SATA Standard spec. for internal connection with FPC cable White Paper

2011-01-31

Background

For application using HDD, there are cases of selecting FPC cable for flexible and longer connection between HDD and Motherboard etc…

Especially for the application such as Car navigation systems, there are many cases to select FPC because of its flexibility as thin and varied length options. Currently, the use case limitation/market condition is varied and up to the specification of each application/each company.

This proposal is to show the result of FPC cable length to meet SATA standard and rough guide for spec. under realistic use case condition.

For the test, we chose Yamaichi made FPC cable (YFLEX™) and connector for all test and simulation.

MOI test with YFLEX™ L=300mm

YFLEX™ L=300mm was tested under condition of "Serial ATA Interoperability Program Tektronix MOI for SI Cable Tests Version .8"

(Test condition and result is followed in this material)

As the test result, there is 2 items which could not be compliant with the current standard. However, there is no problem in performance to use in an application.

Also, Host manufacturers need cable length as same as legacy solution and they need Judge-criteria for FPC.

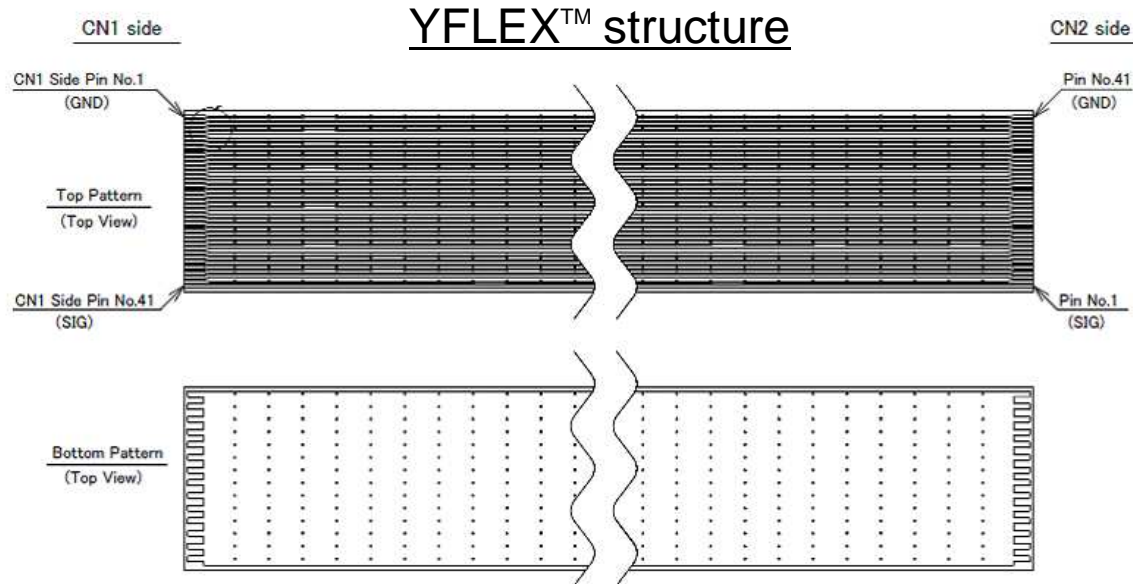Considering use-case of necessary cable length, there are following 2 options.

However, it would be more realistic to define new criteria with considering real use-case.

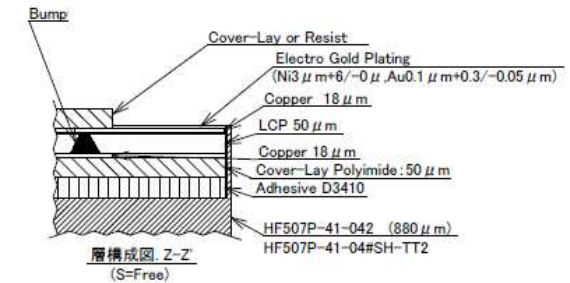1) To loosen standard for 2 items which could not be compliant the current standard,

Or

2) To define FPC length which could be compliant all standard items.

FPC Detail

YFLEX™ structure

CN1 side

CN1 Side Pin No.1
(GND)

Top Pattern
(Top View)

CN1 Side Pin No.41
(SIG)

Bottom Pattern
(Top View)

CN2 side

Pin No.41
(GND)

Pin No.1
(SIG)

YFLEX™ Structure: cross section

Bump
Cover-Lay or Resist
Electro Gold Plating
(Ni3 μm+6/−0 μ ,Au0.1 μ m+0.3/−0.05 μ m)
Copper 18 μ m
LCP 50 μ m
Copper 18 μ m
Cover-Lay Polyimide：50 μ m
Adhesive D3410
HF507P-41-042   (880 μ m)
HF507P-41-04#SH-TT2

層構成図. Z-Z'
(S=Free)

※ FPC Pad area is key factor for its performance. Since there are some effect from contact pitch etc…, it is preferred to specialize design with matching connector.
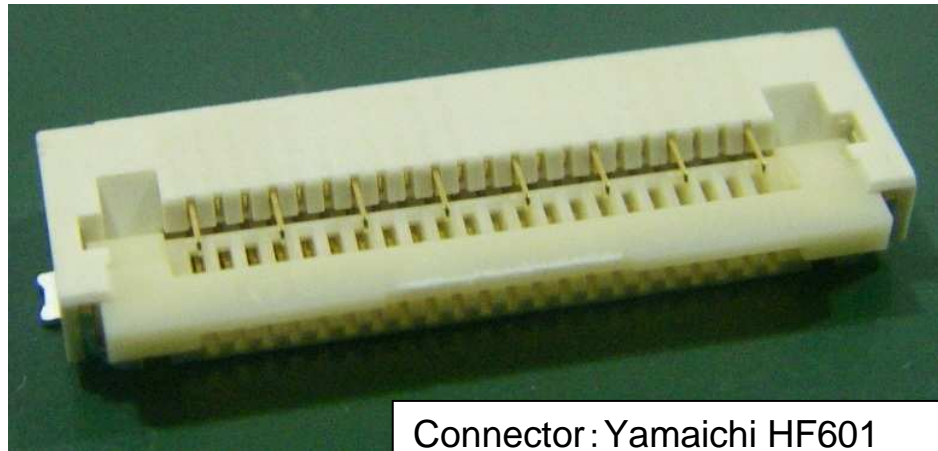
Test sample

L=300mm(200mm)
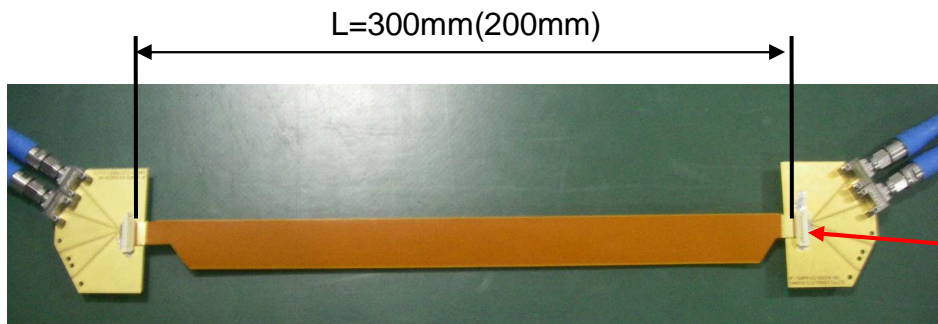
YFLEX cable and connector
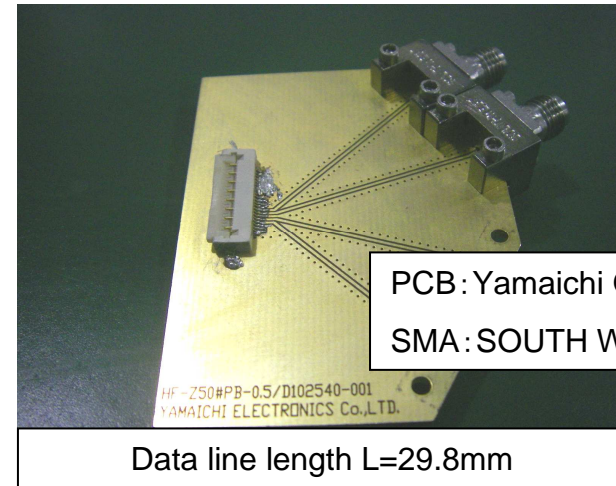(Yamaichi products, YFLEX™ and HF601-22-03)

Connector & Test Board Detail
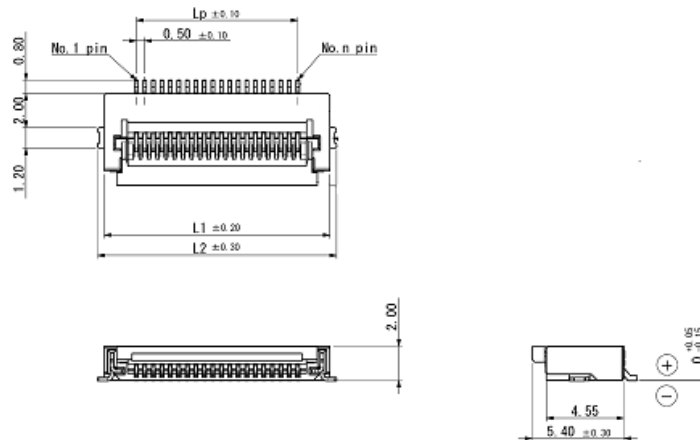
Yamaichi FPC connector

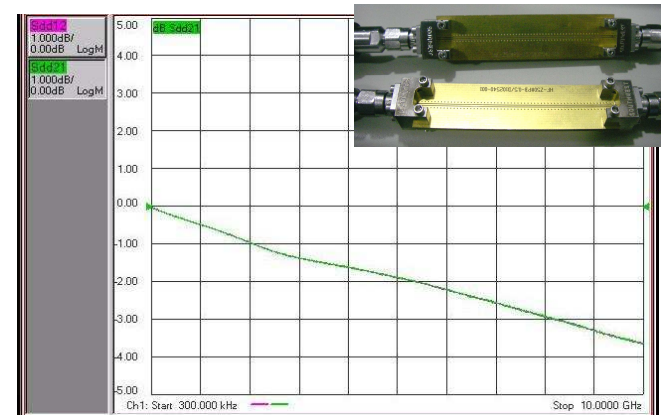

Connector：Yamaichi HF601

Test Board

PCB：Yamaichi Original

SMA：SOUTH WEST

Data line length L=29.8mm

FPC connector outline

Test Board performance

Test items and test equipment

It was measured by referring to "Serial ATA Interoperability Program Tektronix MOI for SI Cable Tests Version. 8" with using DSA8200, I-connect.

* SI-07 cross talk was measured by Agilent N5230A.

