SMPTE Standards Webcast Series

SMPTE Professional Development Academy – Enabling Global Education

32NF-80 DG Report

ST2059 PTP Interoperability Testing and Demonstrations

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Overview of ST 2059 Interop Testing

- The ST 2059 Standard is a complex document, and utilizes an external Standard, IEEE-1588 Precision Time Protocol (PTP).
- PTP is a now-mature technology used in many industries for high-precision timing, but not in broadcast
- ST 2059 Suite:
  - Utilizes PTP to transport virtual legacy reference signals for generation in their native formats in slave devices, including timecode
  - Allows direct generation of legacy reference signals
  - Contains specific metadata for media applications
  - Has a specific PTP Profile for media applications

Why Conduct Interop Testing?

- Limited SMPTE experience with PTP
- Limited SMPTE experience with IP networks
- Alignment and signal generation formulae in ST 2059 had only been simulated
- Ability of PTP to provide the performance required is predicted
- Interoperability with ST 2022-6, draft ST 2110 and AES67
  - Allows for integrated testing

Provides verification of a lot of assumptions made in a complex Standards suite.

Requirements for ST 2059 Interop Testing

Interop testing covers several primary areas:

- Behavior of PTP according to SMPTE Profile
  - Communication modes, message rates
- Behavior of devices using SMPTE Profile
  - Lock time, stability, receipt and use of profile metadata
- Ability of slave devices to generate legacy signals
  - Analog sync timing, SDI, AES3, ST 12 time code
- Ability of Masters to negotiate in redundant configurations
- Impact of traffic on PTP performance
- Beneficial impact of PTP-aware switches on PTP performance with traffic

Report Covers Three Topics

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- Results from the Second SMPTE Interoperability tests June 13 to 17, 2016
- Results from the JT-NM Interoperability tests and IBC planning August 22 to 26, 2016
- Timing demonstrations
  - IBC
  - SMPTE ATC Conference

June SMPTE Interop

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Location:

- Fox NE&O Houston, TX

Dates:

- June 13 to 17 2016

Participating Companies:

- Adeas/Xilinx , ARG, Arista, Cisco, Coveloz, Evertz, Fox, Fox/DVBLink, Imagine Communication, IRT, Media Links, Meinberg, Nevion, Oregano, PacketStorm, Riedel, Ross, Sony, Stagebox, Tektronix

June SMPTE Interop – Fox NE&O

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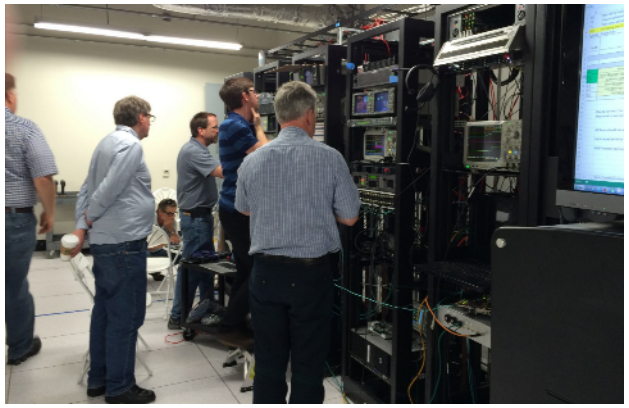

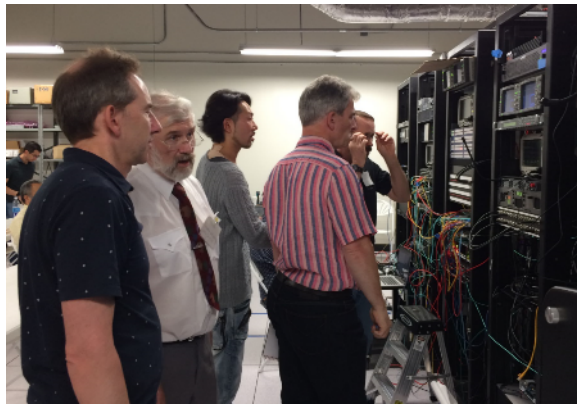

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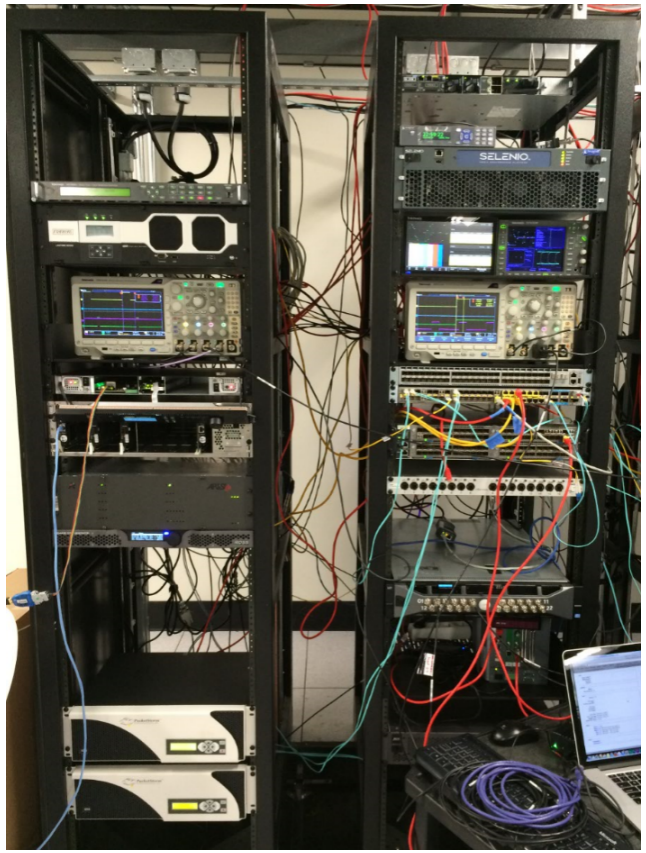

