Correlation between PTP Lock time and Jitter/Wander on 10G/25GbE Networks

May 2019 VSF Meeting Series

Koji Oyama, M3L Inc.

M3L™ Speedy & High Quality

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Agenda

- Introduction
  - Who M3L are
  - Motivation for this evaluation
  - ST 2059 lock time requirement and objective
- Evaluation environment and scenarios
- Scenario A results
  - Video demo
- Scenario B results
  - Video demos
- Conclusion

Introduction

- M3L Inc. (株式会社メディアリンクスエルエスアイラボ) http://www.m3l.co.jp/en/
  - Founded : April 1997
  - Capital : JPY 10M
  - President : Kenji Fukuda
  - Office : Kawasaki, Japan
  - Employees : 10
- Independent IP-Core Design Company
  - IP Core: Reusable logic design blocks (See Wiki)
  - Mission : Speedy & High Quality
  - Vision : Pursue ideal IP cores
- 15+ years Experience with Professional Video Over IP technology
  - IP : Internet Protocol (See Wiki), Professional Video Over IP (See Wiki)

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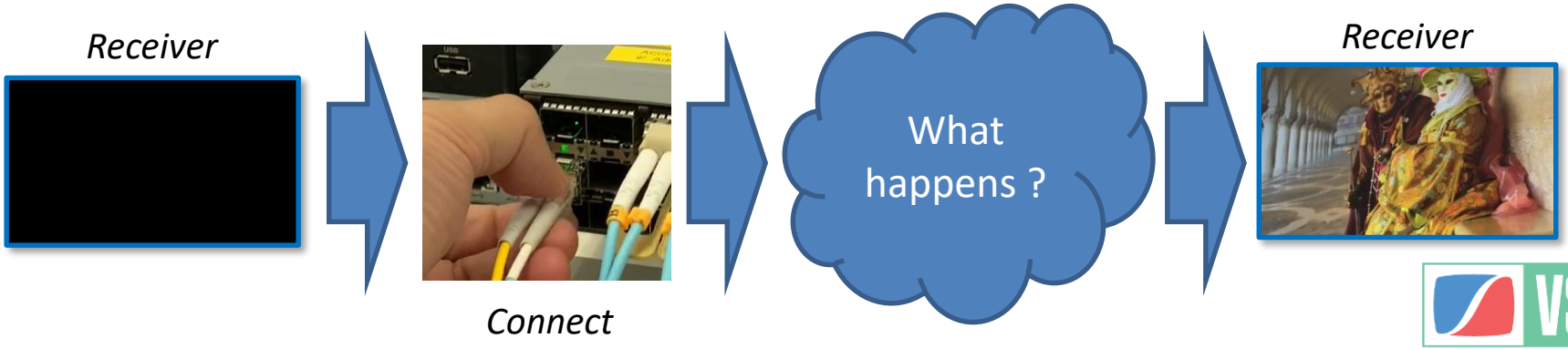
Motivation

- Persuade SDI customers to shift IP network with confidence
  - Need real evaluation data

- Understand what happens when connecting a optical fiber cable

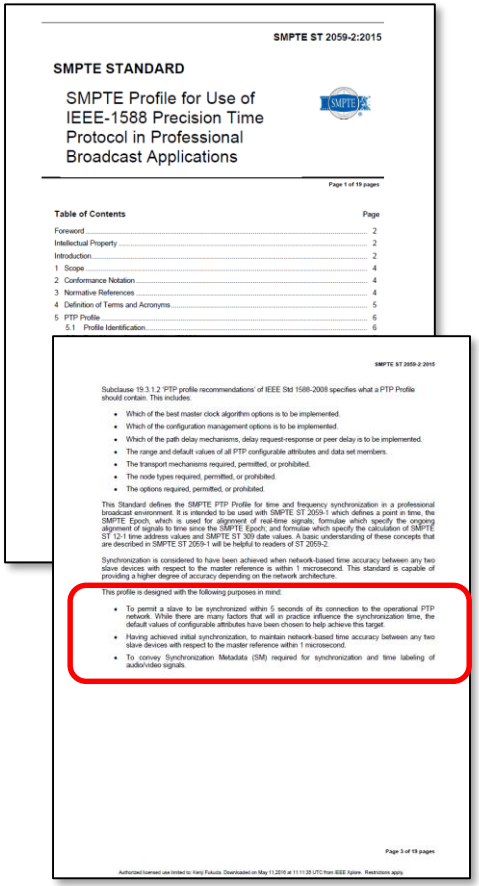


SMPTE ST 2059-2:2015

Introduction (Page 3)

This profile is designed with the following purposes in mind:

- To permit a slave to be synchronized within 5 seconds of its connection to the operational PTP network. While there are many factors that will in practice influence the synchronization time, the default values of configurable attributes have been chosen to help achieve this target.
- Having achieved initial synchronization, to maintain network-based time accuracy between any two slave devices with respect to the master reference within 1 microsecond.
- To convey Synchronization Metadata (SM) required for synchronization and time labeling of audio/video signals.


SMPTE ST 2059-2:2015

SMPTE STANDARD

SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications

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5.1 Profile Identification ... 6

Subclause 19.3.1.2 'PTP profile recommendations' of IEEE Std 1588-2008 specifies what a PTP Profile should contain. This includes:

- Which of the best master clock algorithm options is to be implemented.
- Which of the configuration management options is to be implemented.
- Which of the path delay mechanisms, delay request-response or peer delay is to be implemented.
- The range and default values of all PTP configurable attributes and data set members.
- The transport mechanisms required, permitted, or prohibited.
- The node types required, permitted, or prohibited.
- The options required, permitted, or prohibited.

This Standard defines the SMPTE PTP Profile for time and frequency synchronization in a professional broadcast environment. It is intended to be used with SMPTE ST 2059-1 which defines a point in time, the SMPTE Epoch, which is used for alignment of real-time signals, formulae which specify the ongoing alignment of signals to time since the SMPTE Epoch; and formulae which specify the calculation of SMPTE ST 12-1 time address values and SMPTE ST 309 date values. A basic understanding of these concepts that are described in SMPTE ST 2059-1 will be helpful to readers of ST 2059-2.

Synchronization is considered to have been achieved when network-based time accuracy between any two slave devices with respect to the master reference is within 1 microsecond. This standard is capable of providing a higher degree of accuracy depending on the network architecture.

