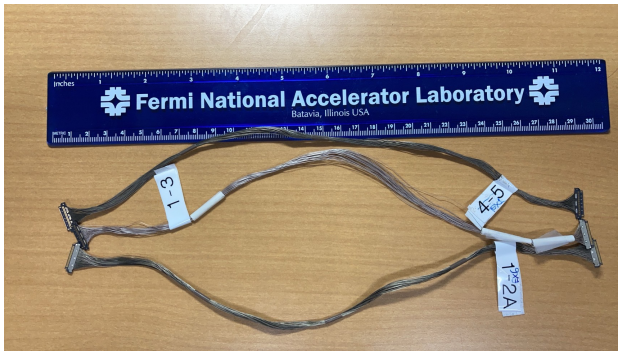
# High Frequency Property of Micro Coaxial Cable

RIKEN/RBRC

Itaru Nakagawa

vs



# Specification Comparison (Executive Summary)

@400MHz

| | FPC | | KEL XSL | | | | IPEX UX-II |
|---|---|---|---|---|---|---|---|
| Length [cm] | **20** | 40 | 10 | 10 | 20 | 30 | 50 |
| AWG | **N/A** | N/A | 46 | 44 | | | 44 |
| Impedance [Ω] | **50** | 50 | 50 | 45 ± 3 | | | 50 |
| Diff Impedance [Ω] | **110** | 110 | 93 | 83 | | | |
| Insertion Loss [%] | **80** | 56 | 84 | 90 | 84 | 80 | |
| Return Loss [%] | **10** | 20 | 25 | | 18 | | |
| Cross Talk [%] | **<12*** | | 1 | | | | |
| Eye Diagram | **similar** | | similar | | | | |

*20cm conversion cable with bus extender

There is no data available for the exactly same condition between FPC and μCoax cables.
Presumably 20cm FPC can be compared to XSL-AWG46-10cm and XSL-AWG44-20cm.
Resulting performances look similar within 20cm. To be executed actual measurement once prototype is made. Hard to extrapolate the performance to 1.41m.

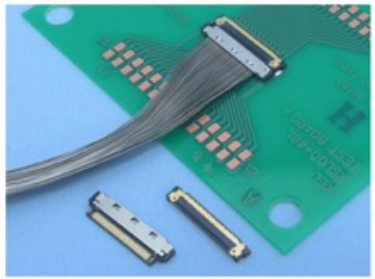
# KEL XSL Series

## XSL series

Extra-fine coaxial cable type

0.25mm pitch extra-fine coaxial cable connector

Features | specification | Download materials | Product list / technical data | Contact & Support



The "XSL series" connector for 0.25 mm pitch micro coaxial cable, and is the industry's smallest level product.

■ Micro coaxial cable

The micro coaxial cable is good at transmission characteristics and the very thin cable has high bending flexibility, so it could connect between PCBs within a small device with a high degree of freedom and the bundle of the cables can pass through a thin hinge part. Micro coaxial cable is small and has good transmission characteristics, there is a wide range of needs from products that require miniaturization and high functionality.
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Features of connector for micro coaxial cable

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## XSL-AWG46 (10cm, 50Ω)

2．サンプル

・XSL00-40L　　（基板側，40pin）
・XSL20-40SS-010-B　（40pin，100mm，1:1）

※開発中の製品の為、品名は変更の可能性があります。

写真１　評価基板及びサンプル

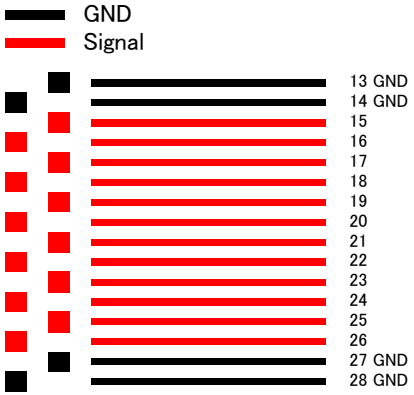



図１　ピンアサイン

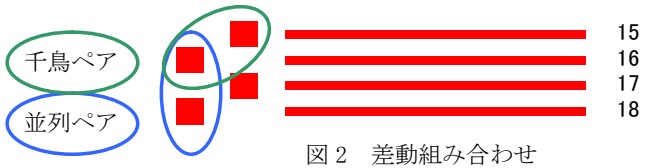



図２　差動組み合わせ

# Staggering Pin Geometry

※開発中の製品の為、品名は変更の
可能性があります。

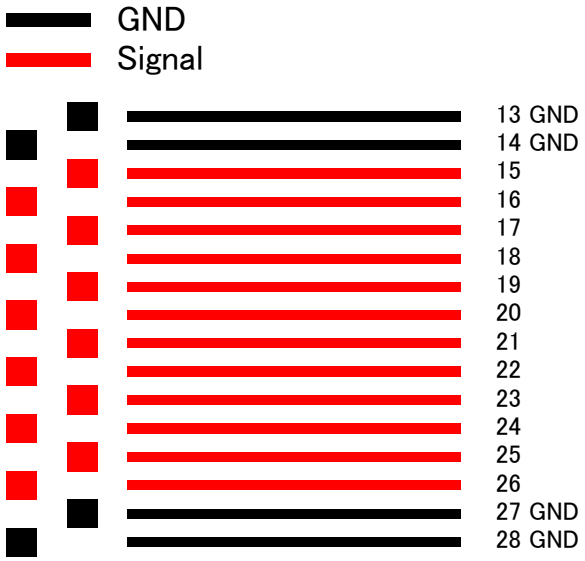
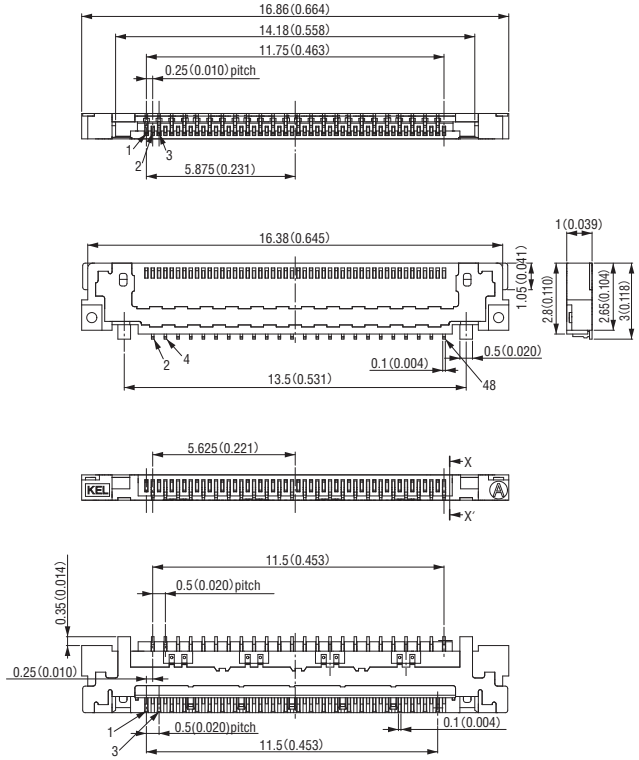
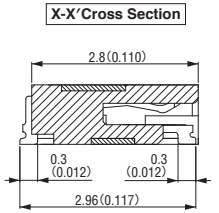



図１　ピンアサイン




**Ground Installation**

| No. of contacts | No. of ground |
|---|---|
| 48 | 8 |

| Packaging style |
|---|
| Embossed tape |

# Comparison with FPC

FPC Conversion Cable

L=20cm, 40cm

KEL XSL Coaxial Cable

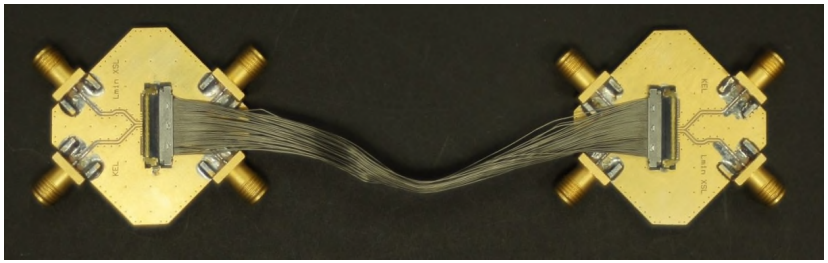


写真 1　評価基板及びサンプル(100㎜)