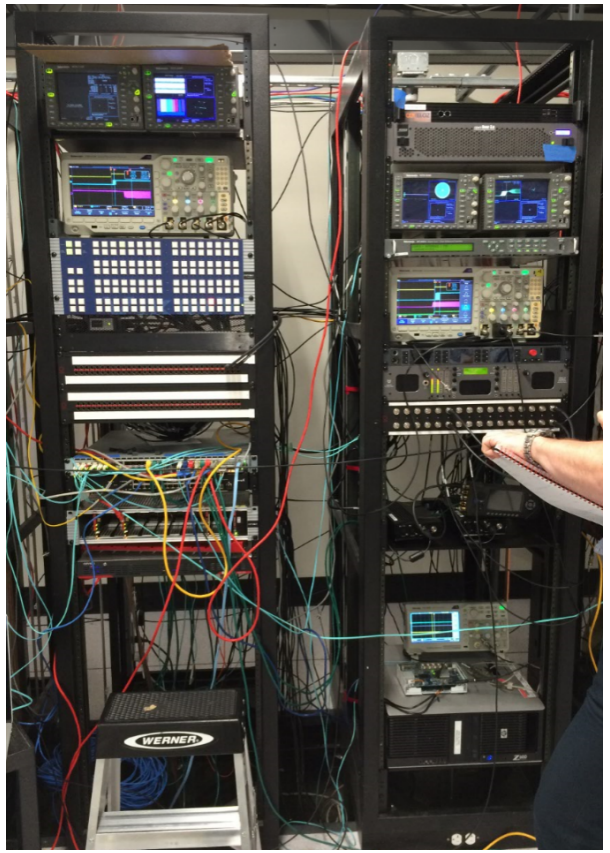

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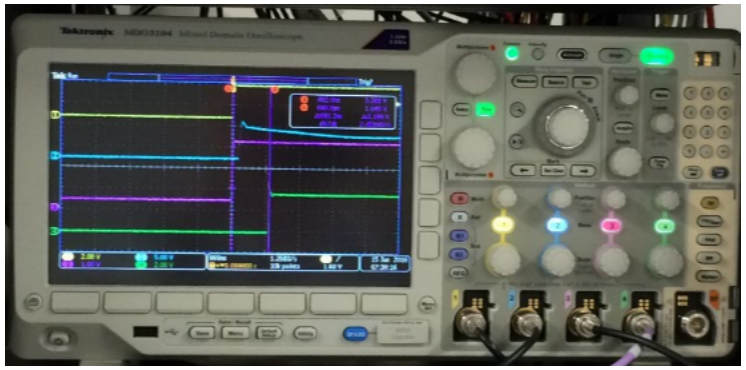

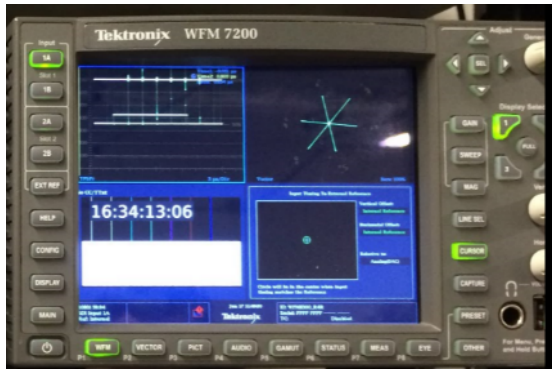

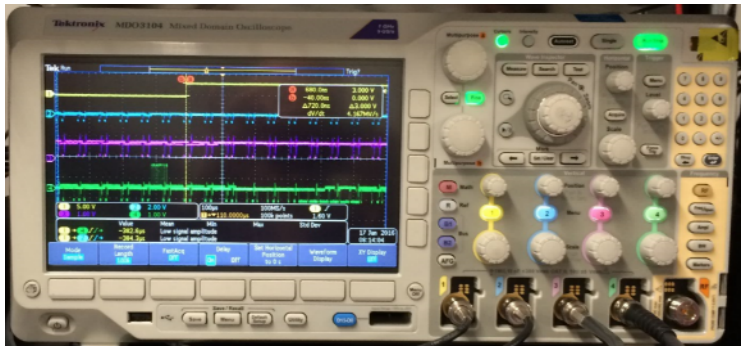

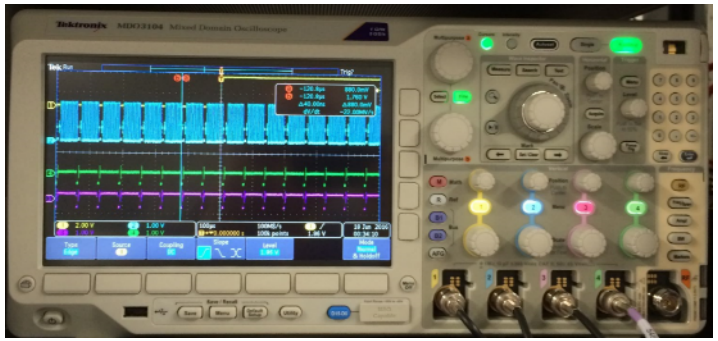

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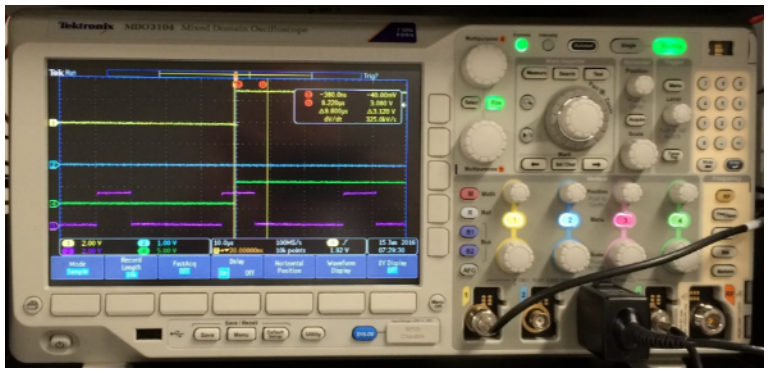

