IP Test and Measurement for ST 2110 Systems

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Traditional SDI Video and Audio Test and Measurement
These displays are traditionally used by Engineers and Technical Production staff for testing SDI signals

But they are not actually testing the integrity of the SDI signal, they are testing the integrity of the colour signal forms.
Status, Eye and Jitter and timing are used to measure the integrity of the SDI signal.

But are they relevant when it comes to measuring ST 2110 sources?
Comparing SDI and IP

<table>
<thead>
<tr>
<th>Compare SDI and IP infrastructure test and measurement requirements</th>
<th>SDI</th>
<th>IP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Connectivity</strong></td>
<td>Physical Layer Coding Baseband Video</td>
<td>7 Layer OSI model</td>
</tr>
</tbody>
</table>
| **Essence** | Single essence per BNC
- 1X 1080p50 unidirectional | Multiple essence per fibre
- 100GbE > 75x 1080p50 bi-directional |
| **Measurement** | Direct Measurement | Indirect Measurement |
| **Transport** | Synchronous Transport | Asynchronous Transport |
| **Cause of Error - Occurrence** | Cable loss Connector contact failure Impedance mismatch Jitter Signal rise and fall time | Packet loss due to network overload
- Excess network traffic
- Bandwidth restrictions due to compensation technologies like FEC, ARQ and hitless protection (1+1)
Error frame discard |
| **Measurement Methods** | Monitoring Cyclic Redundancy Check (CRC) and Timing Reference Signal (TRS) errors | Monitoring Frame Check Sequences (FCS) and Cyclic Redundancy Check (CRC) |

IP Video and Audio Test and Measurement

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ST2110

- SMPTE ST 2110 (Professional Media Over Managed IP Networks)
  - ST 2110-10 (System Timing and Definitions)
  - ST 2110-20 (Uncompressed Active Video)
  - ST 2110-21 (Traffic Shaping and Delivery Timing for Video)
  - ST 2110-30 (PCM Digital Audio)
  - ST 2110-31 (AES3 Audio)
  - ST 2110-40 (Ancillary Data)
IP Measurement

- **Factors that can impact broadcast operation**
  - Packet loss due to network overload, error frame discard
  - Bandwidth restrictions due to compensation technologies like Forward Error Correction (FEC) and Automatic Repeat Query (ARQ) and hitless protection (1+1).
  - When the packet is excessively delayed, the buffer will underflow and it becomes impossible to reproduce the stream
  - PTP is not transmitted stably

- **Measuring method**
  - Frame Check Sequence (FCS), Cyclic Redundancy Check (CRC) monitoring
  - Measure the packet arrival interval and check whether the packet is being transmitted stably
  - Monitoring the stability of PTP

- **Measures**
  - Review of network system, QoS setting of switch etc.
IP Measurement

- As the IP network system becomes more complicated, it is important to monitor each service because of separation at the time of failure.

- Confirm the protocol, rate, address etc. of the received packet.

- Monitoring traffic on each input IP port, as variations might indicate a network issue.

<table>
<thead>
<tr>
<th>IP Stream</th>
<th>Input</th>
<th>Port</th>
<th>Protocol</th>
<th>Source Address Port</th>
<th>Dest. Address Port</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>1</td>
<td>Ethernet</td>
<td>192.168.1.33</td>
<td>239.192.0.100</td>
<td>PTP</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>1</td>
<td>Ethernet</td>
<td>192.168.1.33</td>
<td>239.192.0.100</td>
<td>PTP</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>1</td>
<td>Ethernet</td>
<td>192.168.1.33</td>
<td>239.192.0.100</td>
<td>PTP</td>
</tr>
</tbody>
</table>

- Max 1,500 byte

Packet Jitter Measurement

There is the possibility that an excessive packet delay occurs due to the network system and therefore the stream cannot be reproduced due to the buffer shortage of the receiver.

- By measuring the packet arrival interval, this checks whether the packet is stably transmitted.

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- By measuring the packet arrival interval, this checks whether the packet is stably transmitted.
P1 is the instantaneous latency from transmission to reception of datagrams on path number 1.

P2 is the instantaneous latency from transmission to reception of datagrams on path number 2.

