IP Test and Measurement for ST 2110 Systems

Kevin Salvidge – European Regional Development Manager
Leader Europe Limited

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IP SHOWCASE THEATRE AT IBC2019 : 13–17 SEPT 2019

Traditional SDI Video and Audio Test and Measurement

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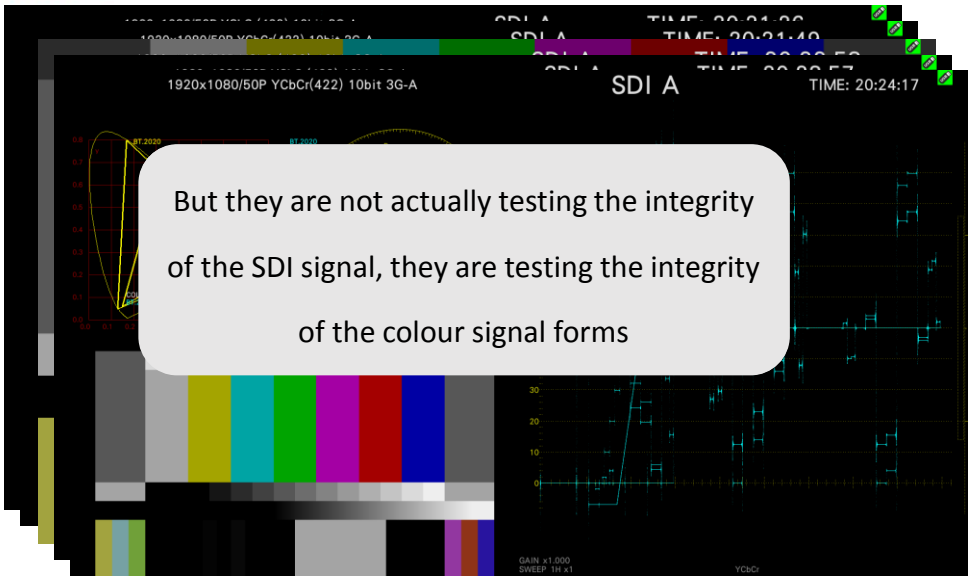
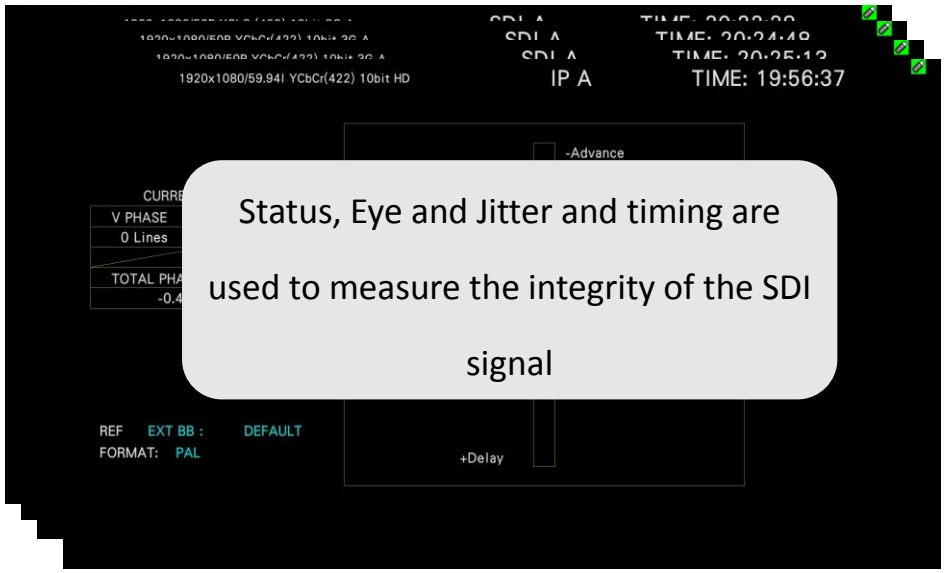
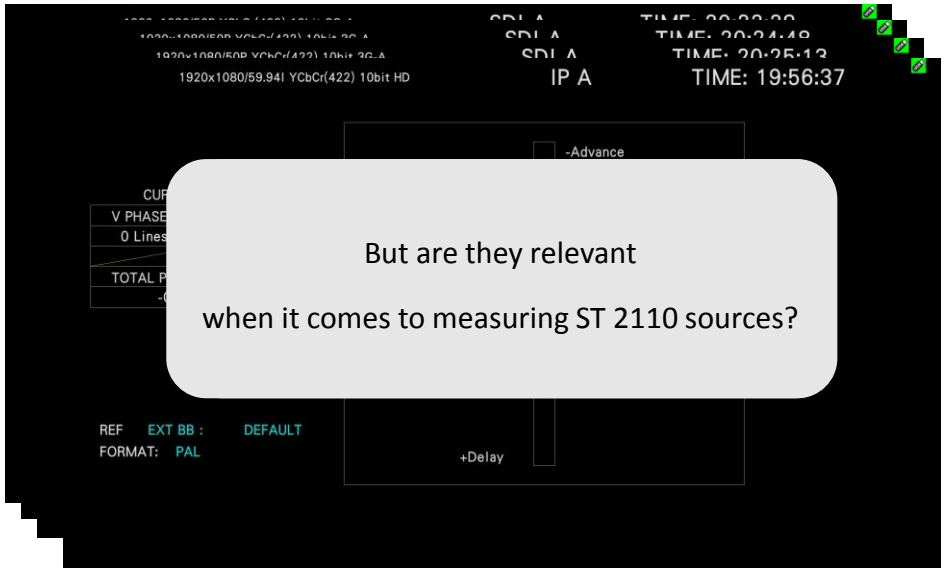
1920x1080/50P YCbCr(422) 10bit 3G-A
SDI A
TIME: 20:24:17
These displays are traditionally used by Engineers and Technical Production staff for testing SDI signals