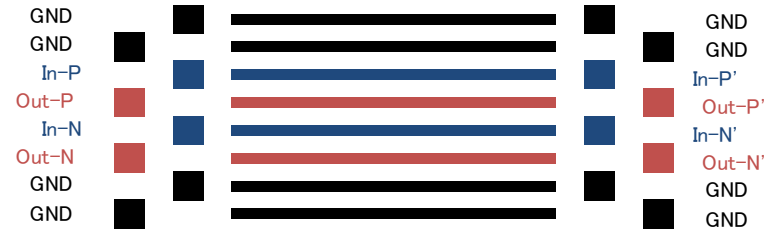


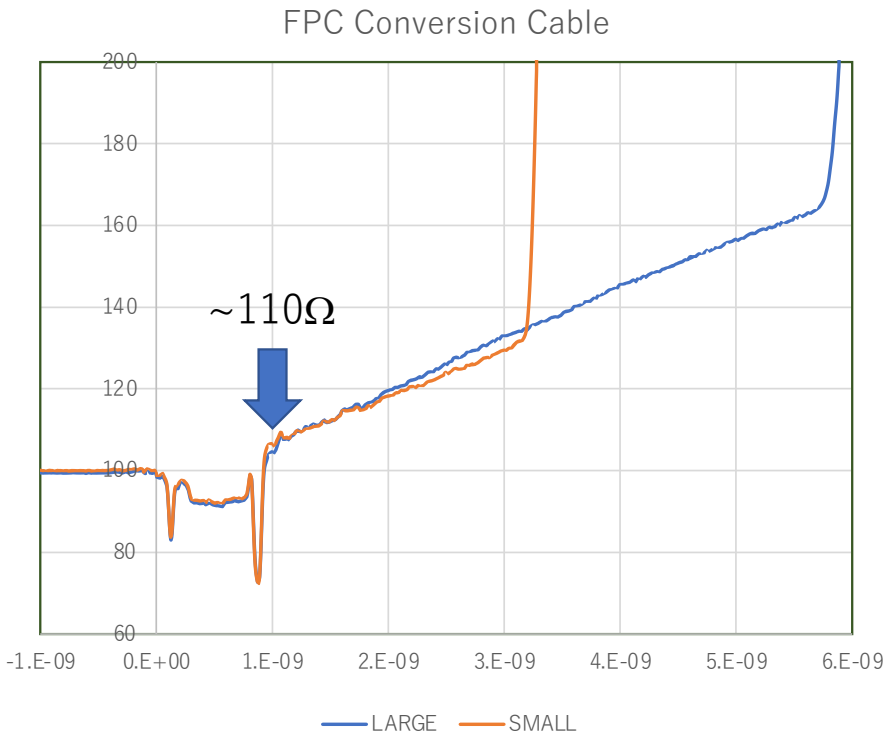

図 1　評価基板ピンアサイン

L=10cm

# Time Domain Reflectometry (TDR)

## Differential Impedance

FPC Conversion Cable




KEL XSL Coaxial Cable

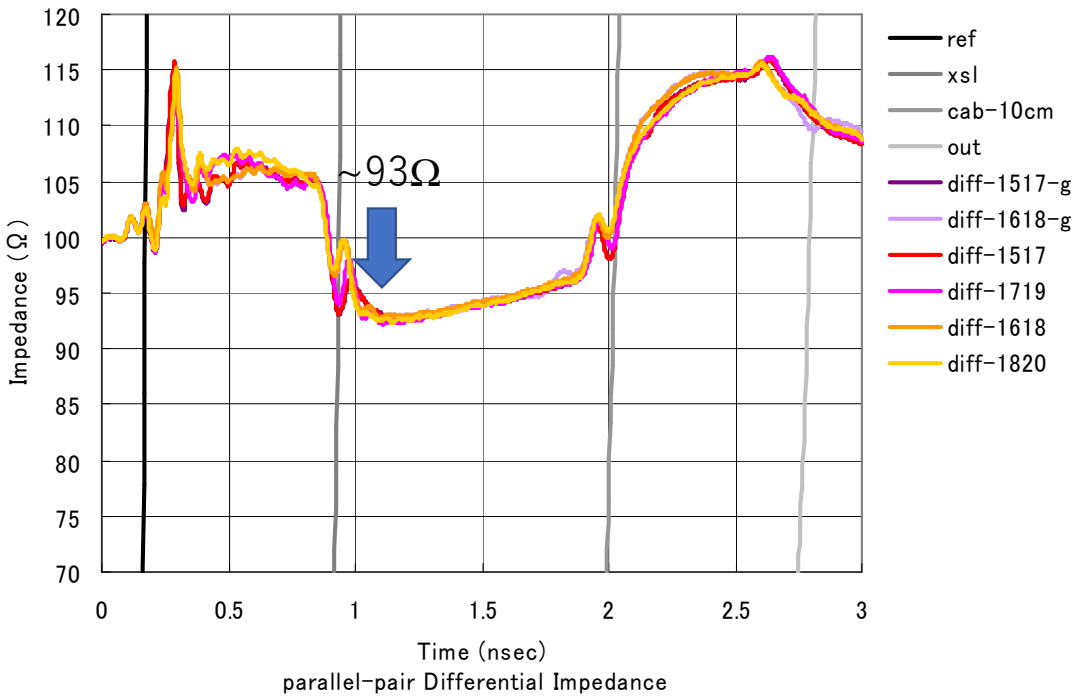
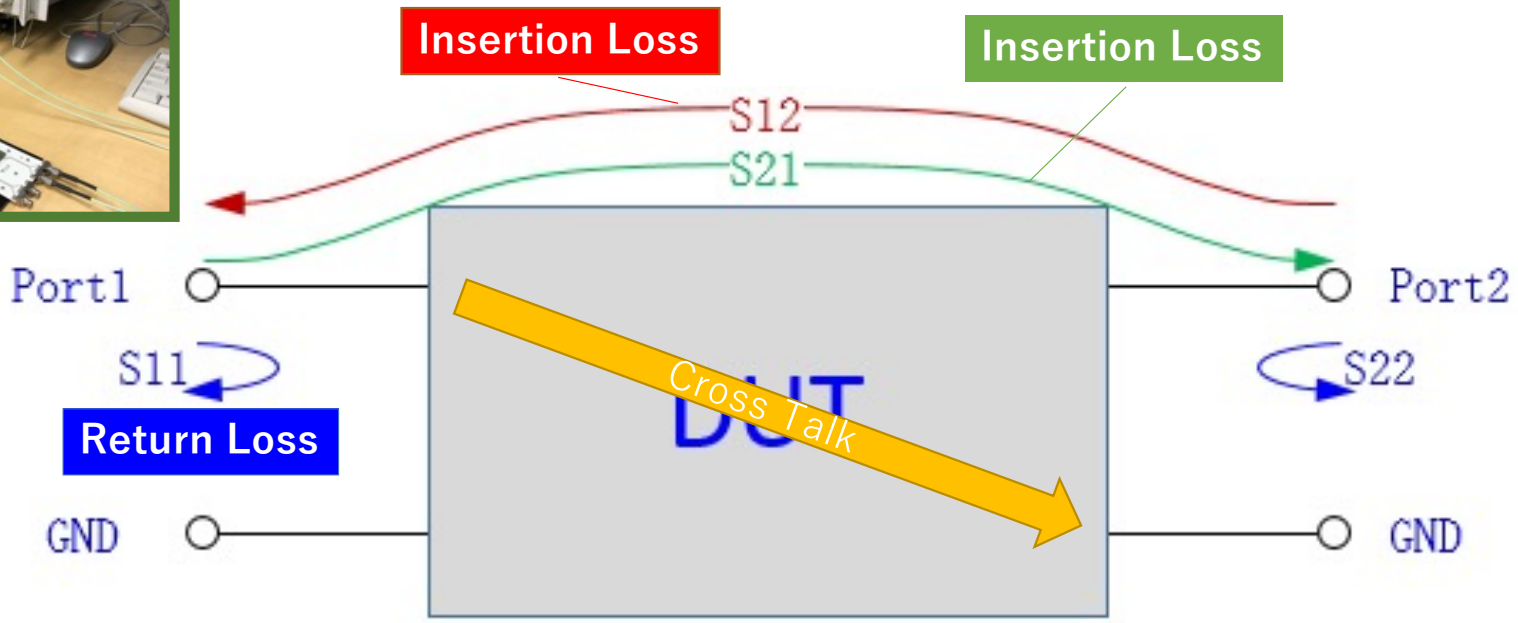



図 5.8　並列ペアの差動インピーダンス

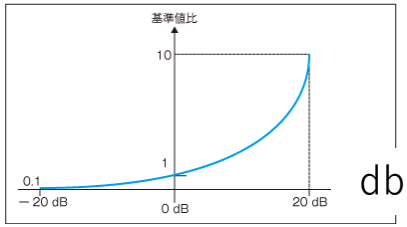
# High Signal Frequency Signal Transmission Performance

