers.

Pass criteria:

- The DuT is able to lock to a new PTP GM
- The DuT is able to receive and reproduce/loopback the stream from the dedicated reference transmitter
- The DuT does not demonstrate disruption in the stream reproduction during both PTP GM changeovers

No Pass criteria:

- The DuT is not able to lock to a new PTP GM
- The DuT is not able to receive and reproduce/loopback the stream from the dedicated reference transmitter
- The DuT demonstrates any kind of disruption in the stream reproduction during any of the PTP GM changeovers

2.6. RX Device PTP (Grand)master Failover Test with "*a=ts-refclk:ptp=traceable"* in a Reference TX SDP

*As this test may be disruptive and/or may require significant network changes, it may be postponed and performed after the rest of the tests are executed. Given the time and resources limitations, this test may be dropped.

Description:** The test validates the receiver's behavior during and after a PTP (Grand)master failover event between 2 equivalent (Grand)masters while receiving a stream from a reference TX device that indicates "a=ts-refclk:ptp=traceable" in the SDP object.

**The motivation for this test is that some users report that during PTP GM failover events, disruptions on some Media Nodes have been observed. While not formally in any standard, users have the expectation that a PTP GM failover event shall not cause disruptions on Media Node outputs.

Validation method: PTP awareness is disabled on the switch interface and the DuT is placed into a special PTP testing VLAN. The DuT is then expected to lock to a dedicated PTP testing master clock. This dedicated PTP clock will have the traceable flag set to true in its Announce messages as well as advertised Clock Accuracy of <= 1us (codes 0x020-0x23). The DuT will be expected to receive a stream from the reference transmitter in the general network area that is locked to the general PTP master clock. The SDP object of that stream will indicate that it is generated from a traceable source (a=ts-refclk:ptp=traceable). It is expected that the DuT is able to successfully receive that stream. After the stable lock and reception are established, a BMCA between the current master and a backup clock is triggered by changing the Priority 1 value on the master clock thus implying a grandmaster changeover for the DuT, while the reference transmitter remains locked to the general master and therefore there is no change to the SDP object. The Priority 1 value of the original master clock is then reverted back to its original value thus triggering it to take over again as the best master.

It is expected that the DuT does not demonstrate any disruption in the output (baseband or loopback) of the stream being received during both of these changeovers.

Pass criteria:

- The DuT is able to lock to a new PTP GM
- The DuT is able to receive and reproduce/loopback the stream from the reference transmitter
- The DuT does not demonstrate disruption in the stream reproduction during both PTP GM changeovers

No Pass criteria:

- The DuT is not able to lock to a new PTP GM
- The DuT is not able to receive and reproduce/loopback the stream from the dedicated reference transmitter
- The DuT demonstrates any kind of disruption in the stream reproduction during any of the PTP GM changeovers

2.7. TX Device PTP (Grand)master Failover Test

*As this test may be disruptive and/or may require significant network changes, it may be postponed and performed after the rest of the tests are executed. Given the time and resources limitations, this test may be dropped.

Description:** The test validates the transmitter's behavior during and after a PTP (Grand)master failover event between 2 equivalent (Grand)masters.

**The motivation for this test is that some users report that during GM failover events, disruptions on some Media Nodes have been observed. While not formally in any standard, users have the expectation that a GM failover event shall not cause disruptions on Media Node outputs.

Validation method: PTP awareness is disabled on the switch interface and the DuT is placed into a special PTP testing VLAN. The DuT is then expected to lock to a dedicated PTP testing master clock. This dedicated PTP clock has the traceable flag set to true in its Announce messages as well as advertises its Clock Accuracy of <= 1us (codes 0x020-0x23). The DuT will be expected to transmit a stream into the general network area. The SDP object of that stream may or may not be generated and may or may not indicate that it is generated from a traceable source (a=ts-refclk:ptp=traceable, or a=ts-refclk:ptp=GM-ID). The stream is then received by a reference receiver. After the stable lock and reception are established, a BMCA between the current master and a backup clock is triggered by changing the Priority 1 value on the master clock thus implying a grandmaster changeover for the DuT, while the reference receiver remains locked to the general master. It is expected that the DuT will either update the GM-ID after no more than 20 seconds***, or preserve the "traceable" in the SDP object of the stream. The Priority 1 value of the original master clock is then reverted back to its original value thus triggering it to take over again as the best master. It is a given that the reference device itself does not demonstrate any disruption because of SDP object change and will accept streams with both GM-ID or "traceable" in the SDP object, or without the SDP at all.

It is expected that there is no disruption of the stream generated by the DuT during both of the changeovers (as monitored by the reference receiver).

***20 seconds is arbitrary, but recommended maximum time for the SDP object updating. A longer time is discouraged, but will not result in not passing the test.

Pass criteria:

- The DuT is able to lock to a new PTP GM
- The DuT is able to generate a valid stream that can be received by the reference receiver
- The DuT does not demonstrate disruption in the outgoing stream during both PTP GM changeovers
- If SDP object of the stream is generated - it indicates either "a=ts-refclk:ptp=traceable", or "a=ts-refclk:ptp=GM-ID" for current active (grand)master

No Pass criteria:

- The DuT is not able to lock to a new PTP GM
- The DuT is not able to generate a valid stream or it cannot be received by the reference receiver
- Any kind of disruption is observed in the generated stream during any of the PTP GM changeovers

- The generated SDP object of the stream does not indicate a=ts-refclk:ptp=traceable, or a=ts-refclk:ptp=GM-ID for current active (grand)master

2.8. Basic Multicast Configuration Test

Description: The Test validates the basic configurability of source and destination multicast IPv4 addresses of the DuT. An ability to independently configure a given set of source and destination multicast IPv4 addresses randomly picked in the 239.0.0.0/8 range is expected. If the DuT is a sender only (a receiver only), the configuration of a destination (source) multicast IPv4 address only will be expected. If the DuT is a sender and a receiver, it is expected that it is possible to configure both a source and a destination multicast IPv4 addresses independently and at the same time. This test counts towards NMOS/TR-1001-1 testing since the 239.0.0.0/8 range is mandated in TR-1001-1. This test is also applied for ST 2022-7 capable products with the same configurability and independence expected on both interfaces.
Validation method: Visible acknowledgment of parameters by the DuT without errors.

Pass criteria:

- The DuT allows independent configuration of source and destination multicast addresses* randomly picked as defined in the description.
  *If a device is a sender only (a receiver only), the configuration of a destination (source) multicast IPv4 address only will be expected
- The ST 2022-7 capable DuT allows independent configuration of source and destination multicast addresses randomly picked as defined in the description on both of its interfaces.

No pass criteria:

- The DuT does not allow independent configuration of source and destination multicast addresses* randomly picked as defined in the description.
  *If a device is a sender only (a receiver only), the configuration of a destination (source) multicast IPv4 address only will be expected
- The ST 2022-7 capable DuT does not allow independent configuration of source and destination multicast addresses randomly picked as defined in the description on both of its interfaces.

2.9. Extended Multicast Range Configurability Test

Description: The Test validates advanced configurability of source and destination multicast IPv4 addresses of the DuT. An ability to independently configure a given set of randomly picked source and destination multicast IP addresses is checked. The given multicast address will not be in the ranges "224.0.0.0 to 224.0.0.255" and "224.0.1.0 to 224.0.1.255". If the DuT is a sender only (a receiver only), the configuration of a destination (source) multicast IPv4 address only will be expected. If the DuT is a sender and a receiver, it is expected that it is possible to configure both a source and a destination multicast IPv4 addresses independently and at the same time. This test is

also applied for ST 2022-7 capable products with the same configurability and independence expected on both interfaces.
Validation method: visible acknowledgment of parameters by the DuT without errors.
Pass criteria:

- The DuT allows independent configuration of source and destination multicast addresses* randomly picked as defined in the description.
  *If a device is a sender only (a receiver only), the configuration of a destination (source) multicast IPv4 address only will be expected
- The ST 2022-7 capable DuT allows independent configuration of source and destination multicast addresses randomly picked as defined in the description on both of its interfaces.