1920x1080/50P YCbCr(422) 10bit 3G-A
SDI A
TIME: 20:24:17
But they are not actually testing the integrity of the SDI signal, they are testing the integrity of the colour signal forms


1920x1080/59.94I YCbCr(422) 10bit HD
IP A
TIME: 19:56:37
-Advance
V PHASE
0 Lines
REF EXT BB : DEFAULT
FORMAT: PAL
+Delay
Status, Eye and Jitter and timing are used to measure the integrity of the SDI signal


1920x1080/59.94I YCbCr(422) 10bit HD
IP A
TIME: 19:56:37
-Advance
V PHASE
0 Lines
REF EXT BB : DEFAULT
FORMAT: PAL
+Delay
But are they relevant
when it comes to measuring ST 2110 sources?

Comparing SDI and IP

Compare SDI and IP infrastructure test and measurement requirements		
	SDI	**IP**
Connectivity	Physical Layer Coding Baseband Video	7 Layer OSI model
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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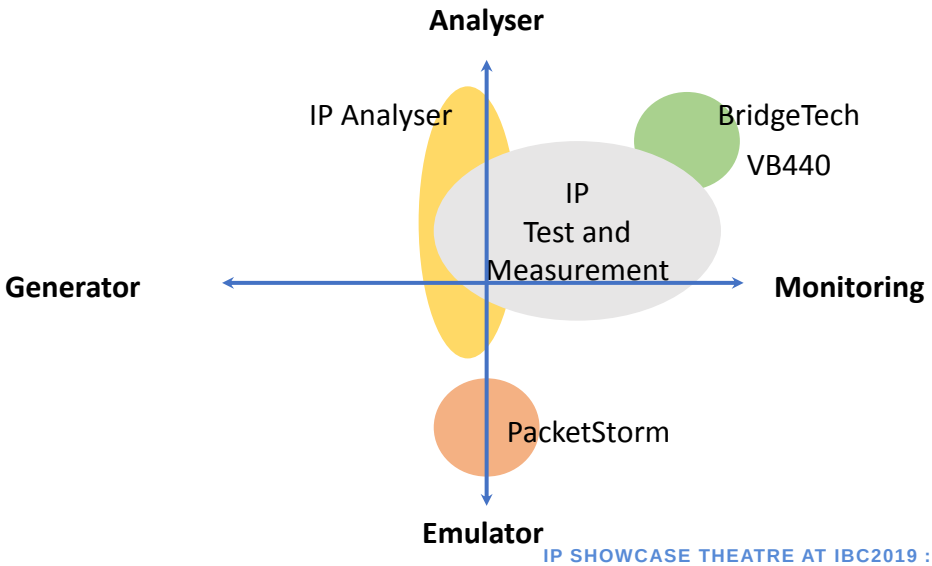
IP Video and Audio Test and Measurement

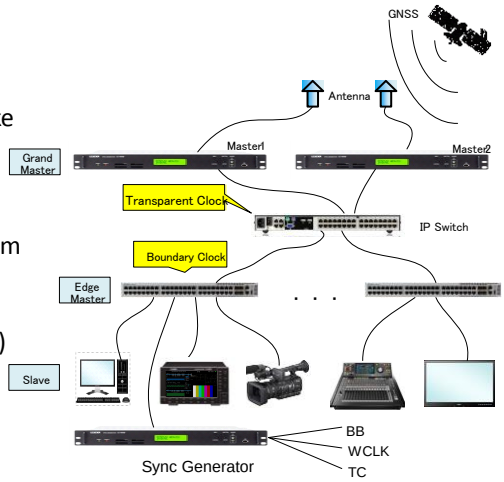


ST2110

- **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.



Packet Arrival Interval Time

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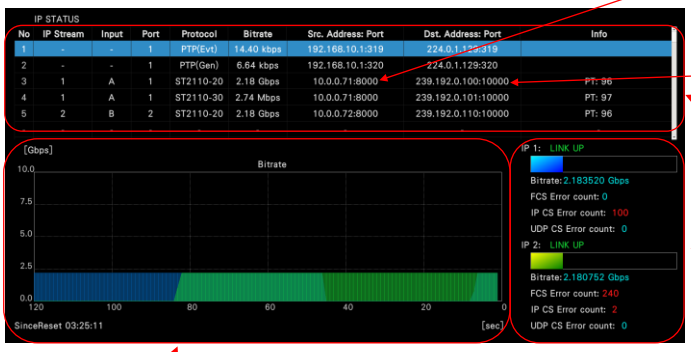
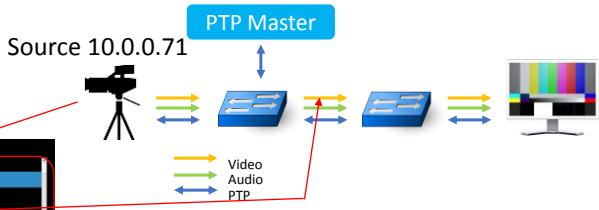
IP Measurement

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



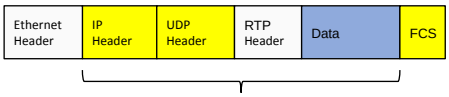
Monitoring traffic on each input IP port, as variations might indicate a network issue



