Fundamentals and tools for SVIP testing

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SDI Video Plant
IP Video Plant
SDI over IP Standards Update

• Transport Standards
  ◦ Regional variations in adoption
    ▪ EMEA – SMPTE 2022-6 based
    ▪ America – ASPEN, SMPTE 2022-6 based
    ▪ Japan – NMI, SMPTE 2022-6 based
  ◦ Increasing adoption of SMPTE 2022-7 as systems become operational
  ◦ Industry converging around ST2110 (TR-03, TR-04 based standard)

• Synchronization Standards
  ◦ Precision Time Protocol (PTP) has been adopted for IP network synchronization
  ◦ Key standard is SMPTE ST 2059-2
  ◦ Black burst continues to be used in SDI domain requiring a hybrid synchronization solution

• Compression Standards
  ◦ The selection of an industry standard is unclear
    ▪ Sony LLVC used with NMI and Sony cameras
    ▪ Dirac/VC2 – Royalty free solution from BBC
    ▪ TICO – Solution most often discussed
  ◦ Increasing discussion of 25G uncompressed solutions
Signal Delay through COAX is Constant

<table>
<thead>
<tr>
<th>Time (nsec)</th>
<th>Length of RG-59 feet</th>
<th>Length of 8281 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.65</td>
<td>0.77</td>
</tr>
<tr>
<td>2</td>
<td>1.3</td>
<td>1.54</td>
</tr>
<tr>
<td>3</td>
<td>1.95</td>
<td>2.3</td>
</tr>
<tr>
<td>4</td>
<td>2.6</td>
<td>3.07</td>
</tr>
<tr>
<td>5</td>
<td>3.25</td>
<td>3.84</td>
</tr>
<tr>
<td>10</td>
<td>6.5</td>
<td>7.68</td>
</tr>
<tr>
<td>20</td>
<td>13</td>
<td>15.4</td>
</tr>
<tr>
<td>30</td>
<td>19.5</td>
<td>23</td>
</tr>
<tr>
<td>40</td>
<td>26</td>
<td>30.7</td>
</tr>
<tr>
<td>50</td>
<td>32.5</td>
<td>38.4</td>
</tr>
<tr>
<td>60</td>
<td>38.9</td>
<td>46.1</td>
</tr>
<tr>
<td>70</td>
<td>45.4</td>
<td>53.8</td>
</tr>
<tr>
<td>80</td>
<td>51.9</td>
<td>61.4</td>
</tr>
<tr>
<td>90</td>
<td>58.4</td>
<td>69.1</td>
</tr>
<tr>
<td>100</td>
<td>64.9</td>
<td>76.8</td>
</tr>
<tr>
<td>200</td>
<td>129.8</td>
<td>153.6</td>
</tr>
<tr>
<td>300</td>
<td>194.7</td>
<td>230.4</td>
</tr>
<tr>
<td>400</td>
<td>259.6</td>
<td>307.2</td>
</tr>
<tr>
<td>500</td>
<td>324.5</td>
<td>384</td>
</tr>
<tr>
<td>1000</td>
<td>649</td>
<td>768</td>
</tr>
</tbody>
</table>
Low-Jitter on Video over IP

Perfect Stream

IP packets carrying video

Point to Point  Jitter is low
High-Jitter on Video over IP

Same stream with Ethernet Jitter
Video Session

- Confirm the health of SDI layer
  - Status indicator to provide a quick view of the status of the parameters contained in each tab
Video Session

- SDI FORMAT
  - SAV/EAV placement, length
- VPID 352
  - SMPTE 352 payload ID
- BIT LEVEL
  - Bit activity
- CRC STATUS
  - Err Fields, ERR Secs, %ERR Fields
Waveform IP Status Picture Audio Bars
Test Equipment Justification Process

What is the Cost of Not Testing?