No pass criteria:

- The DuT does not allow independent configuration of source and destination multicast addresses* randomly picked as defined in the description.
  *If a device is a sender only (a receiver only), the configuration of a destination (source) multicast IPv4 address only will be expected
- The ST 2022-7 capable DuT does not allow independent configuration of source and destination multicast addresses randomly picked as defined in the description on both of its interfaces.

3. ST 2110-10 Tests

Description: This set of Tests validate the basic DuT’s conformance to SMPTE ST 2110-10.
First steps: For DuT with receiving capabilities: the Vendor representative is provided with a multicast IPv4 address with an active stream (audio/video depending on DuT capabilities) that is present and active in the network and requested to receive this stream. For DuT with sending capabilities: an SDP object verification is done. The ability to decode a stream and/or produce a valid stream is neither verified nor expected at this stage.

3.1. IGMPv3 test for a receiver

Description: The Vendor representative is requested to have their DuT join a given multicast group. IGMPv3 communication is expected between the DuT and a switch. Use of Source-Specific Multicast is not expected. **Validation method:** IGMP communication is monitored with Wireshark from a mirrored port of the switch connected to the DuT.
Pass criteria:

- The DuT maintains IGMPv3 communication with a switch.

No pass criteria:

- The DuT uses another version of IGMP.

3.2. SDP object verification for a sender

Description: The Vendor is expected to demonstrate that the DuT has a user-accessible way to expose a valid SDP object. This test is performed alongside tests 4_TX, 5_TX and 6_TX. The SDP object is checked for the respected essence type (-20, -30 and/or -40) when a stream is initiated. If an SDP object is exposed via NMOS IS-04 - this will be accounted for the NMOS/TR-1001-1 testing. **Validation method:** an exposed SDP object is checked with SDPoker and/or manually.
Pass criteria:

- The DuT exposes a user-accessible and valid SDP object.

No pass criteria:

- The Vendor representative is not able to demonstrate that the DuT supports user-accessible SDP data, or the SDP object is not valid.

4_TX. ST 2110-20 Tx tests*

*Applicable only to DuT with video transmitting capabilities
Description: This set of tests validate the basic DuT's conformance to SMPTE ST 2110-20.
First steps: The Vendor representative will be provided with a multicast IPv4 address, a port number, and video format parameters (1080i59.94 and/or 1080p59.94). DuT is expected to be able to initiate a stream with given parameters. Standard MTU size will always be expected. The DuT may use either GPM or BPM for generating the TX stream, a reference receiver will be able to accept both. Separate testing of UHD capabilities (2160p59.94) will be executed. It will be reflected accordingly in the results spreadsheet (e.g. 4.2-UHD).

4.1. Stream basic test Tx

Description: The Vendor representative is expected to configure the DuT so that it initiates a stream of a given configuration with the given multicast address and port number. Packets of the stream are expected to have a valid source and destination MAC and IPv4 addresses.
Validation method: Stream is analyzed in real-time (and/or captured and analyzed offline) via IGMP join and/or from a mirrored port of the switch connected to the DuT. Source and destination MAC and IPv4 addresses are validated either by a test and measurement equipment or manually using Wireshark.
Pass criteria:

- DuT is capable of initiating a stream with given IPv4 address parameters, and video format parameters.
- Stream uses a valid multicast MAC address.

No pass criteria:

- DuT is not capable of initiating a stream with given IPv4 address parameters, and video format parameters.
- Stream uses an invalid multicast MAC address.

4.2. Stream visual validation Tx

Description: A stream initiated during test 4.1. is received with a reference receiver. A basic subjective visual test is done. The stream is expected to have no obvious visual artifacts of digital nature or any other disruptions.
Validation method: A stream is visualized using a reference receiver. If a reference receiver is not capable of decoding the stream - a test and measurement device is used to analyze the stream. The stream will be observed for at least ~60 seconds.
Pass criteria:

- The stream can be received and decoded by a reference receiver and/or a majority of the test equipment. The video signal is free from artifacts of a digital nature or any other disruptions.

No pass criteria:

- The stream cannot be decoded or contains disruptions. A Vendor representative will have an opportunity to articulate why this might be ok.

4.3. ST2110-21 profile sender compliance test Tx

Description: A stream generated during test 4.1. is expected to be compliant to SMPTE ST 2110-21 with either N, NL or W profile. A stream will be analyzed with a test and measurement device to validate conformance.
Validation Method: The generated essence stream will be analyzed for good behavior according to the network compatibility model and the virtual receive buffer model. The stream will be analyzed online. It can also be analyzed offline with a network capture. If the SDP object includes the announcement of the Media Type Parameter TR_{OFFSET}, it will be considered in the VRX results analysis.

Maximum allowable C_{MAX} and VRX_{FULL}:

V	H	T	Color	bit	C_{MAX} N	C_{MAX} W	VRX_{FULL} N	VRX_{FULL} W
1280	720	50	4:2:2	8	4	16	8	720
1280	720	60	4:2:2	8	4	16	8	720
1280	720	50	4:2:2	10	4	16	8	720
1280	720	60	4:2:2	10	4	16	8	720
1920	1080	25	4:2:2	10	4	16	8	720

1920	1080	50	4:2:2	10	4	16	8	720
1920	1080	60	4:2:2	10	5	16	8	726
1920	1080	50	4:2:2	12	5	16	8	726
3840	2160	50	4:2:2	10	17	33	26	2420
3840	2160	60	4:2:2	10	21	40	32	2904
3840	2160	120	4:2:2	10	42	80	64	5808
3840	2160	120	4:4:4	12	75	145	116	10455
3840	2160	120	4:4:4	16	100	193	154	13940

Table 1 - Informative: SMPTE ST 2110-21:2017- Jan 25th, 2019

Pass criteria:

- The test passes if the maximum level of the network compatibility model does not exceed the maximum as described in the standard for the given type of sender (N, NL, W), the maximum level of the virtual receive buffer does not exceed the value described in the standard and the virtual receive buffer does not underrun.

No pass criteria:

- The measured value exceeds the defined maximum or the virtual receive buffer underruns or If the arrival time of the first packet for each frame or field is drifting (this indicates the sender may not be locked to PTP).

4.4. RTP-Timestamp-Test

Description: A stream initiated during test 4.1. is expected to have a media clock to RTP clock offset equal zero (a=mediaclk:direct=0), The relation between the instantaneous RTP timestamp and PTP is expected to remain stable with time.

Validation Method: The instantaneous value of the RTP timestamp is analyzed by a test and measurement device and is related to the current PTP time. The instantaneous value of the RTP timestamp is expected not to be in the future, not to be more than 1 ms in the past (unless there is a clear justification for it to be off, e.g frame synchronization). It is assumed that a stream has originated in the DuT and is not being “processed”. Therefore the question of re-timestamping is not considered.

Pass criteria:

- The instantaneous value of the RTP timestamp of the stream is not in the future, not more than 1 ms in the past (unless justified), and preserves a stable relation to the PTP (should not “drift”).

No pass criteria:

- The instantaneous value of the RTP timestamp of the stream is in the future, more than 1 ms in the past (unless justified), or "drifts".

4_RX. ST 2110-20 Rx tests*

*Applicable only to DuT with video receiving capabilities

Description: This set of Tests validate basic video receiving capabilities of the DuT.

First steps: The Vendor representative is given a multicast source IPv4 address(es), port number, and video format (1080i59.94 and/or 1080p59.94). The streams will be generated by the reference sender using either GPM or BPM. It is expected that the DuT is able to receive both. Standard MTU size will always be used. The stream will be a Narrow Gapped stream. Separate testing of UHD capabilities (2160p59.94) will be executed. It will be reflected accordingly in the results spreadsheet (e.g. 4.6-UHD).

4.5. Reception of GPM and BPM streams

Description: The DuT is expected to be able to receive the streams with both BPM and GPM used.

Validation Method: The reference stream can be received by the DuT without disruptions. Two reference streams will be provided, one with GPM, one with BPM. Receivers should be able to receive both reference streams.