## s-Parameters

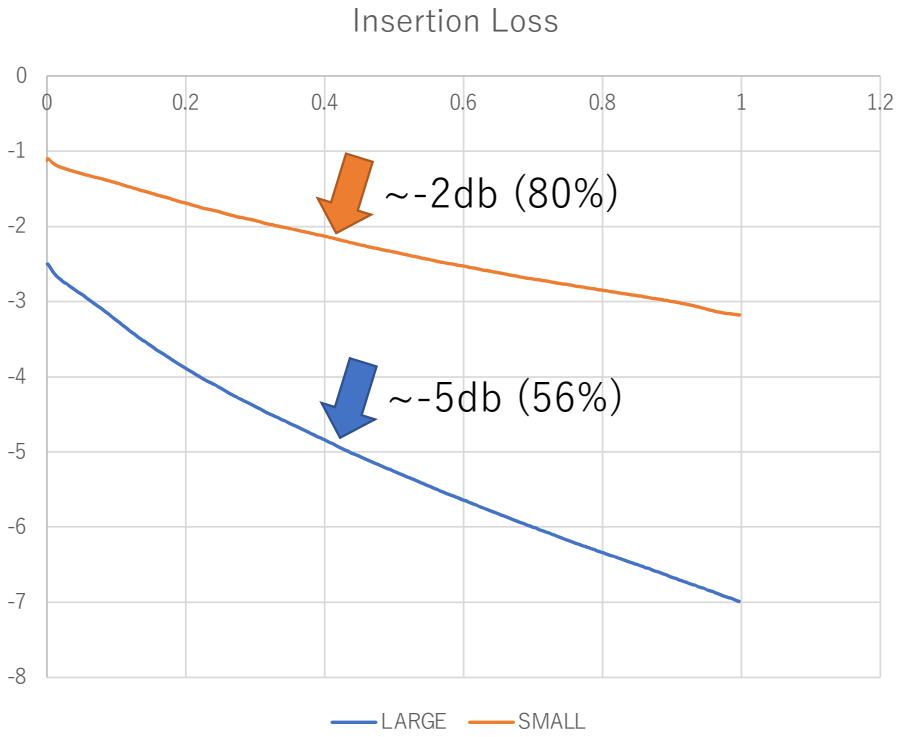



Consider as 2x2 matrix

# Insertion Loss @ 400MHz




FPC Conversion Cable




KEL XSL Coaxial Cable

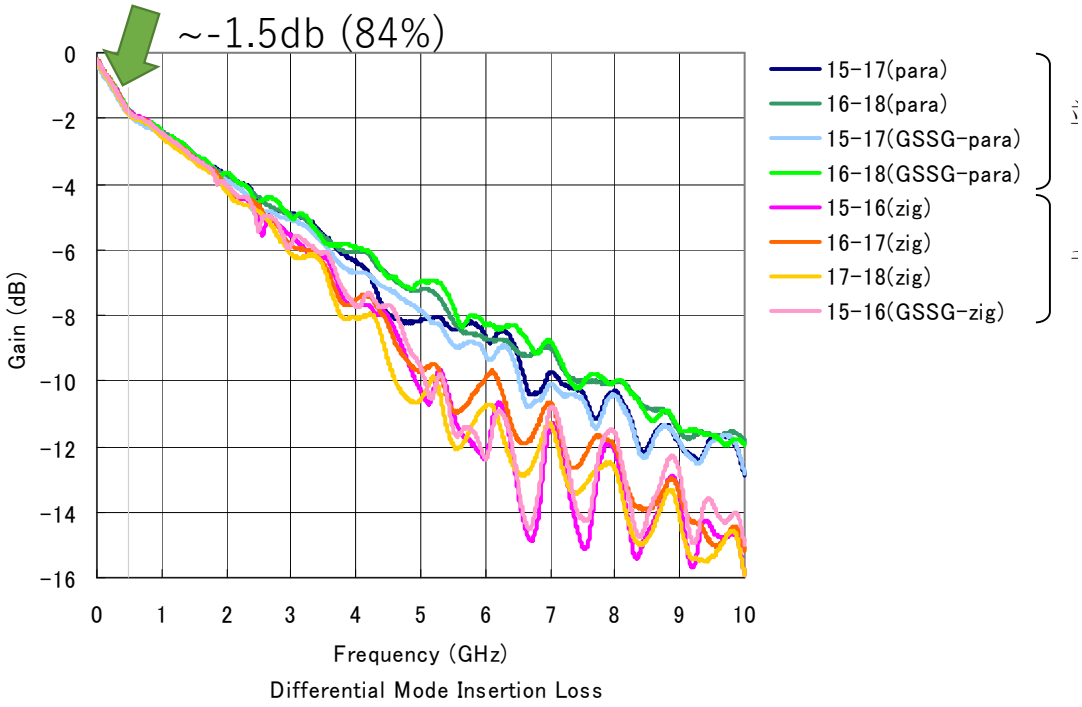
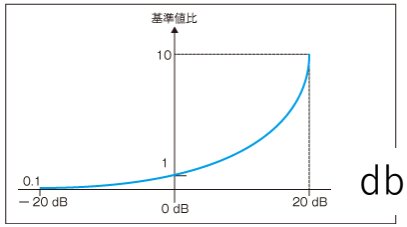
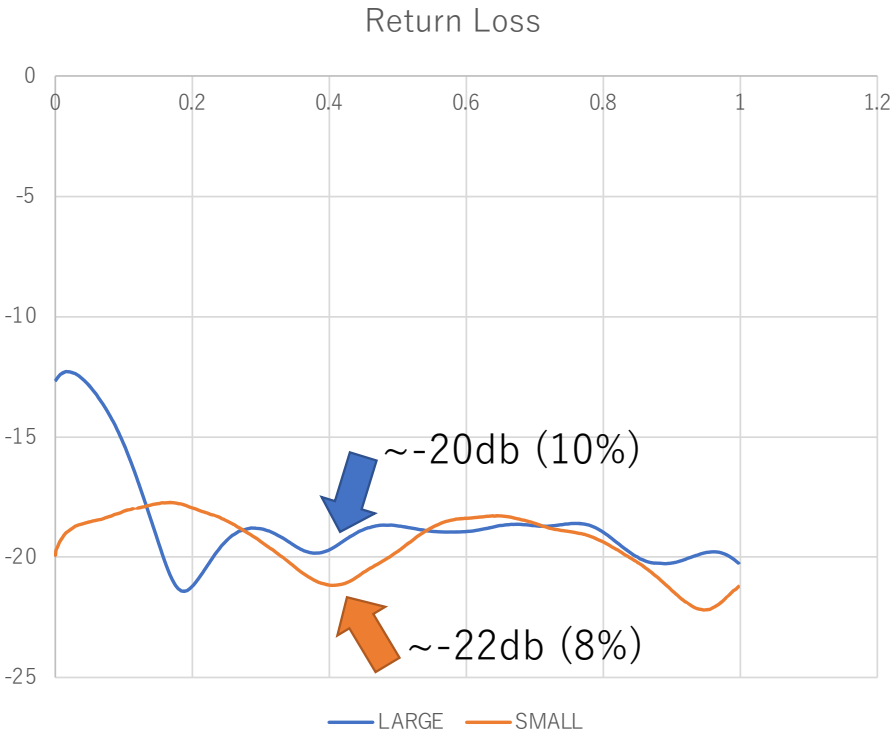



図 7.6　差動のインサーションロス

# Return Loss @ 400MHz




FPC Conversion Cable




KEL XSL Coaxial Cable

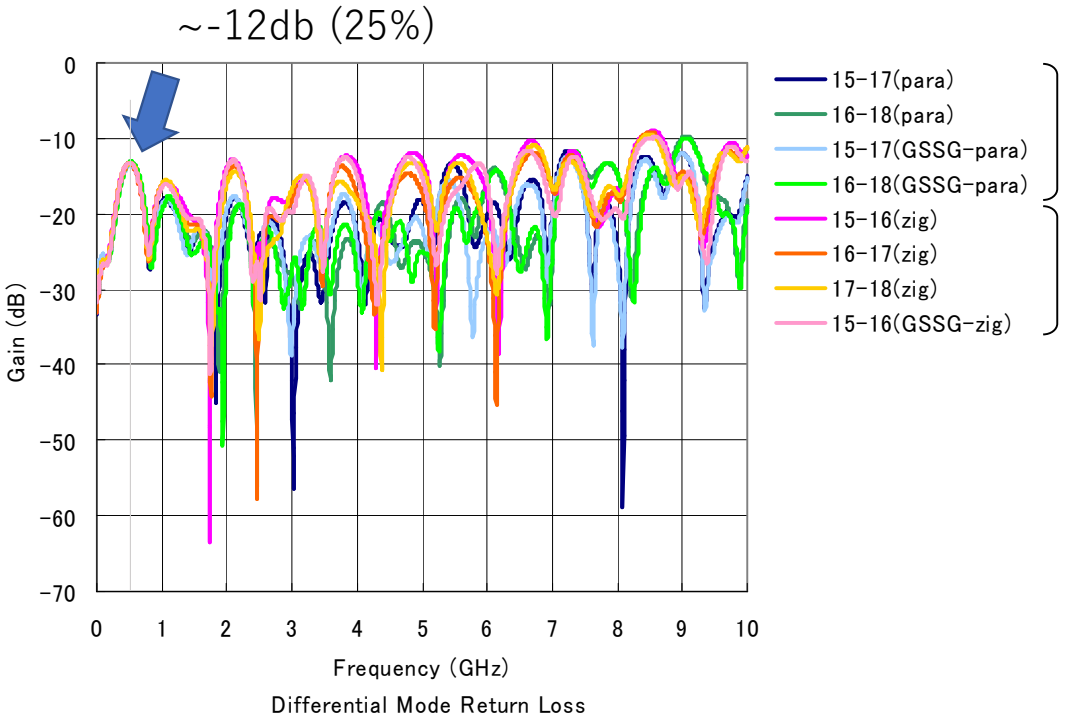
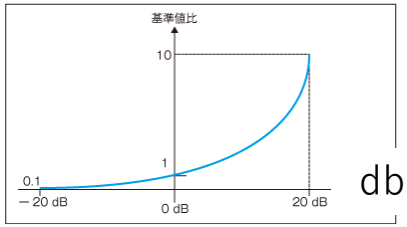



図 7.7　差動のリターンロス

# Cross Talk @ 400MHz




FPC Conversion Cable

KEL XSL Coaxial Cable

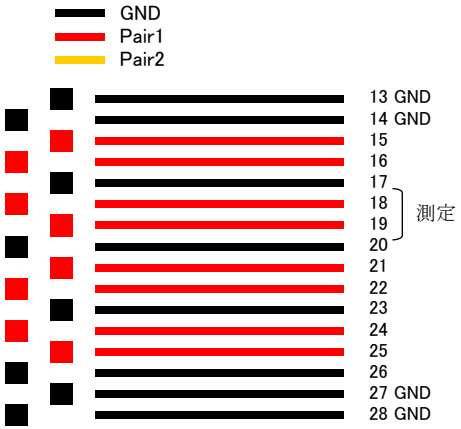



図 6.3　千鳥ペア

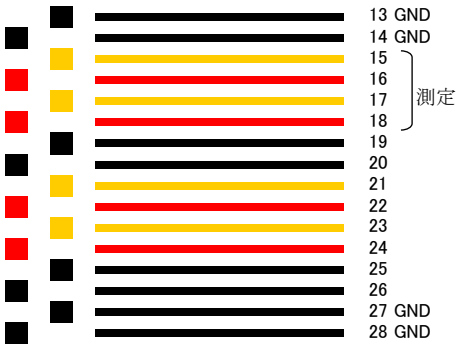



図 6.4　並列ペア

Cross talk mostly occurs at the connector area.
Its magnitude depends on the geometry of pins.

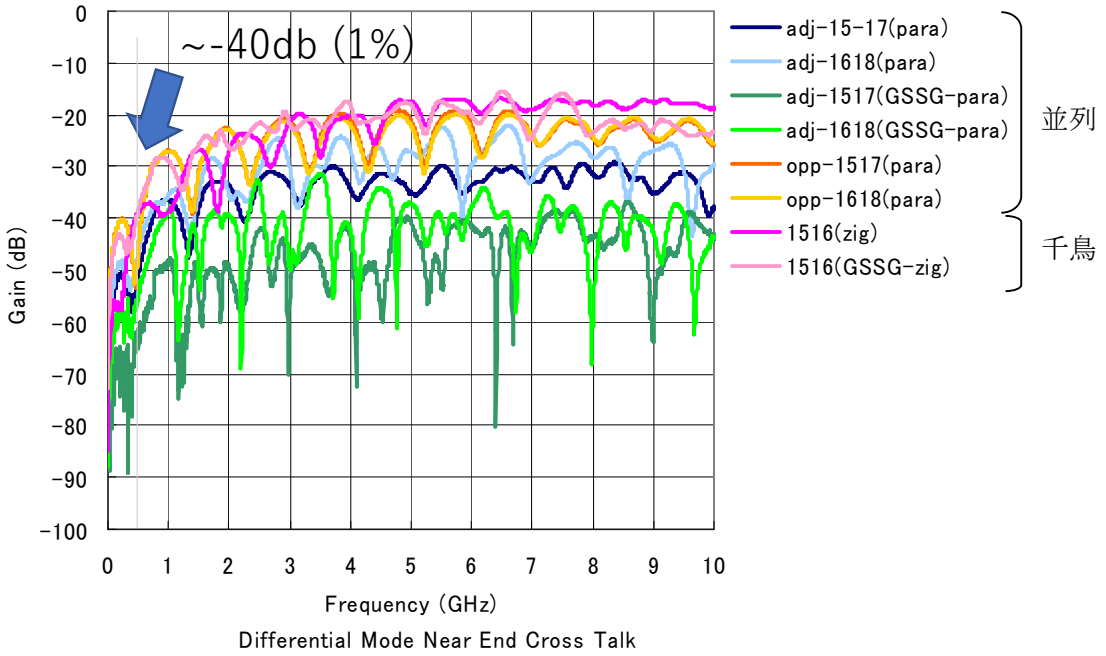
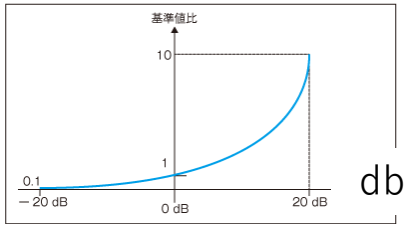