- UNKNOWN UNKNOWNS
- Quality Impacts and Rework
- Not Meeting Delivery Specification
- Missed Schedules and Budgets
- Advertising Revenue
- Legal Contract Issues
- Life and Death
- Truck Roll, Churn, Customer Service Issues
- Unknown Good/Bad Parts Sitting on Shelf
- REAL COST When Something Goes Wrong
Test Equipment Justification Process

Speaking to Management

• Management Might be Non Technical/Non Creative
• Management by Spreadsheet
• Speak in Business Terms
• **Cost Cutting/Saving Money - ROI**
• Make Their Pain Go Away
• Cost of Not Testing
• Write an Easy to Understand Justification
• When Test Equipment Saved the Day Share the Good News
• Once You Acquire Gear USE IT
• Make sure Management Sees You Using Test Equipment
• Read the Manual
• In your Weekly/Monthly Report Tell How Gear Saved the Day
IP Status

• What streams are in the 10GE pipe”
  ◦ Display all streams and communications with error status
  ◦ PTP and the other communications
IP Allocation

• Check the overall incoming stream status intuitively.
• Pie chart with traffic information in a 10 or 25GbE pipe
• Select a stream to monitor
IP Graph

- Time aligned IP Statistics graphs
- Isolate the root cause of the issue, SDI layer or IP layer
- Time Trending Range: 1 min ~ 1 week

• Graphs
  - Total session bit rates
  - Session bit rate
  - Packet Inter-arrival Time
  - Time Stamped Delay Factor
  - RTP Sequence Error
  - CRC Error
Packet Inter-arrival time (PIT)

• “Ensure the healthiness of entire IP system”
  ◦ Too short / long PIT could cause buffer over / under flow
  ◦ The colored bars represent the range from min to max for all the packets within that time interval.
### IP Graph - PIT and RTP Sequence

<table>
<thead>
<tr>
<th>Source/Dest Protocol</th>
<th>192.168.39.211 / 239.0.0.2</th>
<th>Scale 1 second</th>
<th>Interval 1 Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PIT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>7.4 µs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>7.4 µs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>5.4 µs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rtp Sequence Error</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Errors</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Video CRC Error**

[Image of IP Graph with PIT and RTP Sequence data]
# IP Graph- RTP Sequence and Video CRC

## RTP SEQUENCE ERROR, VIDEO CRC ERROR

<table>
<thead>
<tr>
<th>Source/Dest Protocol</th>
<th>Scale</th>
<th>Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 second</td>
<td>1 Minute</td>
</tr>
</tbody>
</table>

### Rtp Sequence Error
- **Errors**: 0
- **Peak**: 0

### Video CRC Error
- **Errors**: 0
- **Peak**: 0

Red dotted line for “No Errors”
PIT Histogram

Source/Dest: 192.168.39.211:10000 / 239.0.0.2:20000
Protocol: IPv4 / UDP (Multi) / S2022.6

Packet Interval
- Max: 7.4295µs
- Min: 5.3815µs
- Mean: 7.424µs
- Std Dev: 32.293ns

Scale: Micro Seconds
PIT Histogram

• “Ensure the healthiness of entire IP system”
  ◦ Burst events at too short / long PIT could cause buffer over / under flow
PIT Histogram

- “Ensure the healthiness of entire IP system”
  - Burst events at too short / long PIT could cause buffer over / under flow
IP Graph - RTP Sequence Error
Time Stamped Delay Factor (TS-DF)

• Network Jitter on RTP Streams
  ◦ EBU Tech3337, the max value of the difference of packet transmission time for all packets against the first packet transmission time within that time interval.

IP Graphs

Source / Dest: 192.168.1.11 / 229.1.1.2
Protocol: S2022.6  Resolution: 1 second

<table>
<thead>
<tr>
<th>TS-DF</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max:</td>
<td>3.9 µs</td>
</tr>
<tr>
<td>Mean:</td>
<td>3.8 µs</td>
</tr>
<tr>
<td>Min:</td>
<td>3.6 µs</td>
</tr>
</tbody>
</table>
Root Cause: RTP Sequence error / CRC error

- IP layer causes RTP Sequence Error and CRC Error
- SDI layer causes CRC Error Only
Event Log