Pass criteria: The DuT passes the test if it is able to receive and display both streams (simultaneously, or one at a time) without disruptions. Devices which are not intended to display the stream will be allowed to suggest appropriate alternative criteria (e.g. loop it back into the network)

No pass criteria: The DuT fails the test if it is not able to receive and display either of two streams without disruptions, or suggest an appropriate alternative.

4.6. ST 2110-21 profile receiver compliance test Rx

Description: The Vendor representative is expected to set up the DuT to join a multicast group provided at the time of the test, in order to receive a stream generated by a reference sender.

Validation Method: The reference stream can be received by the DuT without disruptions. The reference stream will be of Narrow type. Receivers of any type should be able to receive this reference stream.

Pass criteria: The DuT passes the test if it is able to receive and display the stream without disruptions. Devices which are not intended to display the stream will be allowed to suggest appropriate alternative criteria (e.g. loop it back into the network)

No pass criteria: The DuT fails the test if it is not able to receive and display the stream without disruptions, or suggest an appropriate alternative.

4.7. Stream visual validation Rx

Description: the DuT is expected to be able to receive and to decode reference stream(s). A basic subjective visual test is done. The stream is expected to have no obvious visual artifacts of digital nature or any other disruptions.
Validation method: A stream is visualized using the DuT. If the DuT is not capable of reproducing the stream, it is allowed to loopback the stream back into the network and the visual test is done on a reference device. The stream will be observed for at least ~60 seconds.
Pass criteria:

- The DuT is capable of receiving a stream according to its capabilities.
- The stream can be decoded by the DuT. The video signal is free from artifacts of a digital nature or any other disruptions.
- If the stream is looped back into the network - the looped stream can be decoded by a reference receiver. The video signal is free from artifacts of a digital nature or any other disruptions.

No pass criteria:

- The stream cannot be decoded, shows visible artifacts or any other disruptions. A Vendor representative will have an opportunity to articulate why this might be ok.

5_TX. ST 2110-30 Tx tests*

Description: This set of Tests validate the basic audio transmitting capabilities of DuT.
First steps: The Vendor representative is given a multicast destination IPv4 address(es)**, port number, channel configuration**, and audio packetization parameters (packet time)**. The bit depth of the stream is always expected to be 24 bit. Standard MTU size will always be expected. DSCP values for QoS are expected to be configured according to AES67: EF(46) for PTP packets, AF41 (34) for RTP packets, DF (0) for other traffic.
*Applicable only to DuT with audio transmitting capabilities
**Depending on DuT capabilities (e.g. if a device supports the transmission of up to 8 channels with 1ms or up to 64 channels with 125 us packet time - a random number, but not more than 8 channels with either 1ms or 64 channels with 125 us packet time may be selected to be tested.

5.1. Stream - Basic Test

Description: The Vendor representative is expected to configure the DuT such that it initiates a stream of a given configuration and to a given multicast address and port number. Packets of the stream are expected to have a valid source and destination MAC and IPv4 addresses, and the DSCP values according to AES67-2018.
Validation method: the stream is analyzed in real-time (and/or captured and analyzed offline) from a mirrored port of the switch connected to the DuT. Source and destination MAC and IPv4

address as well as DSCP values are validated either by a test and measurement equipment or manually using Wireshark.

Pass criteria:

- DuT is capable of initiating a stream with given IPv4 address parameters, channel configuration, and audio packetization parameters.
- Stream uses a valid multicast MAC address.
- DSCP markings are set according to AES67.

No pass criteria:

- DuT is not capable of initiating a stream with given IP address parameters, channel configuration, and audio packetization parameters.
- Stream uses an invalid multicast MAC address.
- DSCP markings do not match AES67 requirements.

5.2. Stream - audible Validation Tx

Description: A stream initiated during test 5.1. is received with a reference receiver. A basic subjective audition test is done. The stream is expected to have no obvious audible artifacts of digital nature (pops, clicks, distortion) or any other disruptions.

Validation method: A stream is auditioned using headphones connected to a reference receiver for at least ~60 seconds. If a reference receiver is not capable of decoding the stream - a test and measurement device is used to analyze the stream.

Pass criteria:

- The stream can be received and decoded by a reference receiver and/or a majority of the test equipment. The audio signal is free from artifacts of a digital nature or any other disruptions.

No pass criteria:

- The stream cannot be decoded or has disruptions. A Vendor representative will have an opportunity to articulate why this might be ok.

5.3. RTP-Timestamp-test

Description: A stream initiated during test 5.1. is expected to have a media clock to RTP clock offset equal zero (a=mediaclk:direct=0), The relation between the instantaneous RTP timestamp and PTP is expected to remain stable with time.

Validation Method: The instantaneous value of the RTP timestamp is analyzed by a test and measurement device and is related to the current PTP time. The instantaneous value of the RTP timestamp is expected not to be in the future, not to be more than 1 ms in the past (unless there is a clear justification for it to be off, e.g frame synchronization).

Pass criteria:

- The instantaneous value of the RTP timestamp of the stream is not in the future, not more than 1 ms in the past (unless justified), and preserve a stable relation to the PTP (should not “drift”).

No pass criteria:

- The instantaneous value of the RTP timestamp of the stream in the future, more than 1 ms in the past (unless justified), or “drifts”.

5_RX. ST 2110-30 Rx tests*

Description: This set of Tests validate basic audio receiving capabilities of DuT.
First steps: The Vendor representative is given multicast source IPv4 addresses**, port number, channel configuration**, RTP payload ID, and audio packetization parameters (packet time)**. The streams will be generated by the reference sender. The bit depth of the streams is always 24 bit. Standard MTU size will always be used.

*Applicable only to DuT with audio receiving capabilities

**Depending on DuT capabilities (e.g. Level A - 1 to 8 channels with 1 ms packet time, Level B - 8 channels with 125 us packet time, Level C - 64 channels with 125 us packet time)

5.4. Stream - audible Validation Rx

Description: the DuT is expected to be able to receive and to decode reference stream(s) with the given parameters. It is expected that the DuT will either allow configuration of the incoming RTP payload ID or will promiscuously accept any incoming RTP payload ID. A basic subjective audition test is done. The stream is expected to have no obvious audible artifacts of digital nature (pops, clicks, distortion) or any other disruptions. The DuT is not expected to reproduce all channels from the stream if it is not designed to do so (e.g. a stereo-output device will be expected to receive an 8 channel stream, but output a minimum of selected 2 channels).
Validation method: A stream is auditioned using headphones connected to the DuT for ~60 seconds. If a DuT outputs audio embedded in SDI - an SDI analyzer will be used. For receivers that do not provide audio output, a Vendor representative will be allowed to suggest an alternative method to verify fidelity. The Testing team must approve any alternative methods.
Pass criteria:

- The DuT is capable of receiving streams according to its capabilities (Level A, B, or C)
- The streams can be received and decoded by the DuT. The audio signal is free from artifacts of a digital nature or any other disruptions.
- If a stream is looped back into the network - the looped stream can be decoded by a reference receiver. The audio signal is free from artifacts of a digital nature or any other disruptions.

No pass criteria:

- The stream cannot be received and decoded or has disruptions. A Vendor representative will have an opportunity to articulate why this might be ok.

6_TX. ST 2110-31 Tx tests*

Description: This set of Tests validate the capabilities of the DuT to transmit bit-transparent audio while preserving the AES3 channel status bits. All ST 2110-31 tests will be done using 24-bit PCM audio. Non-PCM formats (e.g. Dolby E) are out of the scope of these tests.
First steps: The vendor representative is given a multicast destination IPv4 address(es)**, port number, channel configuration**, and audio packetization parameters (packet time)**. The bit depth of the stream is always expected to be 32 bit (according to AM824). Standard MTU size will always be expected. The transmitter must have a bit transparent base-band interface to source the test signal (AES, MADI or SDI).
*Applicable only to DuT with audio transmitting capabilities
**Depending on DuT capabilities (e.g. if a device supports the transmission of up to 8 channels with 1ms or up to 60 channels with 125 µs packet time - a random number, but not more than 6 channels with either 1ms or 60 channels with 125 µs packet time may be selected to be tested.