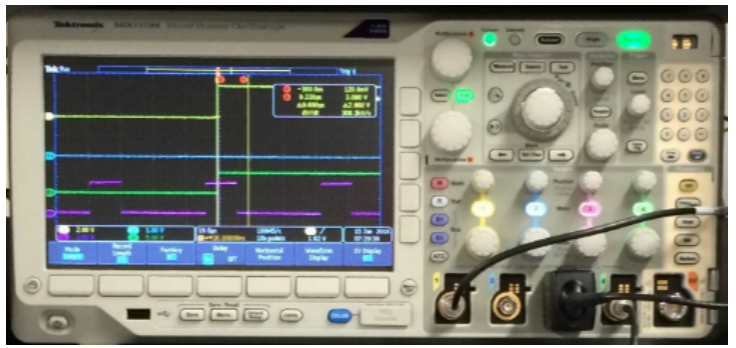

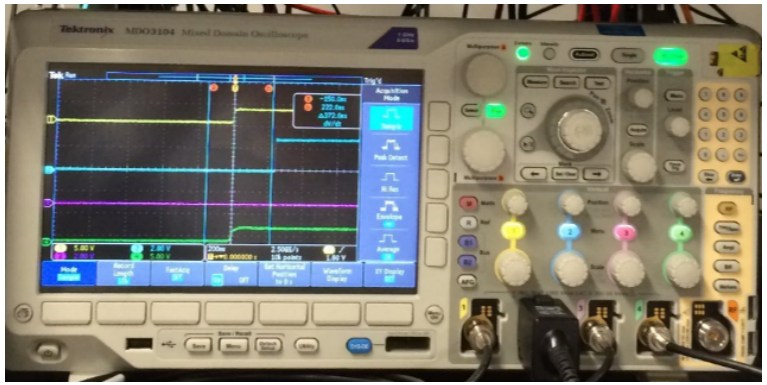

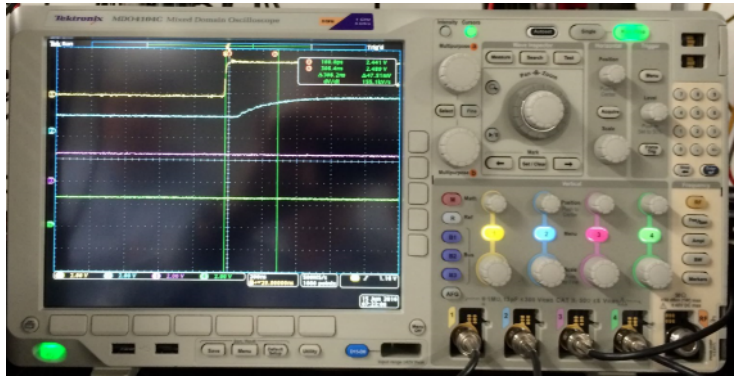

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Objectives of June Interop Event

- Verify compatibility range of ST2059 and AES67 profiles
- Evaluate Performance under traffic load
- Test Boundary Clock and Transparent Clock
- Test Communication modes
- Verify ST2059-1 output signal alignment
- Determine the state of the industry at this point in time

Summary Tests from June SMPTE Interop

Transport Mechanism

- Multicast
- Unicast (Limited)
- Mixed Mode (Limited)

Lock up Time and Phase

- Vary Message rates with multiple simultaneous domains

Interoperability of devices designed for ST2059-2 and AES67

- **2059-1 Signal Alignment**
  - PAL
  - NTSC
- **Traffic Impairment**
  - Delay
  - Jitter
  - Boundary Clock
  - Transparent Clock (Limited)

Example Test Spreadsheet – BC traffic test

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Suite D	Traffic Test 1 - Switch Pair 1																											
Suite #	Test Description	Switch Mode	Traffic Level	Impairment PDV	Communication Mode	Path Delay	Ann. Int.	Sync Int.	Dly Int.	Master	Master 1					Master 1				Master 1				Master 1			
										Slave	Slave 1					Slave 2				Slave 3				Slave 4			
											Interop																	
											PF	T1	TE	TE5	PF	T1	TE	TE5	PF	T1	TE	TE5	PF	T1	TE	TE5
D-1	Slow Message rate, no traffic	Non-1588	0	Off	Multi-cast	E-E	1 (2)	-1 (0.5)	-1 (0.5)	Duplicat	Fail				Fail				Pass	14	600	400	Pass	14	-200	450
D-2	Proposed Common Rate default, No Traffic	Non-1588	0	Off	Multi-cast	E-E	0 (1)	-3 (0.125)	-3 (0.125)	Duplicat	Fail	7	300	1050	Fail	6	80	700	Pass	13.2	370	260	Pass	10	300	360
D-3	Slow Message rate, 90 % traffic	Non-1588	90%	Off	Multi-cast	E-E	1 (2)	-1 (0.5)	-1 (0.5)	TBD	Pass	10	-200	1200	Pass	10	-400	1200	Pass	16.4	800	800	Fail		2500	2500
D-4	Proposed Common Rate default, 90% Traffic	Non-1588	90%	Off	Multi-cast	E-E	0 (1)	-3 (0.125)	-3 (0.125)	TBD	Pass	8	250	580	Pass	9	50	900	Pass	9.2	370	1700	Fail	12	2500	2500
D-5	Slow Message rate, Traffic plus PDV	Non-1588	90%	On	Multi-cast	E-E	1 (2)	-1 (0.5)	-1 (0.5)	TBD																
D-6	Proposed Common Rate default, Traffic plus PDV	Non-1588	15%	On 4µs EXP Jit, 5 µs del	Multi-cast	E-E	0 (1)	-3 (0.125)	-3 (0.125)	TBD	Pass	7	-40	600	Pass	6	-80	1280	Pass	13	800	1900	Fail	5.00	3000	3000
D-7	Faster Message rate - Contingency if slaves under-perform at lower rat	Non-1588	?	?	Multi-cast	E-E	-2 (0.25)	-6 (0.015)	-6 (0.015)	TBD																
D-8	Slow Message rate, no traffic	Boundary	0	Off	Multi-cast	E-E	1 (2)	-1 (0.5)	-1 (0.5)	TBD	Pass	13	20	72	Pass	34	70	32	Pass	13	260	180	Pass	15	300	250
D-9	Proposed Common Rate default, No Traffic	Boundary	0	Off	Multi-cast	E-E	0 (1)	-3 (0.125)	-3 (0.125)	TBD	Pass	6	80	40	Pass	7	80	24	Pass	10.5	370	100	Pass	7	-400	250
D-10	Common rate, Mixed mode Switch test	Boundary	0	Off	Mixed w/o Neg	E-E	0 (1)	-3 (0.125)	-3 (0.125)	TBD																
D-12	Slow Message rate, 90 % traffic	Boundary	90%	Off	Multi-cast	E-E	1 (2)	-1 (0.5)	-1 (0.5)	TBD	Pass	13	80	72	Pass	15	100	80	Pass	14	330	200	Pass	10	250	300
D-13	Proposed Common Rate default, 90% Traffic	Boundary	90%	Off	Multi-cast	E-E	0 (1)	-3 (0.125)	-3 (0.125)	TBD																
D-14	Slow Message rate, Traffic plus PDV	Boundary	90%	On	Multi-cast	E-E	1 (2)	-1 (0.5)	-1 (0.5)	TBD																
D-15	Proposed Common Rate default, Traffic plus PDV	Boundary	90%	On	Multi-cast	E-E	0 (1)	-3 (0.125)	-3 (0.125)	TBD																
D-16	Faster Message rate - Contingency if slaves under-perform at lower rat	Boundary	?	?	Multi-cast	E-E	-2 (0.25)	-6 (0.015)	-6 (0.015)	TBD																

