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SOLUTION BRIEF

How to test video to SMPTE ST 2110 using the SNE

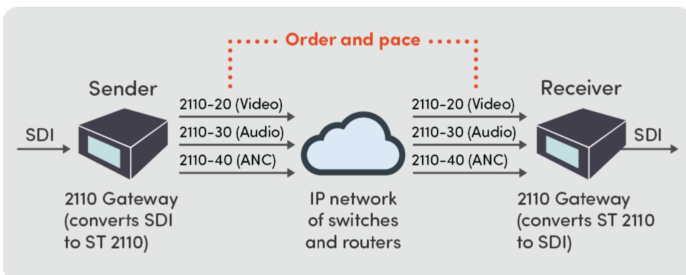
This document provides a brief overview of the SMPTE (Society of Motion Picture and Television Engineers) standards for broadcast over IP networks. It also details the various impairments that can be used when testing for ST 2110-21, and proposes a test procedure to ensure the network system meets ST 2110-21 standards.

Introduction

As the broadcast industry evolves from Serial Digital Interface (SDI) to IP, it's reasonable to expect certain challenges. IP networks are flexible and powerful but can suffer from a range of performance issues such as jitter and packet loss, which adversely affect video transmission.

For instance, for an ST 2110 deployment, how can you be certain that at the receiving end, the network stream will have the exact packet order and pace as at the transmitting end? In most cases it won't have. This doesn't mean that networks are not reliable; it just means that they need to be well designed and tested to ensure they are standards-compliant and working as expected.

Consider the following example:



In the diagram above, the cloud represents a network of switches and routers, and the 2110 gateways provide conversion from SDI to ST 2110 to pass through the IP network, and then conversion from ST 2110 back to SDI at the receiving side. All these elements require testing.

Broadcasting standards — a quick overview

ST 2110

The collection of SMPTE (Society of Motion Picture and Television Engineers) standards that form the basis of most new deployments is the ST 2110 suite (all of which are prefixed with "Professional Media Over Managed IP Networks"), which defines the ideal traffic model for broadcast over IP, as well as the performance of transmitters such as packet pacing, gaps and bursts.

SMPTE ST 2110-10 — System Timing and Definitions. Covers the system as a whole, the timing model, and common requirements (e.g. UDP datagram sizes) across all essence types.

SMPTE ST 2110-20 — Uncompressed Active Video. Deals with the transport of uncompressed active video in ST 2110 systems, using Real-time Transport Protocol (RTP).

SMPTE ST 2110-21 — Traffic Shaping and Delivery Timing for Video. Specifies the timing model for senders and receivers of video RTP streams. Testing to this standard is the main focus of this article.

SMPTE ST 2110-22 — Constant Bit-Rate Compressed Video.

SMPTE ST 2110-30 — PCM Digital Audio. Documents the use of IP-encapsulated PCM audio in a manner compatible with AES67.

SMPTE ST 2110-31 — AES3 Transparent Transport. Specifies the transport of AES3 digital audio signals.

SMPTE ST 2110-40 — Ancillary Data. Documents the transport of SMPTE ST 291-1 Ancillary Data packets using RTP over an IP network.

ST 2022

This suite of standards describes how to send video over an IP network and supports video formats including MPEG-2 and SDI.

SMPTE ST 2022-1 — Forward Error Correction (FEC) for Real-Time Video/Audio Transport Over IP Networks. FEC enables the recovery of a single lost packet or a short burst of lost packets. *This can be tested using the SNE's Drop Packets impairment which allows you to "drop X packets in every Y packets" (or drop packets as a percentage or according to the 2-state Markov chain model).*

SMPTE ST 2022-2 — Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks. Sometimes paired with ST 2022-1 Forward Error Correction, this standard usually concerns ASI (Asynchronous Serial Interface) over IP, though it could equally apply to SDI over IP.

SMPTE ST 2022-6 — Transport of High Bit Rate Media Signals over IP Networks (HBRMT). Concerns the packetization of the SDI signal, enabling uncompressed video to be sent over IP. Often this protocol and ST 2110 are paired with ST 2022-7 described below.

SMPTE ST 2022-7 — Seamless Protection Switching of RTP Datagrams. Defines a method to achieve redundancy through the transmission of multiple streams of identical content over separate paths in the network. If packets from one path are lost, corrupted, or the entire link goes down, the data can be reconstructed at the receiver using packets from the other stream. It's called "seamless" because the switching between streams is instantaneous and therefore has no impact on the received content.

Testing for ST 2022-7 should assess resilience to packet loss, packet corruption and link down. All of these conditions can be emulated using the SNE.

SMPTE ST 2110-21

Two main types of Sender exist — Narrow Senders and Wide Senders. These names refer to the variability of their packet pacing: Narrow Senders adhere much more tightly to narrow timing constraints, while Wide Senders can vary more widely in their packet pacing.