6.1. Stream - Basic Test

*In case a DUT was tested for ST 2110-30, test 6.1 is skipped and the results of the 5.1. test are applied
Description: The Vendor representative is expected to configure the DuT such that it initiates a stream of a given configuration and to a given multicast address and port number. Packets of the stream are expected to have a valid source and destination MAC and IPv4 addresses.
Validation method: A stream is analyzed in real-time (and/or captured and analyzed offline) from a mirrored port of the switch connected to the DuT. Source and destination MAC and IPv4 addresses are validated either by a test and measurement equipment or manually using Wireshark.
Pass criteria:

- DuT is capable of initiating a stream with given IPv4 address parameters, channel configuration, and audio packetization parameters.
- Stream uses a valid multicast MAC address.

No pass criteria:

- DuT is not capable of initiating a stream with given IP address parameters, channel configuration, and audio packetization parameters.
- Stream uses an invalid multicast MAC address.

6.2. Stream - audible Validation Tx

Description: A stream initiated during test 6.1. is received with a reference receiver. A basic subjective audition test is done. The stream is expected to have no obvious audible artifacts of digital nature (pops, clicks, distortion) or any other disruptions.

Validation method: A stream is auditioned using headphones connected to a reference receiver for at least ~60 seconds. If a reference receiver is not capable of decoding the stream - a test and measurement device is used to analyze the stream.
Pass criteria:

- The stream can be received and decoded by a reference receiver and/or a majority of the test equipment. The audio signal is free from artifacts of a digital nature or any other disruptions.

No pass criteria:

- The stream cannot be decoded or has disruptions. A Vendor representative will have an opportunity to articulate why this might be ok.

6.3. RTP-Timestamp-test

Description: A stream initiated during test 6.1. is expected to have a media clock to RTP clock offset equal zero (a=mediaclk:direct=0), The relation between the instantaneous RTP timestamp and PTP is expected to remain stable with time.
Validation Method: The instantaneous value of the RTP timestamp is analyzed by a test and measurement device and is related to the current PTP time. The instantaneous value of the RTP timestamp is expected not to be in the future, not to be more than 1 ms in the past (unless there is a clear justification for it to be off, e.g frame synchronization).
Pass criteria:

- The instantaneous value of the RTP timestamp of the stream is not in the future, not more than 1 ms in the past (unless justified), and preserve a stable relation to the PTP (should not “drift”).

No pass criteria:

- The instantaneous value of the RTP timestamp of the stream in the future, more than 1 ms in the past (unless justified), or “drifts”.

6.4. Bit-Transparency-test

*Test 6.4 is only applicable to the devices that pass the ST 2110-31 streams from the baseband into IP. In case a DUT does not have any baseband connectivity, test 6.4 is not applicable.
Description: A stream initiated during test 6.1 is expected to have an audio encoding according to AM824, including AES3 channel status bits.
Validation Method: The DuT will be provided with a 32-bit test signal (AES3, either natively or embedded in MADI or SDI, depending on the capabilities of the DuT). The stream generated by the DuT will be received by the reference receiver and converted bit-transparently into MADI. The resulting AES3 bitstream will be analyzed with a Bit Scope and compared to the test signal.
Pass criteria:

- The reference receiver can receive the stream properly and generate a valid AES3 signal from it without altering any data.
- Bit Scope analysis shows valid AES3 user bits and audio on all 24 remaining bits.

No pass criteria:

- It is not possible to re-generate a valid AES3 signal from the incoming stream.
- Bit Scope analysis shows invalid AES3 channel status data.

6_RX. ST 2110-31 Rx tests*

Description: This set of Tests validate bit-transparent audio receiving capabilities of DuT.
First steps: The DuT must provide a bit-transparent baseband interface, such as AES3, MADI or SDI. The Vendor representative is given a multicast source IPv4 address(es), port number, channel configuration**, audio packetization parameters (packet time)**, and the RTP payload ID. The streams will be generated by the reference sender. The bit depth of the stream is always 32 bit (according to AM824). Standard MTU size will always be used.
*Applicable only to DuT with audio receiving capabilities
**Depending on DuT capabilities (e.g. Level A - 6 channels with 1 ms packet time, Level B - 8 channels with 125 us packet time, Level C - 60 channels with 125 us packet time)

6.5. Stream - audible Validation Rx

Description: The DuT is expected to be able to receive and to decode reference stream(s). It is expected that the DuT will either allow configuration of the incoming RTP payload ID or will promiscuously accept any incoming RTP payload ID. A basic subjective audition test is done. The stream is expected to have no obvious audible artifacts of digital nature (pops, clicks, distortion) or any other disruptions. The DuT is not expected to reproduce all channels from the stream if it is not designed to do so (e.g. a stereo-output device will be expected to receive a 6 channel stream, but output a minimum of selected 2 channels).
Validation method: A stream is auditioned using headphones connected to the DuT for at least ~60
seconds. If a DuT outputs audio embedded in SDI - an SDI analyzer will be used. For receivers that do not provide audio output, a Vendor representative will be allowed to suggest an alternative method to verify fidelity. The Testing team must approve any alternative methods.
Pass criteria:

- The DuT is capable of receiving a stream according to its capabilities (Level A, B, or C)
- The stream can be decoded by the DuT. The audio signal is free from artifacts of a digital nature or any other disruptions.
- If the stream is looped back into the network - the looped stream can be decoded by a reference receiver. The audio signal is free from artifacts of a digital nature.

No pass criteria:

- The stream cannot be decoded or has disruptions. A Vendor representative will have an opportunity to articulate.

6.6. Bit transparency validation Rx

*Test 6.6 is only applicable to the devices that pass the ST 2110-31 streams from IP intro baseband. In case a DUT does not have any baseband connectivity, test 6.6 is not applicable.

Description: The DuT is expected to receive the reference stream and generate a valid AES3 compliant signal with unaltered channel status data from it. The AES3 signal may be embedded in MADI or SDI, depending on the capabilities of the DuT.

Validation method: The re-generated base-band signal is converted to MADI without altering the data and measured with a Bit Scope.

Pass criteria:

- The re-generated base-band signal is detected as a valid AES3 signal with 24-bit audio and contains correct channel status information.

No pass criteria:

- The re-generated base-band signal is not decodable as a valid AES3 signal.
- Bit Scope measurement shows incorrect channel status information.

7_TX. ST 2110-40 Tx tests*

Description: This set of Tests is expected to validate the basic ancillary data transmitting capabilities of the DuT. The actual services used during the tests will be provided at a later stage.

First steps: The Vendor representative is given a multicast destination IPv4 address(es) and a port number. Standard MTU size will always be expected.

*Applicable only to DuT with ancillary data transmitting capabilities

** 1080i59.94 stream will be used for this test

7.1. Stream -40 validation Tx

Description: The Vendor representative is expected to be able to configure the DuT such that it initiates a valid ancillary data stream with a given multicast address and port number. The Vendor representative will announce the used DID/SDIDs values to the testing team. It is suggested, but not required, to fulfill the requirement by transmitting 6101 North American closed captioning data for 1080i59.94 “NTSC” frame rates, or 4302 OP47 Teletext subtitling data for 1080i50 “PAL” frame rates.

Validation Method:

- The ancillary data stream is received by a T&M device to validate the stream.

Pass criteria:

- The stream contains the DID/SDIDs matching prior Vendor representative’s description
- The stream uses legal values for all SDI line and sample fields
- The stream uses the 'marker' and 'field' bits correctly for the intended video standard
- The stream payload errors are not detected

No pass criteria:

- The stream DID/SDIDs values do not match prior Vendor representative’s description

- The stream does not use legal values for all SDI line and sample fields
- The stream does not use the 'marker' and 'field' bits correctly for the intended video standard
- The stream payload errors are detected

7.2 RTP Timestamp Test

Description: A stream initiated during test 7.1 is expected to have a media clock to RTP clock offset equal to zero (a=mediaclk:direct=0). The relation between the instantaneous RTP timestamp and PTP is expected to remain stable with time.
Validation Method: The instantaneous value of the RTP timestamp is analyzed by a test and measurement device and is related to the current PTP time. The instantaneous value of the RTP timestamp is expected not to be in the future, nor to be more than 35 milliseconds in the past.
Pass Criteria:

- The instantaneous values of the RTP timestamps of the stream are not in the future relative to PTP-locked packet capture time, are not more than 35 milliseconds in the past, and preserve a stable relation to PTP over the course of the capture (should not “drift”).