Serial ATA Interoperability Program Tektronix MOI for SI Cable Tests

	Referred spec.	Equipment
SI-01	Tektronix MOI p8	DSA8200、I-connect
SI-02	Tektronix MOI p10	DSA8200、I-connect
SI-03	Tektronix MOI p12	DSA8200、I-connect
SI-04	Tektronix MOI p13	DSA8200、I-connect
SI-05	Tektronix MOI p14	DSA8200
SI-06	Tektronix MOI p15	DSA8200
SI-07	Tektronix MOI p16	DSA8200、I-connect
SI-08	Tektronix MOI p18	N5230A (Agilent)
SI-09	Tektronix MOI p21	DSA8200、I-connect

Test overview
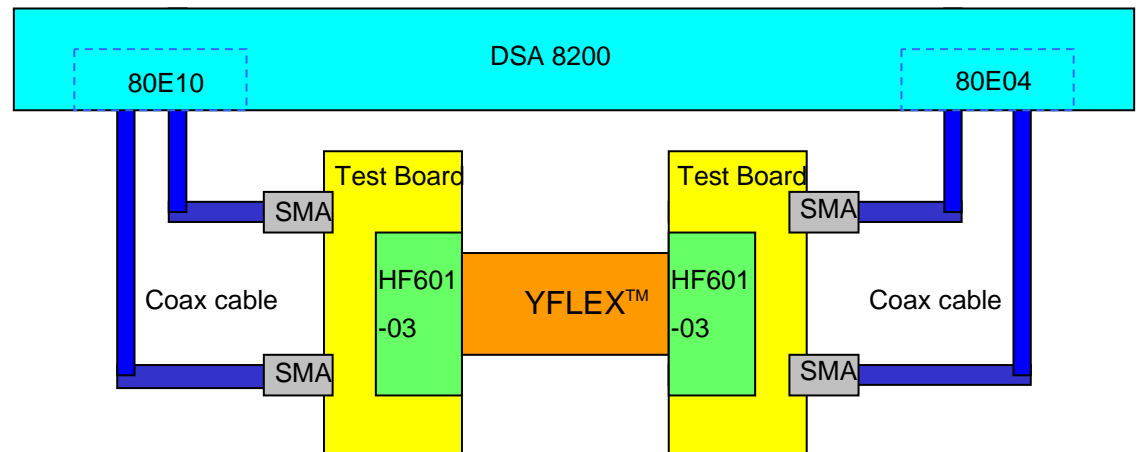
Measurement
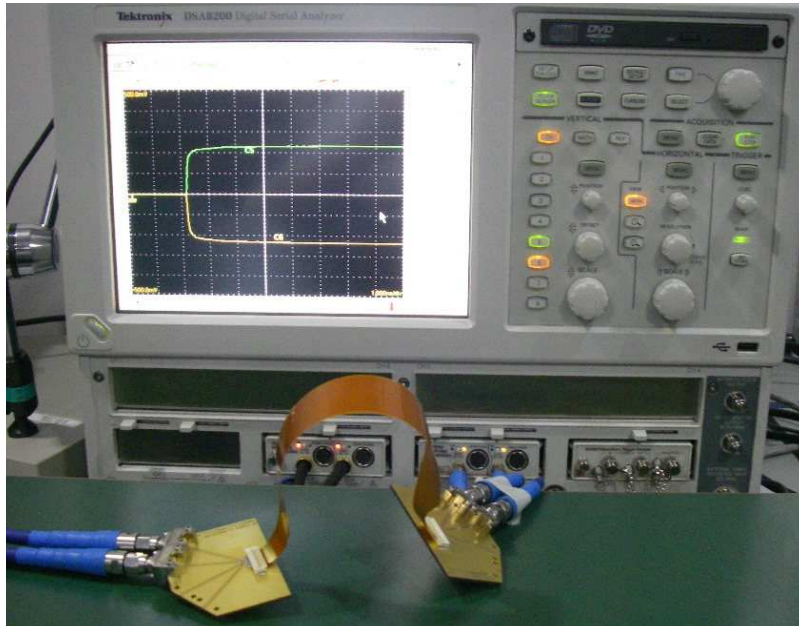
Equipment

DSA8200 (Tektronix)

Measurement condition

SI-01,SI-02,SI-03,SI-04,SI-05,SI-06,SI-07,SI-09 were measured by the connection on the left photo.
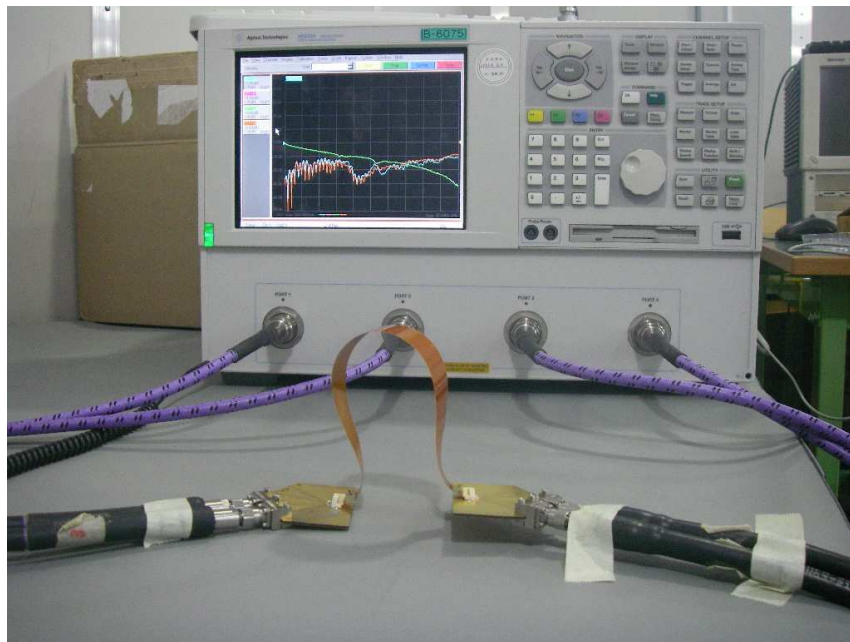
TDT measurement was operated as the left photo.

TDR measurement was operated with setting one side of YFLEX™ as OPEN.

Connection overview

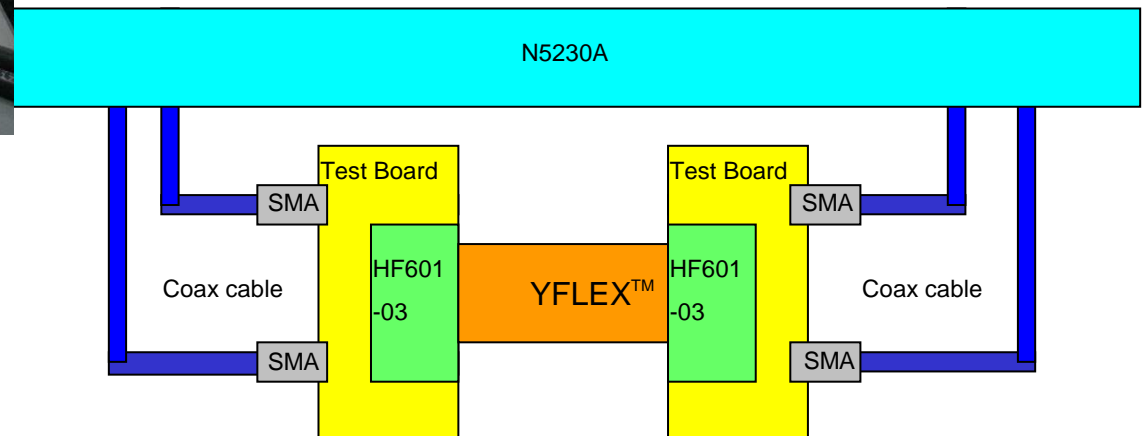# Test overview

Measurement

Equipment

N5230A (Agilent)

Measurement condition

SI-08, etc… were measured by the connection on the left photo.

Cross talk measurement was set coax cable to connect adjacent differential pair and terminated one side.

Connection overview

Test result

	Spec	Spec. value	Result 300mm (200mm)
SI-01	Mated Connector Impedance	100Ω±15%	85.5Ω~103Ω (85.5Ω~103Ω)
SI-02	Cable Absolute Impedance	100Ω±10%	98Ω~100Ω (95~102Ω)
SI-03	Cable Pair Matching	±5Ω	~0.3Ω (~2.9Ω)
SI-04	Common Mode Impedance	25-40Ω	Max:32.5Ω (Max:32.2Ω)
SI-05	Differential Rise Time	85ps	124.6ps (73.3ps)
SI-06	Intra-Pair Skew	10ps	1.0ps (0.1ps)
SI-07	Insertion Loss	6dB@ 10-4500MHz	-7.1dB@4500MHz (-4.7dB@4500MHz)
SI-08	Differential to Differential Crosstalk:NEXT	26dB@ 10-4500MHz	-41dB @ 4500Mhz (-41dB @ 4500MHz)
SI-09	Inter-Symbol Interference	50ps	20.3ps (13.0ps)