Narrow Senders

Narrow Senders are usually FPGA-based and are highly precise, adding a very minimal delay or jitter to the resulting IP stream. Narrow Senders can be divided into two sub-categories, namely Narrow Linear Senders (type NL) and Narrow Gapped Senders (type N — the "gapped" part is implied).

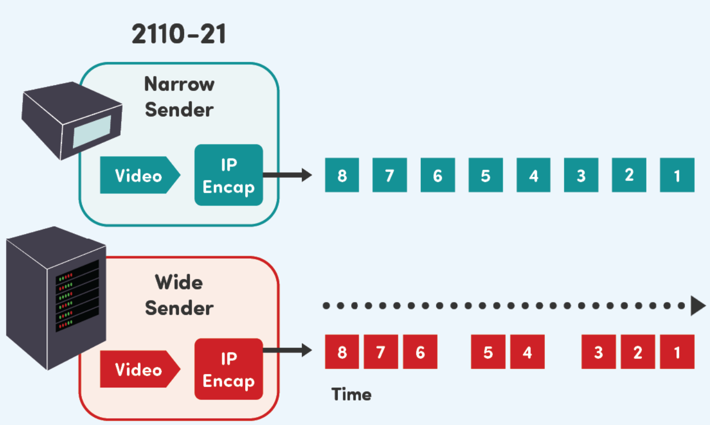
- Narrow Linear Senders space out the packets evenly, as shown on the right of the diagram below.
- Narrow Gapped Senders do not send packets during blanking so will have a short gap during which no packets are sent, as can be seen in the center-right of the diagram below.

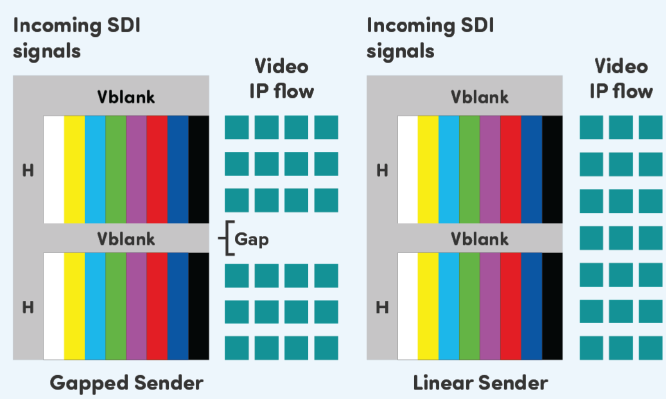
Wide Senders (type W)

A Wide Sender can comprise a regular PC with some dedicated hardware that makes it capable of handling uncompressed video. Even with the dedicated hardware however, the transmitting PC can struggle to output packets at a steady pace. This variability in the rate of transmission places greater demands on the Receiver in terms of the buffering and memory required. As such, if there is a Wide Sender anywhere in your network, you will need a corresponding Wide Receiver.

Receivers

In terms of receivers, the only classifications are Narrow or Wide. There is no distinction between linear and gapped for receivers.





Test methodology

Testing for ST 2110-21 should assess resilience to:

Delay — usually due to physical link length or processing delays introduced by network elements. Introducing delay can also be useful for testing the essences' re-alignment mechanism.

Packet loss — commonly caused by network congestion or as a result of packet corruption, since if the CRC becomes invalid, a store-and-forward switch will drop the packet.

Packet corruption — can be due to a dirty fiber or poor connection, among other causes. Cut-through switches do not perform any CRC error-checking, so error-checking needs to be performed by the receiver.

Bursty conditions — the SNE's Burst Packets mode can be very useful for testing that your buffer size is sufficient.

Reordered packets — on a LAN, the reordering of packets should be rarely seen, but over WANs there are more likely to be multiple routes that packets could take, making reordering more common.

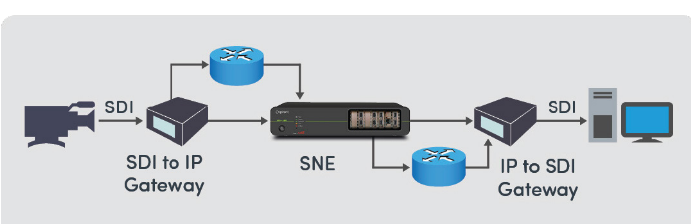
Packet duplication — may occur as a result of misconfiguration (e.g. two streams of data being sent to the same destination by mistake) or some other network issue.

Jitter and packet delay variation (PDV) — this is usually introduced as a result of traffic passing through multiple routers in transit from the source to the destination. Each router will contain some amount of buffer, and these will vary between routers in each of the network "hops".