No Pass Criteria:

- The instantaneous value of the RTP timestamps in the stream are in the future relative to PTP-locked packet capture time, are more than 35 milliseconds in the past, or drift over the course of the capture.

7_RX. ST 2110-40 Rx tests*

Description: This set of Tests validate basic ancillary data receiving capabilities of DuT. The actual services used during the tests will be provided at a later stage.
First steps: A Vendor representative is given a multicast IPv4 address(es) and a port number of a valid ancillary data stream. Standard MTU size will always be used.
*Applicable only to DuT with ancillary data receiving capabilities
** 1080i59.94 stream will be used for this test

7.3. Stream -40 validation Rx

Description: The Vendor representative is expected to configure the DuT to join a SMPTE ST 2110-40 stream generated by a reference sender. It is expected that the DuT will either allow configuration of the incoming RTP payload ID or will promiscuously accept any incoming RTP payload ID. A single source multicast stream will be provided that contains 6101 North American closed captions (CTA-608/708) with actual text in them, plus at least one other 'surprise' DID/SDID.
Validation Method: the DuT is expected to demonstrate at least one of the following features:

- Display the text of the closed captions on a monitoring terminal or video overlay.
- Output the ANC packets into SDI video where they can be read back correctly by an SDI analyzer such as Tektronix.

- Provide a "packet list" display that at a minimum shows the list of DID/SDIDs found in the multicast and the line number settings for each.

Pass criteria:

- the DuT is capable of receiving and decoding an ancillary data stream with either of the features described in the Validation Method without disruptions.

No pass criteria:

- the DuT is not capable of receiving and decoding an ancillary data stream with either of the features described in the Validation Method or demonstrates disruptions.

8. ST 2022-7 tests*

Description: This set of tests validates that the DuT is able to properly transmit and receive redundant (Red path and Blue path) video (-20), audio (-30) and/or ancillary (-40) streams according to the SMPTE ST 2022-7**.** This test will be applied to all devices with respected 2022-7 capabilities alongside the basic essence tests (4_TX, 4_RX, 5_TX, 5_RX and/or 6_TX,6_RX).
First steps: a Vendor representative is given a set of multicast IPv4 addresses and port numbers. The DuT will be expected to initiate or receive a ST 2022-7 compliant redundant stream with a given set of parameters. The essence type will be picked according to the type of tests performed alongside (4_TX, 4_RX, 5_TX, 5_RX or 6_TX,6_RX). It is expected that the DuT has no multicast IP addressing limitations when receiving or generating ST 2022-7 streams (within the limits of the tests 2.8 and 2.9 and independently for both interfaces)
*Applicable only to DuT with -20, -30 and/or -40 capable devices with 2022-7 functionality

8.1. Stream - Basic Redundancy Test Tx*

Description: This test validates that the DuT is able to properly transmit redundant (Red path and Blue path) video (-20), audio (-30) and/or ANC (-40) ST2022-7 streams**.** The DuT is expected to be able to initiate a redundant stream with different destination multicast IPv4 and MAC addresses on Red Path and Blue Path. The unicast source IPv4 and MAC addresses of the Red Path and Blue Path are expected to be different.
Validation Method: The Red and Blue streams generated by the DuT will be analyzed with a T&M device and/or received by a reference receiver(s) to determine if both streams are compliant with ST 2110-20, -30 or -40, depending on the essence under test.
Pass criteria:

- It is possible to independently assign destination multicast IPv4 addresses on both interfaces within the limits of the tests 2.8 or 2.9.
- The DuT is able to initiate a valid redundant stream with different destination multicast IPv4 and MAC addresses on Red Path and Blue Path.
- The unicast source IPv4 and MAC addresses of the Red Path and Blue Path are different.

No pass criteria:

- It is not possible to independently assign destination multicast IPv4 addresses on both interfaces within the limits of the tests 2.8 or 2.9.

- The DuT is not able to initiate a valid redundant stream with different destination multicast IPv4 and MAC addresses on Red Path and Blue Path.
- The unicast source IPv4 and MAC addresses of the Red Path and Blue Path are the same.

*Applicable only to DuT with -20, -30 and/or -40 senders with 2022-7 capability

8.2. Stream - Basic Redundancy Test Rx*

Description: This test validates that the DuT is able to properly receive redundant (Red path and Blue path) video (-20), audio (-30) and/or ANC (-40) ST2022-7 streams with different source, multicast, IPv4 and MAC addresses on Red Path and Blue Path initiated by a reference sender**.** The unicast source IPv4 and MAC addresses of the Red Path and Blue Path will be different. The DuT is expected to have different unicast IPv4 and MAC addresses on redundant ports.

Validation Method: One of the switch interfaces, to which the DuT is connected, is disabled (logically, not physically). It is expected that DuT will demonstrate no disruption in the stream reproduction. Visual reporting, video/audio output and/or logging of the DuT will be used to validate proper redundant stream receiving. The MAC address table of a switch is used to validate if redundant ports of the DuT have different MAC addresses.

Pass criteria:

- It is possible to independently assign source multicast IPv4 addresses on both interfaces within the limits of the tests 2.8 or 2.9.
- The DuT Receiver is able to properly receive a redundant (Red Path and Blue Path) video, audio and/or ancillary stream with different host IPv4 addresses and multicast mac addresses without errors.
- The DuT demonstrates no disruption in the stream reproduction after losing one of the paths.
- The unicast IPv4 and MAC addresses of redundant ports of the DuT are different.

No pass criteria:

- It is not possible to independently assign source multicast IPv4 addresses on both interfaces within the limits of the tests 2.8 or 2.9.
- The DuT Receiver is not able to properly receive a redundant (Red Path and Blue Path) video, audio and/or ancillary stream with different host IPv4 addresses and multicast mac addresses.
- The DuT demonstrates disruption in the stream reproduction after losing one of the paths.
- The unicast IPv4 and MAC addresses of redundant ports of the DuT are the same.

*Applicable only to DuT with -20, -30 and/or -40 receivers with 2022-7 capability

8.3. Seamless Protection Switching Test

Description: This test validates that the DuT receiver has properly implemented Seamless Protection Switching (Hitless Protection) on ST 2022-7 redundant streams (Red path and Blue path) video (-20), audio (-30) and ancillary (-40) when both paths are impaired with a network emulator. The following impairments may be applied:

- Synchronized Alternating Loss of 25%:
    - Packet loss using RTP Sequence Number Pattern on Red Path (XXXX XXXX 00XX XXXX) and Blue Path (XXXX XXXX 11XX XXXX). This results in a 25% packet loss and ensures that different packets are dropped in each path.
    - For self-testing/independent testing - Any other method to achieve a 25% synchronized alternating packet loss may be used.
- Differential Latency with Synchronized Alternating Loss of 25%
    - Packet loss using RTP Sequence Number Pattern on Red Path (XXXX XXXX 00XX XXXX) and Path 2 (XXXX XXXX 11XX XXXX) with Delay of 150us in Blue Path. This results in a 25% packet loss, ensures that different packets are dropped in each path and provides a delta delay of 150us between paths.
    - For self-testing/independent testing - Any other method to achieve 25% synchronized alternating packet loss and a delta delay of 150us between paths may be used.
- Differential Latency and Packet Delay Variation (PDV/Jitter) with Synchronized Alternating Loss of 25%.
    - Packet loss using RTP Sequence Number Pattern on Red Path (XXXX XXXX 00XX XXXX) and Blue Path (XXXX XXXX 11XX XXXX) with Delay of 90us and Jitter (Non-Reordering) of 60us. This results in a 25% packet loss, ensures that different packets are dropped in each path and provides a delta delay of 150us and Jitter of 60us between paths.
    - For self-testing/independent testing - Any other method to achieve 25% synchronized alternating packet loss, a delta delay of 150us between paths and a non-reordering jitter of 60 us may be used.