<table>
<thead>
<tr>
<th>EVENT</th>
<th>SOURCE</th>
<th>DATE</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>IOSLAVE_ALARM_SIG_LOSS</td>
<td>IP Video 0:0 0</td>
<td>2016-08-19</td>
<td>20:07:10.983</td>
</tr>
<tr>
<td>IP_ALARM_Ethernet_SIG_LOSS</td>
<td>Port 0:8</td>
<td>2016-08-19</td>
<td>20:07:10.984</td>
</tr>
<tr>
<td>IP_ALARM_Ethernet_CRC</td>
<td>Port 0:8</td>
<td>2016-08-19</td>
<td>20:07:11.224</td>
</tr>
<tr>
<td>PTP_ALARM_NO_LOCK</td>
<td></td>
<td>2016-08-20</td>
<td>00:11:51.352</td>
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<tr>
<td>IOSLAVE_ALARM_SIG_LOSS</td>
<td>IP Video 0:0 0</td>
<td>2016-08-20</td>
<td>00:11:51.963</td>
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<tr>
<td>IP_ALARM_Ethernet_SIG_LOSS</td>
<td>Port 0:8</td>
<td>2016-08-20</td>
<td>00:11:51.964</td>
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<td>IOSLAVE_ALARM_SIG_LOSS</td>
<td>IP Video 0:0 0</td>
<td>2016-08-20</td>
<td>00:19:28.713</td>
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<td>IP_ALARM_Ethernet_CRC</td>
<td>Port 0:8</td>
<td>2016-08-20</td>
<td>00:19:28.717</td>
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<tr>
<td>IP_ALARM_Ethernet_SIG_LOSS</td>
<td>Port 0:8</td>
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<td>IP_ALARM_Ethernet_CRC</td>
<td>Port 0:8</td>
<td>2016-08-20</td>
<td>00:19:28.723</td>
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<td>IP_ALARM_Ethernet_CRC</td>
<td>Port 0:8</td>
<td>2016-08-20</td>
<td>00:19:28.734</td>
</tr>
</tbody>
</table>
PTP Session

- PTP Lock status to check the PTP system in the IP facility
PTP Graphing

PTP Graphs

- Source / Dest: ----
- Resolution: 1 second
- Protocol:

Master-Slave Delay
- Max: 10.0 µs
- Mean: 10.0 µs
- Min: 9.9 µs

Slave-Master Delay
- Max: 14.3 µs
- Mean: 9.6 µs
- Min: 9.6 µs

PTP Graphs

- Source / Dest: ----
- Resolution: 1 second
- Protocol:

Master-Slave Variation
- Max: 253.0 ns
- Mean: 118.4 ns
- Min: 27.0 ns

Slave-Master Variation
- Max: 980.0 ns
- Mean: 74.9 ns
- Min: 30.0 ns

INPUT: IP 2110
720p 59.94
Timing display

• Ensure the timing between the streams is consistent for seamless switching
• Show the timing of a stream against PTP or BB
First Steps to Troubleshooting PTP

VERIFY THE SETTING OF THE GRANDMASTER (GM)

• Setting of all the slave clocks need to match the setting of the GM
  • Domain
    • Domain is defined a number from 0 to 127
  • Profile
    • General Profile send Sync commands 1 per Sec
    • AES Profile send Sync commands 4 per Sec
    • SMPTE Profile send Sync commands 8 per Sec
  • Communication Mode
    • Multicast,
    • Unicast
    • SMPTE Mixed Mode
  • Delay Mechanism
    • Peer to Peer
    • End to End
  • Step
    • One Step
    • Two Step
Verify PTP Domain

- Domain is defined by a number from 0 to 127
- Verify all devices are in the correct PTP Domain (0 to 127)
  - In order for Devices to share PTP commands they need to be in the same Domain
- Each Domain will have a Grandmaster Clock
- SPG8000a can support two Domains

Note:
If you do not know the Domain -
Check your GM settings or
Capture a Pcap
Each PTP IP packet will have the Domain value.
Verify PTP Profile

PROFILES HAVE DIFFERENT ANNOUNCE AND SYNC INTERVAL

- The three Profiles use in Broadcasting are:
  - **General Profile** sends Sync commands 1 per Sec
  - **AES Profile** sends Sync commands 4 per Sec
  - **SMPTE Profile** sends Sync commands 8 per Sec