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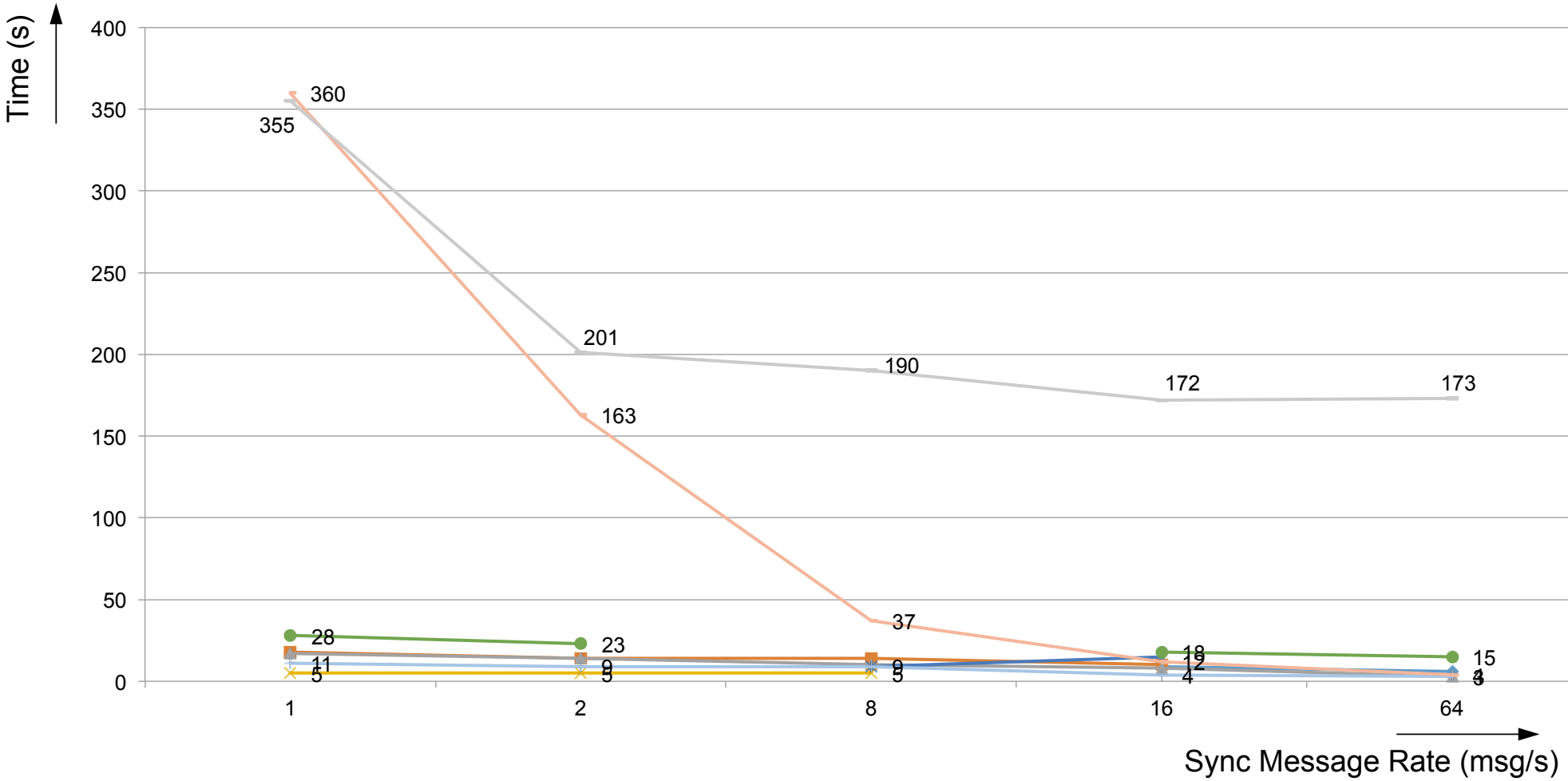
Basic Multicast Communication Test Results

PTP Slave \ PTP Master	Master 1	Master 2	Master 3	Master 4	Master 5	Master 6	Master 7	Master 8	Master 9	Master 10
Slave 1	Pass	Pass	Pass	Pass	Fail	Fail	Fail		Fail	Fail
Slave 2	Pass	Pass	Pass	Pass	Fail	Fail	Fail		Fail	Fail
Slave 3	Pass		Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass
Slave 4		Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass
Slave 5										Pass
Slave 6										Pass
Slave 7		Pass			Pass					
Slave 8		Pass	Pass	Pass	Pass	Pass	Pass		Pass	Pass
Slave 9	Pass		Pass						Pass	
Slave 10		Pass	Pass	Pass	Pass	Pass	Pass		Pass	Pass
Slave 11		Pass	Pass	Pass	Pass	Pass	Pass		Pass	Pass
Slave 12			Pass						Fail	Pass
Slave 13		Pass	Pass	Pass	Pass		Pass	Fail	Pass	Pass
Slave 14	Pass	Pass	Pass	Pass	Pass	Pass		Fail	Pass	Pass
Slave 15	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass
Slave 16		Pass	Pass	Fail	Pass	Pass	Pass	Fail	Pass	Pass
Slave 17	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Pass