2.7.1. SI-01 : Mated Connector Impedance

<SPEC>　　　Mated Connector Differential Impedance 100Ohms ±15%
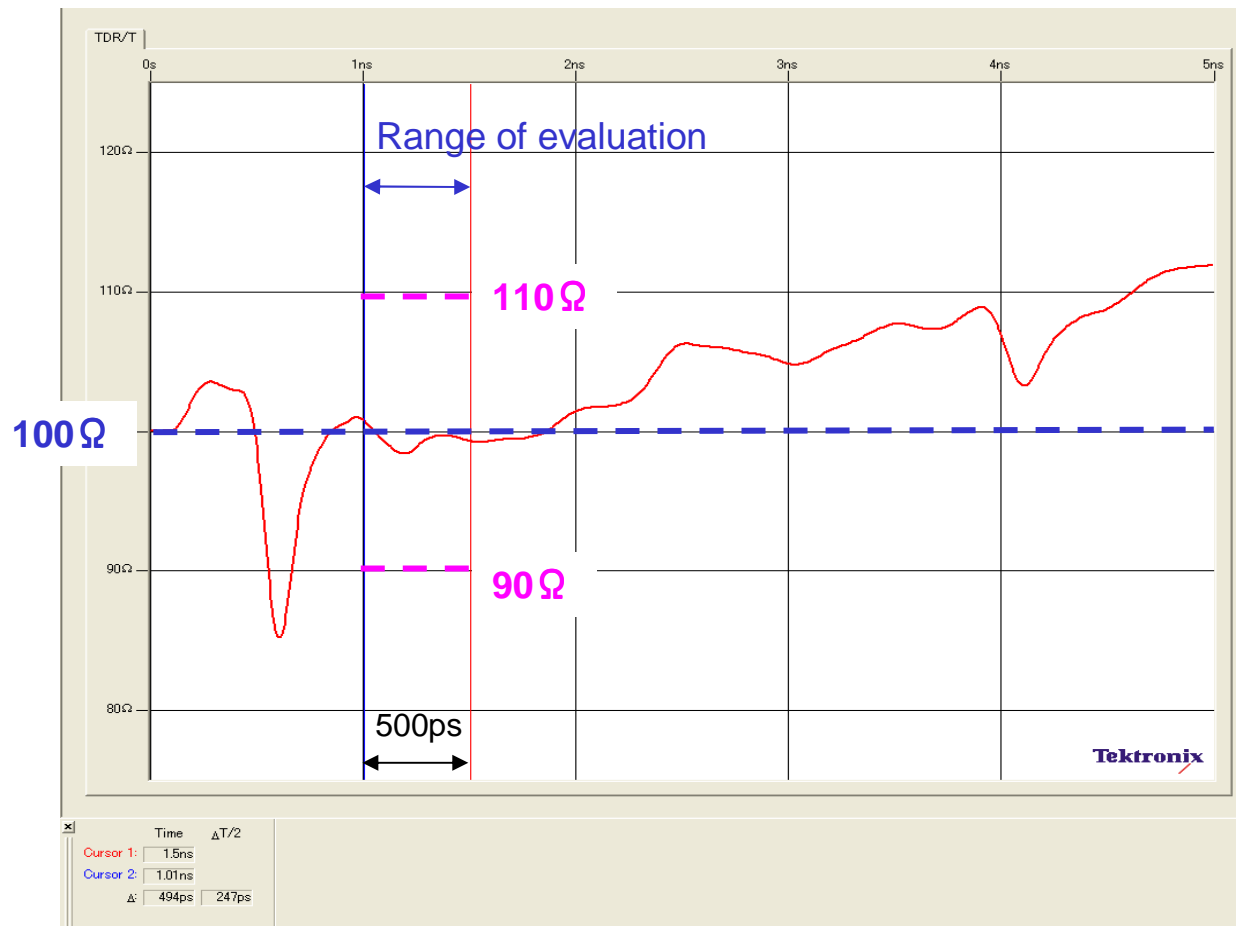
<Result>　　　MAX:103Ω　MIN:85.7Ω
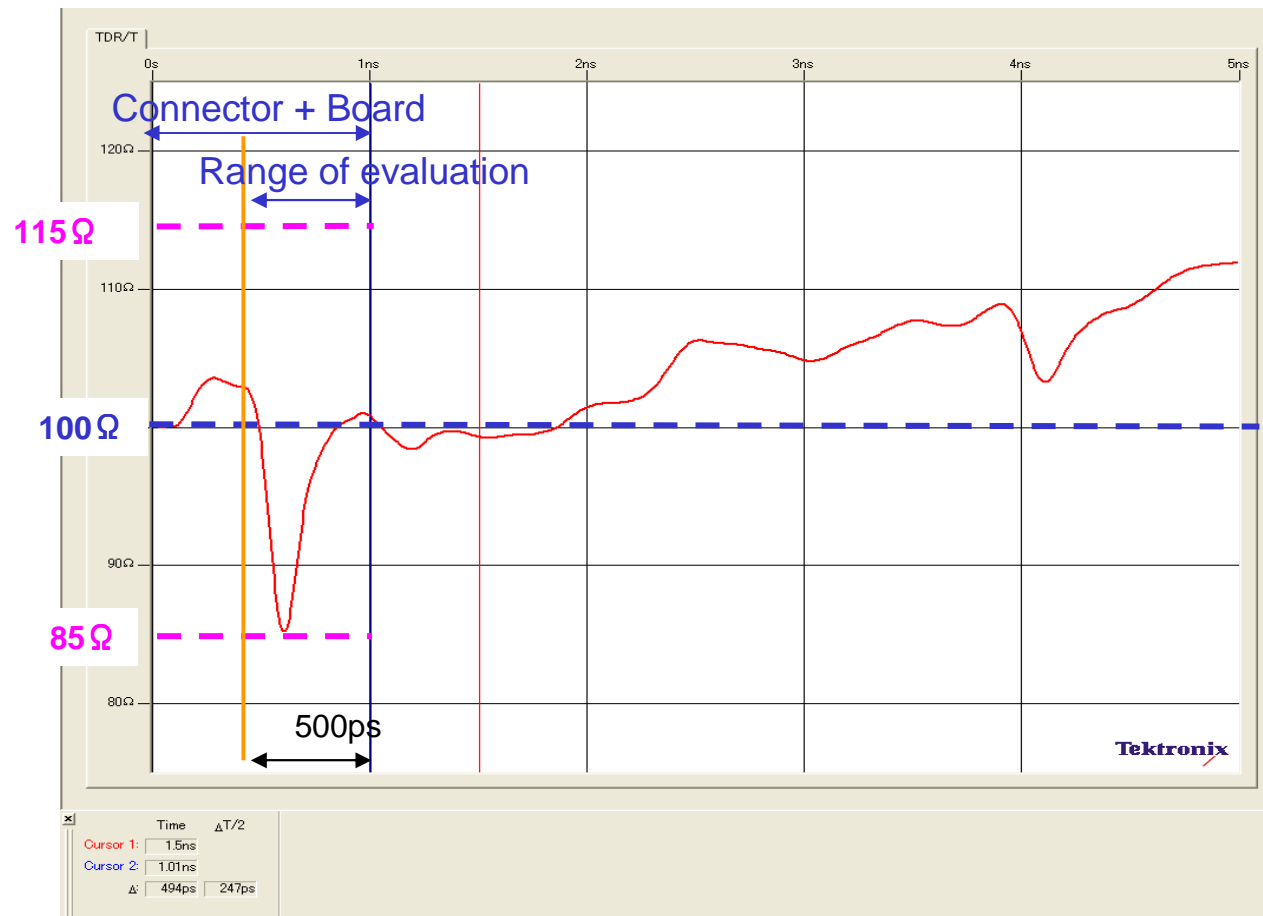
2.7.2. SI-02 : Cable Absolute Impedance

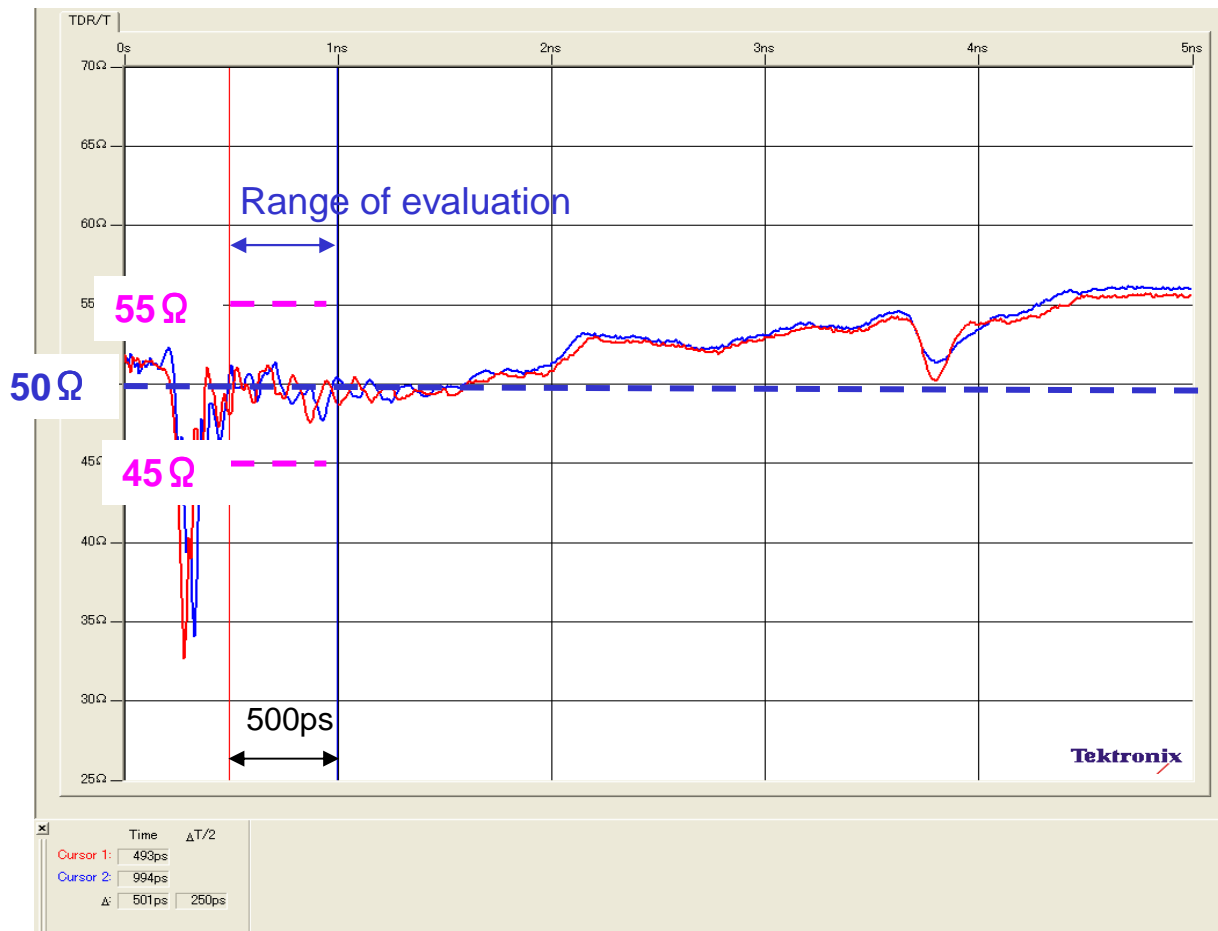<SPEC>　　　Cable Absolute Differential Impedance 100Ohms±10%

