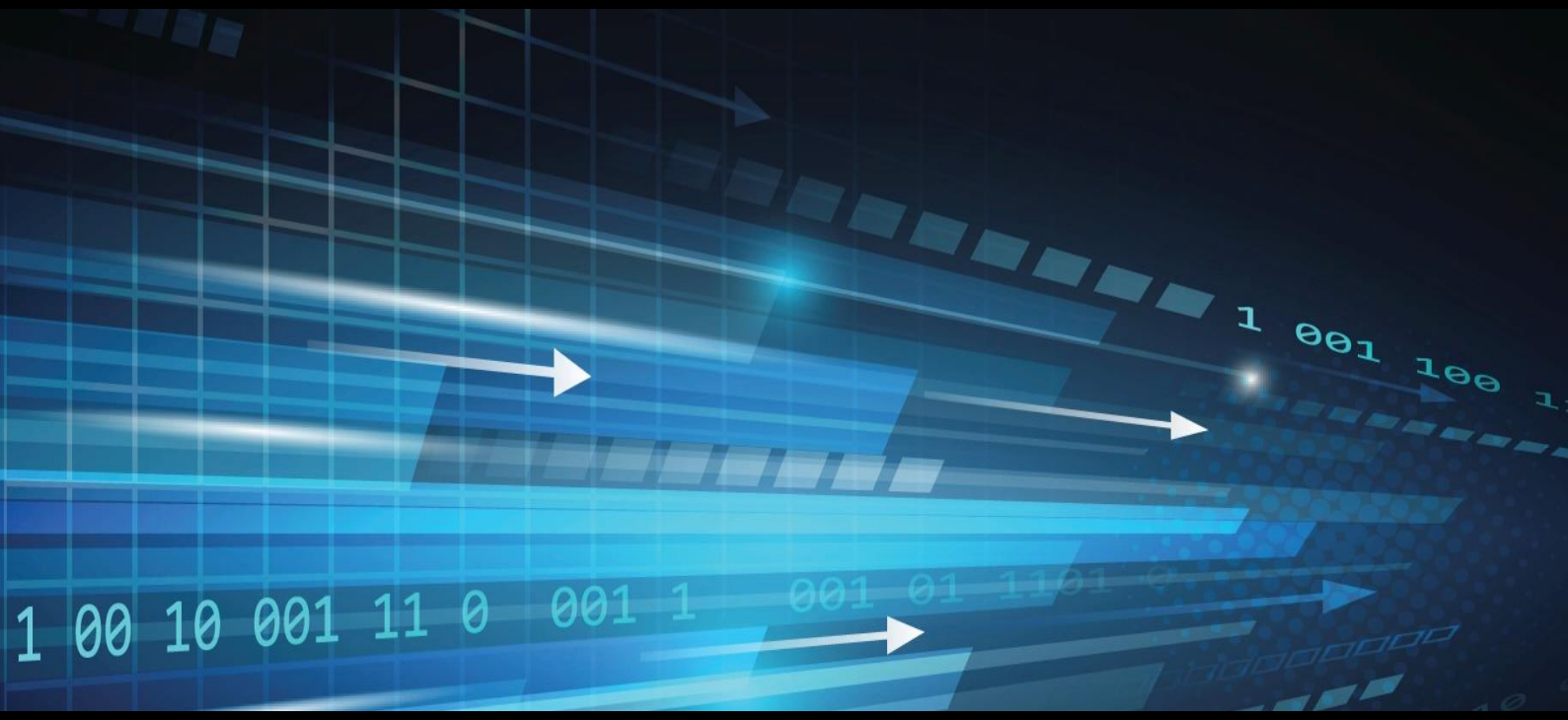
NICOMATIC

CREATIVE INTERCONNECT SOLUTIONS

LF Contacts Characterisation

QTR17014.a



HIGH SPEED

APPLICATIONS

CONTENTS

	Name	Duty	Date	Visa
Written by	**A.JAGHMIM**	**Test & Measurement Manager**	**22/11/17**	**AJ**
Test Operator(s)	**A.JAGHMIM**	**Test & Measurement Manager**	**22/11/17**	**AJ**
Checked by	**F.MOREL**	**Smart Co Manager**	**22/11/17**	**FM**
Approved by	**A.ZANCHETTA**	**R&D Director**	**22/11/17**	**AZ**
Requested by	**A.VULLIEZ**	**R&D Manager**	**22/11/17**	**AV**

1 Conclusion

The CMM connectors are characterized in this report in Frequency domain (S parameters) and in Time domain (eye diagram). The Frequency range of connectors is depending on requirement, in dB, of Insertion Loss, Return Loss and Crosstalk. Eye diagrams are defining the ability of the connectors to pass a signal at the speed tested, in Gbps. It cannot include the validation of performances at lower speeds but it can give trends.