Destination 239.192.0.100

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

Monitor whether errors in packets occur

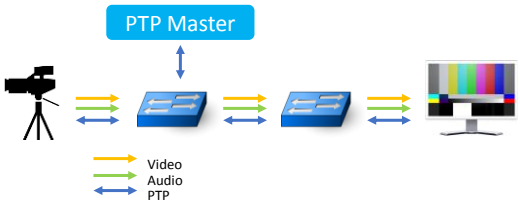


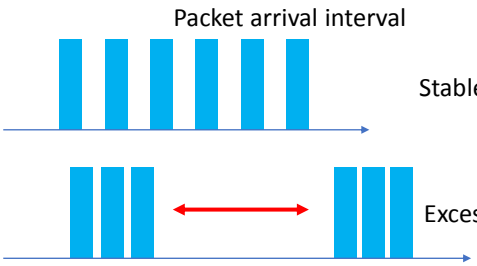
Max 1,500 byte

Packet Jitter Measurement

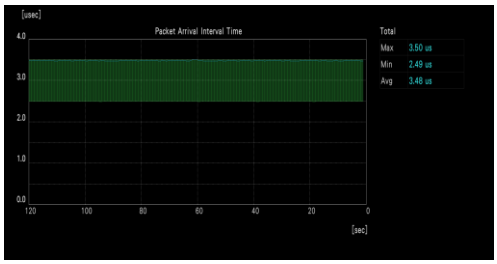
There is the possibility that an excessive packet delay occurs due to the network system and therefore the stream can not be reproduced due to the buffer shortage of the receiver.

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





Packet arrival interval time

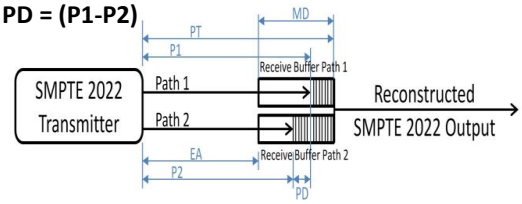


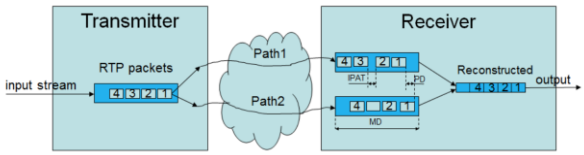
ST 2022-7

- **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**).

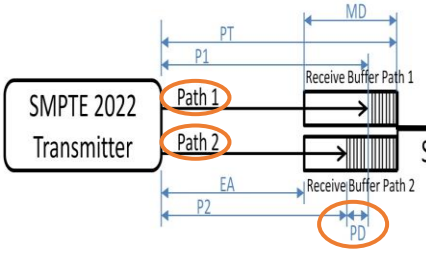
PD = (P1-P2)





ST 2022-7

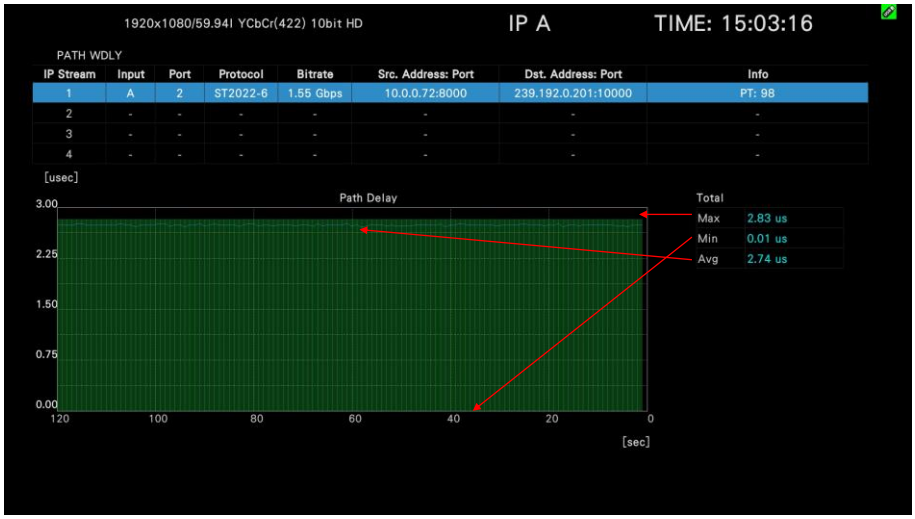
Path 1



Path Differential

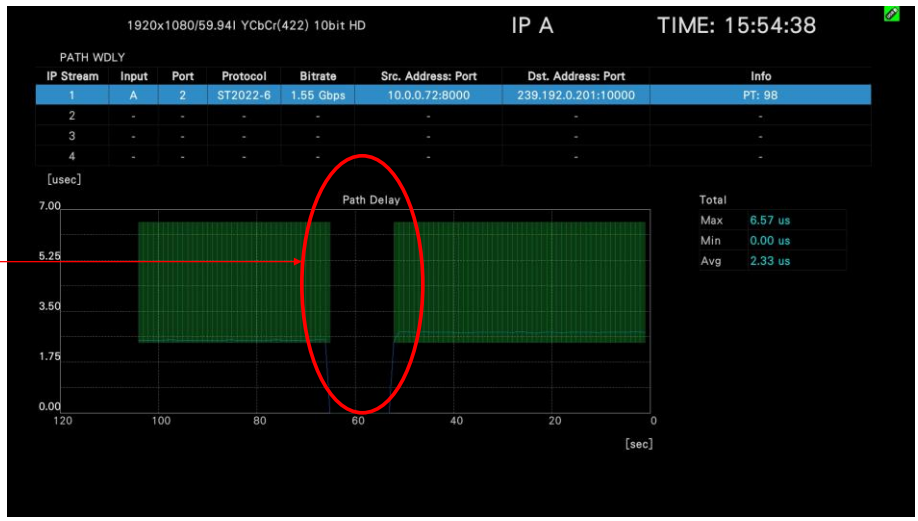
Path 2

ST 2022-7



ST 2022-7

Loss of one path



Precision Time Protocol

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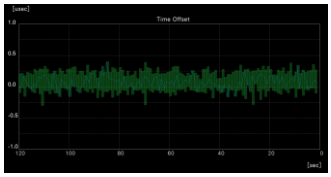
PTP Measurement