<Result>　　　MAX:100Ω　MIN:98Ω

Test result

2.7.3. SI-03 : Cable Pair Matching

<SPEC>   Cable Pair Matching Impedance ±5Ohm

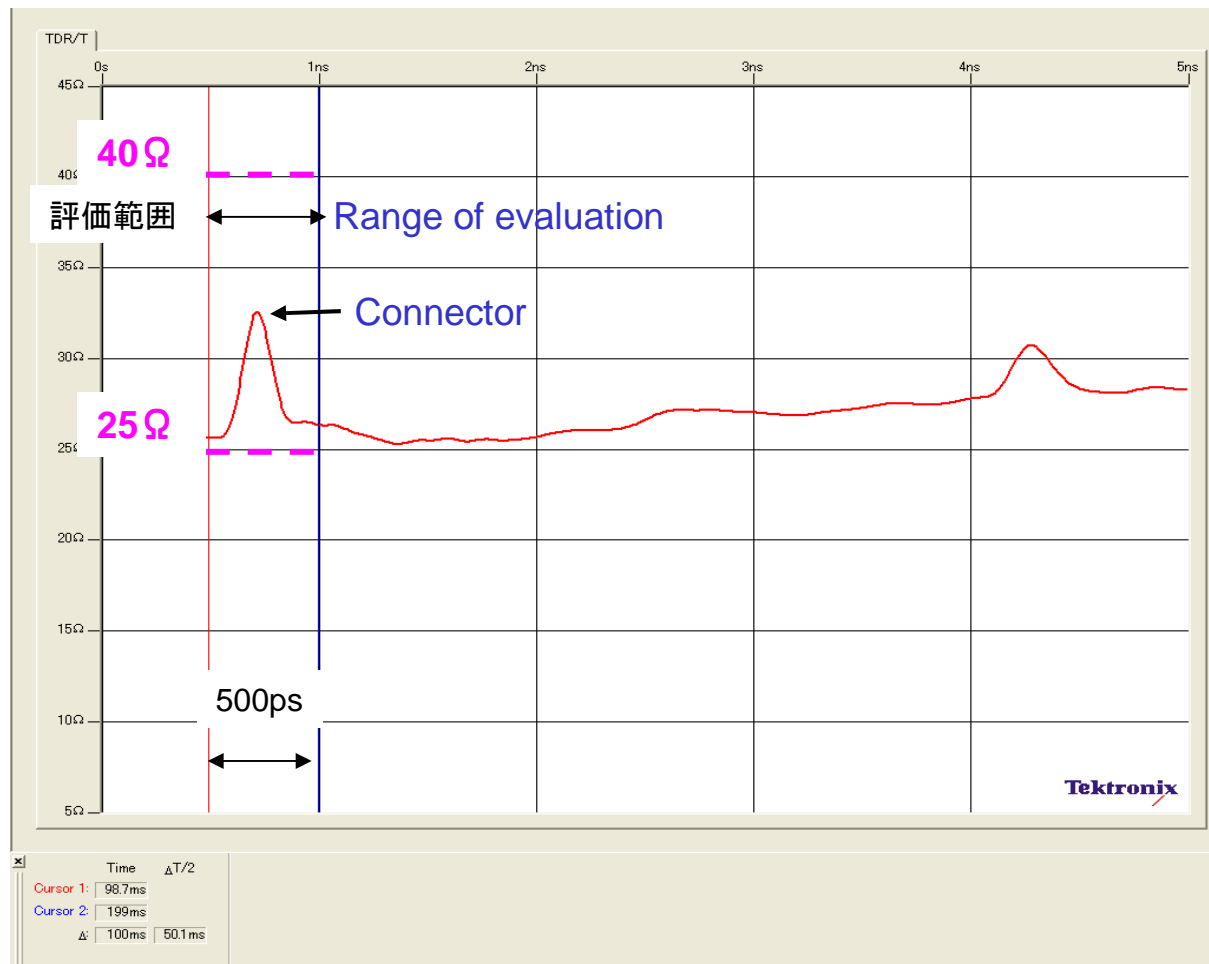<Result>   Min-Min:0.1Ω   Max-Max:0.3Ω

Test result

2.7.4. SI-04 : Common Mode Impedance

<SPEC>　　　Common Mode Impedance 25-40Ohms

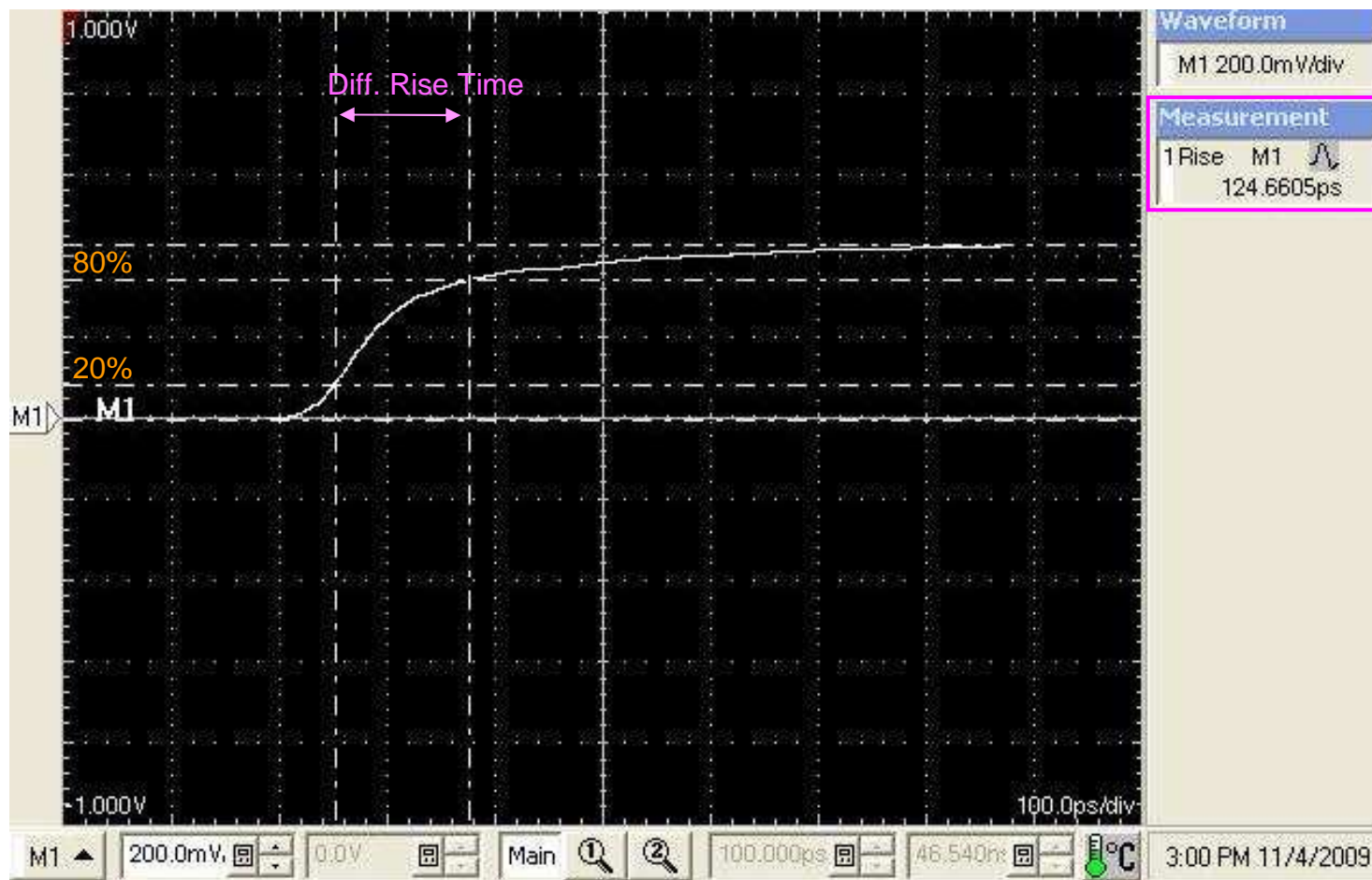<Result>　　　Max:32.5Ω

Test result

2.7.5. SI-05 : Differential Rise Time

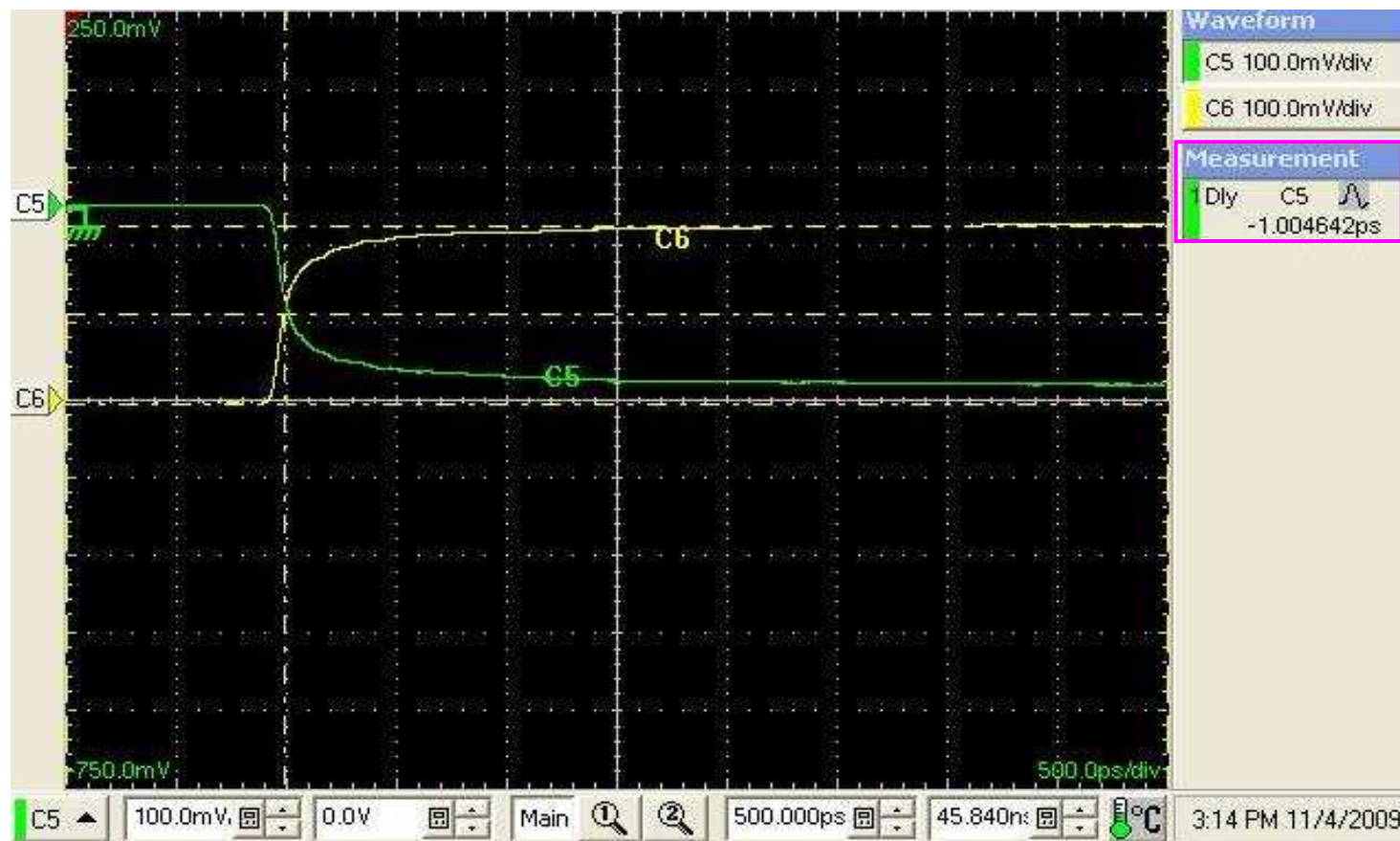<SPEC>   Maximum Rise Time 85ps(20%-80%)