Performance Test (Lock-up time vs. rate) Results



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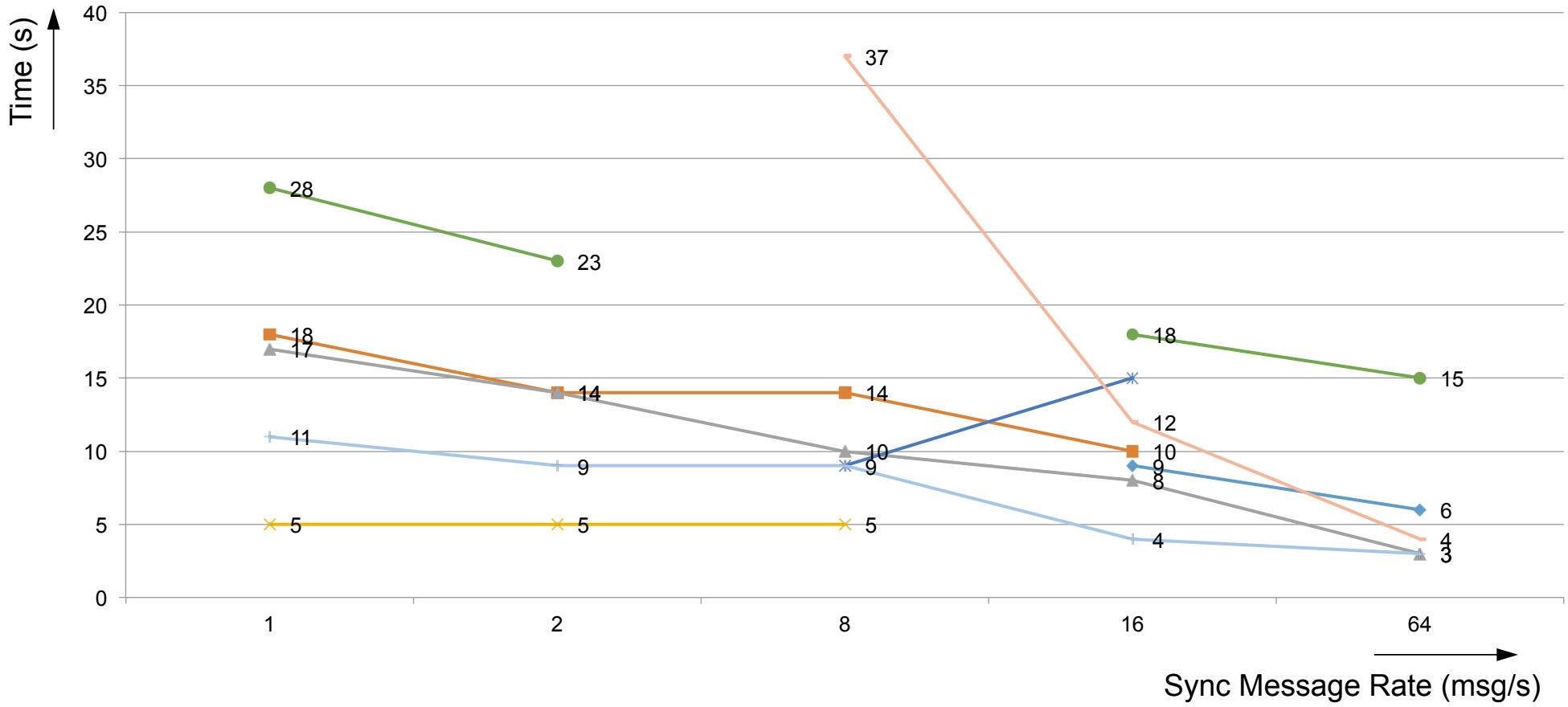
Performance Test (Lock-up time vs. rate) Results

[Expansion]



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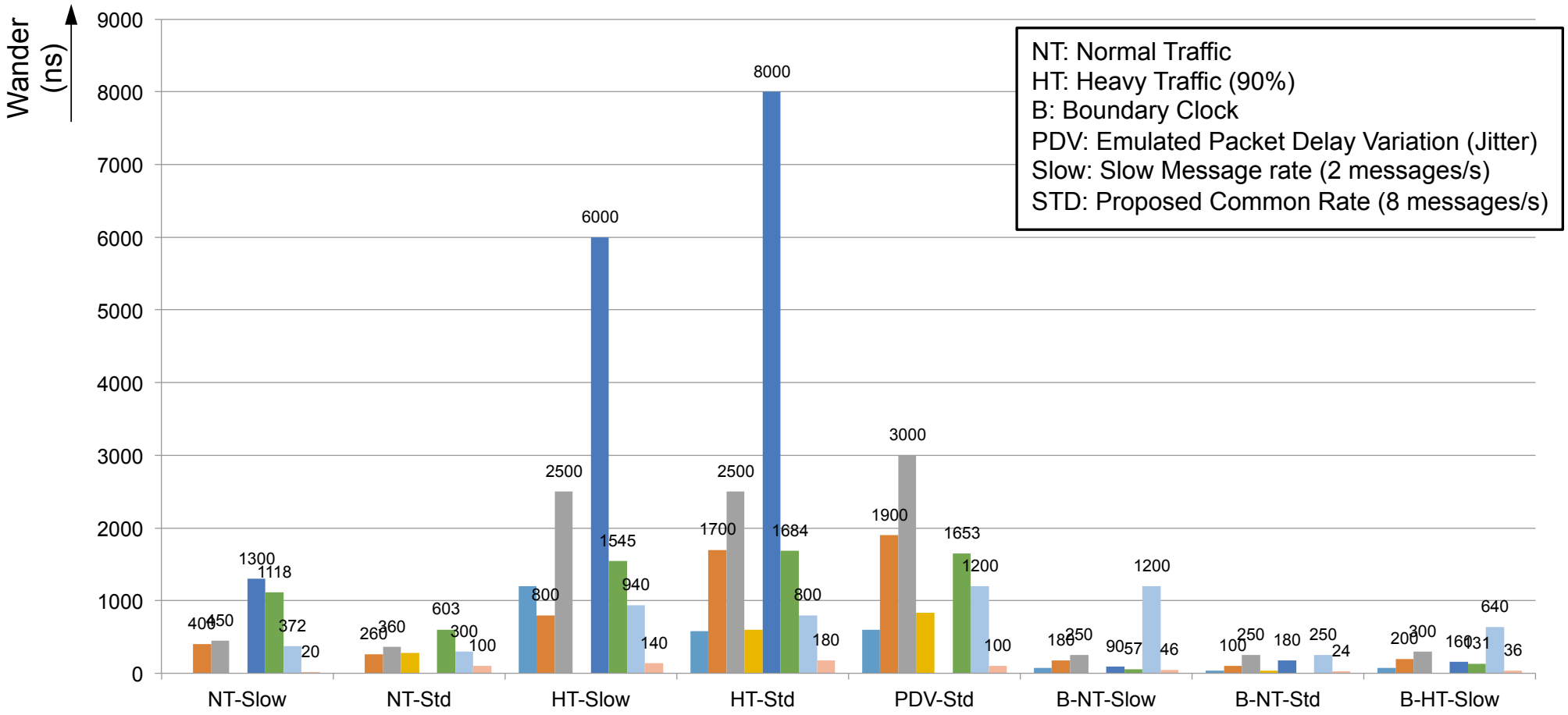
Traffic Test (Wander) Results