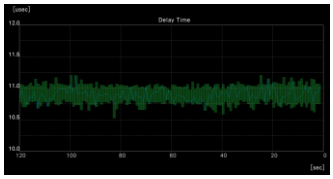
PTP synchronization

- 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.

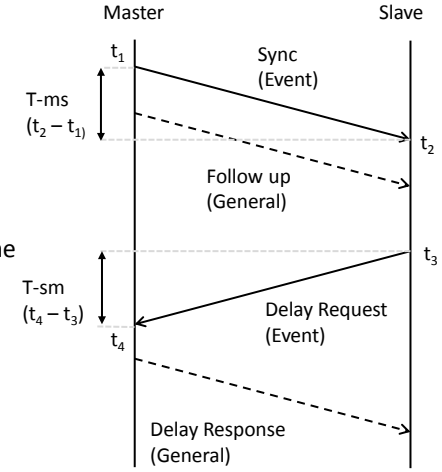
- Is time synchronization accuracy of less than 1 us maintained?
- Phase of PTP and video, Phase of PTP and audio are stable



Time Offset



Delay Time

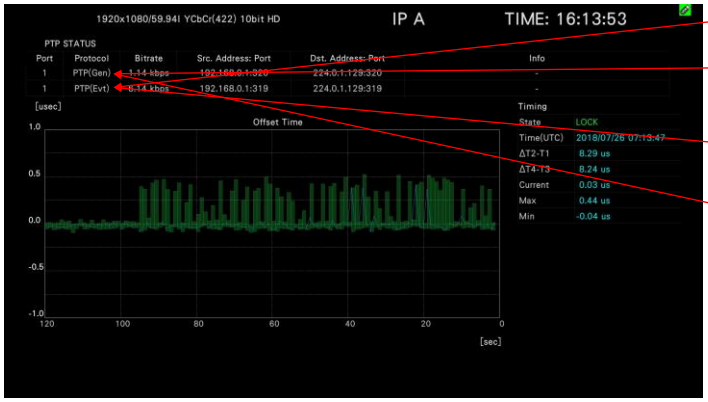


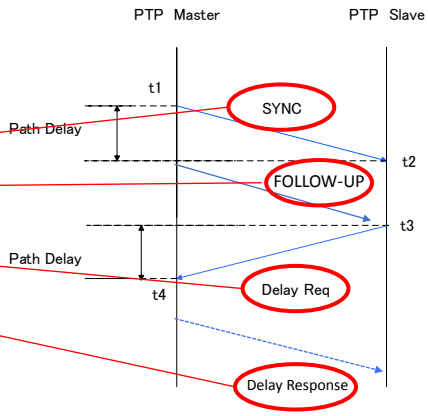
Time Offset = $((t_2-t_1) – (t_4-t_3)) /2$

Delay Time = $((t_2-t_1) + (t_4-t_3)) /2$

PTP Measurement – Protocol - Messages

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





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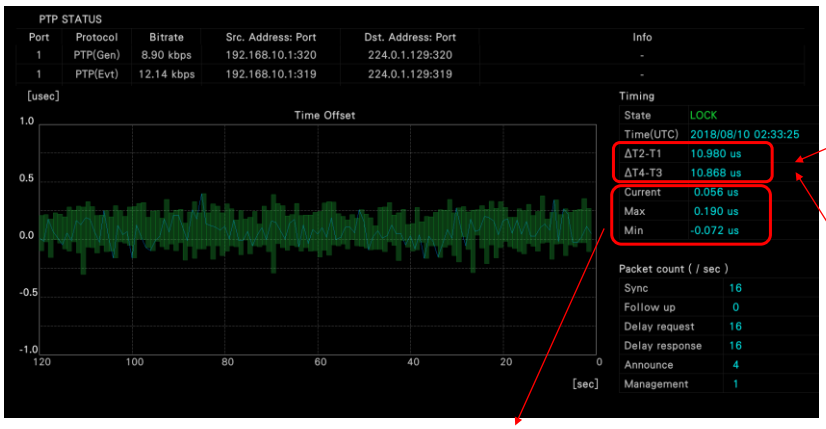
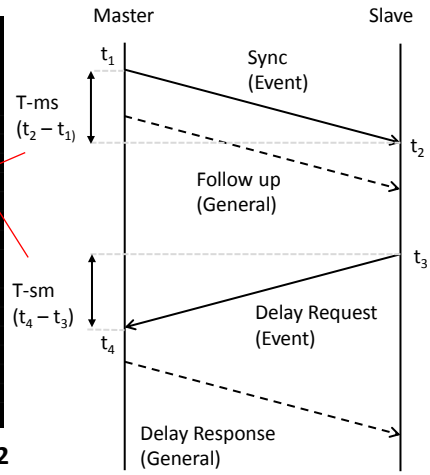
PTP Measurement





Time Offset = ($(t_2-t_1) – (t_4-t_3)$) /2

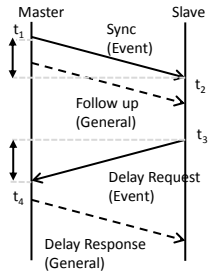
As SMPTE ST.2110-20 contains a large volume of asynchronous data, if the network switch cannot handle this data rate, it can impact upon the propagation delay of the PTP announcements. The Time Offset and Time Delay graph display the stability of the PTP announcements.