<Result>   124.6ps

2.7.6. SI-06 : Intra-Pair Skew

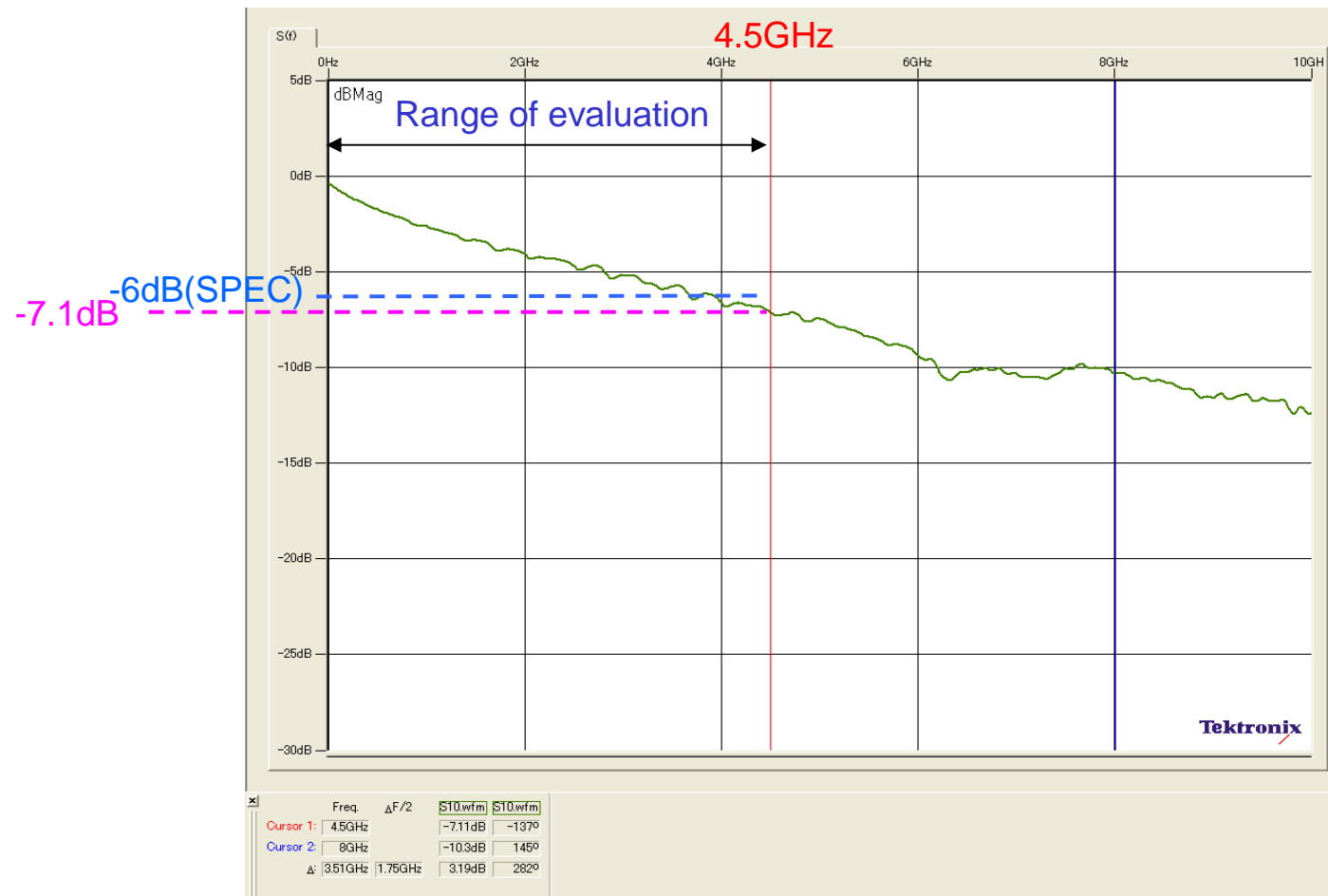<SPEC>   Maximum Intra-Pair Skew 10ps

<Result>   1.0ps

2.7.7. SI-07 : Insertion Loss

<SPEC>   Maximum insertion Loss (10-4500MHz)6dB
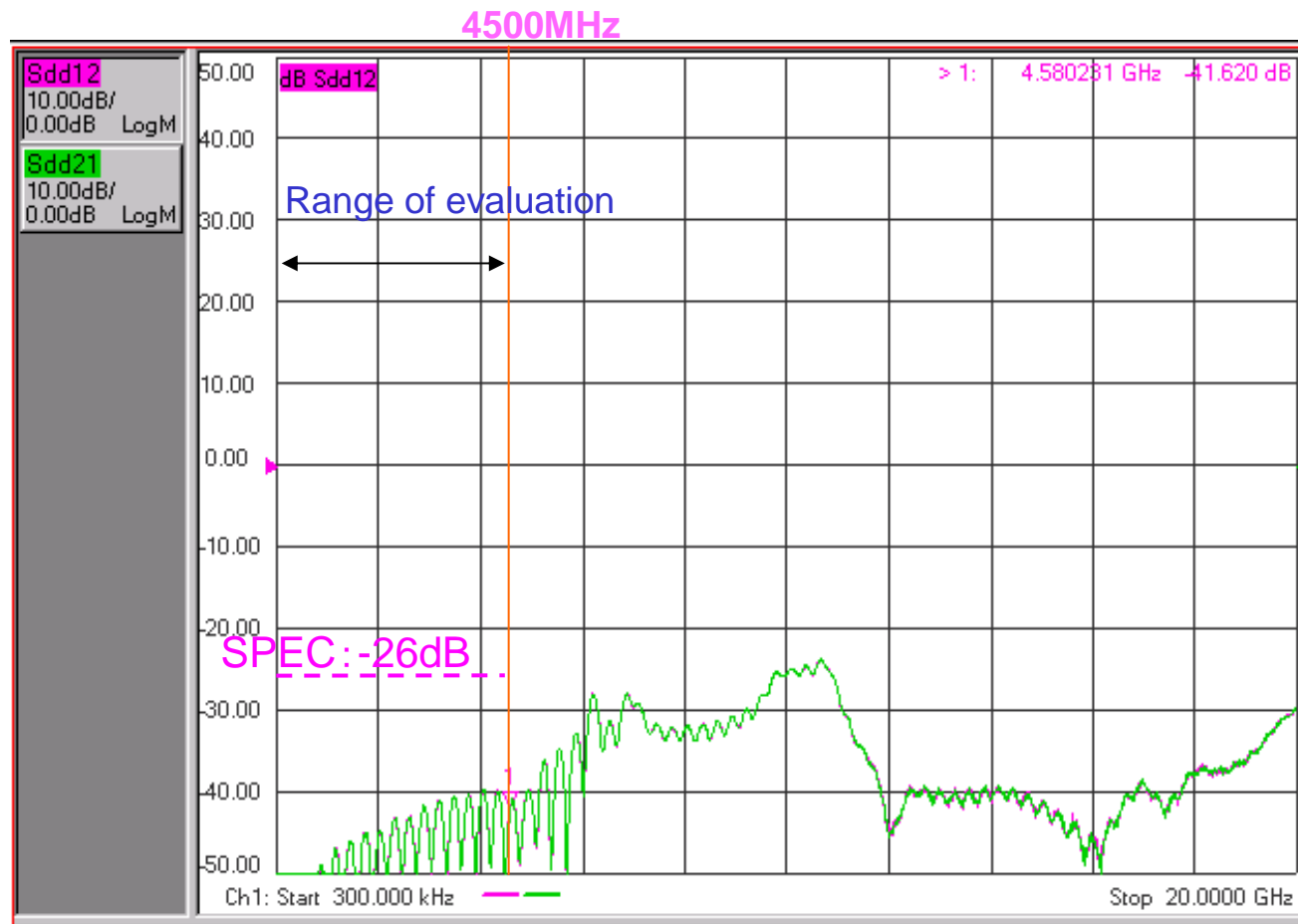
<Result>   -7.1dB@4500MHz