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Compatibility Range Between ST2059 and AES67 Profiles Conclusions

- Most devices achieved lock at the ST2059-2 default rates
- Most devices achieved lock at the IEEE 1588 default rates

- Most devices achieved lock at the proposed common ST2059 / AES 67 rates

Performance Under Traffic Load Conclusions

- Timing stability with 90% traffic load in a non-PTP-aware network was degraded but still in a reasonable range
- Timing stability was significantly better with the same traffic in a PTP-aware network
- A network impairment emulator set to 5μs delay and 4μs exponential jitter was a reasonable emulation of 90% loaded 10G link with a mixture of 2022-6 video and AES67 audio traffic
- The effect of network line rate (1G, 10G etc.) should be investigated further

Boundary Clock and Transparent Clock Conclusions

- Running all switches in Boundary Clock mode significantly improved phase alignment accuracy and stability
- Only limited testing of Transparent Clock mode was performed and no conclusions could be drawn
- Need to do further testing to quantify the results
- Need to test more representative network topologies

Communication Modes Conclusions

- Most master-slave combinations were able to communicate and synchronize in multicast mode
- There was no formal testing of unicast or mixed mode but some devices operated successfully in these modes

ST2059-1 Output Alignment Conclusions

- Most master-slave combinations achieved a phase offset of less than 500 ns.
- Some devices which produced black & burst output did not take account of the color field sequence. (They aligned to correct point in frame but not necessarily the frame containing field 1 of the color field sequence.)

Lock Time Conclusions

- Few devices achieved the ST 2059-2 target lock time of 5 seconds
  - One device achieved it at ST 2059-2 default rate of 8 messages per second
  - Some devices achieved it at increased rate of 64 messages per second
- Most devices achieved lock in under 20 seconds
- In general, higher sync and delay request message rates led to shorter lock times but the behavior varied significantly between different slaves.
- The effect of announce rate on lock time was not investigated

State Of The Industry At This Point In Time Conclusions

- Independent implementations of ST2059 have successfully interoperated
  - Many of the implementers were able to improve their designs through the interop testing
  - Participation in the interop was vital to successful product design
- The Interop provided valuable verification to the ST2059 and AES67 Standards
  - Feedback needs to be incorporated in the 1 year review of ST2059
- ST2059 and AES67 systems can interoperate at common message rates

August JT-NM Interop and IBC demo trial

Location:

- Fox NE&O Houston, TX

Dates

- August 22-26 2016

Objectives

- Redundant Master Test
- Traffic Test
- SDI Output Phase Test
- Prepare for IBC and SMPTE ATC Demos

August JT-NM Interop and IBC demo trial

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PARTICIPATING COMPANIES:

SUPPORTING COMPANIES:

Not all companies participated in the Timing Area

Summary Tests for Timing Section

- Transport Mechanism
  - Multicast basic communication between all master and slave combinations
- BMCA
- Traffic on Non-aware, Boundary and Transparent modes
- 2059-1 signal alignment
- Multiple simultaneous domains
- For each test
  - Verified connection plan and operation
  - Choose devices for IBC demo

August JT-NM Interop – Fox NE&O

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Future Interops

Future interop are recommended

- Not all tests were conclusive
- Not all critical aspects of ST2059 – 1/2 have been tested Examples:
  - Mixed mode
  - Unicast
  - Timecode generation from metadata
  - ST2022 -7 topologies and profiles
- Opportunity for new participants
- Are events needed in other geographies?
- Interop in March 2017

IBC and SMPTE ATC Timing Demos

- IBC
  - Three separate demonstrations
    - NMOS Discovery, PTP Timing, Transport
  - Co-located with the VRT live IP demonstration
- SMPTE ATC
  - PTP Demonstration only
  - Incorporated the experiences from IBC Demonstration
- Demonstrated Best Master Clock Algorithm (BMCA), effects of traffic in different switch modes and signal alignment.
- Did not present any results or conclusions from the interoperability tests

PTP Timing Demonstration

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- Interoperability of masters, switches, and slaves
- Operation at proposed common rates for ST2059-2 and AES67
- Displays alignment of traditional signals generated from PTP
- Illustrates the effects of traffic on different IP switch types
  - Non-PTP aware
  - Transparent Clock
  - Boundary Clock
- Master redundancy