Informative:

As with the rest of the test plan, a participant must self-test their RX DuT with any test case that demonstrates ST 2022-7 functionality. A test case that demonstrates ST 2022-7 functionality is a test case that causes dropped packets on both links and the same RTP sequence number is not dropped on both links. The possible tests that can be executed with any network emulator include but are not limited to:

- *The "zebra" pattern explained above*
- *Alternate dropping a frame on each link*
- *Dropping all the RTP marker packets on Red Path and dropped some non-marked packets on the Blue Path*
- *Dropping 3 packets on Red Path, then 6 packets on Blue Path, then repeat*
- *Dropping 11 packets on Red Path then 22 packets on Blue Path, then repeat*
- *Dropping packets on Red Path for 10 seconds and then dropping packets on Blue Path for 10 seconds*

During the on-site validation the following tests will be applied given the availability of specialized equipment:

8.3.1 Synchronized Alternating Burst Loss of 25%.

8.3.2 Differential Latency with Synchronized Alternating Burst Loss of 25%.

8.3.3 Differential Latency and Packet Delay Variation (PDV/Jitter) with Synchronized Alternating Burst Loss of 25%.

Test #	Sync Burst Loss (Continuous)	Path 1 RTP Seq Number Pattern	Path 2 RTP Seq Number Pattern	T1	Imp	T2	Imp	T3	Imp	Drop Now (Pkts) Red Path	Delay (us) Blue Path	PDV (us) Blue Path NRO Peak
8.3.1B	25%	XXXX XXXX 00XX XXXX	XXXX XXXX 11XX XXXX	5s	no	10s	dec	10s	no	1000		
8.3.2 B	25%	XXXX XXXX 00XX XXXX	XXXX XXXX 11XX XXXX	5s	no	10s	dec	10s	no	1000	150	
8.3.3B	25%	XXXX XXXX 00XX XXXX	XXXX XXXX 11XX XXXX	5s	no	10s	dec	10s	no	1000	90	60

Table 2 - Informative: Sample of the Network Emulator Setup used on site

Informative:

Testing for loss of ancillary data will be performed during on-site validation using a special closed caption pattern with densely packed text data to make it easier to see any discontinuities in the receiver output using only a standard on-screen caption decoder (IP or SDI). Sample clips demonstrating this data will be made available to participants ahead of the test. However, in self-test vendors may use any ancillary packet data stream along with a method that will reliably detect discontinuities in this data stream.

Validation Method: Where available/applicable - video/audio/ancillary output will be observed to validate a proper implementation of Seamless Protection Switching (Hitless Protection) of redundant ST 2022-7 streams. Visual reporting and/or logging of the DuT may also be used.

Pass criteria:

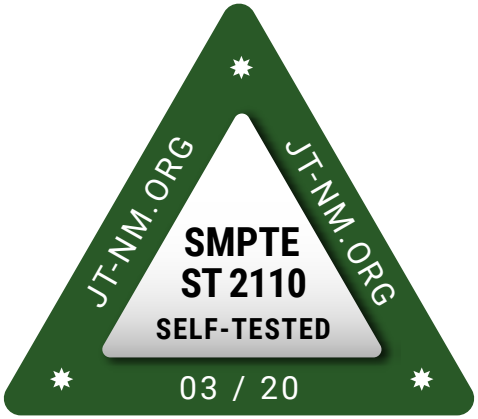
- The DuT receiver is able to properly and without any disruption receive a redundant ST 2022-7 streams with test conditions 8.3.1, 8.3.2 and 8.3.3

No pass criteria:

- The DuT receiver is not able to properly receive redundant ST 2022-7 streams with test conditions 8.3.1, 8.3.2 and 8.3.3 without errors (video artifacts, audio artifacts and/or loss of ancillary data) or any other disruption.

Appendix

JT-NM Tested March 2020 – SMPTE ST 2110 Self-Testing Results



Self-Tested Results

For the first time, this catalog includes Self-Tested results, and, for vendors who submitted their own test results, JT-NM has created a Self-Tested badge. The JT-NM was unable to hold a planned face-to-face meeting in March of 2020 where vendor-submitted tests could be validated. We decided to modify our program so that vendors who self-tested their products in accordance with the JT-NM Tested test plans could submit their results for publication in this catalog. JT-NM is responsible for the development and publication of the test plans. Vendors are solely responsible for any representations they have made in the self-tested results they have submitted; JT-NM is simply reprinting the submitted results in this catalog.

JT-NM Tested Results

For NMOS Controllers, the JT-NM Test Team was able to independently validate the vendor submitted test results using a Virtual Private Network and a lab at CBC/Radio Canada. In the case of these controller tests, the JT-NM is responsible for development and publication of the controller test plan, and also for validating vendor results included in this catalog.