2 Technical Features Proposal

There is 2 ways to use the data of this report:
1 – If a customer wants to know what is the performance of a connector at a specific frequency, we should give him Insertion Loss, Return Loss and Crosstalk performance (in dB).

2 – If a customer wants to know if a connector could be used at a specific frequency, the Insertion Loss, Return Loss and Crosstalk performances have to be required from the customer.

The results could be used for CMM and DMM because the materials, pitch and diameter contact are the same. The shell of the DMM doesn't affect the signal. It have been proved by measuring the same configuration between CMM and DMM and compared in the report QTR17015.a.

3 Connate Reports

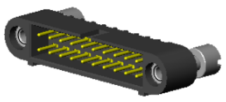
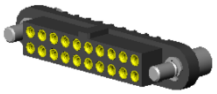
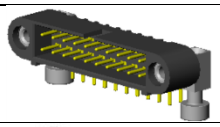
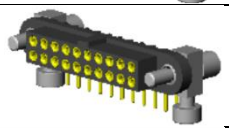
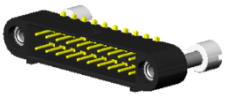
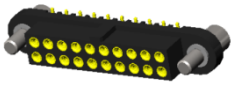
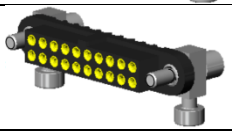
NICOMATIC CMM LF SERIES and DMM HF SERIES MEAUREMENT REPORT.pdf

4 Information about the tests

4.1 Object

The object of those tests is to characterise our connector with LF contacts in frequency, in order to analyse the influence of our connectors in a transmission line.

4.2 Tested Products

Designation	Article Reference	Drawing	Batch / DI	Quantity
Connector CMM220 M straight on PCB 26 pts F22	221Y26F22		DI6664	3
Connector CMM220 F straight on PCB 26 pts M16	222Y26M16		DI6665	3
Connector CMM220 M 90° on PCB 26 pts F26	221V26F26		DI6671	3
Connector CMM220 F PCB 90° 26 pts M21	222V26M21		DI6672	3
Connector CMM220 M straight SMT 26 pts F24	221T26F24		DI6673	3
Connector CMM220 F straigth SMT 26 pts M16	222T26M16		DI6674	3
Connector CMM220 M 90° SMT 26 pts F26	221R26F26		DI6675	3
Connector CMM220 F 90° SMT 26 pts M21	222R26M21		DI6676	3

4.3 Persons present during the tests

Name	Duty
Su-Wei CHANG	Director TMYtek
Tzu-Chieh HUNG	Engineer
Hedy CHUANG	Engineer