Using the SNE to test ST 2110-21

Test system setup

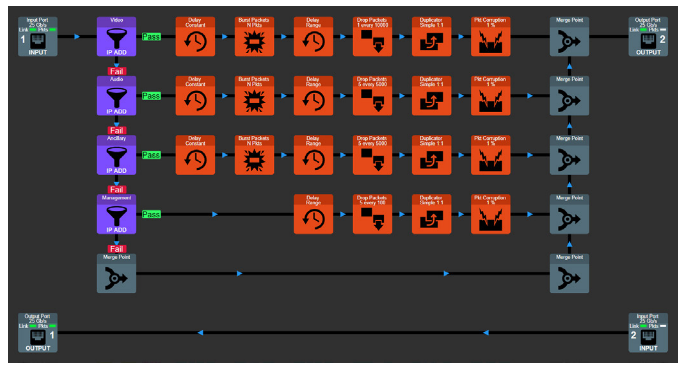
The SNE can be used to test SMPTE ST 2110-21 with a setup like the one shown below.



On the left of the diagram, a video feed converted to SDI is sent to an ST 2110 encapsulator (SDI to IP Gateway), then passes through the SNE to the ST 2110 decapsulator (IP to SDI Gateway), where it is converted back to SDI. The resulting video is displayed on a PC monitor so we can observe the effects of the impairments that we will apply with the CSNE.

Network emulation map

An example of a network emulation map that can be used to test devices to ST 2110 is shown below. (A similar map is included in the Map Templates folder on the Maps screen of the SNE Web UI.)



Packets enter via the Input Port (grey block) at the top-left of the map and the various essences are filtered into separate paths using IP Address Filters (the purple blocks). Each of the different impairments (orange blocks) can be enabled individually in each path, and after impairment, the packets from the various paths are recombined before exiting via the Output Port at the top-right. There's a return path at the bottom of the map which simply passes packets straight through in the reverse direction.

Impairment settings

Constant delay should not affect anything, so we can use almost any value by default (within reason). The choice of value for the Burst Packets impairment will depend on the settings of your receiver — some receivers will not handle packet bursts well. The value you set for Range Delay will depend on your receiver class. Packet Drop can be configured to almost anything; it really depends on the receiver and whether 2022-7 is being used (receivers that employ 2022-7 should be able to cope with any amount of packet loss). When introducing Packet Corruption, packets should be considered dropped by the MAC layer of the decapsulator/receiver, so a clear correlation should be seen between Corruption introduced and packet loss observed.

Test procedure

Start with 2022-7 disabled on the receiver and all the impairments on the network emulation map disabled (use the Group Select function in the SNE's Map Toolbar to disable or enable multiple impairments simultaneously). Then enable each impairment individually to observe the effect that each has on the video/audio/ancillary data.

When enabling the Drop Packets impairment, you will likely see that the receiver is unable to cope because there is no 2022-7 enabled. If the receiver's frame buffer is too small, the result will be very jerky or black video. Subsequently, disabling the packet drop should allow the SDI video to clear up again.

Now enable the Jitter impairment. If the SDI video starts to flicker, this indicates that the buffer is not set to a high enough value. Increasing the buffer value should result in the video becoming smooth again.

Disable the Jitter again, and this time enable the Range Delay impairment to apply a packet-by-packet delay value (in our example, this is set to range from 20µs to 10ms). Without 2022-7 enabled, this may be too much for the receiver to manage, so try enabling 2022-7 and the secondary flow should enable it to cope with this amount of Packet Delay Variation.

Suggested modifications

There is plenty of scope for expanding the example map shown above. For example, for the Packet Duplicator, we could choose only to duplicate one packet in every X packets rather than duplicating every packet. For the Management traffic we could easily introduce impairments in the reverse direction as well as the forward direction, if desired.

An alternative map could be created that filters the video, audio, and ancillary streams by UDP source port rather than IP address. This may be a little more "realistic" but would be slightly less easy to test and/or debug.

Further considerations

Other points worth considering when testing to ST 2110 include:

Test with a range of packet sizes — depending on your application, you may want to test with a range of packet sizes, perhaps including jumbo frames (e.g. for testing 4K video). The SNE fully supports the use of jumbo frames, enabling you to test to ST 2110 at packet sizes of up to 9216 bytes.

Test redundancy and resiliency of Management traffic — Management traffic is an important aspect of an ST 2110 network and should be tested. If your network uses in-band network management then this can be easily tested at the same time with the map shown above.

Test network switches and routers — all network elements may introduce some amount of delay and/or jitter, so you should also test your switches and routers. Some switches have a large, configurable buffer, so the testing is conceptually similar to receiver testing.

Free EBU LIST utility — the European Broadcasting Union (EBU) provides a free software tool to enable you to validate your ST 2110 Sender. The EBU Live IP Software Toolkit allows you to upload a packet capture from your network and will analyze it for you, including providing an indication of compliance to the SMPTE standards.

Key highlights of SNE

- 100GbE, 50GbE, 25GbE, 10GbE and 1GbE interfaces supported
- Web-based user interface
- RESTful API for easy remote control in your automation environment
- Multi-user
- Multi-port — best-in-class port density with up to 8 ports 100GbE/50GbE/25GbE, 16 Ports 10 GbE/1GbE
- Connect any-port to any-port without limitations

Over 55 impairments and tools

- Comprehensive list of dedicated impairments and filters
- AV specific tooling including:
  - MPEG corruption
  - Large buffer
  - Markov model packet loss

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