→**In order to obtain stable PTP synchronization it is necessary to set PTP compatible network switch or QoS**

PTP Measurement

Port Number 319

Message type	Message class	Value (hex)
Sync	Event	0
Delay_Req	Event	1
Pdelay_Req	Event	2
Pdelay_Resp	Event	3
Reserved	—	4-7
Follow_Up	General	8
Delay_Resp	General	9
Pdelay_Resp_Follow_Up	General	A
Announce	General	B
Signaling	General	C
Management	General	D
Reserved	—	E-F



Port Number 320

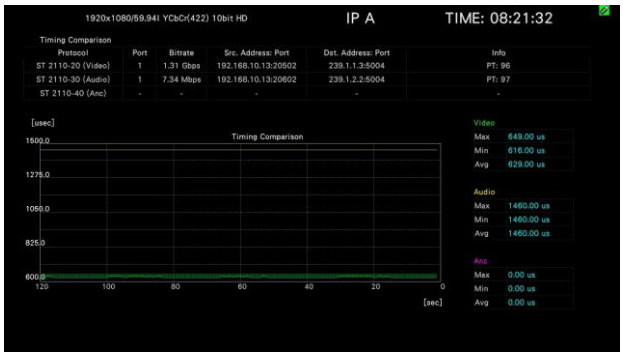
Display count of PTP messages per second

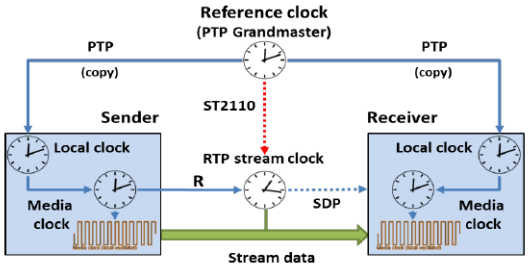
→ Confirm what message rate is being sent from the master of PTP

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





※AIMS white paper

The transmitting side transmits the stream according to the time of the PTP, and the receiving side reproduces in accordance with the time of the PTP

Timing Comparisons

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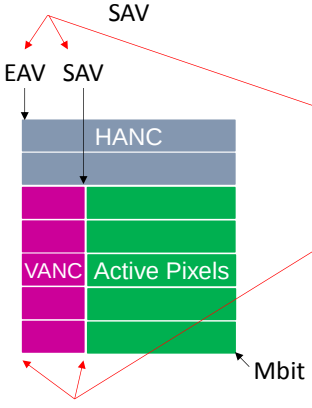
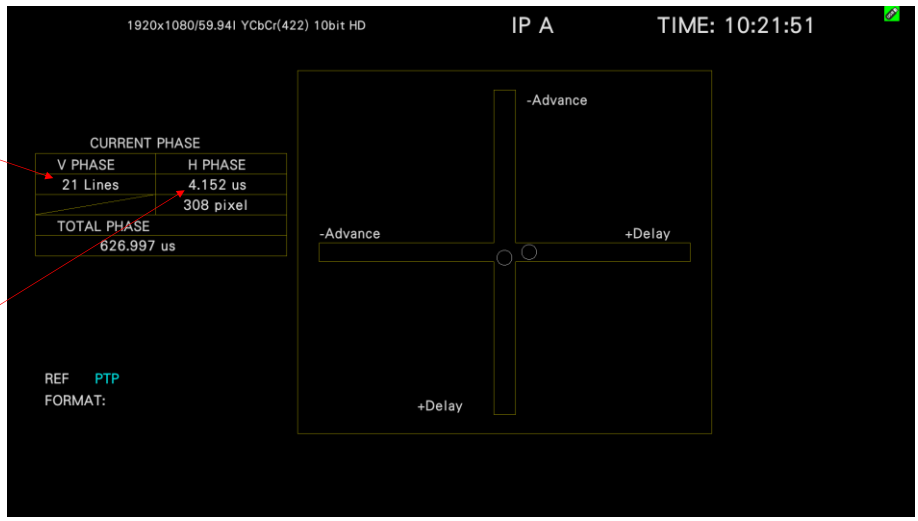
RTP / PTP Timing - ST 2110

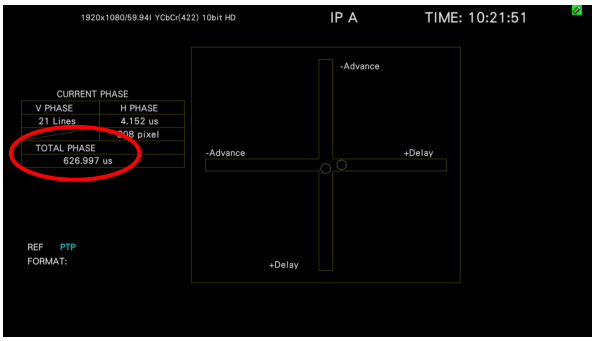
V Phase Delay of 21 lines is the delay between EAV and SAV