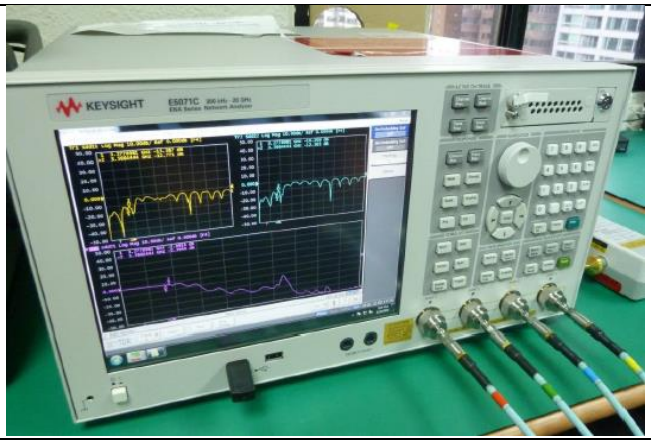
4.4 Date and place of the tests

Tests are done by TMYtek Lab. from 01/10/16 to 27/12/16

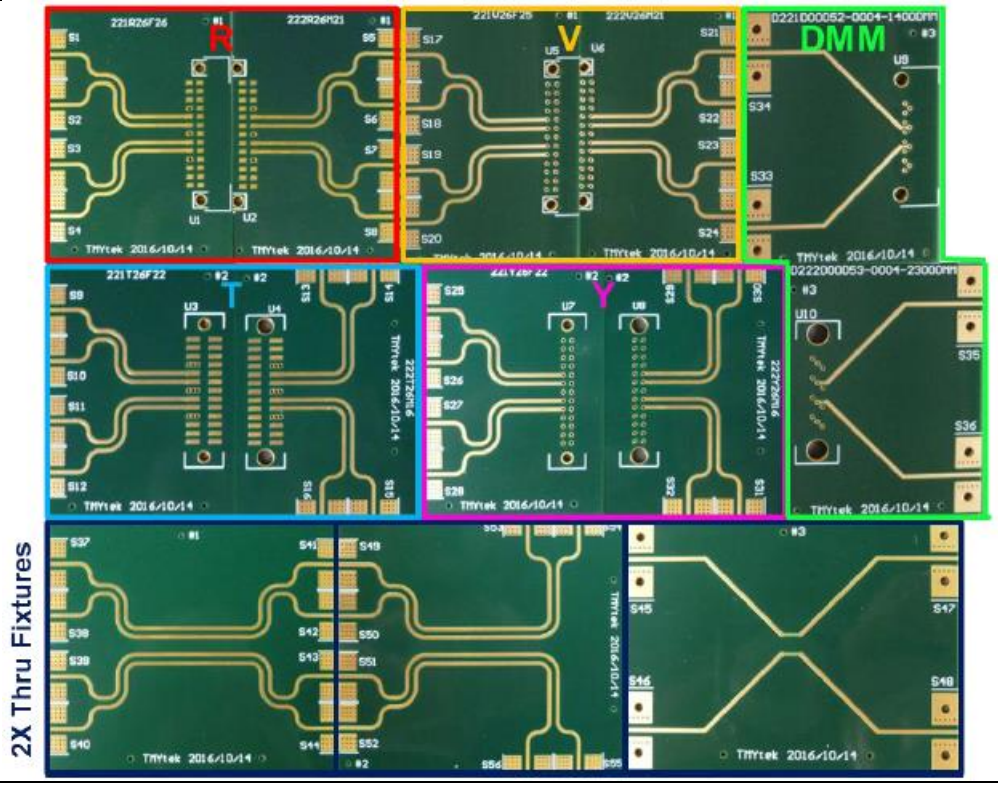
4.5 Environmental conditions

Ambient temperature: ambient
Pressure: ambient
Humidity: ambient

4.6 Test Equipment

Designation
Keysight E5071C ENA Network Analyzer, 300kHz to 20 GHz

The equipment chosen to perform the entire measurement for the completion of this report is Keysight E5071CENA Network Analyzer (shown in Figure 1). This network analyzer is capable of performing both the s-parameter test for frequency range of 300kHz to 20 GHz and the eye diagram test, which is sufficient for the needs of the tested CMM LF and DMM HF series.

Designation
Keysight E5071C ENA Network Analyzer, 300kHz to 20 GHz



In order to measure the PCB-type connectors, 50-Ω transmission lines have been designed using the suggested layout of each connector. Automatic-Fixture-Removal (AFR) 2X Thru calibration method has been implemented in order to move the measured reference plane from the input of the SMA connectors to the input pins of the Nicomatic connectors. The AFR2X Thru calibration kits have been designed to cover frequency range from 300 kHz to 6GHz for CMM series and 300 kHz to 10 GHz for DMM series. All the circuits and calibration kit are manufactured using 4-layer FR-4 laminate with gold (Au) plating and thickness of 0.4 mm (shown in Figure 4).

Calibration technology: AFR2X Thru calibration
Impedance: 50Ω (single ended), 100 Ω (differential)
PCB laminate: FR-4
RF connector (CMM): SMA end launch jack (up to 18 GHz)
Measured parameters: S-parameter and eye diagram

5 Test description

5.1 50 Ω Transmission Line Verification

Before starting any measurement, the 50 Ω transmission lines should be verified with the end-launch connectors mounted, wich are used on the CMM LF series PCBs (R, V, T, Y, Fixture #1 and Fixture #2). The 3.5 mm end-launch connectors could operate up to 27 GHz, which are used on the DMM HF series PCBs (DMM and Fixture #3).