This profile is designed with the following purposes in mind:

- To permit a slave to be synchronized within 5 seconds of its connection to the operational PTP network. While there are many factors that will in practice influence the synchronization time, the default values of configurable attributes have been chosen to help achieve this target.
- Having achieved initial synchronization, to maintain network-based time accuracy between any two slave devices with respect to the master reference within 1 microsecond.
- To convey Synchronization Metadata (SM) required for synchronization and time labeling of audio/video signals.

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SMPTE ST 2059-2:20xx (Revision)

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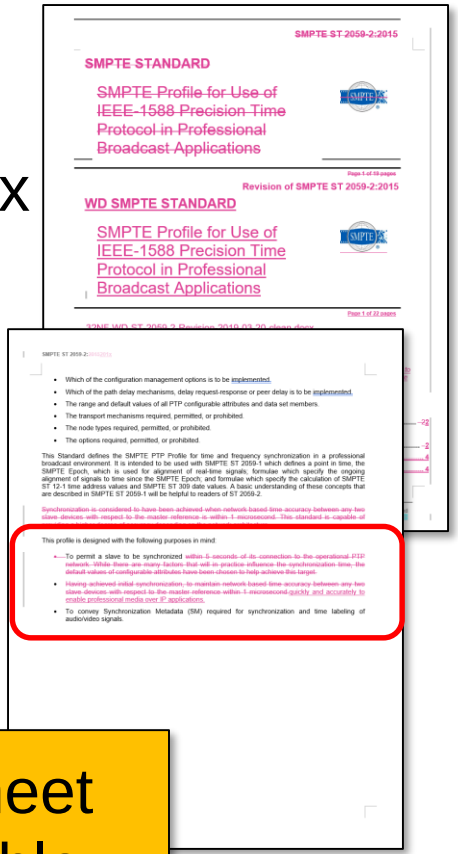
SMPTE ST 2059-2:2015

SMPTE STANDARD

SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications

Revision of SMPTE ST 2059-2:2015

WD SMPTE STANDARD

SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications

- Which of the configuration management options is to be implemented.
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- The range and default values of all PTP configurable attributes and data set members.
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This profile is designed with the following purposes in mind:

- To permit a slave to be synchronized within 5 seconds of its connection to the operational PTP network. While there are many factors that will in practice influence the synchronization time, the default values of configurable attributes have been chosen to help achieve this target.
- Having achieved initial synchronization, to maintain network based time accuracy between any two slave devices with respect to the master reference within 1 microsecond quickly and accurately to enable professional media over IP applications.
- To convey Synchronization Metadata (SM) required for synchronization and time labeling of audio/video signals.

Introduction (Page 3)

This profile is designed with the following purposes in mind:

- To permit a slave to be synchronized quickly and accurately to enable professional media over IP applications.
- To convey Synchronization Metadata (SM) required for synchronization and time labeling of audio/video signals.

The ST 2059 slave logic core is designed to meet 1 uS accuracy in 5 seconds as much as possible

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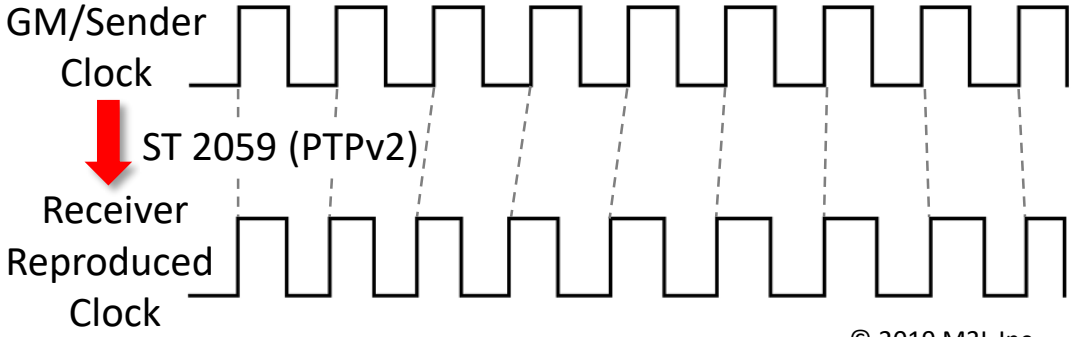
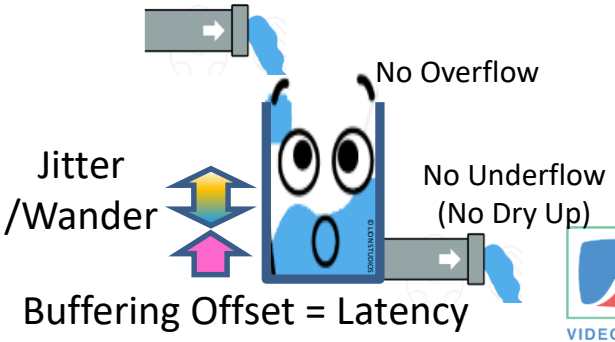
Objective of PTP synchronization