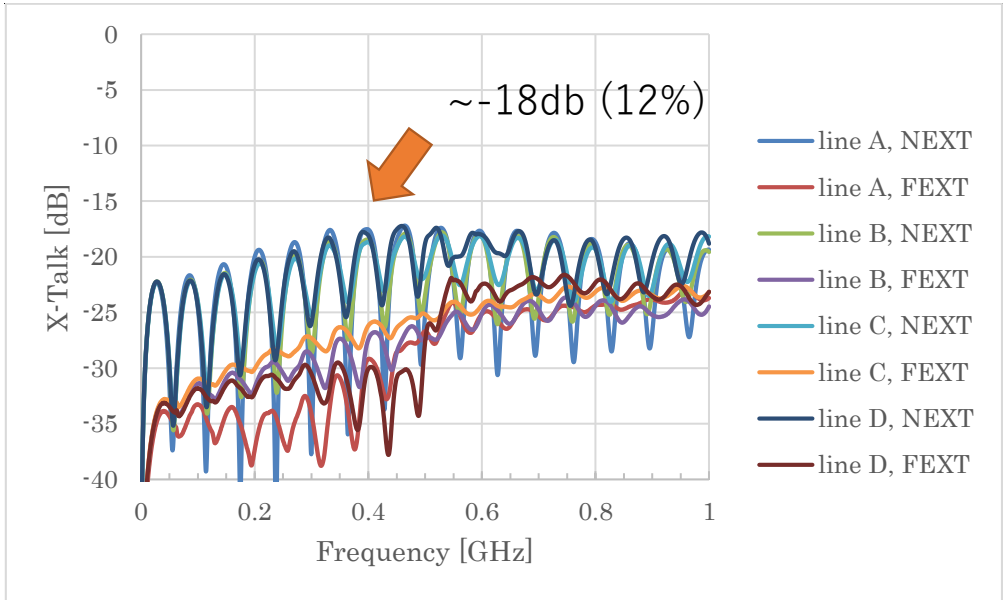

図 7.9　差動の近端クロストーク

# Cross Talk @ 400MHz




FPC Conversion Cable

KEL XSL Coaxial Cable




20cm CC + Bus Extender Measurement
近藤崇「設計ノート#14」

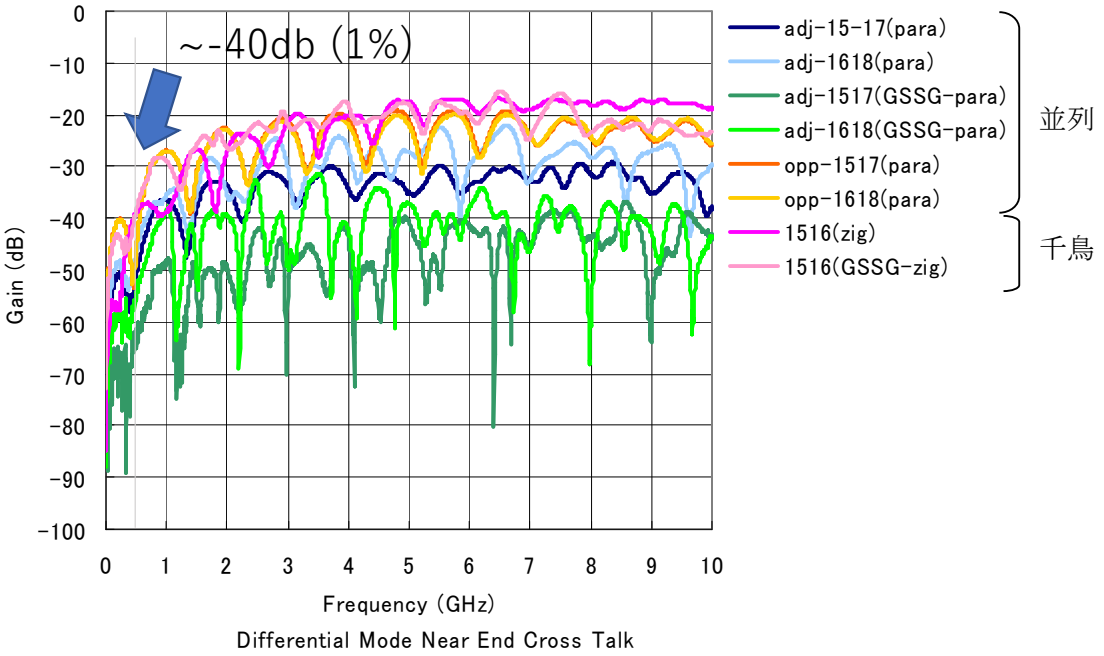
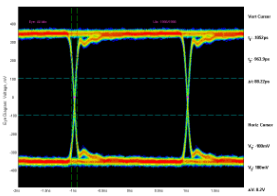