5.2 Definition

S parameters:

Linear two-port (and multi-port) networks are characterized by a number of equivalent circuit parameters, such as their transfer matrix, impedance matrix, admittance matrix, and scattering matrix. Figure 1 shows a typical two-port network.

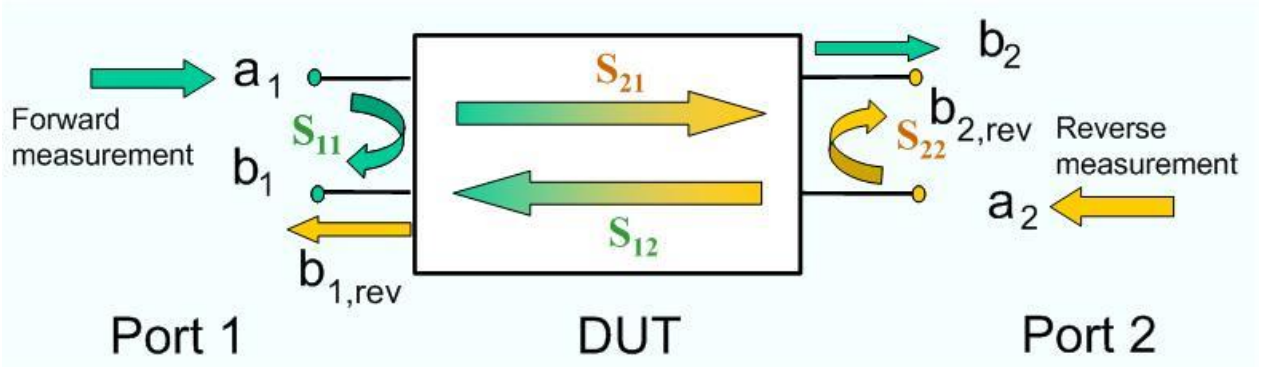


Figure 1 : Two-port network (DUT = Device Under Test)

Insertion loss (S21):

Insertion Loss or Attenuation is the degree of signal amplitude decrease (or loss), measured in Decibels. Electrical signals transmitted by a link lose some of their energy as they travel along the link. Insertion loss measures the amount of energy that is lost as the signal arrives at the receiving end of the cabling link. The insertion loss measurement quantifies the effect of the resistance the cabling link offers to the transmission of the electrical signals.

It is the extra loss produced by the introduction of the device under test (DUT) between the 2 reference planes of the measurement. Notice that the extra loss can be introduced by intrinsic loss in the DUT and/or mismatch.

It is thus given by:

$$IL = -20\log_{10}|S_{21}| \text{ dB.}$$

Return Loss: Return loss is the loss of power in the signal returned/reflected by a discontinuity in a transmission line. Return Loss measures the total energy reflected on each wire pair. Return Loss is to be measured from both ends of the link-under-test for each wire pair.

- **Input return loss (S11):**

Input return loss (RLin) can be thought of as a measure of how close the actual input impedance of the network is to the nominal system impedance value. Input return loss expressed in decibels is given by:

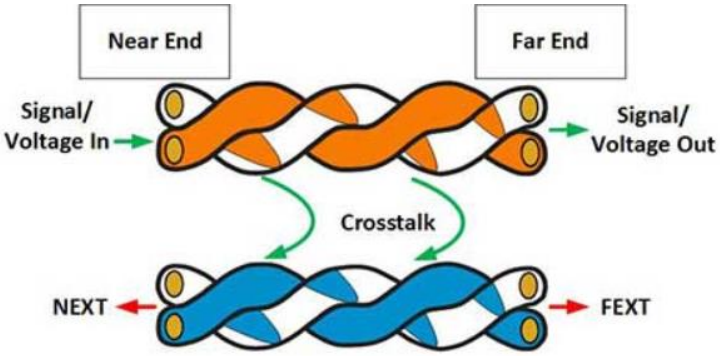
$$RL_{\text{in}} = 10\log_{10}\left|\frac{1}{S_{11}^2}\right| = -20\log_{10}|S_{11}| \text{ dB.}$$

- **Output return loss (S22):**

The output return loss (RLout) has a similar definition to the input return loss but applies to the output port (port 2) instead of the input port. It is given by:

$$RL_{\text{out}} = -20\log_{10}|S_{22}| \text{ dB.}$$

Crosstalk: Crosstalk is defined as the unwanted induction of signal from one circuit to another.