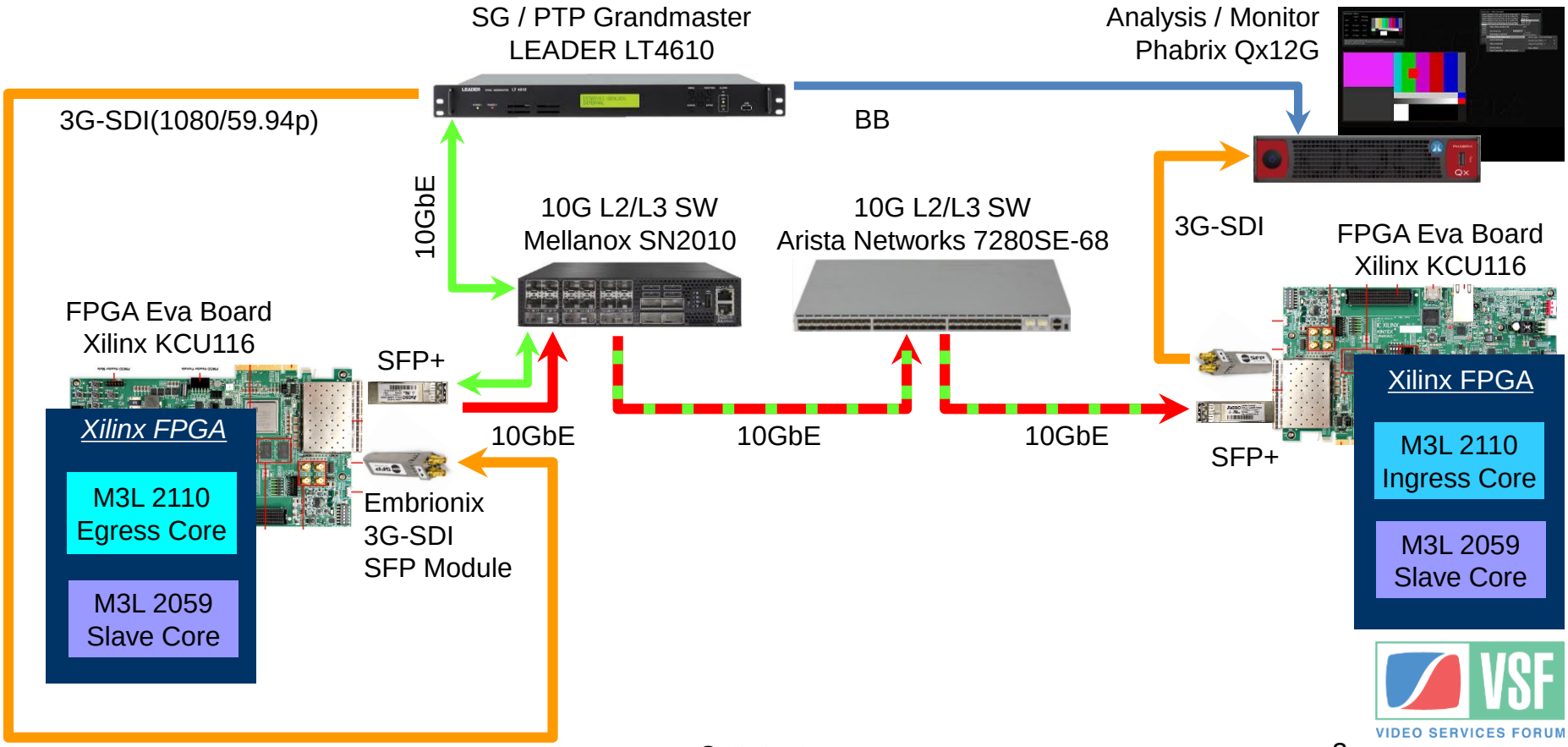
- Less data buffering = Low Latency
  - Ideal Case : Zero → No Reality
    - No Error → Perfect Clock Recovering → Zero buffering → Zero Latency
  - Reality : Reasonable Adjustment by Feedback Control
    - Correct Errors
    - More Robustness (Higher Noise Immunity)