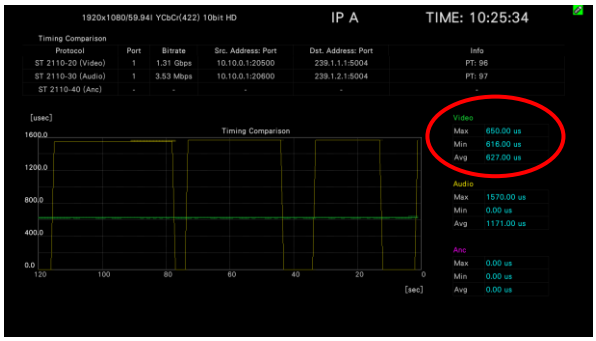


H Phase Delay of 4.152us

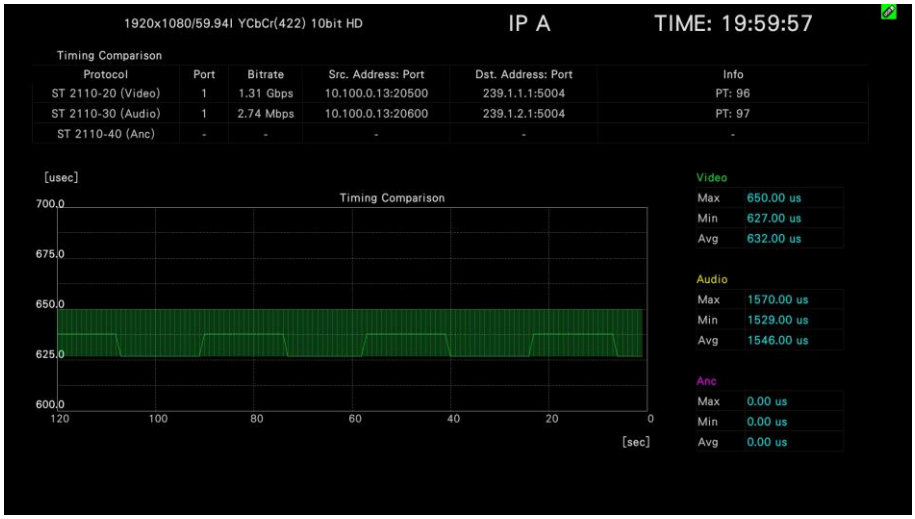


RTP / PTP Timing - ST 2110

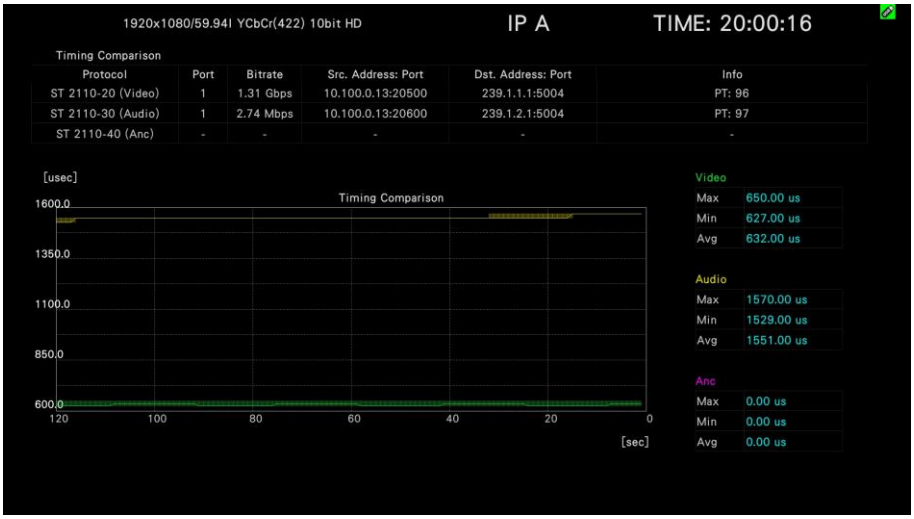




ST 2110-20 – Timing Comparison

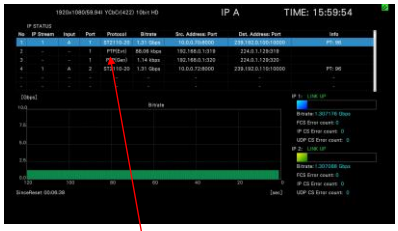


ST 2110-20/30 – Timing Comparison



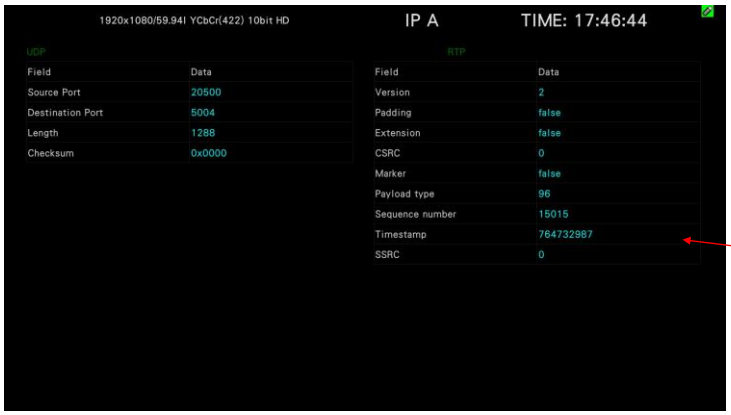
Packet Header Information

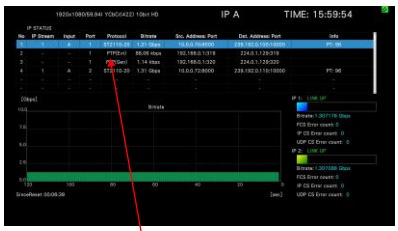
Packet Header Information



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

Packet Header Information





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

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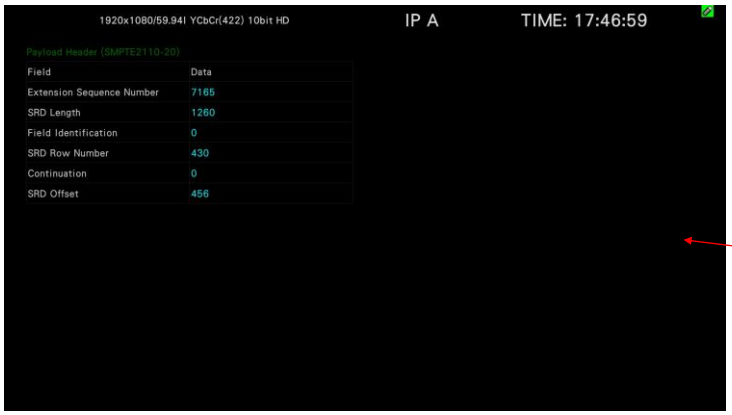
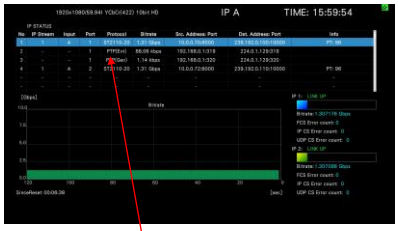