5.3 Measurement of Thru fixtures

5.3.1 Test Fixture #1

Test fixture #1 (Figure 2) is designed for 90° PCB differential signal configuration, which is used to calibrate **type R and V PCBs**.

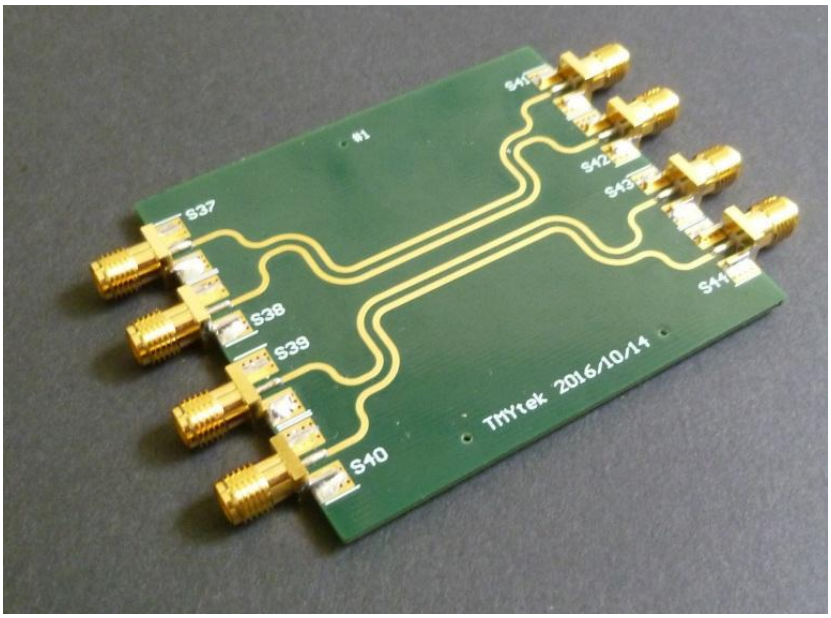


Figure 2 - Fixture #1 with SMA end-launch jack mounted

According to the measurement result, the 50-Ω transmission line for this type of configuration could be used up to 6GHz (Figure 3).

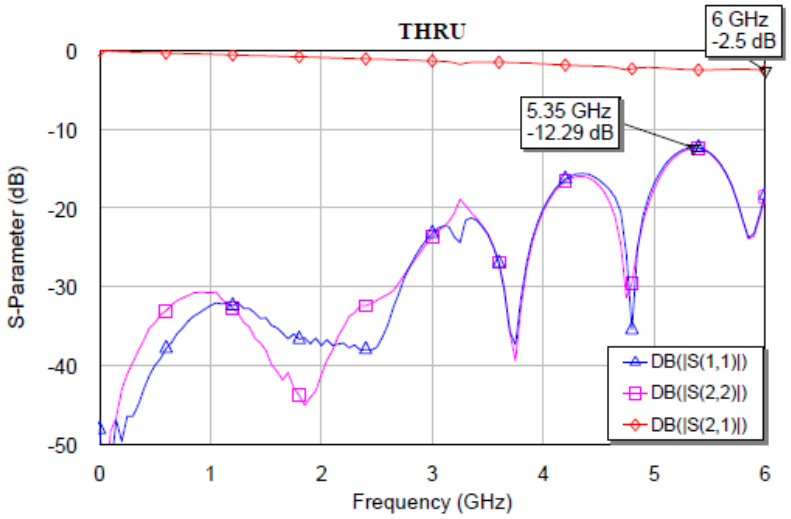


Figure 3 - S-parameter measurement result of Fixture #1

5.3.2 Test Fixture #2

Test fixture #2 (Figure 4) is designed for straight PCB differential signal configuration, which is used to calibrate **type T and Y PCBs**.