      → Low Jitter & Wander, Less Lock Time, Prevent Resonance

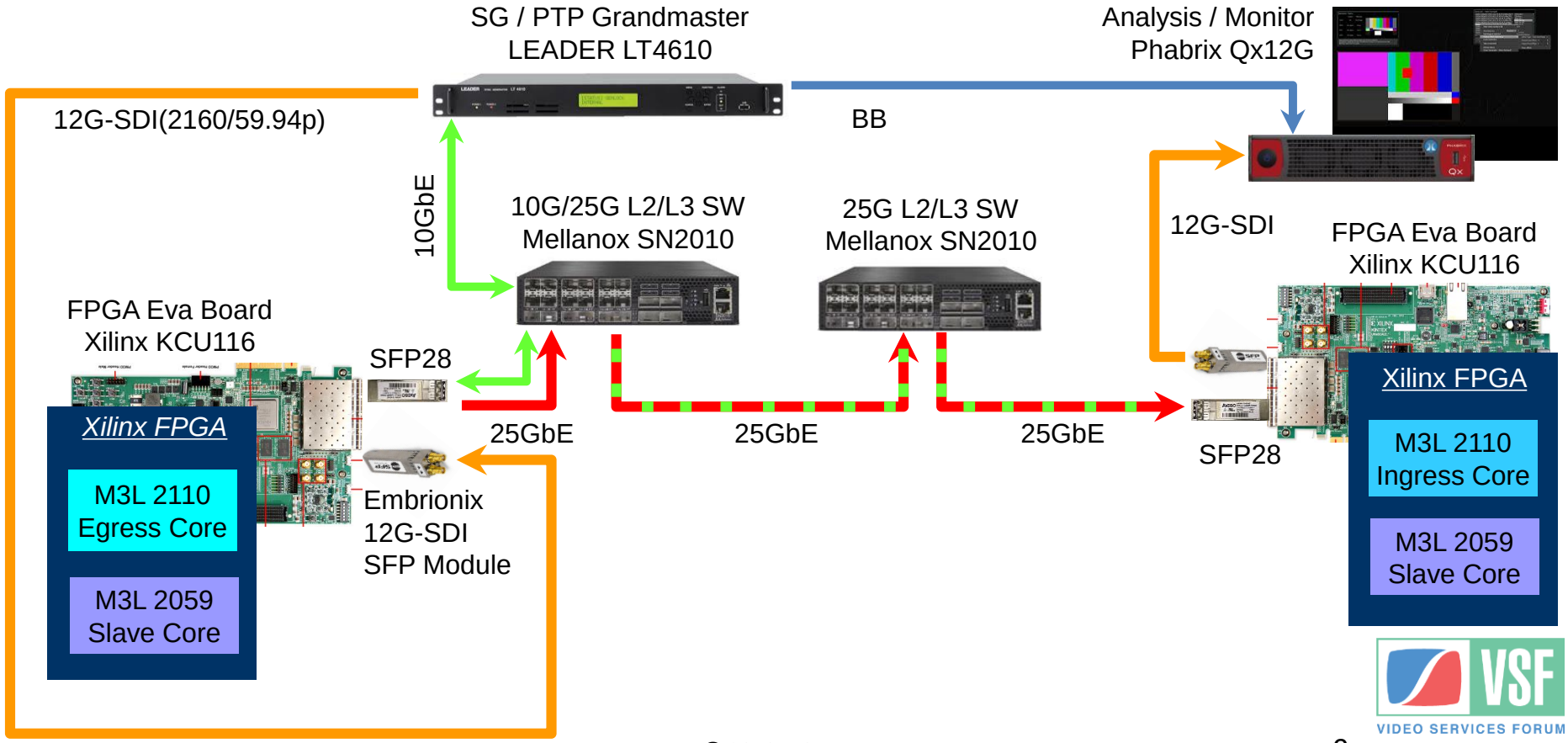




10GbE Evaluation Environment



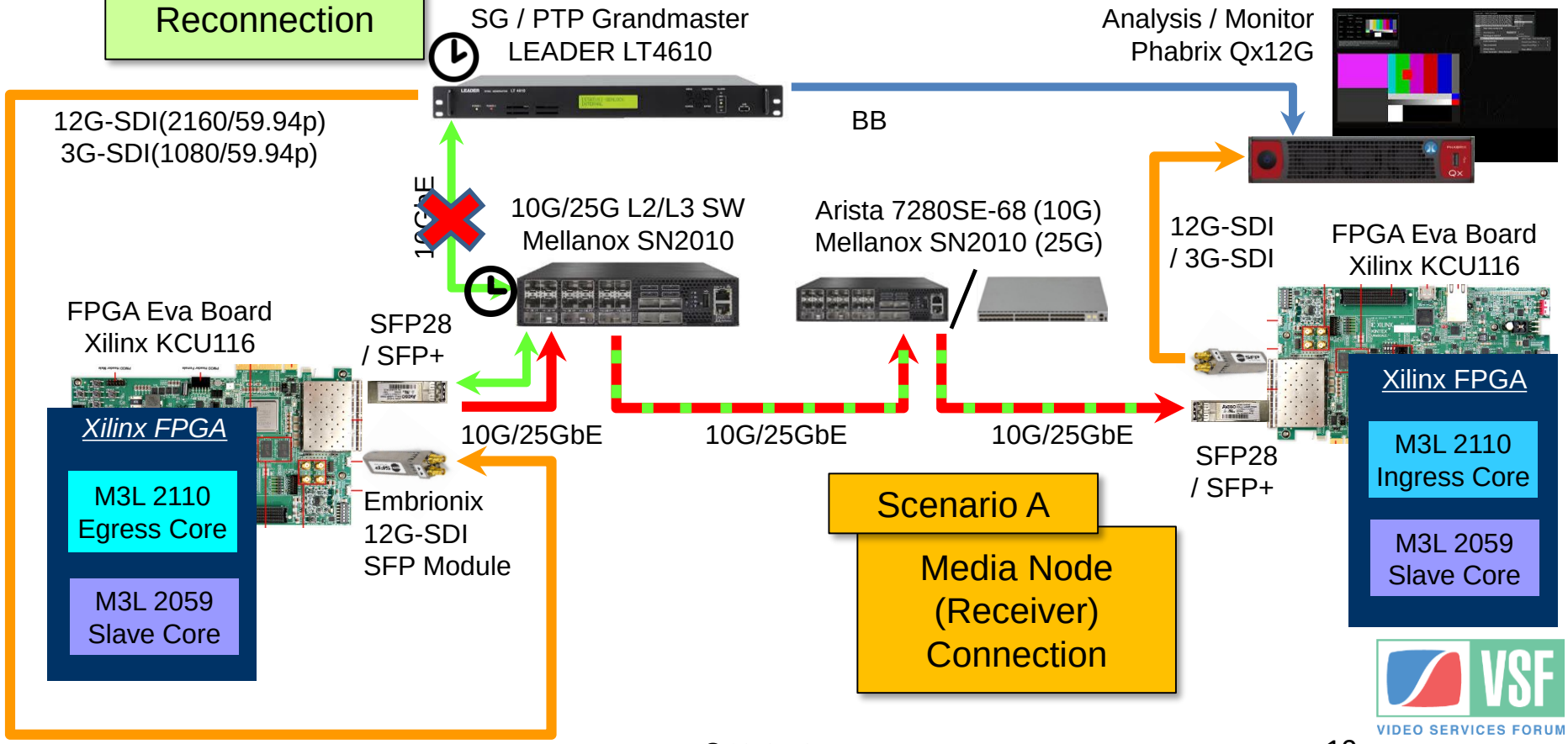
25GbE Evaluation Environment



Evaluation Scenarios

Scenario B

GM Lost & Reconnection



Scenario A example

Fiber Cable Connected

Video Out (Ether PHY Linked)

Start PTP Locking

PTP Locked

Jitter Stable

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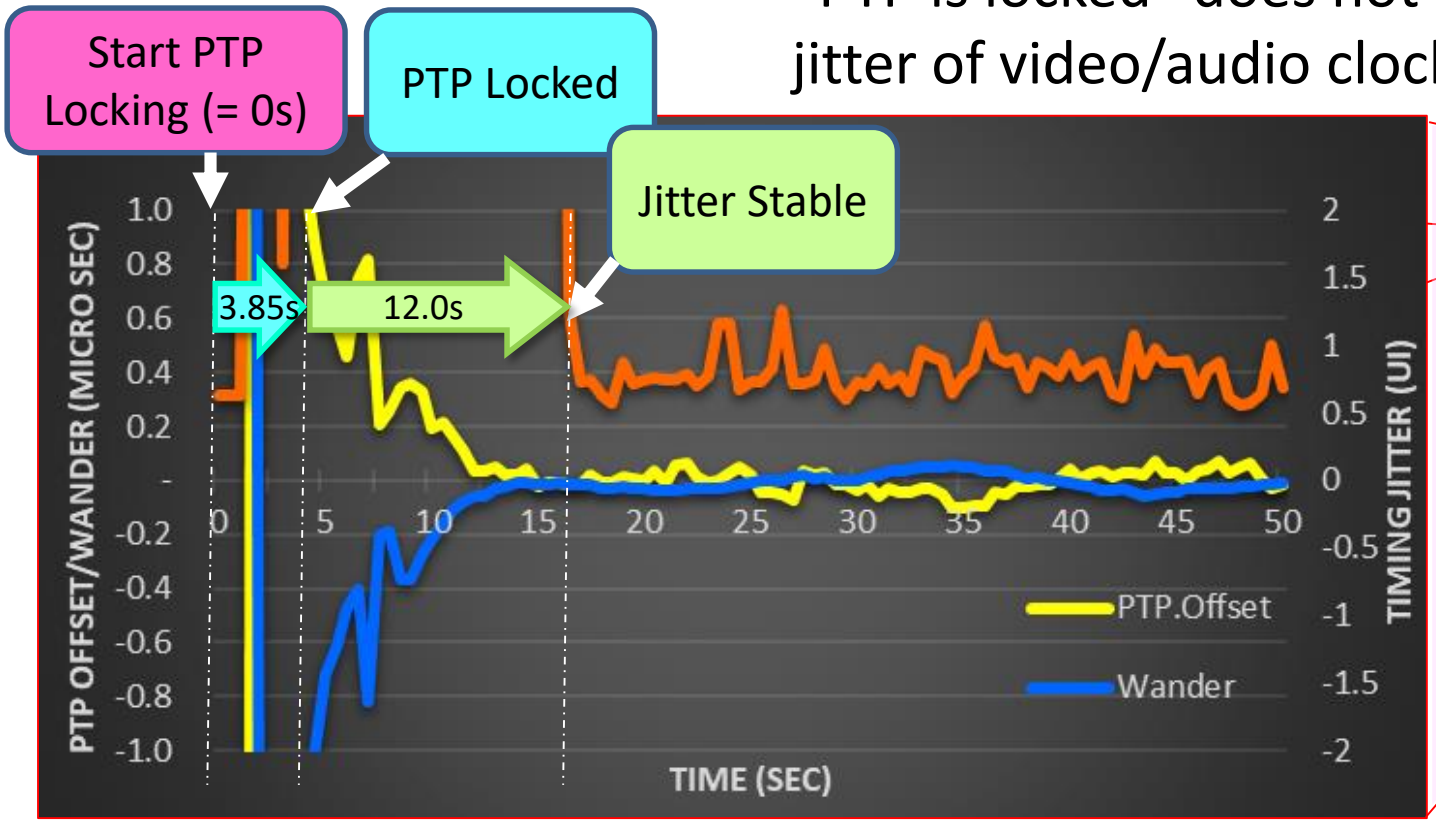
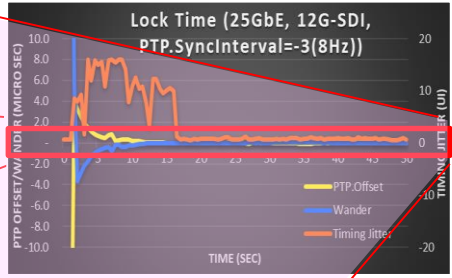
Lock Time for 12G-SDI over25GbE w/8Hz PTP