Packet Header Information



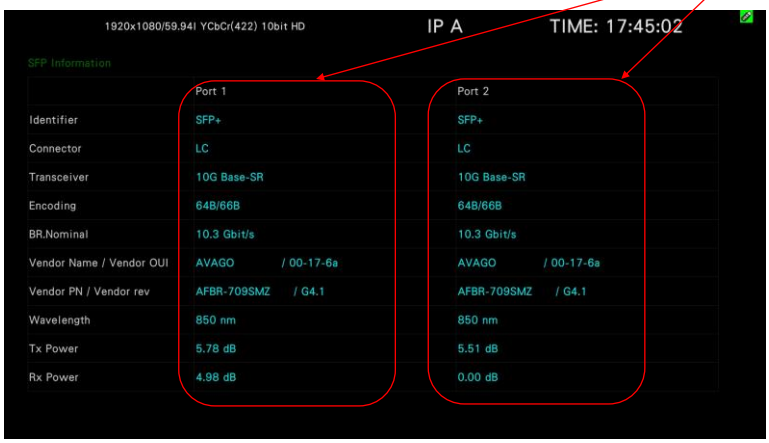


For packets selected in blue

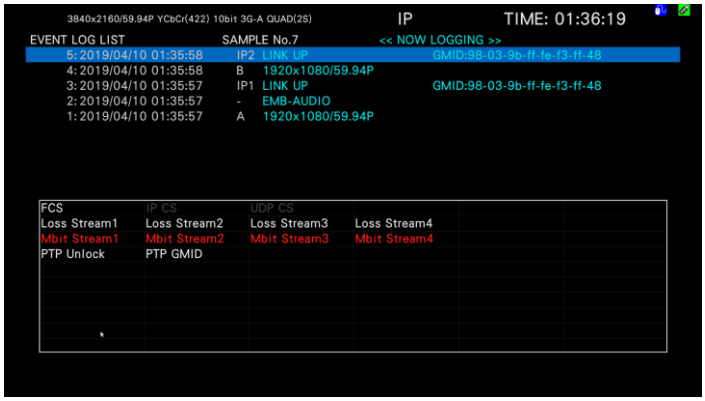
Display header information in MAC / IP / UDP / RTP / **PAYLOAD.**

SFP Information

Display information of SFP + transceiver module (IP 1/2)



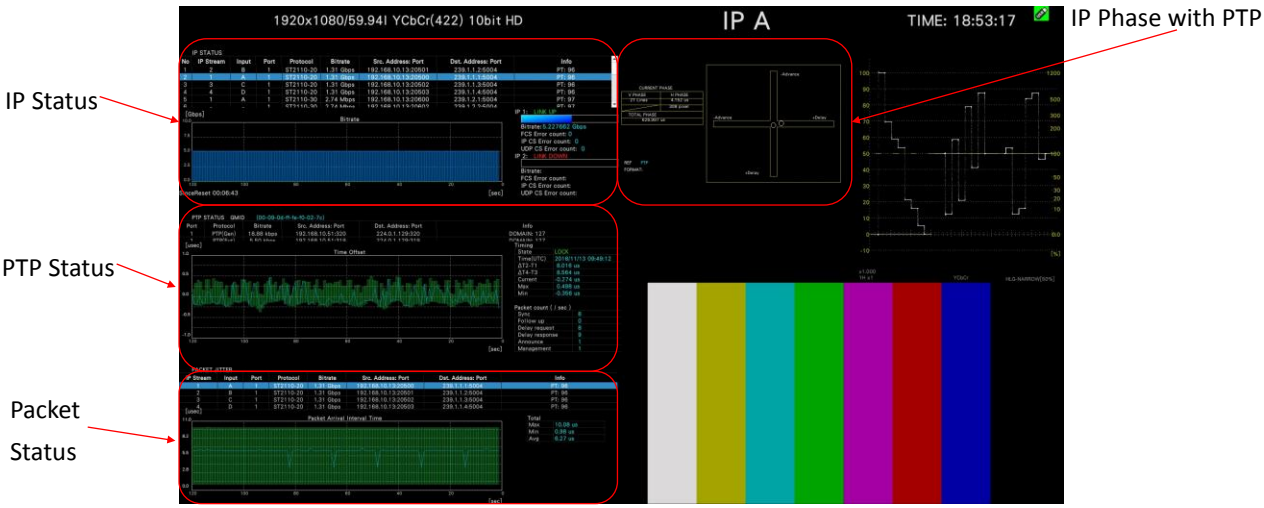
IP Event Log



Event Name	Content
FCS	Frame Check Sequence (FCS) Error
IP CS	IP Checksum Error
UDP CS	UDP Checksum Error
Los Stream 1	IP Stream 1 Packet Los Error
Los Stream 2	IP Stream 2 Packet Los Error
Los Stream 3	IP Stream 3 Packet Los Error
Los Stream 4	IP Stream 4 Packet Los Error
PTP Unlock	PTP Unlock Error

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.