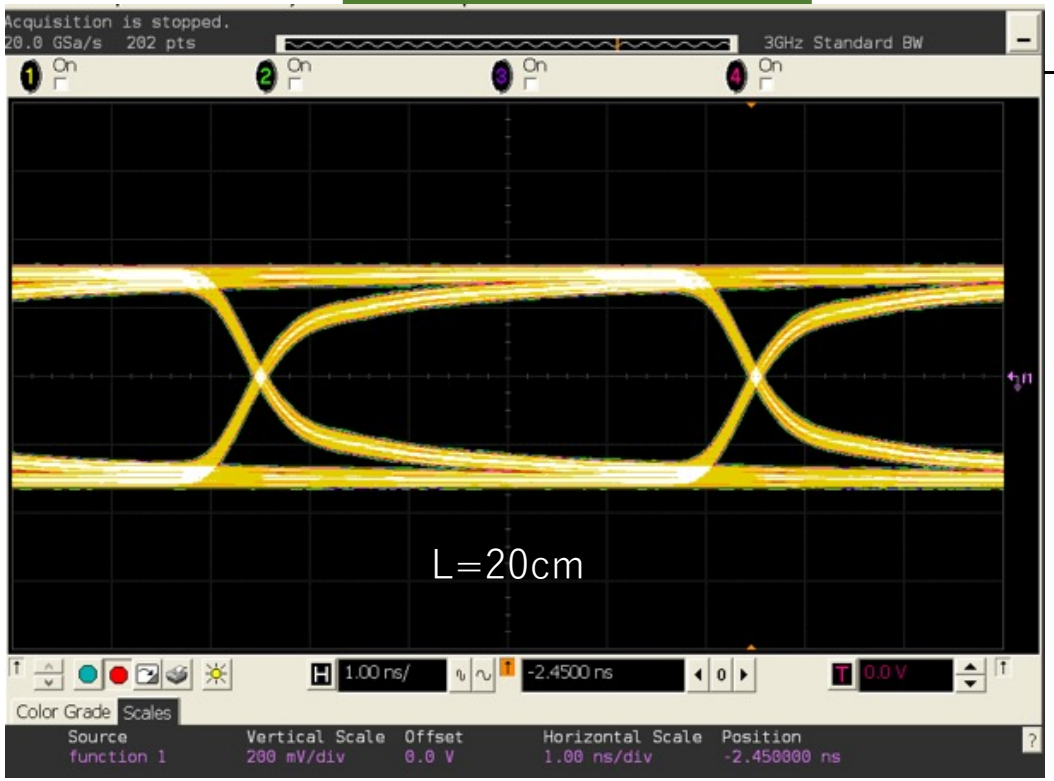

図 7.9　差動の近端クロストーク

# Eye Diagram @ 400 (500) MHz

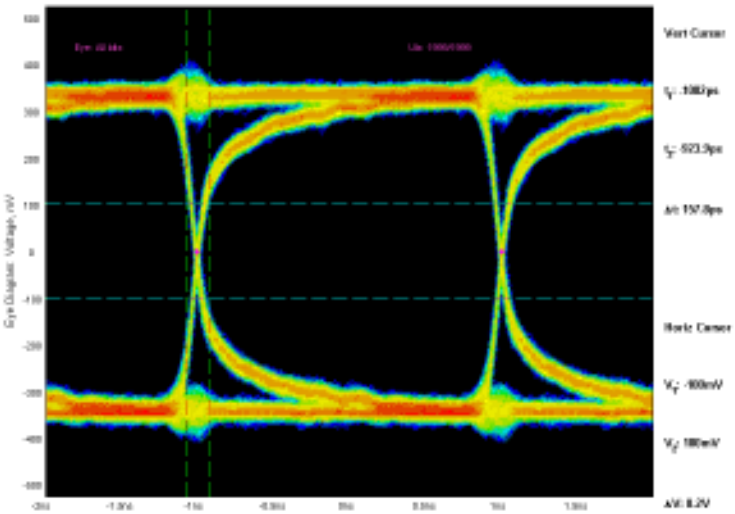
Input Signal

| | 350mV |
|---|---|
| 500Mbps |  |
| | Jitter=4.4% (±100mV) |

FPC Conversion Cable

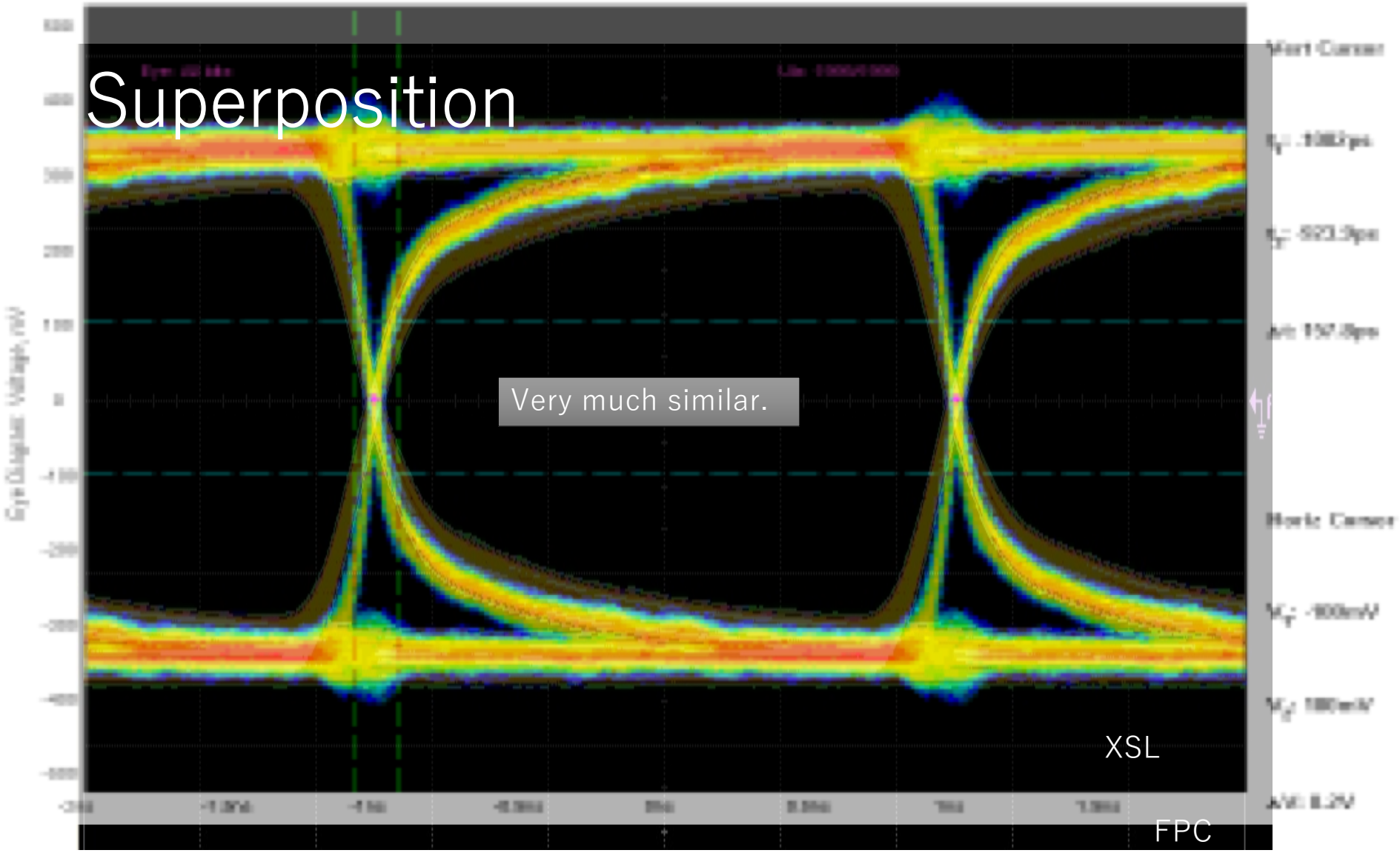



KEL XSL Coaxial Cable

| | 千鳥ペア(18-19) |
|---|---|
| 500Mbps |  |
| | Jitter=7.9% (±100mV) |

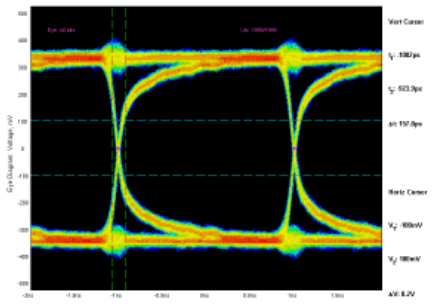
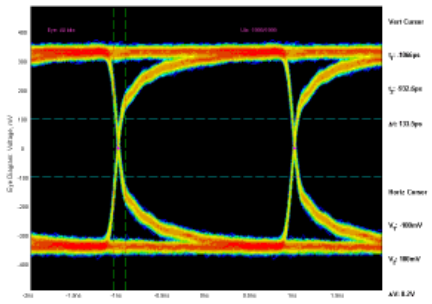
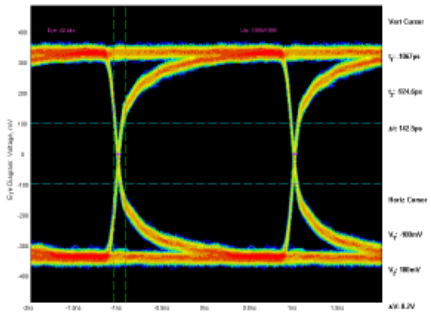
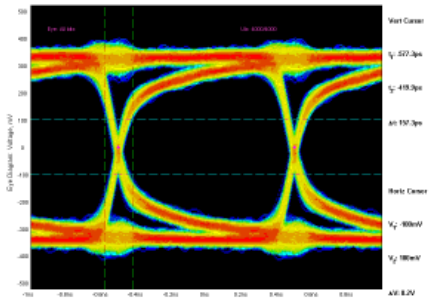
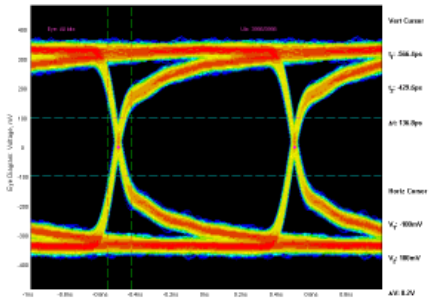
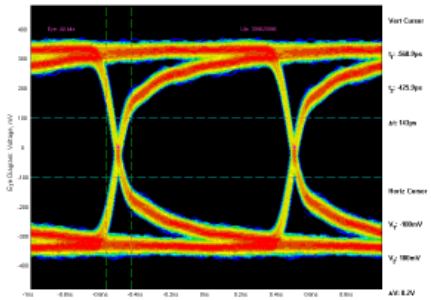
Hard to evaluate quantitatively, but at least it is not significantly worse .

# Superposition



# XSL Eye Diagram

・±350mV

| | 千鳥ペア(18-19) | 並列ペア(内側, 15-17) | 並列ペア(外側, 16-18) |
|---|---|---|---|
| 500Mbps |  |  |  |
| | Jitter=7.9%（±100mV） | Jitter=6.7%（±100mV） | Jitter=7.1%（±100mV） |
| 1Gbps |  |  |  |
| | Jitter=15.7%（±100mV） | Jitter=13.7%（±100mV） | Jitter=14.3%（±100mV） |

# KEL AWG44 (45Ω) – 10cm, 20cm, 30cm

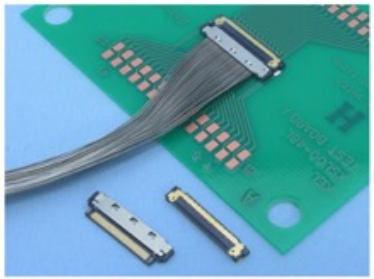
# KEL XSL Series

## XSL series

Extra-fine coaxial cable type

0.25mm pitch extra-fine coaxial cable connector

Features | specification | Download materials | Product list / technical data | Contact & Support



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We are supplying value-added and highly original products to many

Impedance : 45Ω

2．サンプル

・XSL00-48

・XSL20-48 （ 100/200/300mm ）

・ケーブル仕様

AWG44 細線同軸ケーブル UL11130CX-SW(PFA) 1X44AWG D=0.23(V)（日立金属株式会社製）

内部導体:0.06mm 仕上外径:0.23mm 特性インピーダンス 45±3Ω ケーブル長:100～30

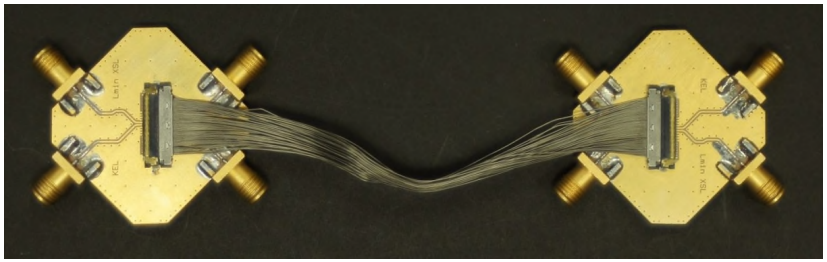


写真 1 評価基板及びサンプル(100mm)

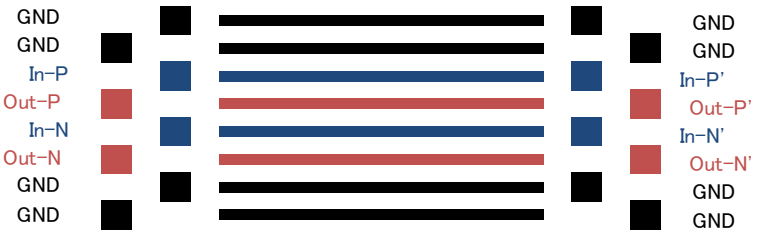



図 1 評価基板ピンアサイン

# Comparison with FPC

## FPC Conversion Cable

## KEL XSL Coaxial Cable

２．サンプル

・XSL00-48

・XSL20-48　（ 100/200/300mm ）

・ケーブル仕様

AWG44 細線同軸ケーブル UL11130CX-SW(PFA) 1X44AWG D=0.23(V)（日立金属株式会社製）

内部導体:0.06mm　仕上外径:0.23mm　特性インピーダンス 45±3Ω　ケーブル長:100～30

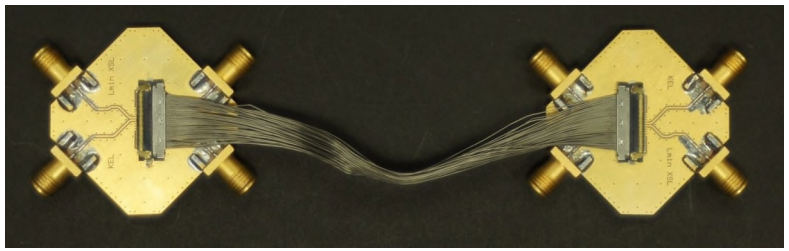


写真１　評価基板及びサンプル(100mm)

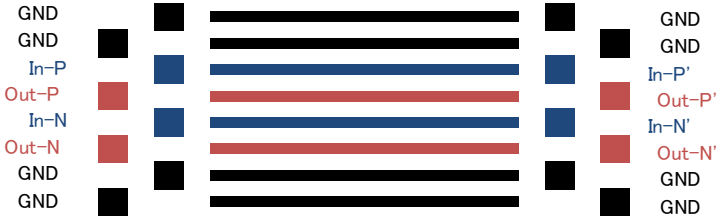
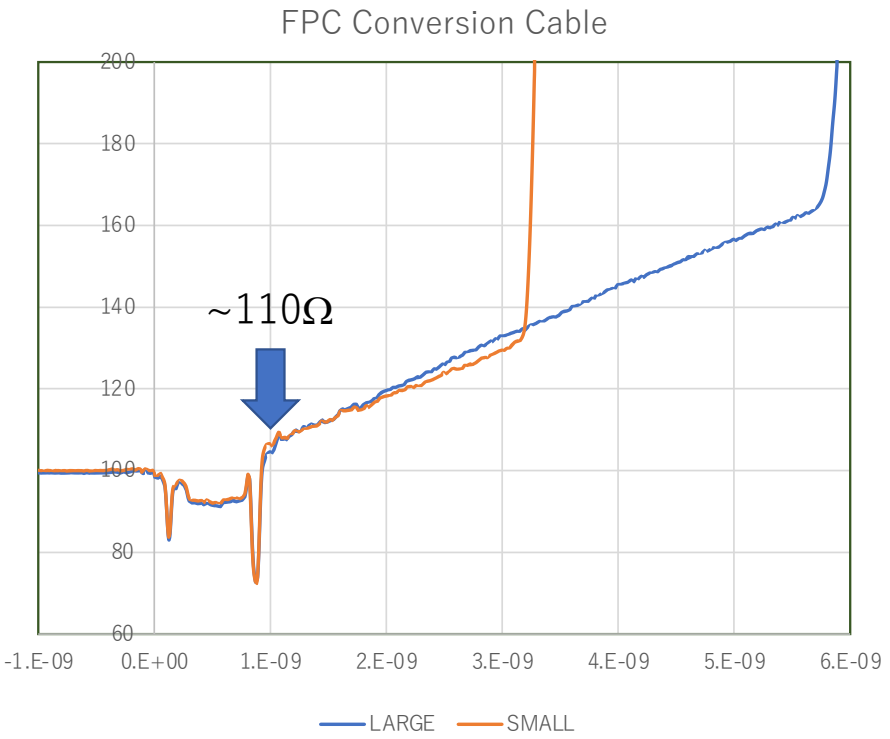