2.7.8. SI-08 : Differential to Differential Crosstalk:NEXT

<SPEC>   Maximum Crosstalk:NEXT (10-4500MHz)26dB

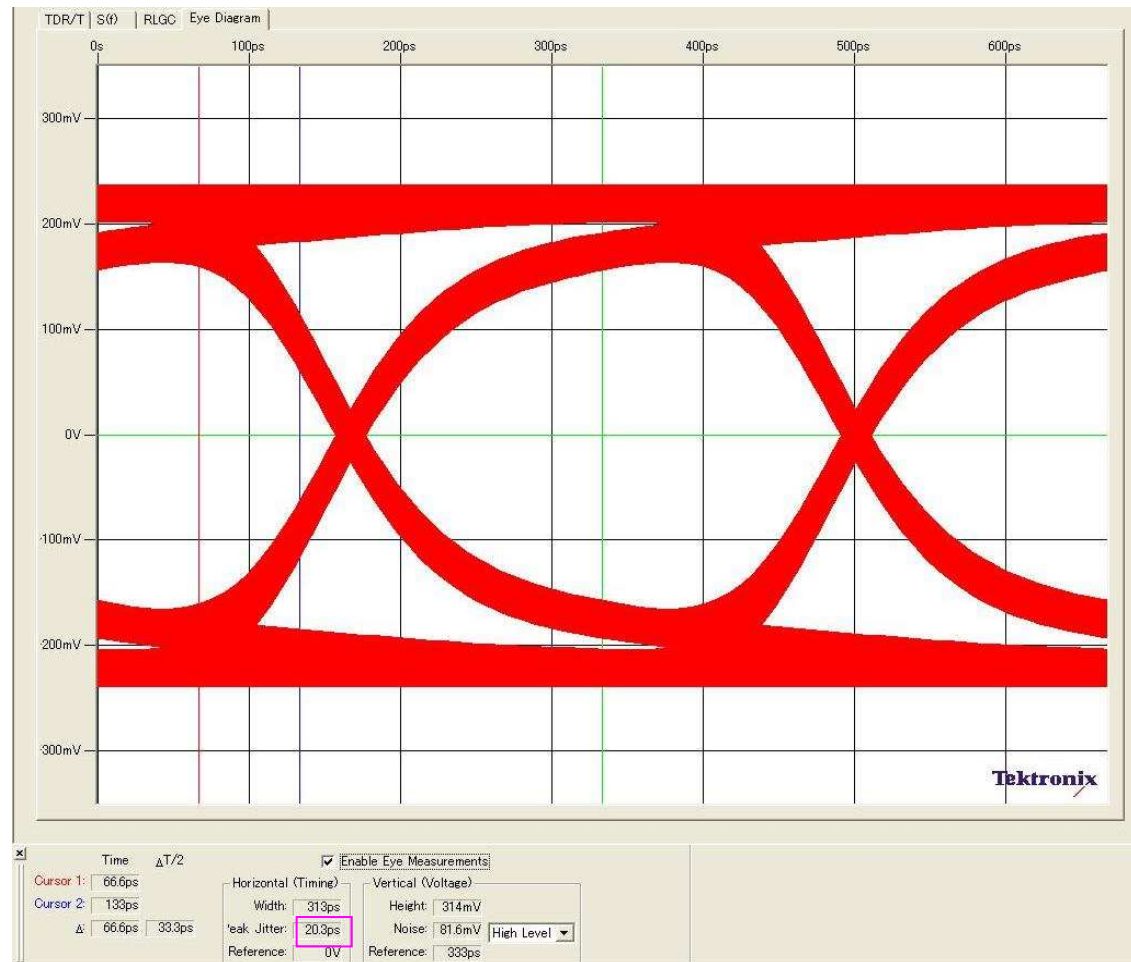<Result>   -41dB @ 4500Mhz

2.7.9. SI-09 : Inter-Symbol Interference

<SPEC>   Maximum Inter-Symbol Interference 50ps

<Result>   20.3ps

There is no significant problem under real use case in an application even though YFLEX^{TM} L=300mm could not compliant with cable spec.
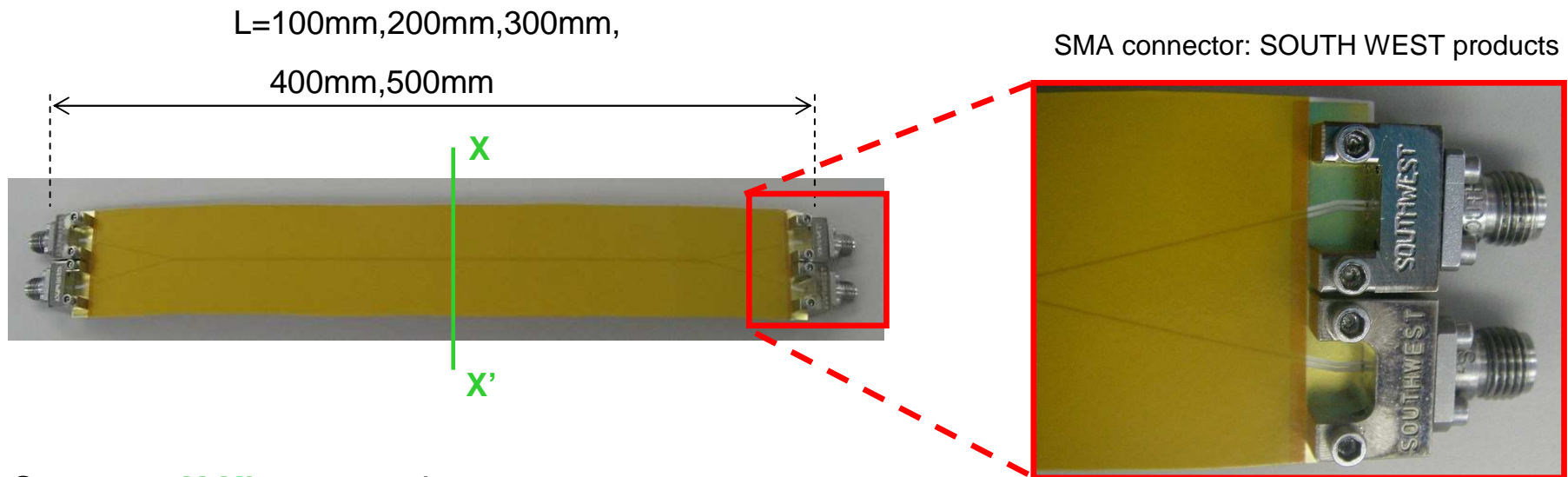" Serial ATA Interoperability Program Tektronix MOI for SI Cable Tests Version .8

However, it should be defined limitation of usage as criteria.

Therefore, Yamaichi operated simulation and test with proto-type sample for defining criteria of use-limitation based on test result in previous slides.
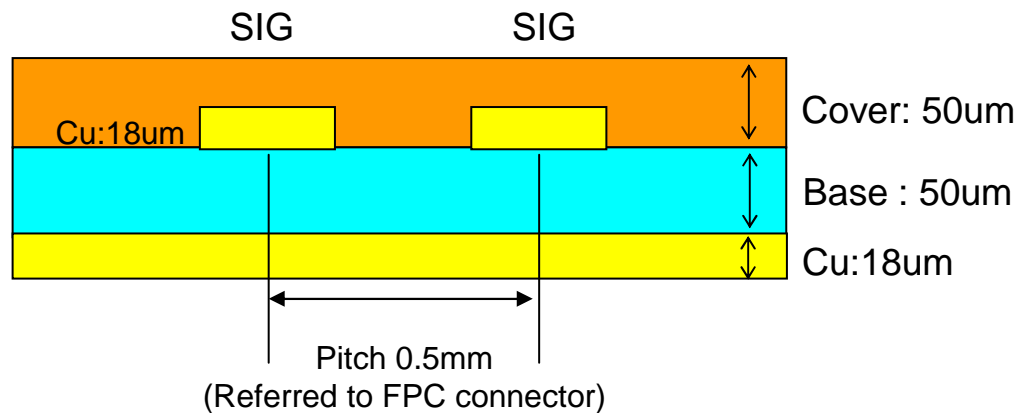
* Cable length was considered as actual length to use and its tolerance range.

YFLEX™ design by simulation and evaluation

YFLEX™ design overview (Single end : 50ohm / Differential : 100ohm)
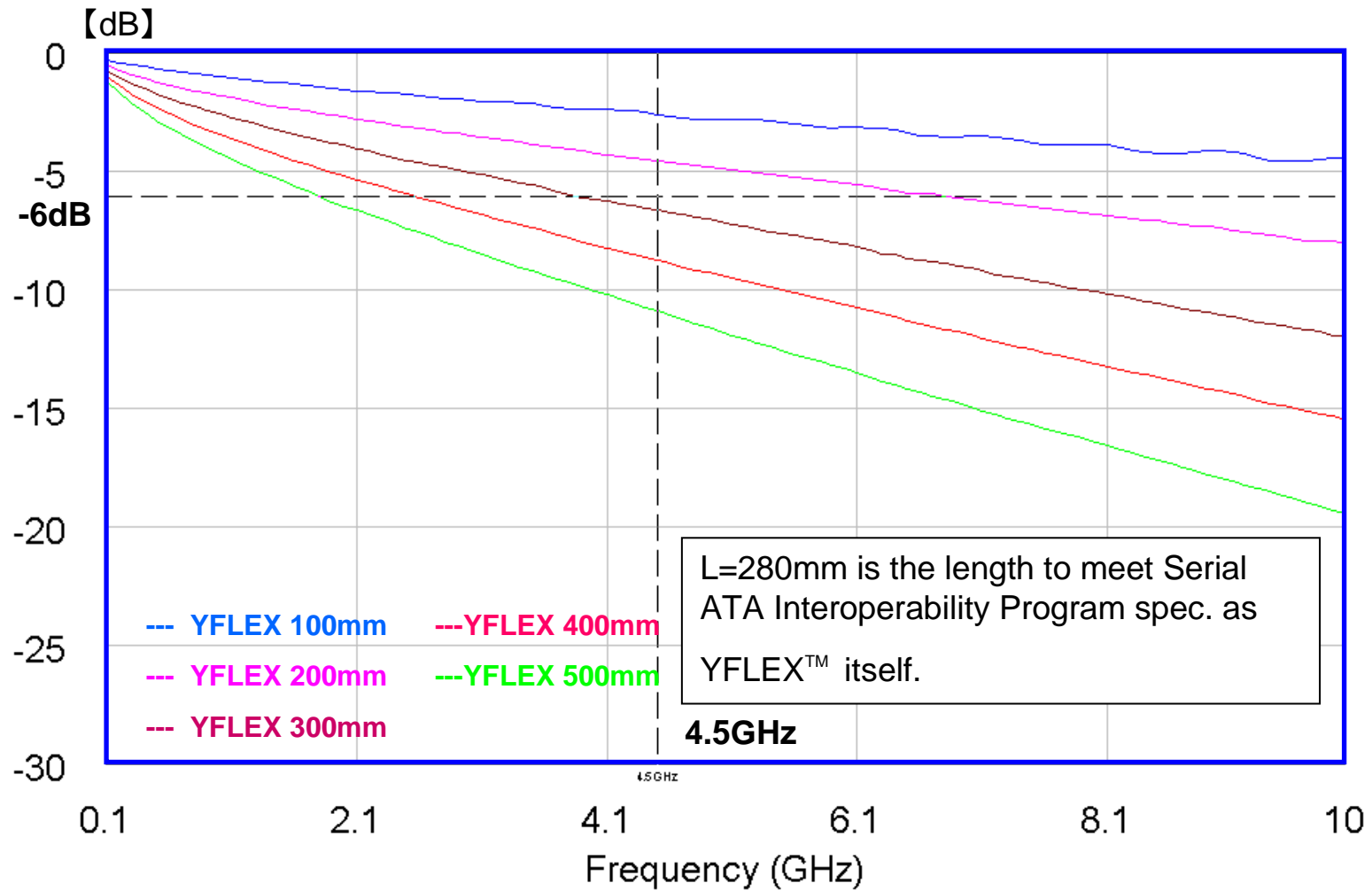
L=100mm,200mm,300mm,