Combined IP Measurement



Hybrid IP and SDI Video and Audio Test and Measurement

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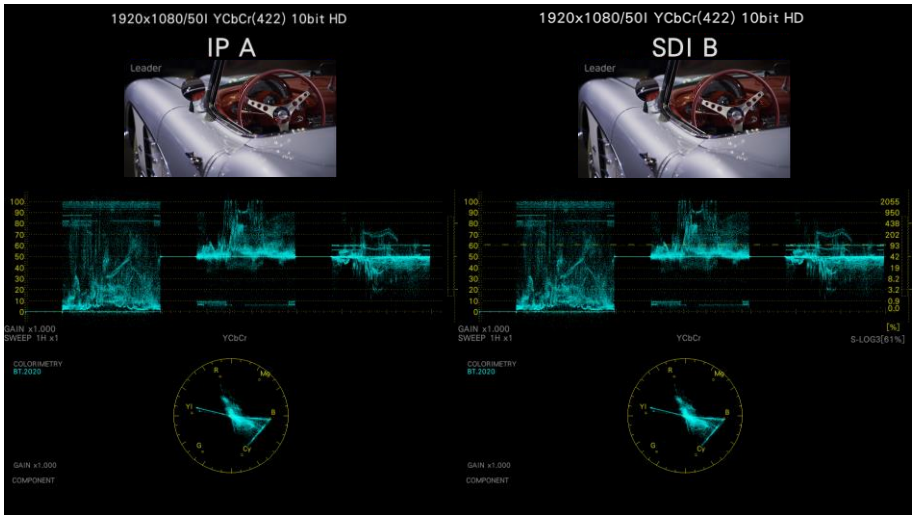
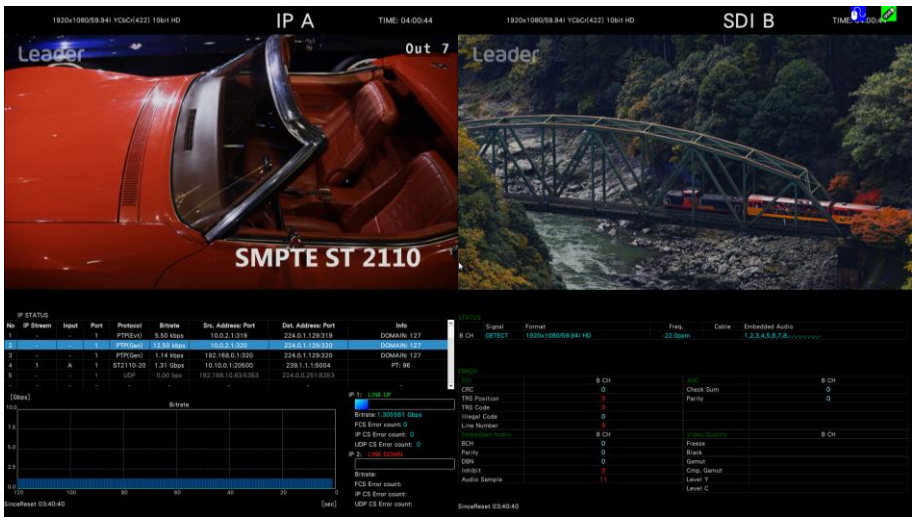
Why do we need Hybrid Operation ?

- 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



Hybrid Operation



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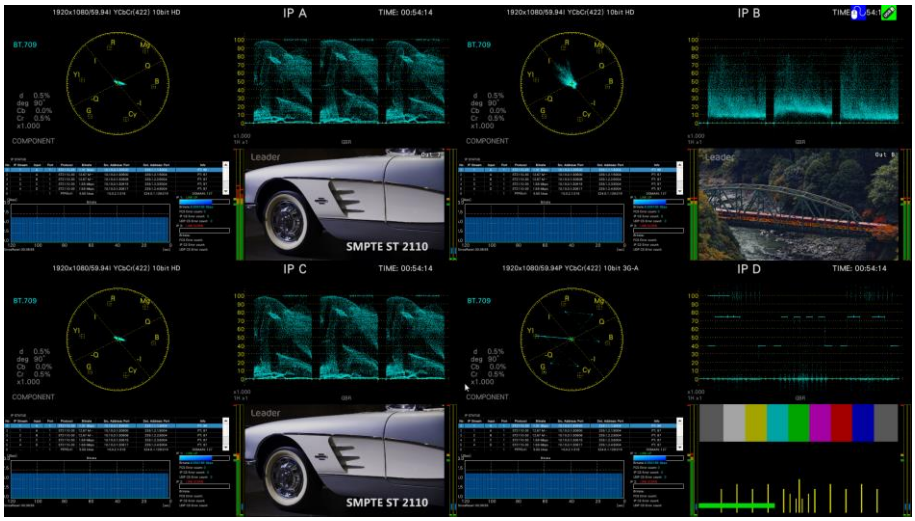
Multi Channel - IP Operation



Questions

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

Thank you

Kevin Salvidge, Leader Europe Limited
Salvidge@leadereurope.com Tel : +44 7826 178 752

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