図１　評価基板ピンアサイン

# Time Domain Reflectometry (TDR)

## Differential Impedance

FPC Conversion Cable




KEL XSL Coaxial Cable

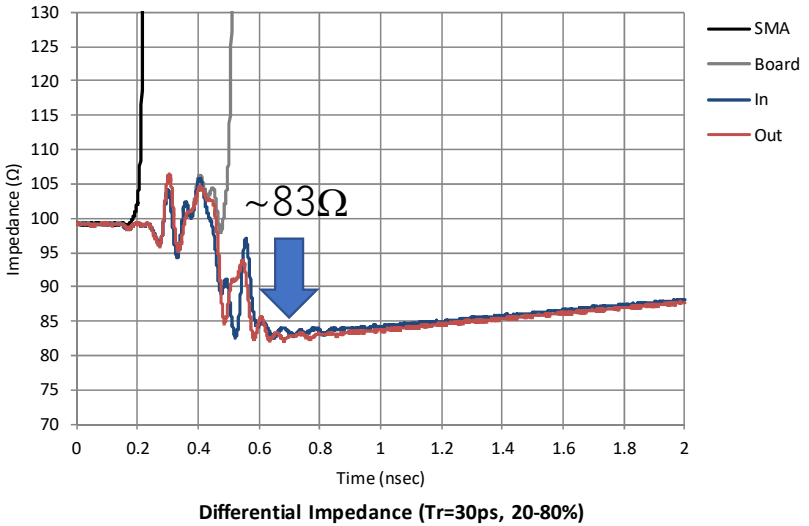
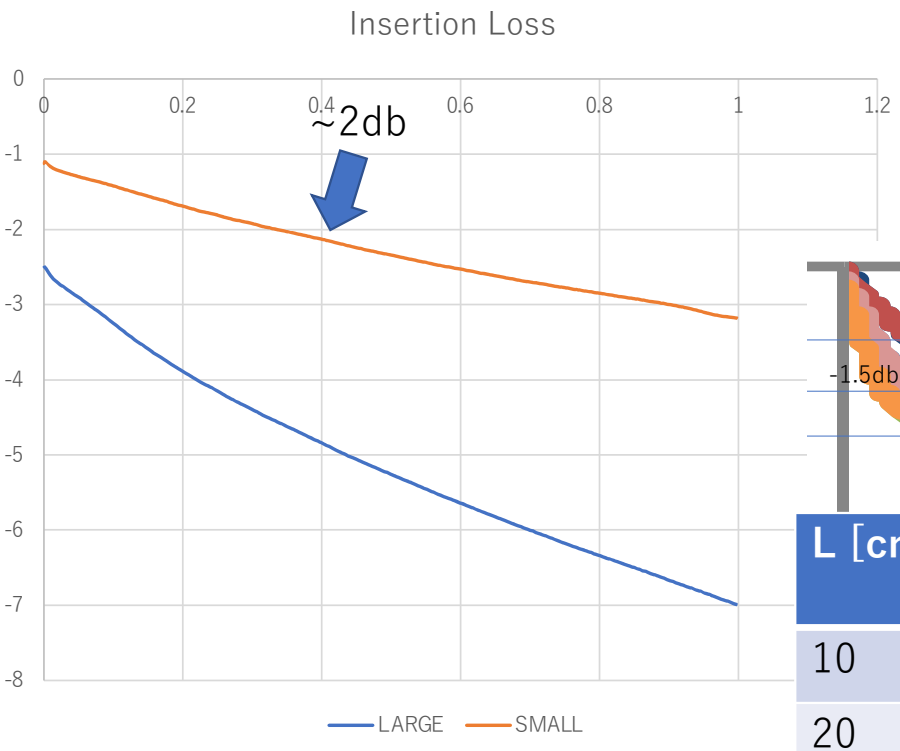