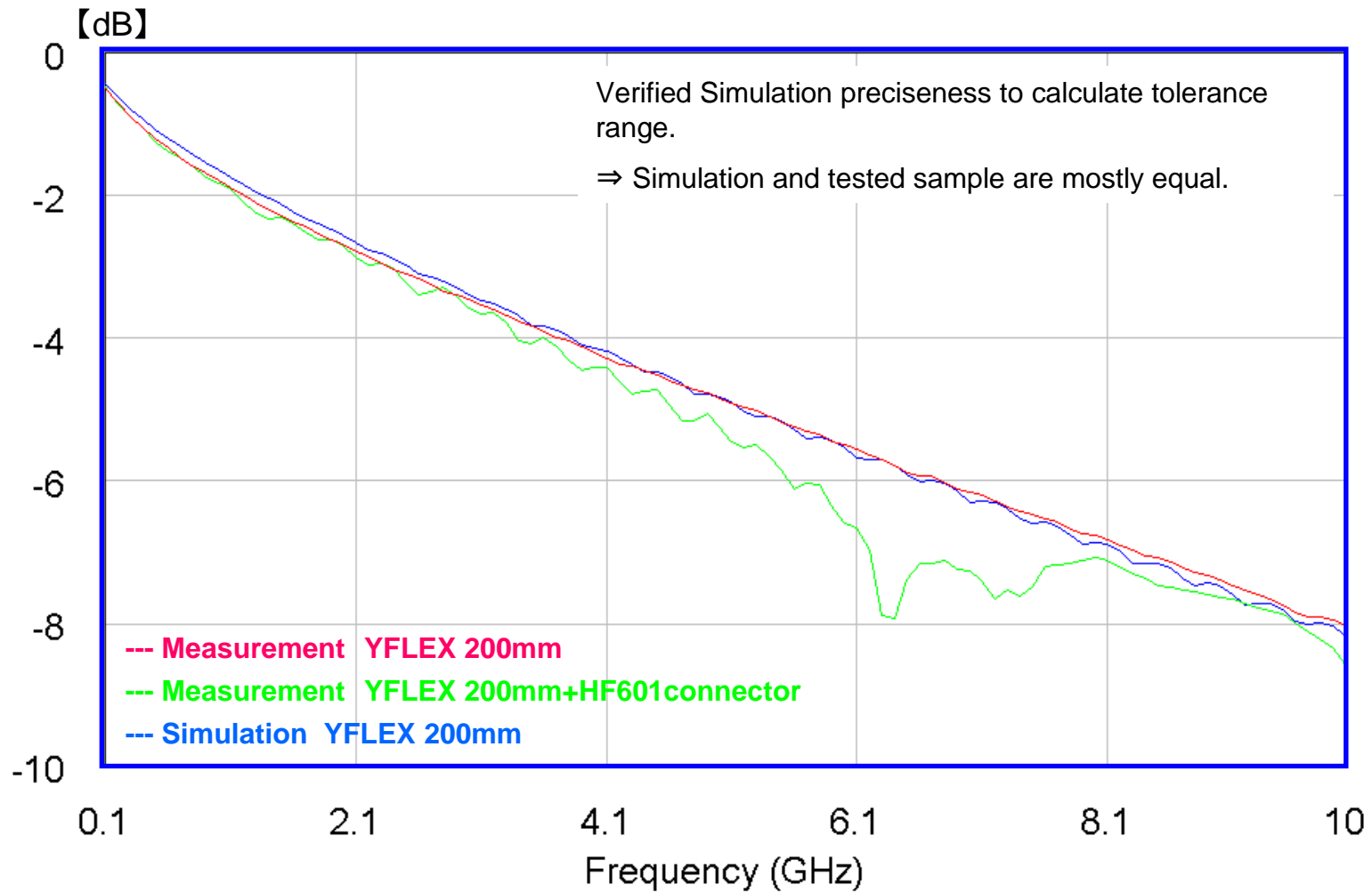400mm,500mm

X

X'

SMA connector: SOUTH WEST products

Structure, **X-X'** cross section

SIG   SIG

Cu:18um

Cover: 50um

Base : 50um

Cu:18um

Pitch 0.5mm
(Referred to FPC connector)

Insertion Loss per Length difference

Test result

【dB】

L=280mm is the length to meet Serial ATA Interoperability Program spec. as YFLEX™ itself.

--- YFLEX 100mm   ---YFLEX 400mm

--- YFLEX 200mm   ---YFLEX 500mm

--- YFLEX 300mm   4.5GHz

-6dB

Frequency (GHz)

Insertion Loss difference between measured data and simulation data

Test result

【dB】

Verified Simulation preciseness to calculate tolerance range.

⇒ Simulation and tested sample are mostly equal.

--- **Measurement   YFLEX 200mm**
--- **Measurement   YFLEX 200mm+HF601connector**
--- **Simulation   YFLEX 200mm**

Frequency (GHz)

Insertion Loss with considering tolerance variation

Simulation result
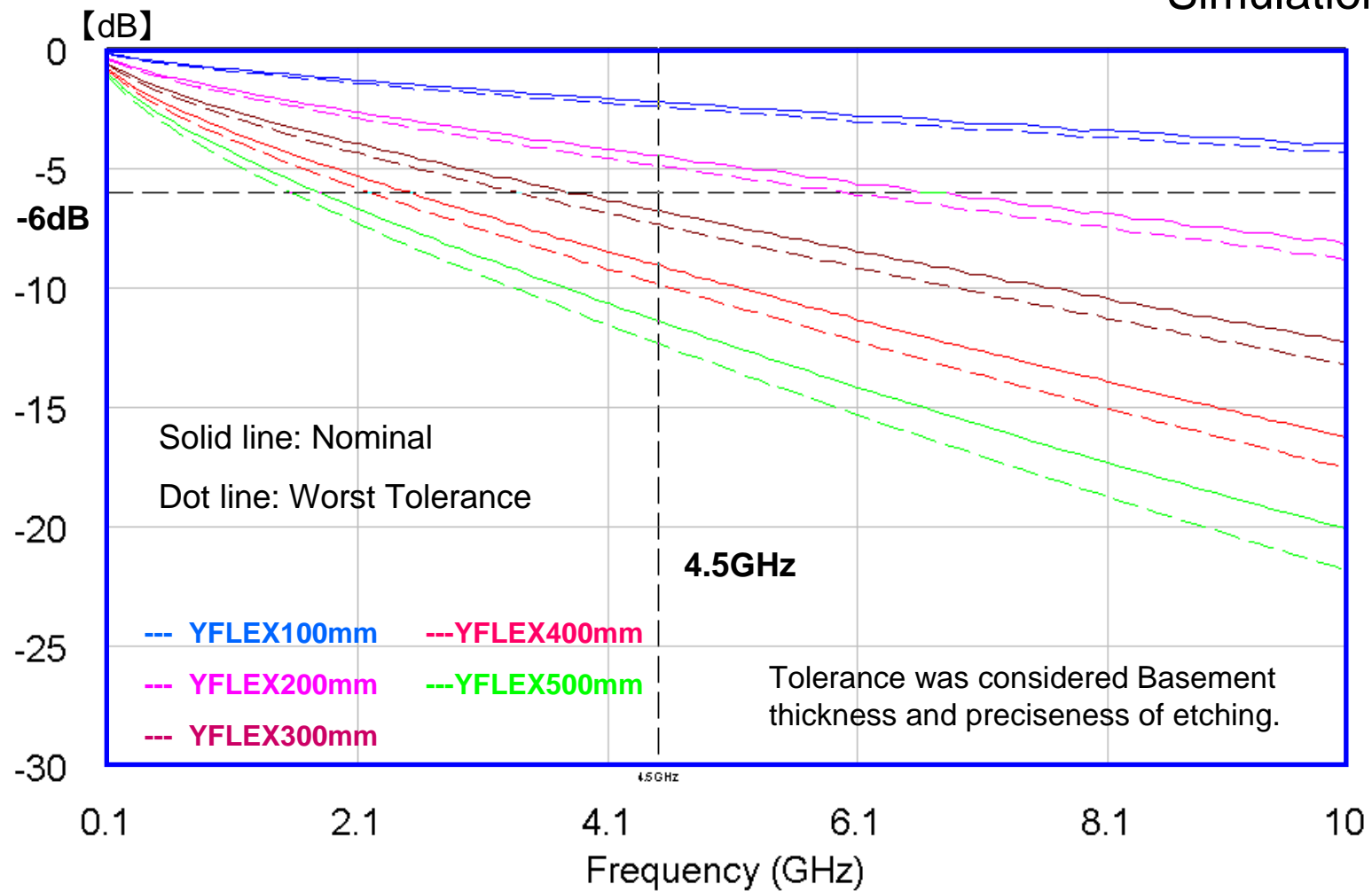
【dB】

Solid line: Nominal

Dot line: Worst Tolerance

4.5GHz

--- **YFLEX100mm**   ---**YFLEX400mm**

--- **YFLEX200mm**   ---**YFLEX500mm**

--- **YFLEX300mm**

Tolerance was considered Basement thickness and preciseness of etching.

Frequency (GHz)

Simulation result

L=240mm approx. is the length to meet spec. as YFLEX™ itself.

--- Simulation YFLEX 240mm
Worst Tolerance

4.5GHz

Insertion Loss Measurement (YFLEX^{TM} itself)
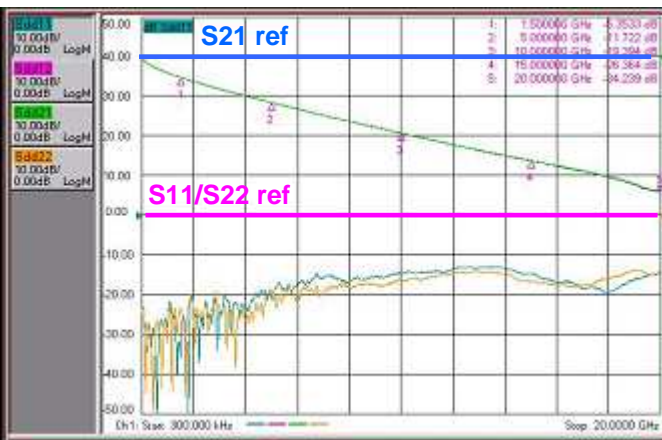
Test result