"PTP is locked" does not mean that jitter of video/audio clock is stable



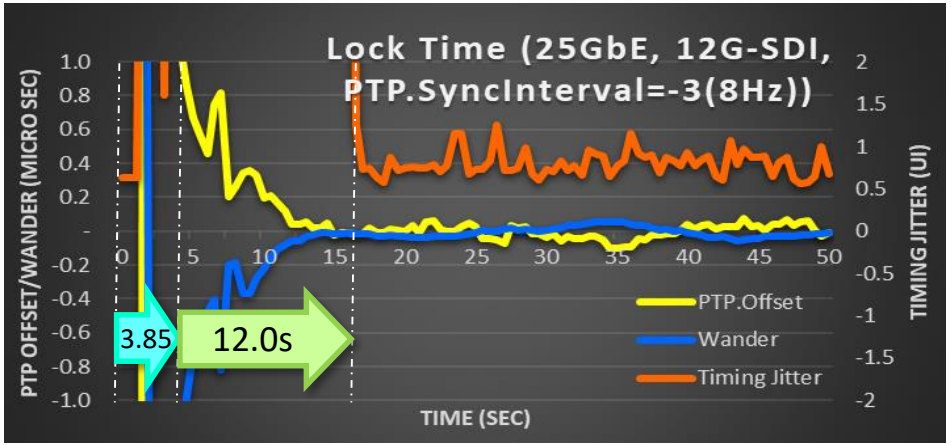


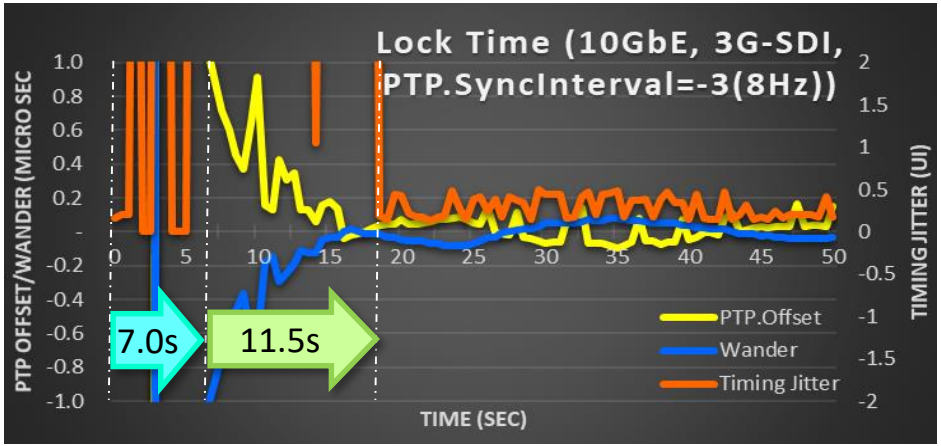
PTP offset
= slave clock time
– master clock time
= Receiver current time
– GM time

Parameters and Results for Scenario A

- Parameters
  - Ethernet media : 25GbE, 10GbE
  - SDI media : 12G-SDI(2160/59.94p), 3G-SDI(1080/59.94p)
  - PTP Interval (portDS.logSyncInterval) : n=[-1, -2, down to -7] (2^n sec)
  - Network load : PTP only (PTP non-muxed), PTP+ST2110 (PTP muxed)
- Results
  - Timing **Jitter** of a reproduced SDI signal (UI)
  - Phase Sync with BB/source signal (uS) → **Wander**
  - **Lock time** (sec) → PTP locked time, Jitter stable time