JT-NM Tested March 2020 – SMPTE ST 2110 Self-Testing Results

Device Under Test							1. General Network Interface Tests						2. Media Network Related Tests																	3. ST 2110-10 Tests				4. ST 2110-20 Tests																			
Vendor Name	Model	HW version	SW Version	Format: HD / UHD / N/A	Tx, Rx, Tx/Rx	Video Only, Audio Only, Full	1.1 Management Network Interface Test	1.1.1 Ping Respons	1.1.2 TTL > 16	1.2 Media Network Interface Test	1.2.1 Ping Respons	1.2.1 TTL > 16	2.1 Basic PTP configuration Test	2.1.1 Ping Respons to dedicated PTP port	2.1.2 Set PTP Domain	2.1.3 Lock to PTP	2.1.4 Do Not Become Master	2.1.5 Doesn't Reply to TLV Management Messages	2.2 Manual PTP configuration Test	2.2.1 Ping Respons to dedicated PTP port	2.2.2 Set PTP Profile	2.2.3 Lock to PTP	2.3 BMCA Master/Slave test	2.8 Basic Multicast Configuration test	2.8.1 The DUT allows independent configuration of source and destination Mcast addresses	2.8.2 The SMPTE ST 2022-7 DUT allows independent configuration of source and destination Mcast addresses	2.9 Extended Multicast Configuration test	2.9.1 The DUT allows independent configuration of source and destination Mcast addresses	2.9.2 The SMPTE ST 2022-7 DUT allows independent configuration of source and destination Mcast addresses	3.1 IGMPv3 test for a receiver	3.2 SDP verification for a sender	3.2.1 Tx provides an SDP	3.2.2 SDP is validaded with SDPoker and correct	4.1 Stream Basic text Tx	4.1.1 Stream Present?	4.1.2 Multicast Address Correct?	4.1.3 Video Format Correct?	4.2 Stream Visual Validation Tx	4.2.1 Decoded by Reference Rx	4.2.2 No visible Errors	4.2.3 No errors reported by PRISM	4.3 SMPTE ST 2110-21 profile sender compliance test Tx	4.3.1 Network Compatibility Model (Cmax)	4.3.2 Virtual Receiver Buffer (VRX)	4.4 RTP Timestamp test Tx	4.4.1 RTP timestamp isbetween -1ms and 0ms	4.4.2 RTP timestamp is not drifting	4.6 SMPTE ST 2110-21 profile receiver compliance test Rx	4.6.1 Receive Stream	4.6.2 Display Stream	4.7 Stream Visual Validation Rx	4.7.1 Receive Stream	4.7.2 Video is free of artifacts
Axon	NPG1600	0.2	2.7.4	HD	1. Tx/Rx	1. Full																																															
Adeas/Nextera	SDI IP Gateway	v3.0	v3.1	HD/UHD	1. Tx/Rx	1. Full																																															
Cobalt Digital	9904-UDX-4K-IP	N/A	160	HD	1. Tx/Rx	1. Full																																															
Dalet	Brio	N/A	3,19	HD/UHD	1. Tx/Rx	1. Full																																															
DELTACAST	DELTA-ip ST2110	20022601	6,15	HD	1. Tx/Rx	1. Full																																															
EVS	XT-VIA	6.2	Muticam 16.3	HD	1. Tx/Rx	1. Full																																															
Evertz	Scorpion	Scorpion	102	HD/UHD	1. Tx/Rx	1. Full																																															
Evertz	670	670IPG	1346-F	HD/UHD	1. Tx/Rx	1. Full																																															
Grass Valley	XIP-3901-UDC-IP	Rev AJ	1.0.0.372	HD/UHD	1. Tx/Rx	1. Full																																															
Imagine Communications	SNP	A	1.5.0.9	HD/UHD	1. Tx/Rx	1. Full																																															
Macnica ATD	EASYSS10	2.0.0	2.0.0	HD	1. Tx/Rx	1. Full																																															
Matrox	X.mio5 Q25	RevA	10.2.010	HD/UHD	1. Tx/Rx	1. Full																																															
Matrox	DSX LE5 D25	RevA	10.2.010	HD/UHD	1. Tx/Rx	1. Full																																															
Mellanox	Rivermax 1.5	ConnectX-5	1.5.13	HD/UHD	1. Tx/Rx	1. Full																																															
Mellanox	Rivermax 1.5	ConnectX-6Dx	1.5.13	HD/UHD	1. Tx/Rx	1. Full																																															
Nevion	Virtuoso MI	V1.0	V1.4	HD/UHD	1. Tx/Rx	1. Full																																															
Pebble Beach Systems	Dolphin	N/A	1.16	HD	1. Tx/Rx	1. Full																																															
Riedel (Montreal)	FusioN 6B with APP ST2110-SDI Gateway	200	3.0	HD/UHD	1. Tx/Rx	1. Full																																															
Riedel (Montreal)	FusioN 3B with APP ST2110-SDI Gateway	200	3.0	HD/UHD	1. Tx/Rx	1. Full																																															
Riedel (Montreal)	MuoN B with APP SDI-ST2110 Gateway	200	3.0	HD/UHD	1. Tx/Rx	1. Full																																															
Sony	NXLK-IP50Y Series	2.1	2.1	HD/UHD	1. Tx/Rx	1. Full																																															
Sony	HDCU-3000/5000 Series	2.5	2.5	HD/UHD	1. Tx/Rx	1. Full																																															
Sony	HDCE series	1.0	1.0	HD	1. Tx/Rx	1. Full																																															
Sony	XVS Series	3.4	3.4	HD/UHD	1. Tx/Rx	1. Full																																															
Sony	PWS-4500	2.8	2.8	HD/UHD	1. Tx/Rx	1. Full																																															
TAG - V.S	MCM-9000	N/A	4.9.72	HD/UHD	1. Tx/Rx	1. Full																																															
Telestream	PRISM 25G	MPI2-25G	2.0.2	HD	1. Tx/Rx	1. Full																																															
Telestream	PRISM 10G	MPI-10G	1.10.4	HD	1. Tx/Rx	1. Full																																															
Appear TV	SDI-TICO-HD-Enc	2.1459	v2.2.2	HD	2. Tx	1. Full																																															
MediaKind	RX1	1.1.0.36	10.5.0.2	HD	2. Tx	1. Full																																															
Net Insight AB	N640	A1	LX-users.0	HD	2. Tx	1. Full																																															
PHABRIX Ltd	SxTAG - Encap	1 ID11.0	2	HD	2. Tx	1. Full																																															
Riedel (Montreal)	MuoN A10 with APP SDI-ST2110-2E Gateway	100	3.3	HD	2. Tx	1. Full																																															
Appear TV	IP-2110-Encoder	3.1635	v1.0	N/A	3. Rx	1. Full																																															
Bridgetech	VB440 100G	1.1	6.0.1	N/A	3. Rx	1. Full																																															
EVS	XS-NEO	PMR 1.0	1,2	N/A	3. Rx	1. Full																																															
Grass Valley	Kaleido IP	N/A	11.1.0	HD	3. Rx	1. Full																																															
MediaKind	MKEL	N/A	11.8	N/A	3. Rx	1. Full																																															
Net Insight AB	N640	A1	LX-users.0	HD	3. Rx	1. Full																																															
PHABRIX Ltd	Qx	9	3.4	HD	3. Rx	1. Full																																															
PHABRIX Ltd	SxTAG - Decap	1 ID11.0	2	HD	3. Rx	1. Full																																															
Riedel (Montreal)	MuoN A10 with APP SDI-ST2110-2D Gateway	100	3.3	HD	3. Rx	1. Full																																															
Synamedia	VDCM-K9	VN-NODE-M	17.0.3	HD	3. Rx	1. Full																																															
EVS	DYVI PMY	G4	2.0.7	HD	1. Tx/Rx	2. Video Only																																															
EEG	Alta	2	2.40	N/A	1. Tx/Rx	4. ANC Only																																															
Calrec Audio	Type-R	N/A	v1.3	N/A	1. Tx/Rx	3. Audio Only																																															
Calrec Audio	ImPulse	N/A	v1.0	N/A	1. Tx/Rx	3. Audio Only																																															
DirectOut GmbH	MONTONE.42	1,1	HW 4.5 / SW 4.23	N/A	1. Tx/Rx	3. Audio Only																																															
DirectOut GmbH	PRODIGY RAV.IO	1,1	HW 0.13 / SW 0.17	N/A	1. Tx/Rx	3. Audio Only																																															
Merging Technologies	ZMAN	Rev.C (module)	1.1	N/A	1. Tx/Rx	3. Audio Only																																															
Riedel Communications	Artist 1024	D11	8.0.11	N/A	1. Tx/Rx	3. Audio Only																																															
Riedel Communications	Artist 32/64/128	10.03	8.0.11	N/A	1. Tx/Rx	3. Audio Only																																															
Riedel Communications	RSP-1232	1	1.1.0	N/A	1. Tx/Rx	3. Audio Only																																															
Riedel (Montreal)	MuoN B with APP Audio Router	200	1.2	N/A	1. Tx/Rx	3. Audio Only																																															
Solid State Logic	HC Bridge	1.1.2.1	4.2.0.12	N/A	1. Tx/Rx	3. Audio Only																																															
Solid State Logic	SB 8.8	4.0.2.11	4.2.0.28	N/A	1. Tx/Rx	3. Audio Only																																															
Solid State Logic	A16.D16	4.0.2.11	4.2.0.28	N/A	1. Tx/Rx	3. Audio Only																																															
Solid State Logic	HC Bridge SRC	1.1.2.1	4.2.0.12	N/A	1. Tx/Rx	3. Audio Only																																															
Stage Tec	NEXUS XFIP/RIF67	4.5	4.23	N/A	1. Tx/Rx	3. Audio Only																																															