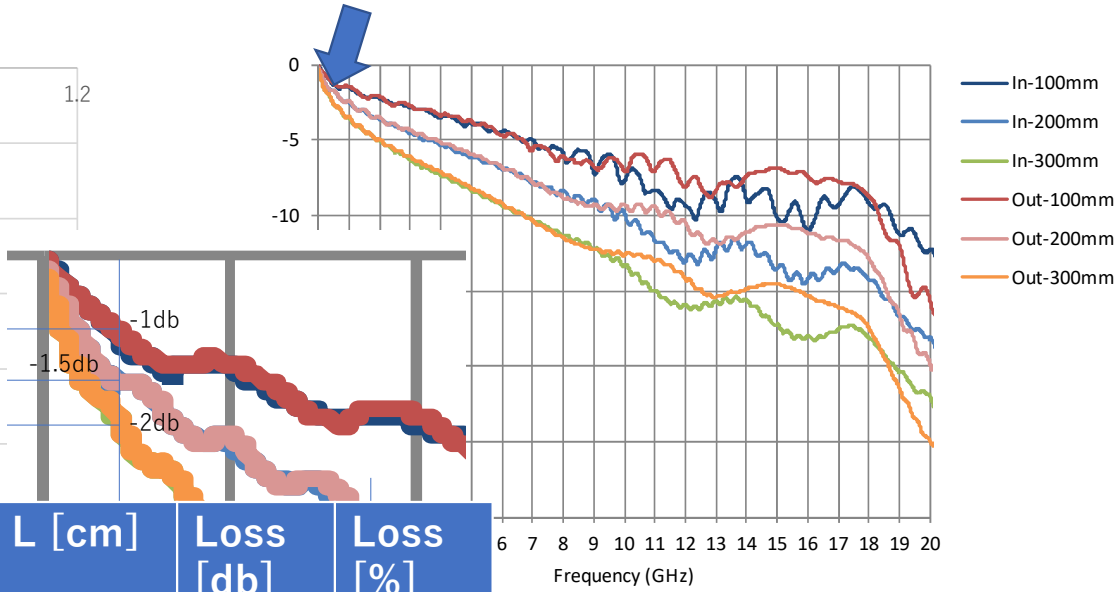

図 5.1　差動インピーダンス（Tr=30ps，20-80%）

# Insertion Loss

FPC Conversion Cable



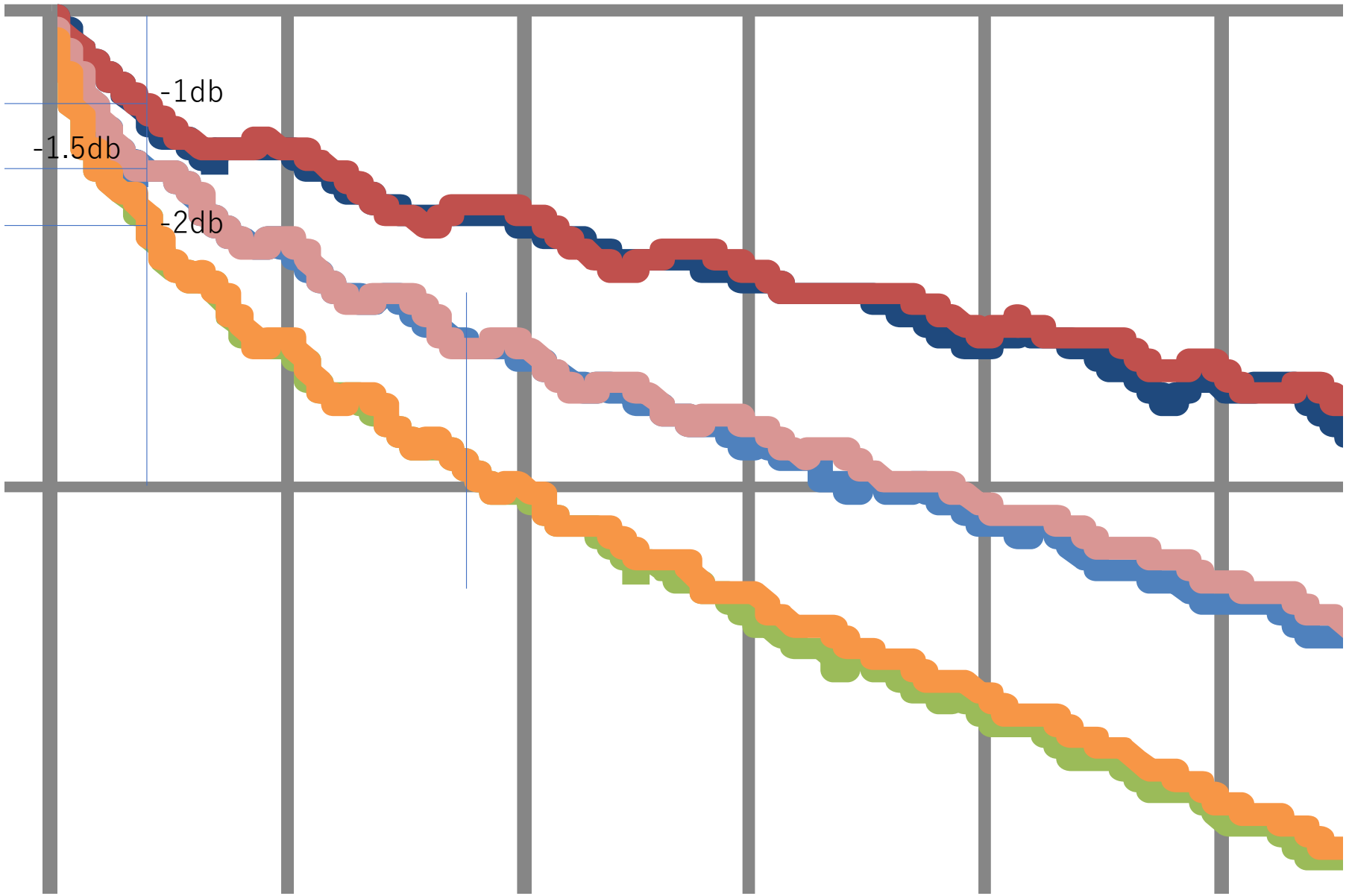

KEL XSL Coaxial Cable




ifferential Mode Insertion Loss

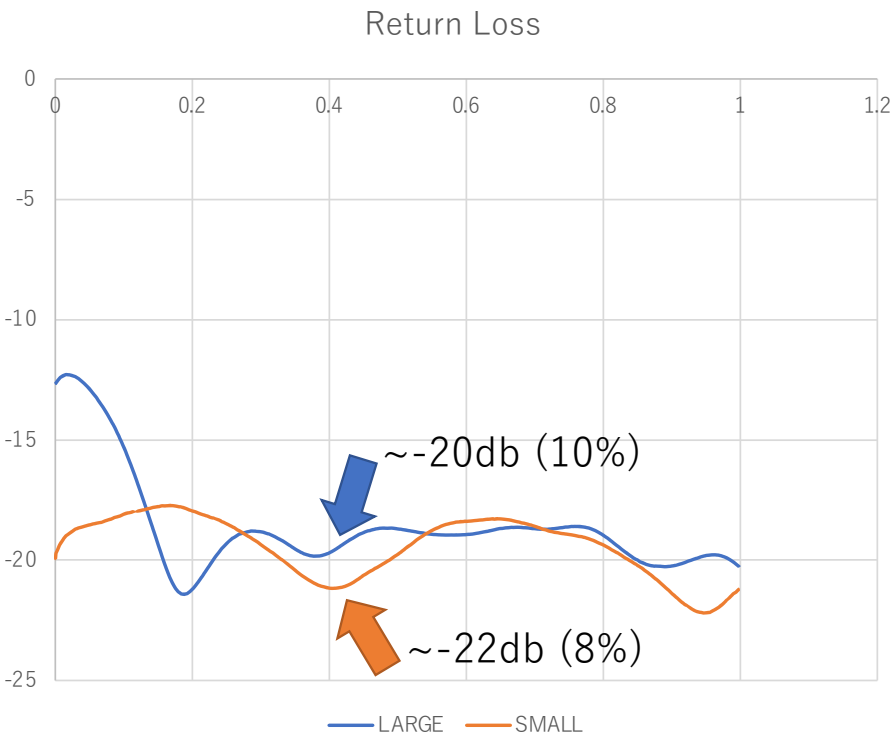
図 6.1　差動インサーションロス

| L [cm] | Loss [db] | Loss [%] |
|---|---|---|
| 10 | -1db | 90 |
| 20 | -1.5db | 84 |
| 30 | -2db | 80 |


-1db
-1.5db
-2db

# Return Loss

FPC Conversion Cable




KEL XSL Coaxial Cable

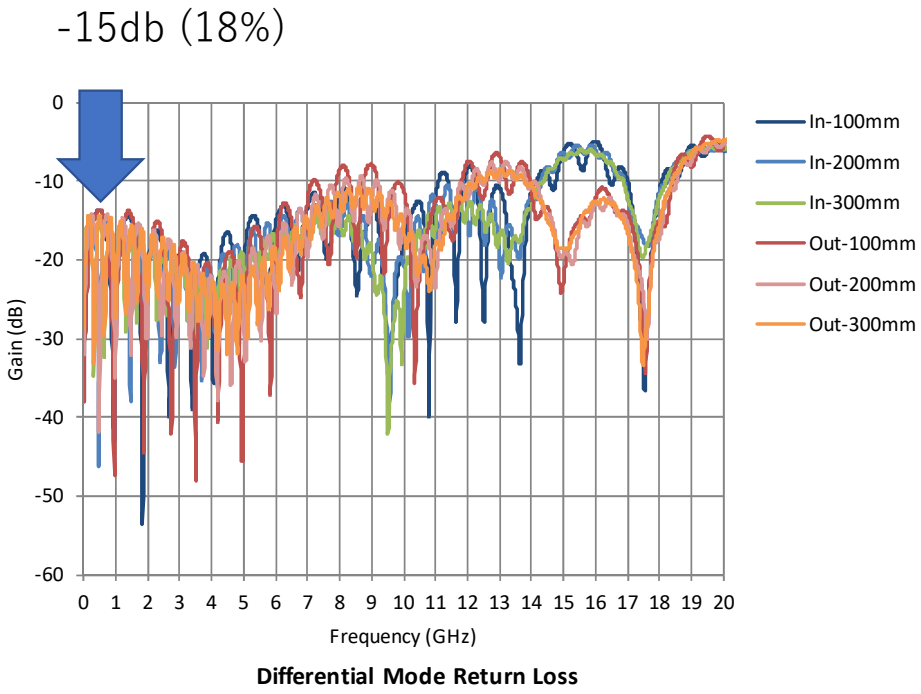
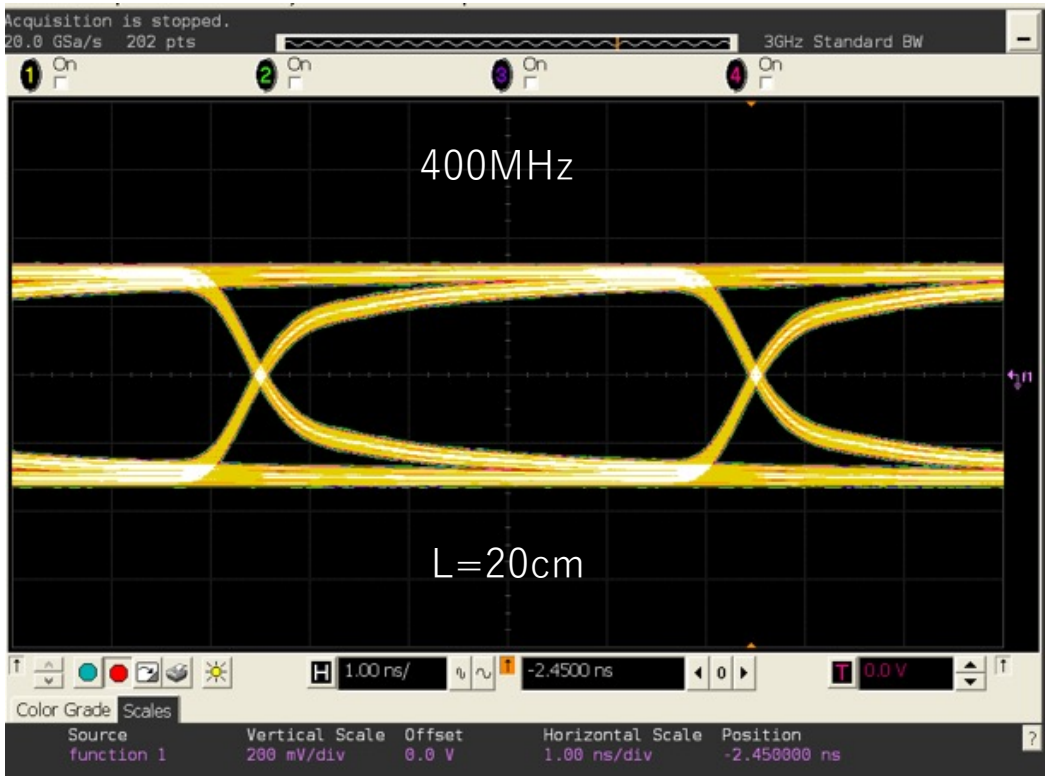



図 6.2　差動リターンロス

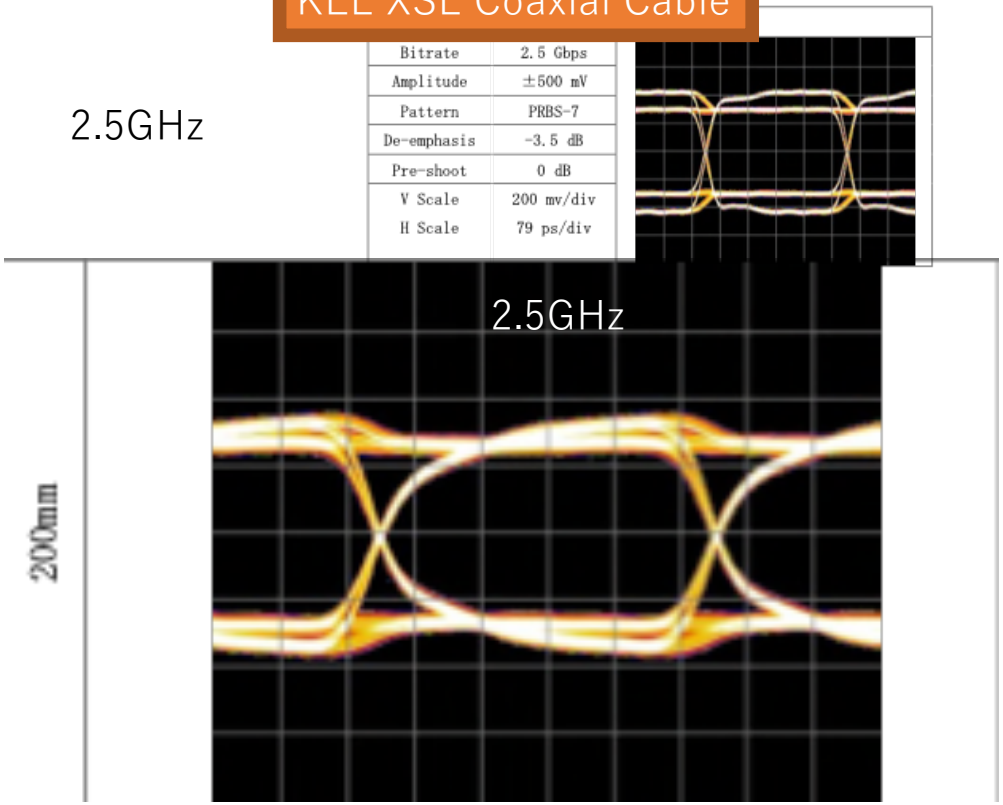
# Eye Diagram 400MHz vs 2.5GHz

FPC Conversion Cable




KEL XSL Coaxial Cable

2.5GHz




No 400MHz eye is available for 45Ω.