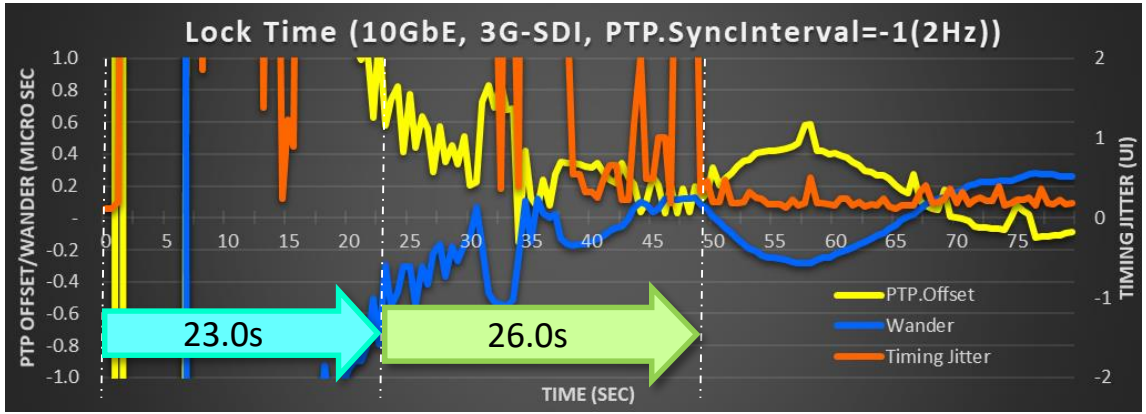
Scenario A Result : 25GbE vs 10GbE

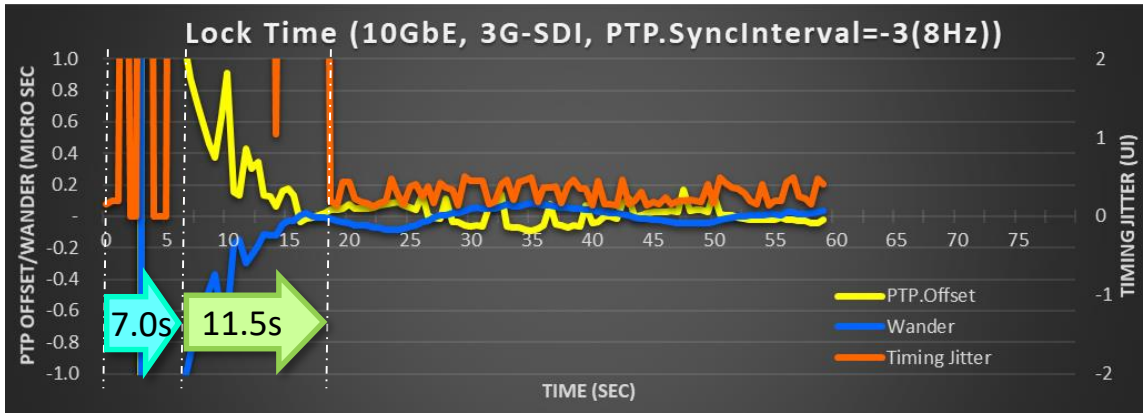




- 25G vs 10G
  - PTP lock time and jitter stable time are almost the same
  - Jitter at stable time is 4:1
    - Absolute value almost the same
- Common features
  - Yellow line (PTP offset) is negative phase of Blue line (phase sync value)
  - Orange line (jitter) becomes stable if Blue & Yellow lines are stable
    - Like differential value