LEGEND

Green square = test passed

Grey square = test failed or not tested

White square = test not applicable

JT-NM Tested March 2020 – SMPTE ST 2110 Self-Testing Results

Device Under Test						
Vendor Name	Model	HW version	SW Version	Format: HD / UHD / N/A	Tx, Rx, Tx/Rx	Video Only, Audio Only, Full
Axon	NPG1600	0.2	2.7.4	HD	1. Tx/Rx	1. Full
Adeas/Nextera	SDI IP Gateway	v3.0	v3.1	HD/UHD	1. Tx/Rx	1. Full
Cobalt Digital	9904-UDX-4K-IP	N/A	160	HD	1. Tx/Rx	1. Full
Dalet	Brio	N/A	3,19	HD/UHD	1. Tx/Rx	1. Full
DELTACAST	DELTA-ip ST2110	20022601	6,15	HD	1. Tx/Rx	1. Full
EVS	XT-VIA	6.2	Muticam 16.3	HD	1. Tx/Rx	1. Full
Evertz	Scorpion	Scorpion	102	HD/UHD	1. Tx/Rx	1. Full
Evertz	670	670IPG	1346-F	HD/UHD	1. Tx/Rx	1. Full
Grass Valley	XIP-3901-UDC-IP	Rev AJ	1.0.0.372	HD/UHD	1. Tx/Rx	1. Full
Imagine Communications	SNP	A	1.5.0.9	HD/UHD	1. Tx/Rx	1. Full
Macnica ATD	EASYSS10	2.0.0	2.0.0	HD	1. Tx/Rx	1. Full
Matrox	X.mio5 Q25	RevA	10.2.010	HD/UHD	1. Tx/Rx	1. Full
Matrox	DSX LE5 D25	RevA	10.2.010	HD/UHD	1. Tx/Rx	1. Full
Mellanox	Rivermax 1.5	ConnectX-5	1.5.13	HD/UHD	1. Tx/Rx	1. Full
Mellanox	Rivermax 1.5	ConnectX-6Dx	1.5.13	HD/UHD	1. Tx/Rx	1. Full
Nevion	Virtuoso MI	V1.0	V1.4	HD/UHD	1. Tx/Rx	1. Full
Pebble Beach Systems	Dolphin	N/A	1.16	HD	1. Tx/Rx	1. Full
Riedel (Montreal)	FusioN 6B with APP ST2110-SDI Gateway	200	3.0	HD/UHD	1. Tx/Rx	1. Full
Riedel (Montreal)	FusioN 3B with APP ST2110-SDI Gateway	200	3.0	HD/UHD	1. Tx/Rx	1. Full
Riedel (Montreal)	MuoN B with APP SDI-ST2110 Gateway	200	3.0	HD/UHD	1. Tx/Rx	1. Full
Sony	NXLK-IP50Y Series	2.1	2.1	HD/UHD	1. Tx/Rx	1. Full
Sony	HDCU-3000/5000 Series	2.5	2.5	HD/UHD	1. Tx/Rx	1. Full
Sony	HDCE series	1.0	1.0	HD	1. Tx/Rx	1. Full
Sony	XVS Series	3.4	3.4	HD/UHD	1. Tx/Rx	1. Full
Sony	PWS-4500	2.8	2.8	HD/UHD	1. Tx/Rx	1. Full
TAG - V.S	MCM-9000	N/A	4.9.72	HD/UHD	1. Tx/Rx	1. Full
Telestream	PRISM 25G	MPI2-25G	2.0.2	HD	1. Tx/Rx	1. Full
Telestream	PRISM 10G	MPI-10G	1.10.4	HD	1. Tx/Rx	1. Full
Appear TV	SDI-TICO-HD-Enc	2.1459	v2.2.2	HD	2. Tx	1. Full
MediaKind	RX1	1.1.0.36	10.5.0.2	HD	2. Tx	1. Full
Net Insight AB	N640	A1	LX-users.0	HD	2. Tx	1. Full
PHABRIX Ltd	SxTAG - Encap	1 ID11.0	2	HD	2. Tx	1. Full
Riedel (Montreal)	MuoN A10 with APP SDI-ST2110-2E Gateway	100	3.3	HD	2. Tx	1. Full
Appear TV	IP-2110-Encoder	3.1635	v1.0	N/A	3. Rx	1. Full
Bridgetech	VB440 100G	1.1	6.0.1	N/A	3. Rx	1. Full
EVS	XS-NEO	PMR 1.0	1,2	N/A	3. Rx	1. Full
Grass Valley	Kaleido IP	N/A	11.1.0	HD	3. Rx	1. Full
MediaKind	MKEL	N/A	11.8	N/A	3. Rx	1. Full
Net Insight AB	N640	A1	LX-users.0	HD	3. Rx	1. Full
PHABRIX Ltd	Qx	9	3.4	HD	3. Rx	1. Full
PHABRIX Ltd	SxTAG - Decap	1 ID11.0	2	HD	3. Rx	1. Full
Riedel (Montreal)	MuoN A10 with APP SDI-ST2110-2D Gateway	100	3.3	HD	3. Rx	1. Full
Synamedia	VDCM-K9	VN-NODE-M	17.0.3	HD	3. Rx	1. Full
EVS	DYVI PMY	G4	2.0.7	HD	1. Tx/Rx	2. Video Only
EEG	Alta	2	2.40	N/A	1. Tx/Rx	4. ANC Only
Calrec Audio	Type-R	N/A	v1.3	N/A	1. Tx/Rx	3. Audio Only
Calrec Audio	ImPulse	N/A	v1.0	N/A	1. Tx/Rx	3. Audio Only
DirectOut GmbH	MONTONE.42	1,1	HW 4.5 / SW 4.23	N/A	1. Tx/Rx	3. Audio Only
DirectOut GmbH	PRODIGY RAV.IO	1,1	HW 0.13 / SW 0.17	N/A	1. Tx/Rx	3. Audio Only
Merging Technologies	ZMAN	Rev.C (module)	1.1	N/A	1. Tx/Rx	3. Audio Only
Riedel Communications	Artist 1024	D11	8.0.11	N/A	1. Tx/Rx	3. Audio Only
Riedel Communications	Artist 32/64/128	10.03	8.0.11	N/A	1. Tx/Rx	3. Audio Only
Riedel Communications	RSP-1232	1	1.1.0	N/A	1. Tx/Rx	3. Audio Only
Riedel (Montreal)	MuoN B with APP Audio Router	200	1.2	N/A	1. Tx/Rx	3. Audio Only
Solid State Logic	HC Bridge	1.1.2.1	4.2.0.12	N/A	1. Tx/Rx	3. Audio Only
Solid State Logic	SB 8.8	4.0.2.11	4.2.0.28	N/A	1. Tx/Rx	3. Audio Only
Solid State Logic	A16.D16	4.0.2.11	4.2.0.28	N/A	1. Tx/Rx	3. Audio Only
Solid State Logic	HC Bridge SRC	1.1.2.1	4.2.0.12	N/A	1. Tx/Rx	3. Audio Only
Stage Tec	NEXUS XFIP/RIF67	4.5	4.23	N/A	1. Tx/Rx	3. Audio Only

Test group	Tests
5. ST 2110-30 Tests	5.1 Stream Basic Test Tx; 5.1.1 Stream Present; 5.1.2 Multicast Address is correct; 5.1.3 DSCP markings are set according to AES 67; 5.2 Stream Audible Validation Tx; 5.3 RTP Timestamp test Tx; 5.3.1 RTP timestamp isbetween -1ms and 0ms; 5.3.2 RTP timestamp is not drifting; 5.4 Stream Audible Validation Rx; 5.4.1 Receive Stream Level A; 5.4.2 Receive Stream Level B; 5.4.3 Receive Stream Level C; 5.4.4 No audible Artifacts on Headphones
6. ST 2110-31 Tests	6.1 SMPTE ST 2110-31 Basic Test; 6.1.1 Capable of initiating stream with given IP addresses; 6.1.2 Valid Multicast MAC address; 6.2 Stream Audible Validation Tx; 6.2.1 The stream can be received and decoded; 6.2.2 The steam is free of artifacts; 6.3 RTP-Timestamp Test; 6.3.1 RTP timestamp isbetween -1ms and 0ms; 6.3.2 RTP timestamp is not drifting; 6.4 Bit-Transparancy-test; 6.4.1 Reference receiver can receive stream properly; 6.4.2 Valid AES3 user bits and audio on all 24 remaining bits; 6.5 Stream audible Validation RX; 6.5.1 Receive Stream Level A; 6.5.2 Receive Stream Level B; 6.5.3 Receive Stream Level C; 6.5.4 Stream can be decoded and is free of artifacts; 6.5.5 Looped stream can be decoded and free of artifacts; 6.5 Bit transparancy validation RX; 6.6.1 The regenerated base-band signal is valid AES3 with 24-bit audio
7. ST 2110-40 Tests	7.1 Stream -40 validation Tx; 7.1.1 DID/SDID match expectations; 7.1.2 Legal Values for SDI line and sample fields; 7.1.3 Marker and Field bits correct for format; 7.1.4 No Stream Payload Errors; 7.2 RTP Timestamp Test; 7.3 Stream -40 Validation Rx; 7.3.1 Display Closed Caption Text; 7.3.2 Output ANC into SDI and read on Test Equipment; 7.3.3 Provide a packet list with at least DID/SDID and line numbers
8. ST 2022-7 Tests	8.1 Stream Basic Test Tx; 8.1.1 Initiate Redundant Stream; 8.1.2 Red and Blue on different MAC and IP Addresses; 8.2 Stream Basic test Rx; 8.2.1 Receive stream without artifacts; 8.2.2 Red and Blue on different MAC and IP Addresses

LEGEND

Green square = test passed

Grey square = test failed or not tested

White square = test not applicable