Rolling Slides used at IBC and SMPTE ATC Demonstrations

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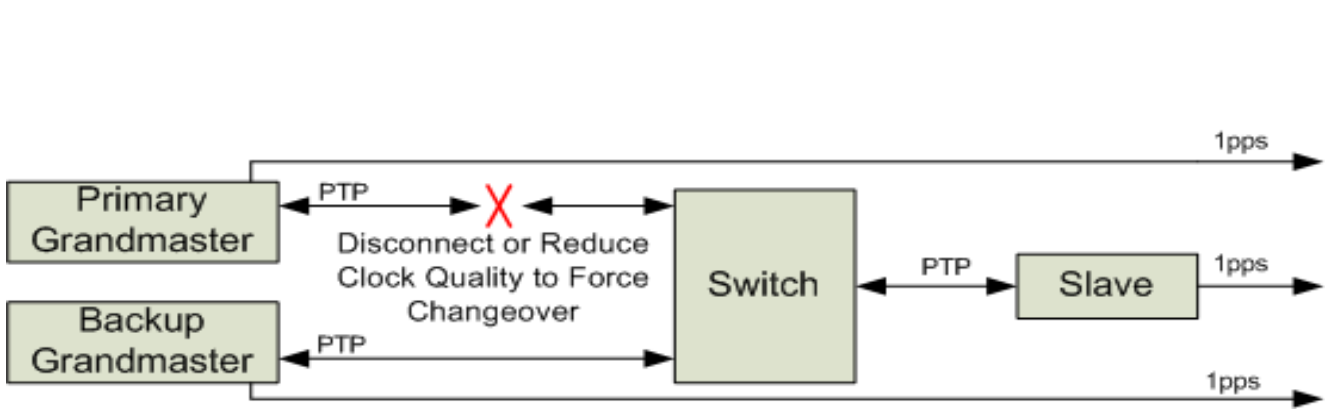
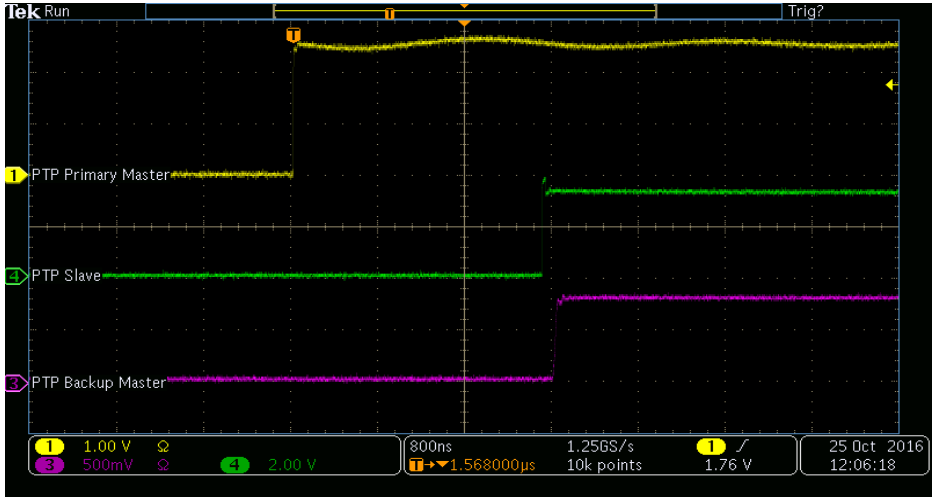
Redundant Master Demo





- Two Grandmasters, Primary and Backup
  - Backup Grandmaster is intentionally offset in time
- Periodically degrade the PTP from the Primary Grandmaster to force a changeover, see the slave align with other master
- Illustrates Slaves switching between Primary Grandmaster and Backup Grandmaster

Rolling Slides used at IBC and SMPTE ATC Demonstrations

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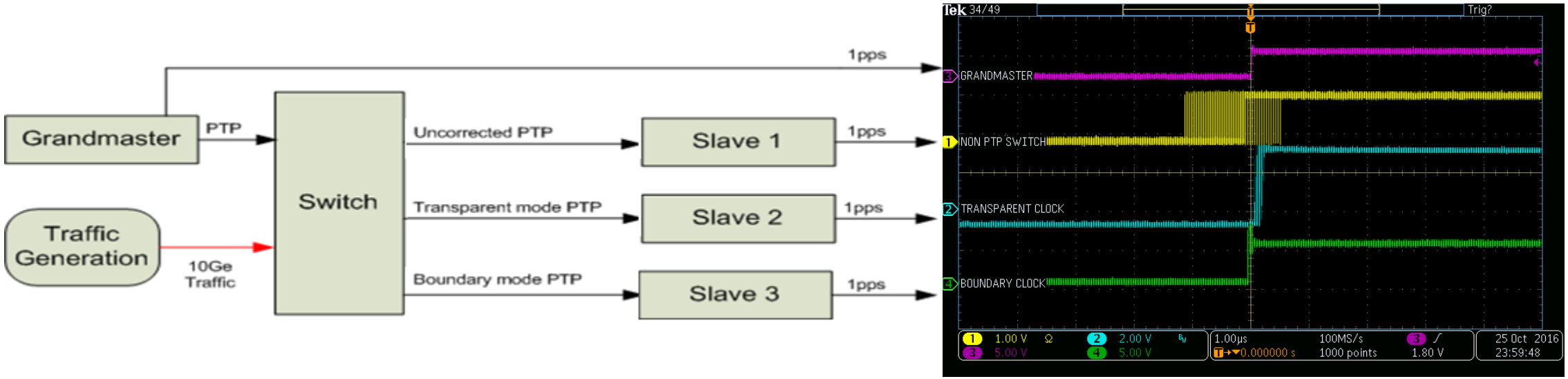
Traffic Test Demo



- Switch output ports in Non-PTP, Transparent Clock and Boundary Clock modes
- Media traffic load on switches
- Compare 1 pps signal from the master and the 3 slaves
- Illustrates Transparent Clock and Boundary Clock outputs have less jitter