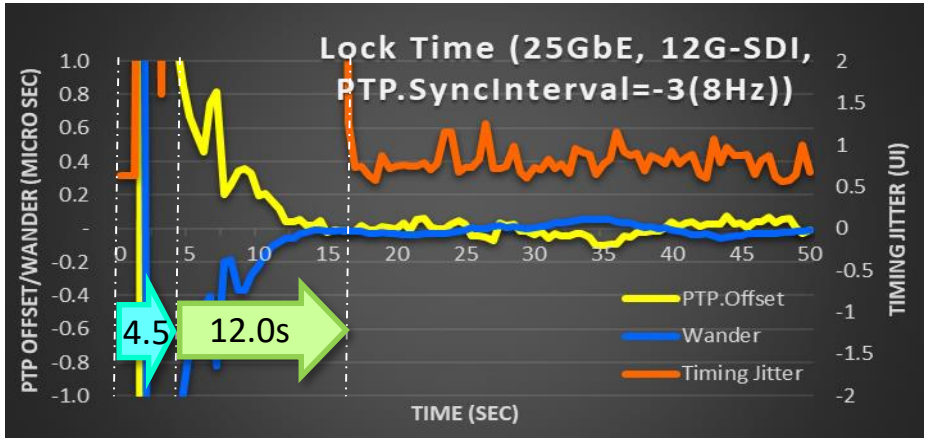
Scenario A Result : PTP Sync Interval

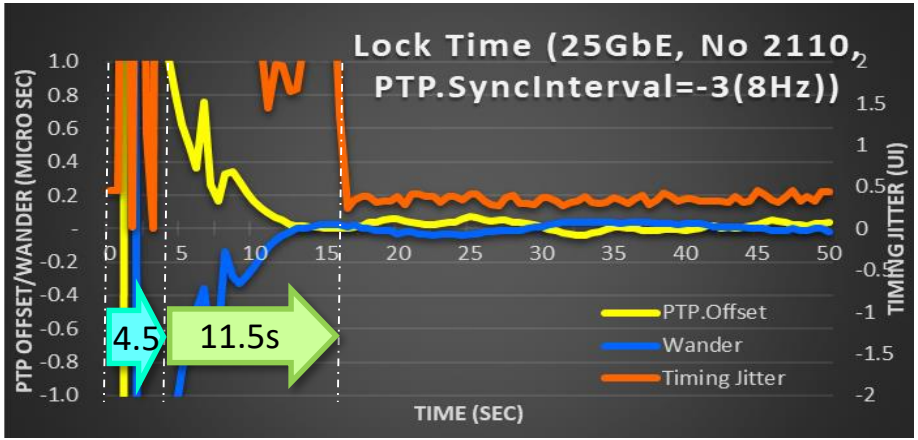




- Less PTP sync interval needs longer PTP lock and jitter stable time

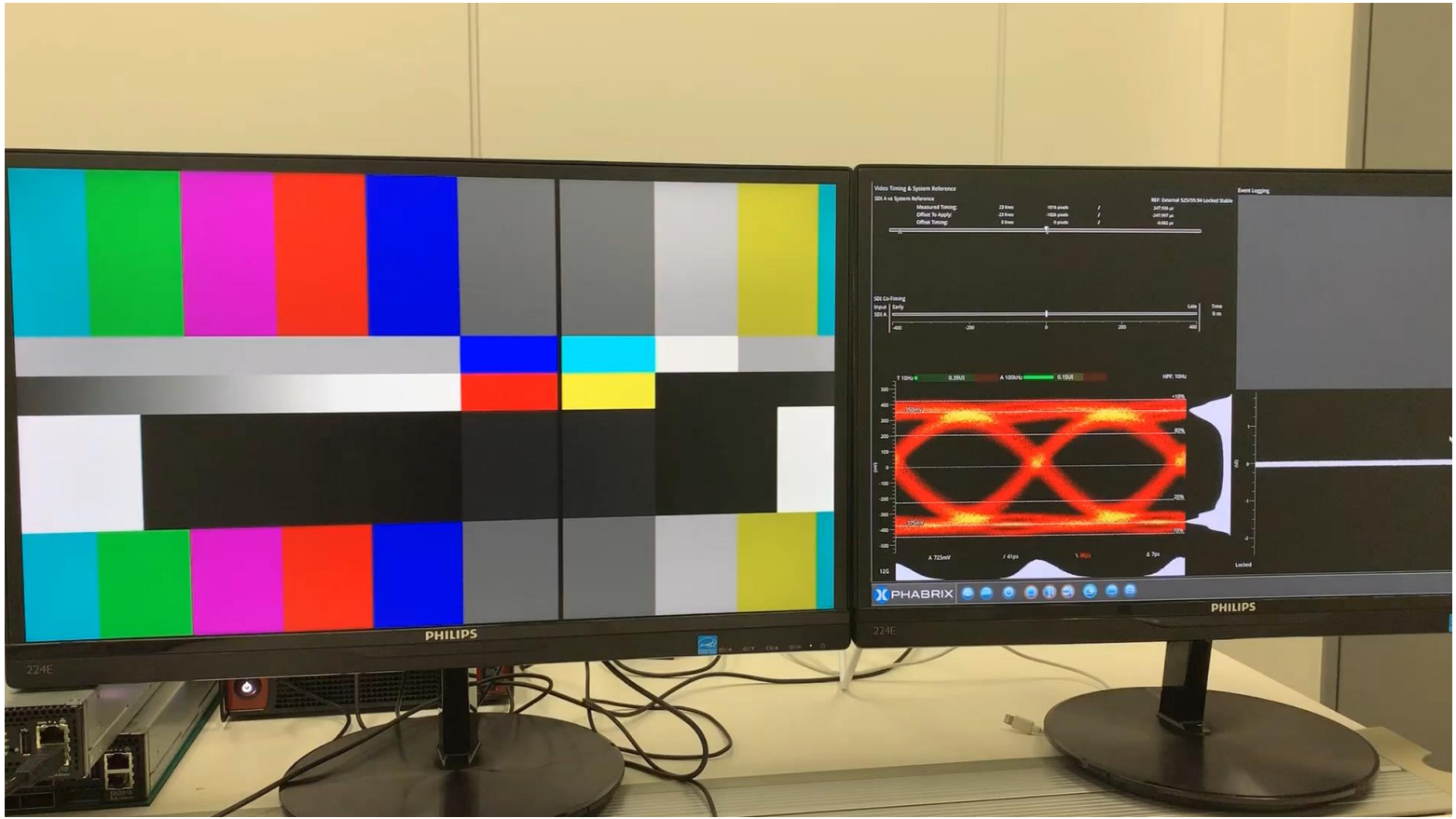
Scenario A result : PTP muxed vs non-muxed





- No difference for PTP lock and Jitter stable time

Scenario B example #1



GM Lost

GM Reconnected

Start PTP Locking

PTP Locked

Jitter Stable

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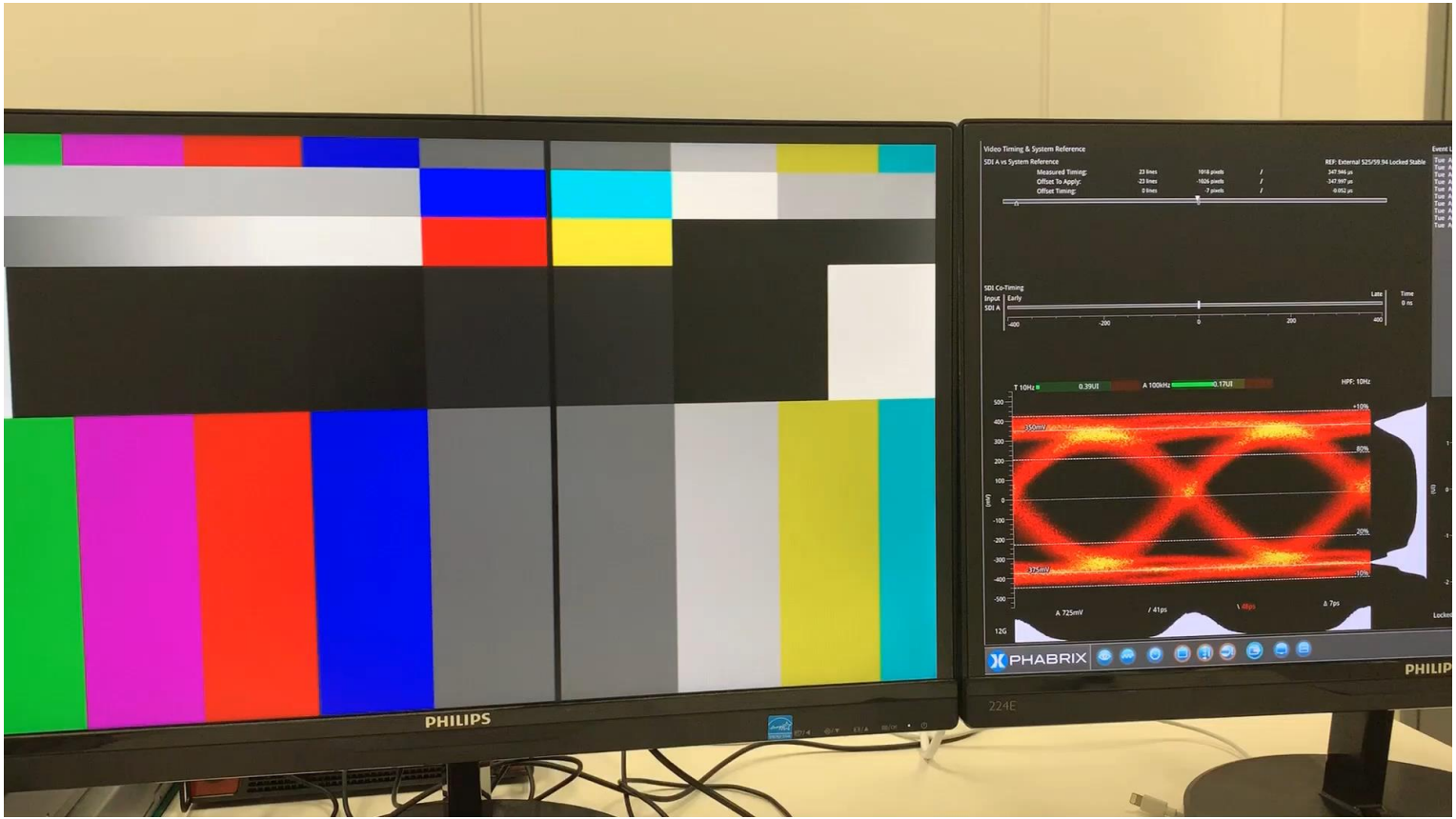
Scenario B example #2