P1 and P2 are inclusive of any network jitter.

PT is the latency from transmission to the final reconstructed output. It is also the latest time that a packet could arrive at the receiver to be part of the reconstructed output.

EA is the earliest time that a packet could arrive at the receiver to ensure seamless reconstruction.

MD is the maximum differential and is the difference of PT and EA.

\[
MD = (PT - EA)
\]

PD is the instantaneous path differential and is always equal to the absolute value of (P1 – P2).

\[
PD = |P1 - P2|
\]
ST 2022-7

Loss of one path
PTP synchronization

- Time synchronization of PTP is done by Sync, Follow up, Delay Request, Delay Response.
- Calculate the time difference offset assuming that the message is transmitted from the master to the slave and from the slave to the master at the same time.
- An asymmetric packet delay time occurs due to packet retention time in the switch, path change of the network, etc., so that the average transmission time fluctuates.
- Is time synchronization accuracy of less than 1 us maintained?
- Phase of PTP and video, Phase of PTP and audio are stable

\[ \text{Time Offset} = \frac{(t_2 - t_1) - (t_4 - t_3)}{2} \]

\[ \text{Delay Time} = \frac{(t_2 - t_1) + (t_4 - t_3)}{2} \]
PTP Measurement – Protocol - Messages

- **PTP(Gen)** – General (port 320)
- **PTP(Evt)** – Event (port 321)

As SMPTE ST.2110-20 contains a large volume of asynchronous data, if the network switch cannot handle this data rate, it can impact upon the propagation delay of the PTP announcements. The Time Offset and Time Delay graph display the stability of the PTP announcements.

→ In order to obtain stable PTP synchronization it is necessary to set PTP compatible network switch or QoS.
Display count of PTP messages per second

→ Confirm what message rate is being sent from the master of PTP

PTP and RTP Measurement

- PTP and RTP timing measurement
  - It can be confirmed whether video, audio and ANC signals are synchronized with PTP by comparing the time information of PTP and the time stamp
Timing Comparisons

RTP / PTP Timing - ST 2110

V Phase Delay of 21 lines is the delay between EAV and SAV.

H Phase Delay of 4.152us

<table>
<thead>
<tr>
<th>Current Phase</th>
<th>V Phase</th>
<th>H Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 Lines</td>
<td>4.152us</td>
<td>308 pixel</td>
</tr>
<tr>
<td>Total Phase</td>
<td>626.997us</td>
<td></td>
</tr>
</tbody>
</table>

Mbit
RTP / PTP Timing - ST 2110

ST 2110-20 – Timing Comparison
ST 2110-20/30 – Timing Comparison

Packet Header Information

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Packet Header Information

For packets selected in blue
Display header information in **MAC / IP / UDP / RTP / PAYLOAD**.

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Packet Header Information

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Display header information in MAC / IP / UDP / RTP / PAYLOAD.

SFP Information

Display information of SFP + transceiver module (IP 1/2)
Regarding the display colors in the frame, gray is not counted, white is no event occurrence, red is an event occurrence, green is an event in the past, it means that it has not occurred at present.
Hybrid IP and SDI Video and Audio Test and Measurement

Why do we need Hybrid Operation?

- With ST-2110, the timing information has been removed from the underlaying hardware layer making the distribution asynchronous.
- With current broadcast formats, video must be frame synchronous at the camera’s sensor and at the viewers television screen.
- The intermediate IP distribution network is asynchronous but the variance in packet jitter directly affects latency leading to potentially longer video and audio delays than we have come to expect from SDI infrastructures.
- Although uncompressed video such as that provided by ST-2110 does map to the active video parts of SDI, two major changes have occurred;
  - The PTP and SPG may or may not be the same device
  - Signal distribution in IP is asynchronous and multiplexed.
- The only way to make any meaningful comparisons between SDI and IP signals in a broadcast facility transitioning to IP is to use SDI and IP monitoring and analysis equipment that resides within the same unit.
Hybrid Operation

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Hybrid Operation

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Multi Channel - IP Operation

Questions

• Recommended Reading
  
  • Broadcast Bridge - Essential Guide - Hybrid IP and SDI Test and Measurement
Thank you

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