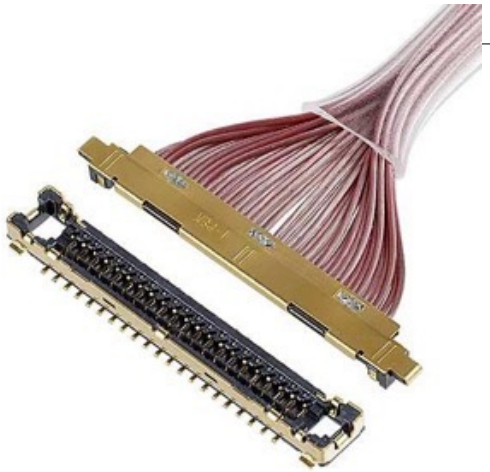
# Alternative Model

IPEX UX-II

# CABLINE®-UX II

## The simulation for transmission performance

Part No. Plug: 20531-0**T-02, Receptacle: 20533-0**E



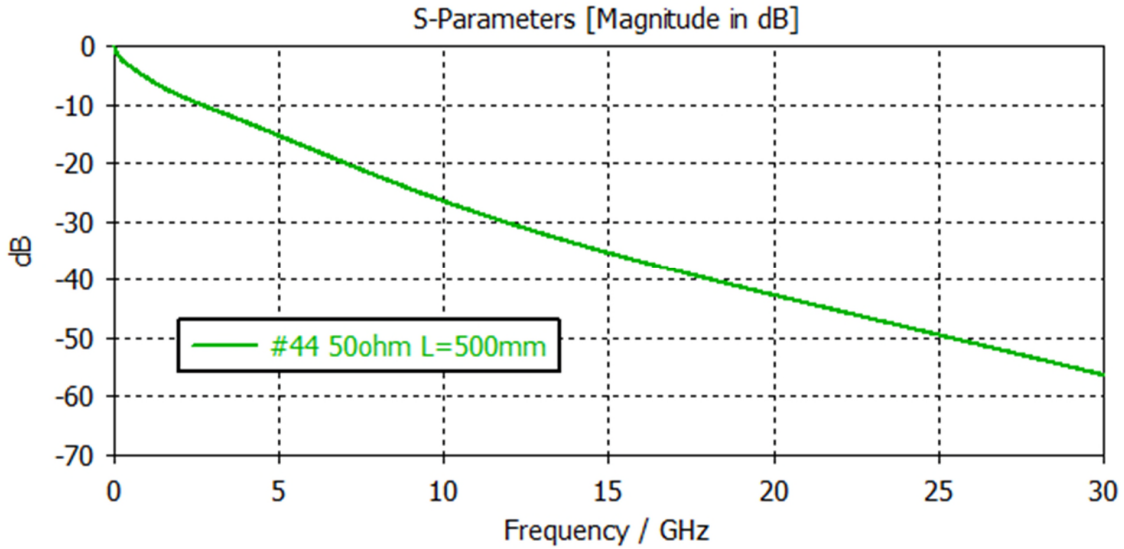
## Technical Report

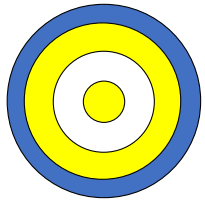
| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| 0 | R21018 | 2021/01/18 | A.Koyanagi | T.Tanigawa | H.Ikari |
| Rev. | ECN | Date | Prepared by | Checked by | Approved by |

# CABLINE-UX II The simulation for transmission performance

1. Simulation condition
   Cable insertion loss : MCX cable AWG#44, L=500mm

AWG#44 50Ω



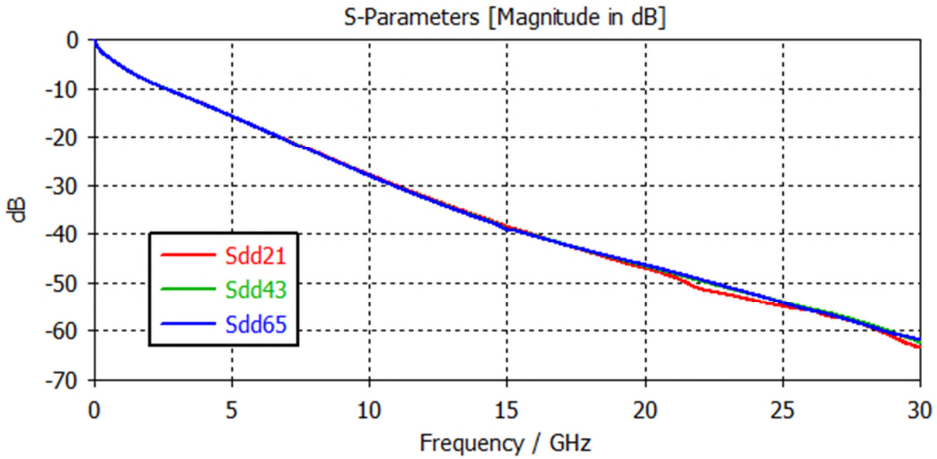
MCX Model

| (dB) | 5GHz | 10GHz | 15GHz | 20GHz | 25GHz | 30GHz |
|---|---|---|---|---|---|---|
| #44 | -15.36 | -26.55 | -35.42 | -42.72 | -49.54 | -56.38 |

## 2. Simulation result (Insertion loss, Return loss)
S-parameter (Differential)

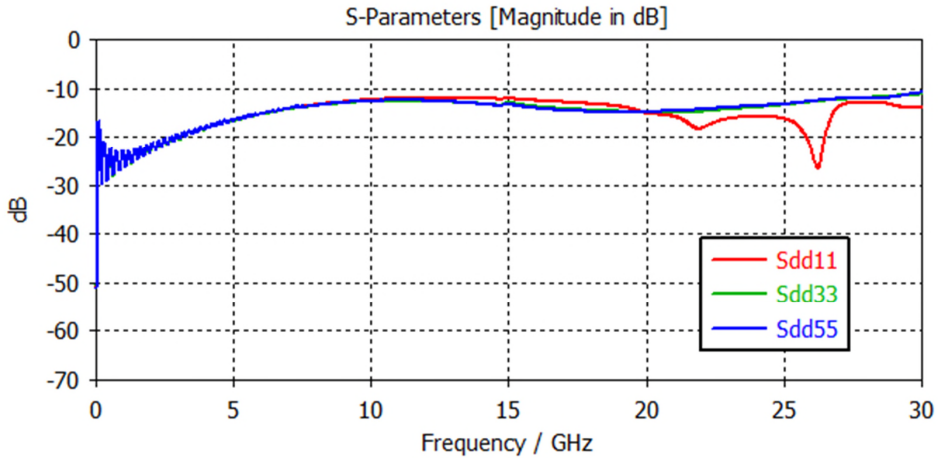
differential

### Insertion loss



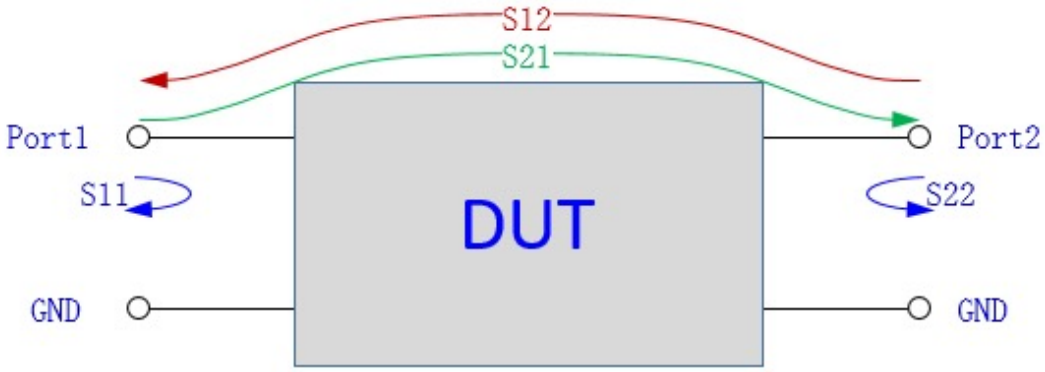

| (dB) | 5GHz | 10GHz | 15GHz | 20GHz | 25GHz | 30GHz |
|---|---|---|---|---|---|---|
| Sdd21 | -15.74 | -27.96 | -38.63 | -47.02 | -54.99 | -63.43 |
| Sdd43 | -15.76 | -28.10 | -39.11 | -46.57 | -54.06 | -62.31 |
| Sdd65 | -15.77 | -28.11 | -39.15 | -46.37 | -54.20 | -61.89 |

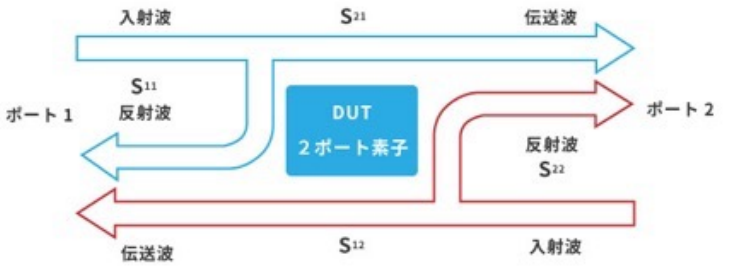
### Return loss




| (dB) | 5GHz | 10GHz | 15GHz | 20GHz | 25GHz | 30GHz |
|---|---|---|---|---|---|---|
| Sdd11 | -16.61 | -12.31 | -11.96 | -15.08 | -16.24 | -16.24 |
| Sdd33 | -16.66 | -12.67 | -12.84 | -14.87 | -13.33 | -13.33 |
| Sdd55 | -16.57 | -12.57 | -13.16 | -14.79 | -13.21 | -13.21 |

# Backup




$S_{11} = \frac{\text{反射波電圧}}{\text{入射波電圧}}$ ： 順方向の反射係数

$S_{12} = \frac{\text{伝送波電圧}}{\text{入射波電圧}}$ ： 逆方向の伝送係数

$S_{21} = \frac{\text{伝送波電圧}}{\text{入射波電圧}}$ ： 順方向の伝送係数

$S_{22} = \frac{\text{反射波電圧}}{\text{入射波電圧}}$ ： 逆方向の反射係数

# Specification Comparison

| | FPC | KEL XSL Coaxial |
|---|---|---|
| Signal Line [$\mu m^2$] | 60 x 9 | $\pi$ x $60^2$ ($0.002mm^2$) |
| Direct Current Resistance [$\Omega$] | 16* | |
| Impedance | 50 | 45 $\pm$ 3 |
| | | |
| | | |

*Measurement by Genta Nakano https://wiki.bnl.gov/sPHENIX/index.php/Conversion_Cable