GM Lost

GM Reconnected

Start PTP Locking

PTP Locked

Jitter Stable

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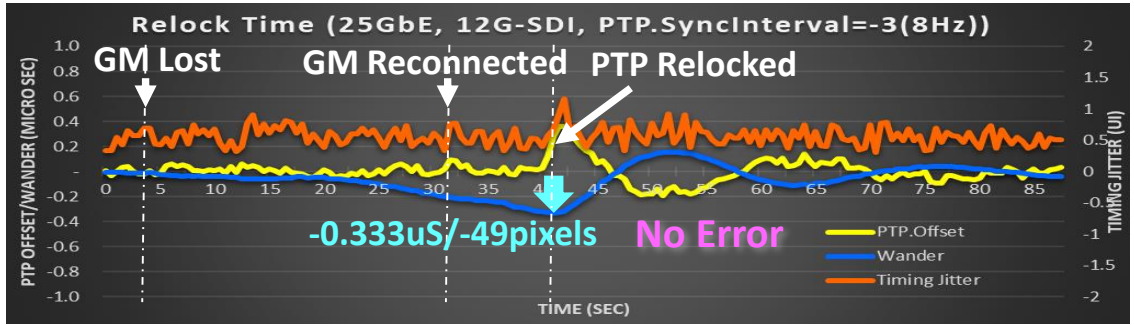
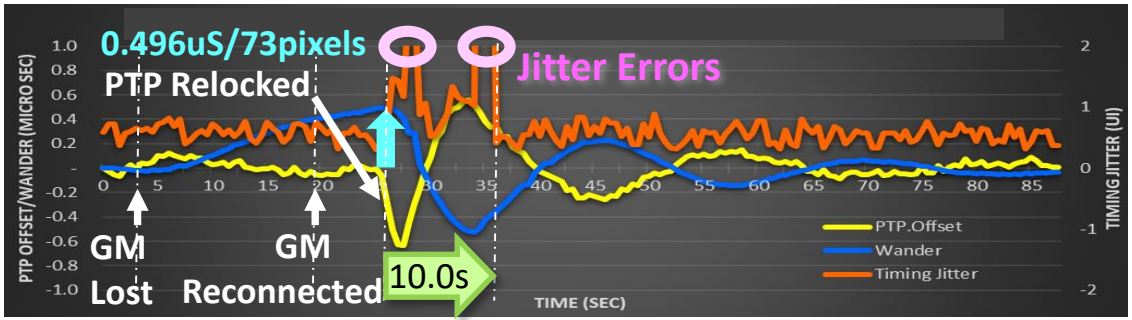
Parameters and Results for Scenario B

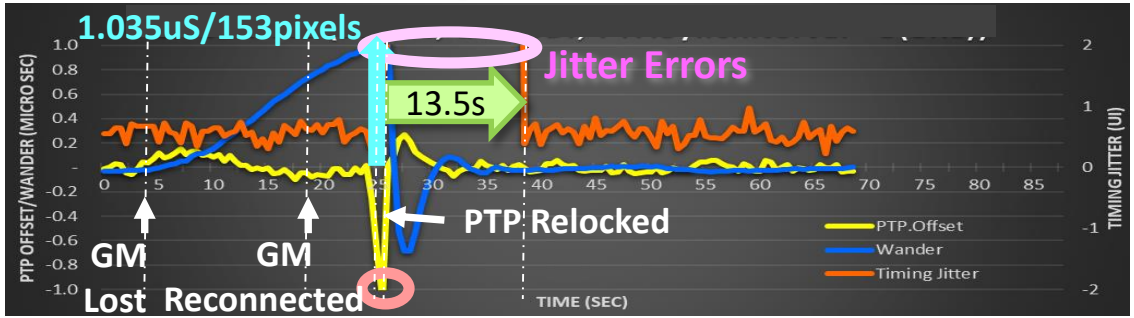
- Parameters
  - Phase shift value when GM is lost

- Results
  - **Errors** : PTP offset errors, Jitter errors
  - Timing **Jitter** of a reproduced SDI signal (UI)
  - Phase Sync with BB/source signal (uS) → **Wander**
  - **Lock time** (sec) → PTP relocked time, Jitter stable time

Scenario B results







PTP Errors

- There are 3 types of recovery for GM lost & reconnection
  1. Recover without an error
  2. Reconnect with jitter errors
  3. Reconnect with PTP and jitter errors
- Aggressive Lock speed sometimes makes errors
  - Depends on implementation
- Once PTP errors occur, reconnection scheme seems to be the similar as the one for Scenario A
  - Depends on implementation

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Correlation btw Lock-time and Jitter/Wander

- “PTP locked” dose not mean “Jitter stable”
- No effect on lock time with the difference of 25G/10G and PTP muxed/non-muxed
- PTP offset (correction time) is negative phase of phase sync value (time difference between master and slave)
  - Offset(t) = Slave(t) – Master(t)
  - Phase(t) = Master(t) – Slave(t) = – Offse(t)
- Less PTP Sync interval needs longer PTP lock and Jitter stable time
- Aggressive lock speed sometimes makes PTP and Jitter errors

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Conclusion

- We could know some correlation between lock time and jitter/wander.
  - M3L is going to keep on disclosing such evaluation data in public

- We understood much better than before what happens at the cable connection and GM lost & reconnection (or switchover)

- We hope these evaluated data helps SDI customers become familiar with IP technology
  - No criteria → Evaluated data

Thank You !

Koji Oyama, M3L Inc.

oyama@m3l.co.jp +81-90-1127-2023 +1(408)714-8808

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