100mm
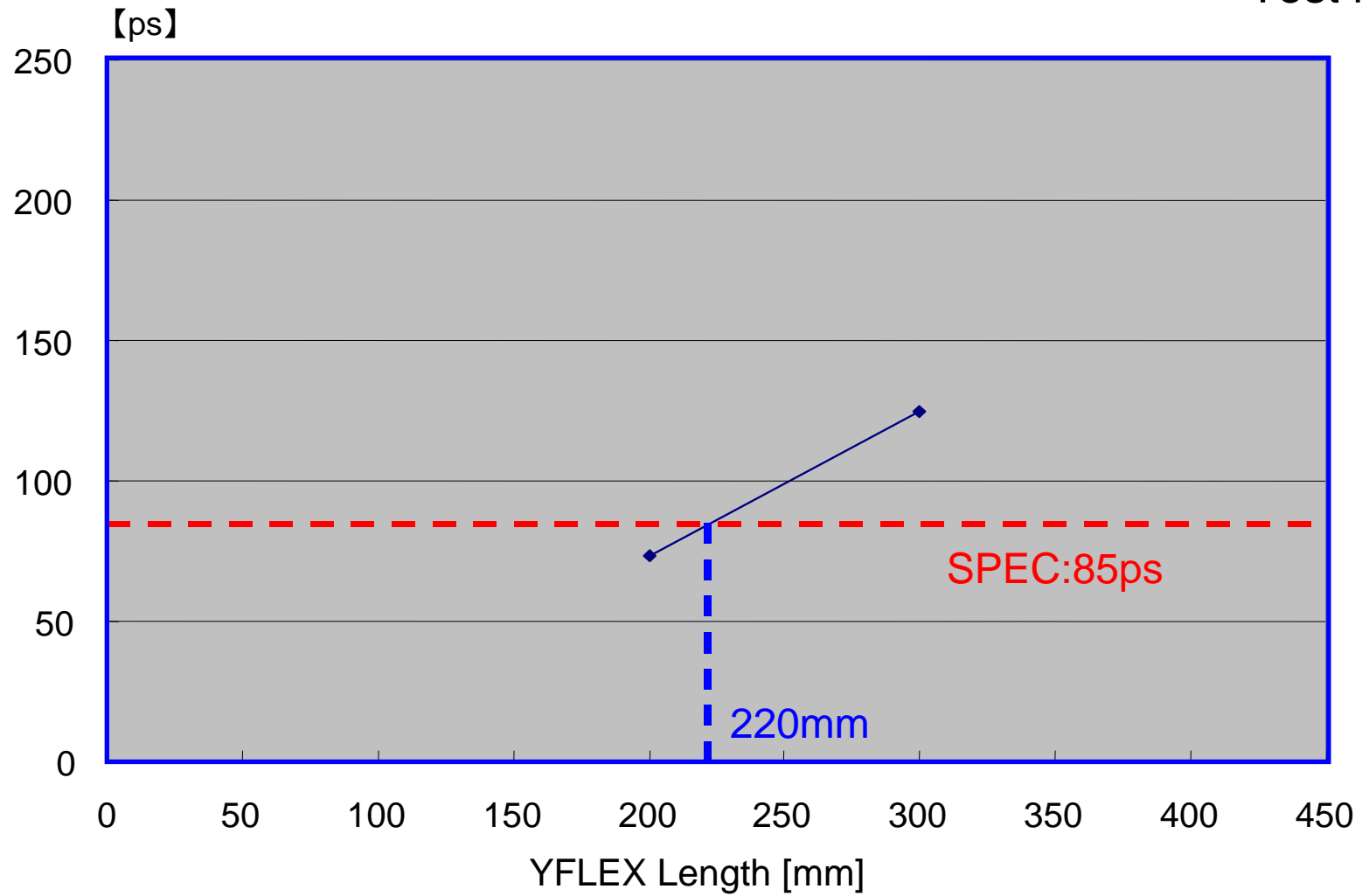

200mm

300mm

400mm
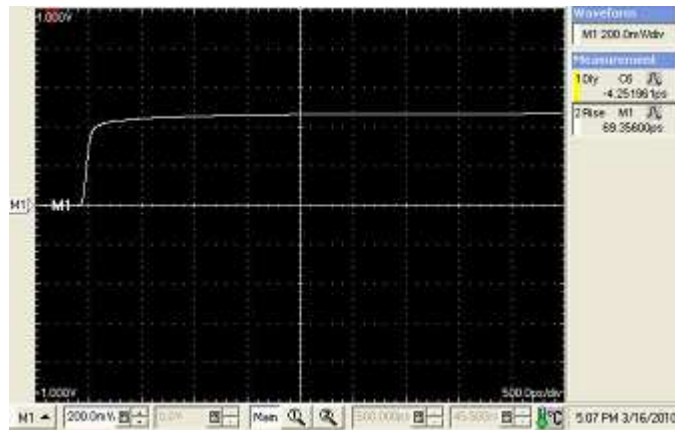

500mm

Differential Rise Time (YFLEX™ itself)
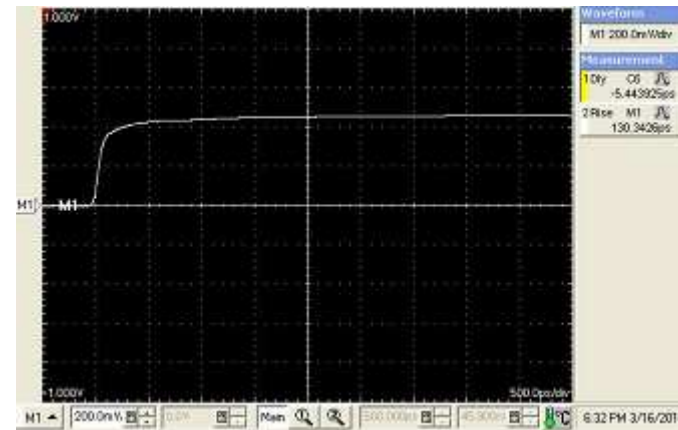
Test result

Differential Rise Time Measurement (YFLEX™ itself)

Test result

200mm

300mm
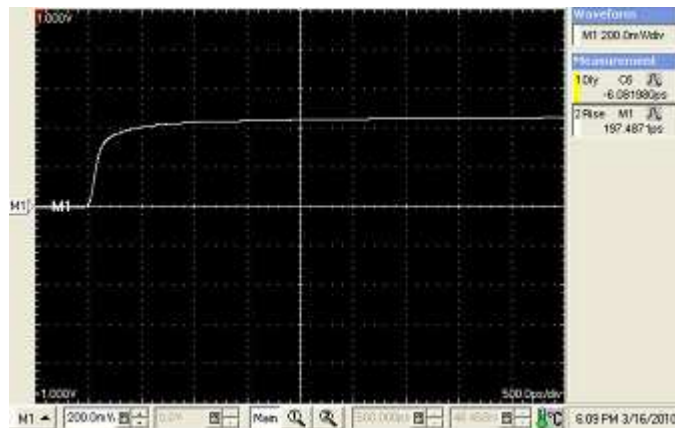

400mm

Insertion Loss Measurement (YFLEX™ + Connector)

Test result

Test result
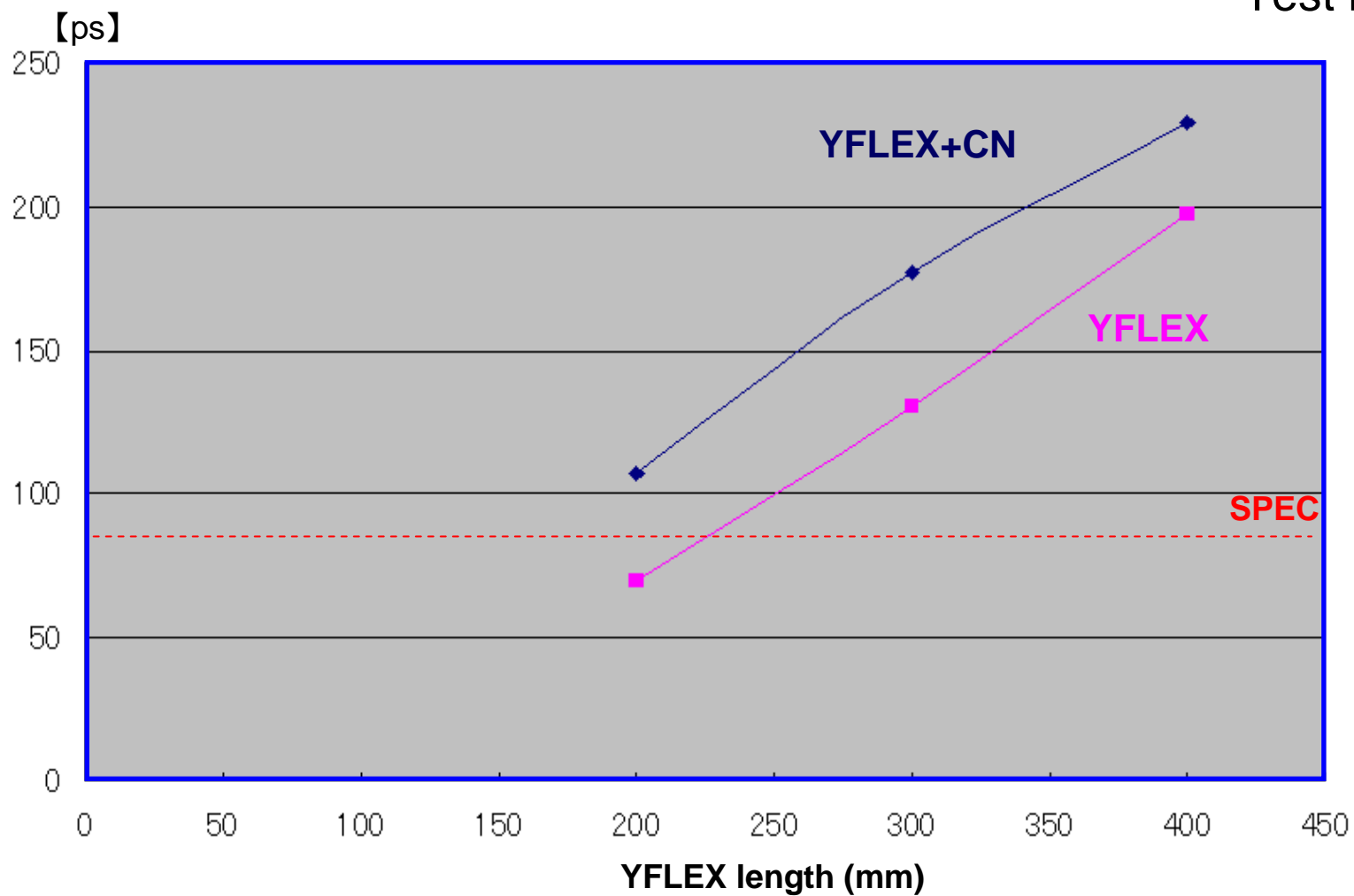
Result

• In case to prioritize compliance with Serial ATA Interoperability Program standard, Length should be around 240mm from Insertion Loss criteria.

• In case to prioritize to prioritize the length for internal connection, Length should be necessary 300mm max and Insertion Loss criteria should loosen around −7.5dB.

• In case to prioritize compliance with Serial ATA Interoperability Program standard, Length should be around 230mm from Differential Rise Time criteria.

• For Differential Rise Time test, FPC connector effect could not be ignored. FPC connector should be designed for high speed data transmission capability.

• All the test/simulation was operated with estimated cable length and it would be necessary for more detailed analysis for longer cable requirement. Also, connector for FPC cable, it is preferred to select a connector with high speed data transmission capability,

Proposal

Yamaichi propose to add [FPC + connectors] as one of data transmission methods on S-ATA spec to meet market inquiry.

Host internal connection should be 300mm maximum.

With measured data as we introduced in this material, Yamaichi propose following 2 options on "Insertion Loss" and setting "Differential Rise Time" as exception. The reason "Insertion Loss" and "Differential Rise Time" are selected for spec compliance is because these 2 are the toughest among several compliance check items in S-ATA Interoperability Program standard.

Insertion Loss Option: either 1 or 2, *proposal*

1. To compliant current Insertion Loss spec as –6dB@4.5GHz, defining whole data transmission length as 250mm

   or

2. Loosen Insertion Loss spec to around -7.5dB@4.5GHz, to meet Host internal connection(market request) of 300mm maximum as for whole data transmission length

Differential Rise Time, *proposal*

To set this item as EXCEPTION for [FPC + FPC connector] S-ATA data transmission, because SI characteristics shall be able to check by Insertion Loss and other compliance check items in S-ATA Interoperability Program.