- There are other differences between the Profiles:
  - SMPTE has a mixed communication mode
  - Mixed Mode uses both Multicast and Unicast
Check PTP Communication Modes

- ST2059 supports:
  - **Multicast**
    - Sending a packet form one host to a selected group of hosts
    - PTP uses a default Multicast address 224.0.1.129
    - Announce & Follow-UP messages uses port 320
    - Sync & Delay-Request messages uses port 319
  - **Unicast**
    - Need to enter IP Address of all possible GM
  - **Mixed Mode**
    - Announce/Sync/Follow-up all Multicast from GM
    - Delay messaging from the Slaves are Unicast
  - **Mixed SMPTE w/o negotiation**
    - Mixed SMPTE without negotiation
      - does not allow master to regulate load
Verify Network Switches support Multicast

PTP USES A DEFAULT MULTICAST ADDRESS (224.0.1.129)

- PTP aware device should automatically join the PTP Multicast
  - Announcement, Delay-Response, & Follow-Up messages uses port 320
  - Sync & Delay-Request messages uses port 319
- Port 319 carries the time sensitive messages
Verify the PTP Grand Master (GM)

- Master based on several parameters that are carried by the Announce
  - Priority 1 (Default Value 128)
    - Lowest value wins (Range 0-255)
    - Use to exclude devices from being able to be the GM
  - Clock Class
  - Clock Accuracy
  - Clock Variance
  - Priority 2 (Default Value 128)
    - Lowest value wins (Range 0-255)
    - Use to designate user default GM
  - Final tie breaker
    - Clock ID usually MAC address

Denotes quality of GM Lock

BMCA Values from the GM

Verify Master ID Matches desired GM
PTP in Pictures

Offset = \frac{(Master\_To\_Slave \Delta t - Slave\_To\_Master \Delta t)}{2} = 5\text{ Mins}

Oneway Delay = \frac{(Master\_To\_Slave \Delta t + Slave\_To\_Master \Delta t)}{2} = 1\text{ Min}
TekMOS Machine Learning Algorithm
Feature to Score correlations for each distortion class

MP2 distorted images
4.8
0.9
1.1
MP2 Corr

MP4 distorted images
1.8
2.8
2.7
MP4 Corr

Noise distorted images
4.1
1.1
2.5
Noise Corr

Blur distorted images
3.5
3.9
1.6
Blur Corr
Pixel-Based No-Reference PQ (trained feature classifier)

- Define a set (vector) of N features more-or-less correlated with human visual perception of image quality (i.e. sharpness, contrast, low-noise, adjacent pixel distribution variations from “natural” image pixel statistics).
- Create a SVM (Support Vector Machine) classifier training set from a large set of subjectively graded images.
- Use a trained SVM (Support Vector Machine) as regressor (SVR) to fit the N-dimensional data from arbitrary test frames to estimate the image quality based on the classifier support vector training.

Uses Machine Learning to look for bad video based on best match to many, subjectively scored, training images.

TekMOS uses ~ 2000 scored images based on 79 ref images distorted with various levels of jpg, mp4, blur, and noise extracting 42 pixel features from each.
Capturing Camera RAW Footage (SpyderCube)
• Setup your within the scene
• Adjust the lighting to evenly illuminate
• Adjust the camera controls to set the levels
  ◦ ISO/Gain, Iris, Shutter, White Balance
Side by side 709 and PQ
SpyderCube S Log 2 shot with Camera Raw

Showing Graticules in Digital Values and Stops

Digital Values on the Left side

Stop values on the right side.
SpyderCube S Log 2 shot with Camera Raw

Showing S Log 2 in normal 709 type screens
S log 2 to PQ Curve

Showing Graticules in Nits ST2084 1K

SMPTE Levels

1000 Nits
Max Highlights
Monitor dependent

~100-200 Nits
Normal White

20 Nits
18% Grey

Reflective Black
S Log 2 to Rec. 709
How to Test the New Stuff

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