Rolling Slides used at IBC and SMPTE ATC Demonstrations

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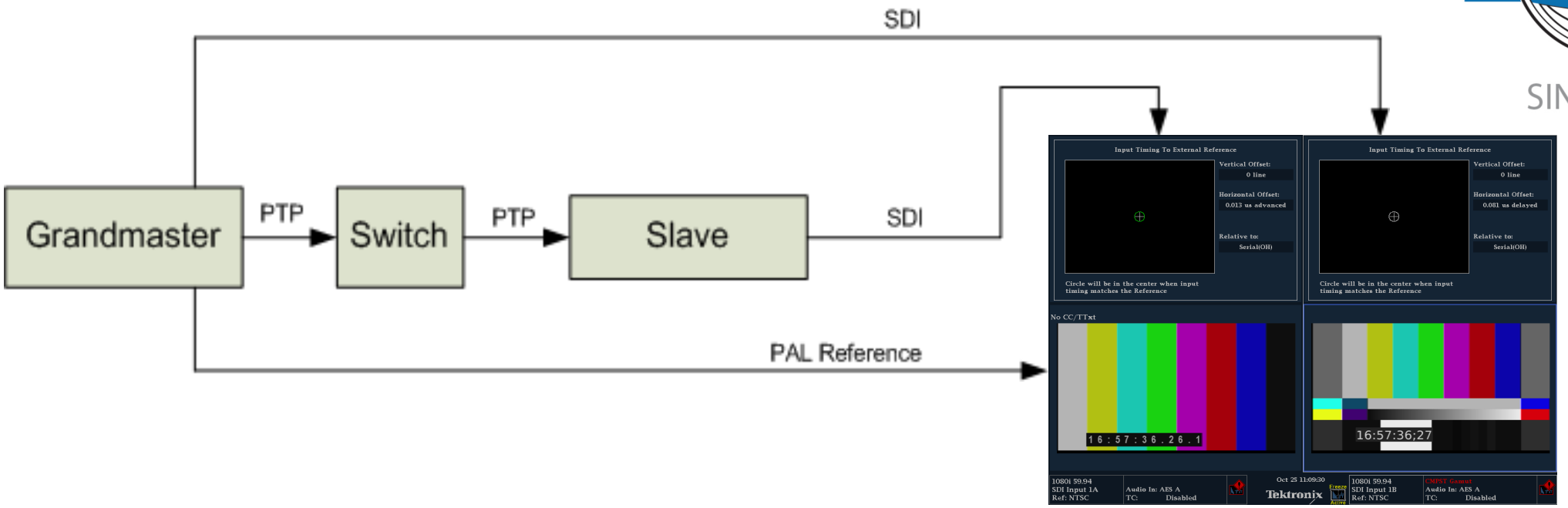
SDI Output Phase Demo



- Display shows SDI timing from Master and Slave
  - Both relative to PAL Black from Master
- Illustrates SDI alignment when generated from PTP

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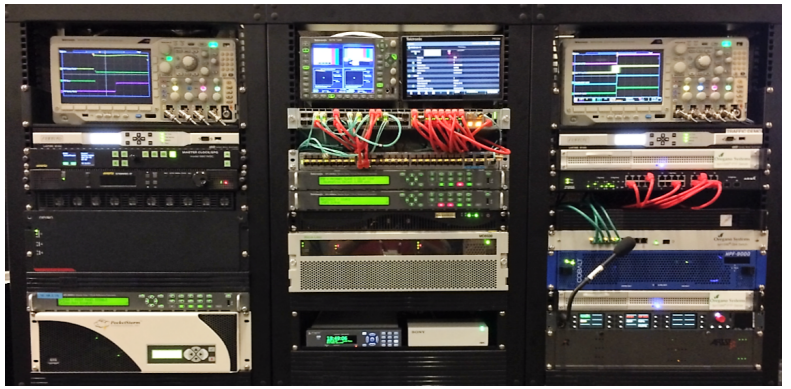
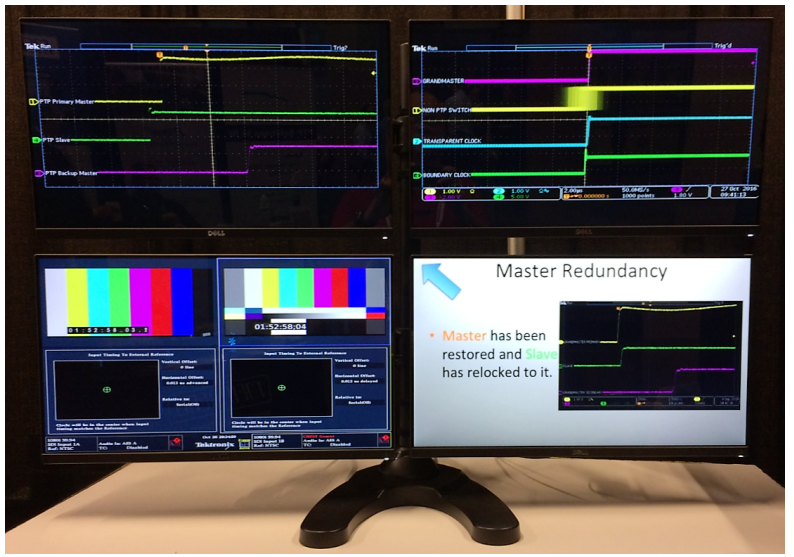
ST2059 Precision Time Protocol (PTP) Timing and AES67 Demonstration SMPTE ATC Conference – October 25 -27, 2016





SMPTE 2016
ANNUAL TECHNICAL CONFERENCE & EXHIBITION

SMPTE ST2059 (PTP Timing) and AES 67 Interop Demonstration

Sponsored by FOX

Companies Demonstrating Interoperability

ARISTA, A-R-G, CISCO, COVELOZ, everlz, Imagine Communications, Media Links, MEINBERG, Oregano Systems, RIEDEL, SONY, Tektronix

Other companies which have verified PTP Timing interoperability

Adeas, BBC, ROSS, Snell Advanced Media, Stagebox, XILINX

Interop Supporting Companies

21ST CENTURY FOX, COBALT, DVBLink, IRT, PacketStorm Communications, Inc., Televisionary, AUDIO ES, SMPTE, VSF

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Interop and Demonstration

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Interop in March 20 to 24, 2017

- Fox NE&O Houston, TX

NAB Demonstration April 22 to 27, 2017

- Las Vegas, NV

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