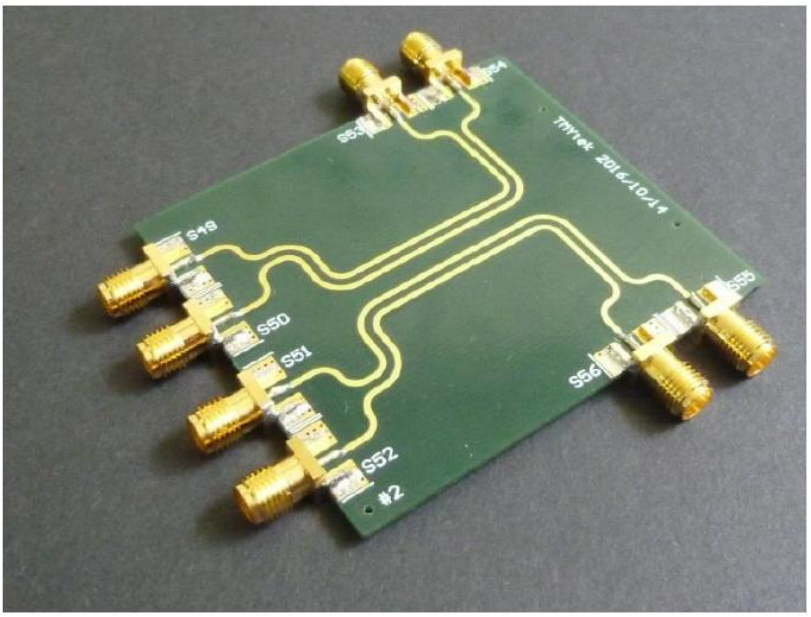


Figure 4 - Fixture #2 with SMA end-launch jack mounted

According to the measurement result, the 50-Ω transmission line for this type of configuration could be used up to 6 GHz (Figure 5).

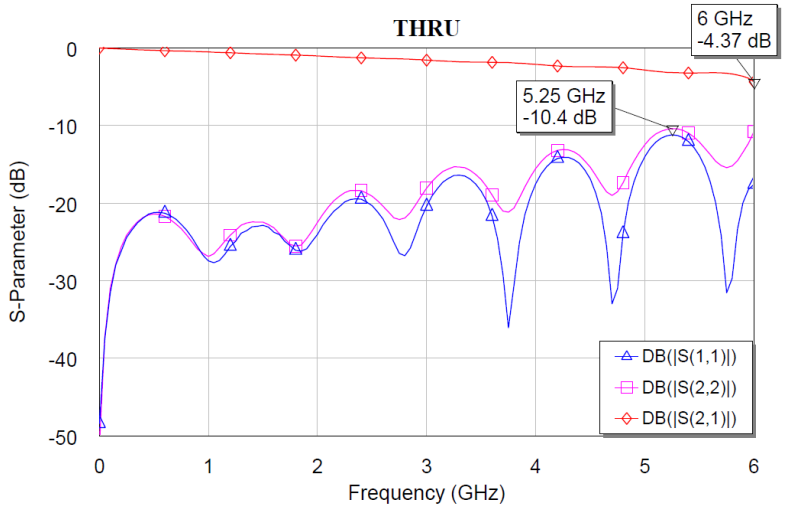


Figure 5 - S-parameter measurement result of Fixture #2

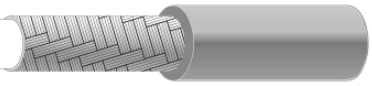
5.4 High frequency coaxial cable specification and measurement

In order to properly evaluate the RF performance of the straight on coaxial cable (S-type) connector, the performance of the cable itself should first be evaluated. The RG-316 type cable (shown in Figure 6) has been used in this case.

Figure 6 - RG-316 cable with SMA connectors

5.4.1 RG-316 Specification

The frequency performance of the RG-316 cable is up to 6GHz. The specification has been summarized in Table 1.



Conductor	Insulation	Shield	Jacket
Material: Silver-Coated Copper Clad Steel	Material: FEP	Material: Silver-Coated Copper	Material: FEP
Construction: AWG 26(7/0.175mm)	Average Thickness: 0.51 mm	Construction: 16 / 5 / 0.092 mm	Average Thickness: 0.30 mm
Diameter: 0.53 mm	Color: Clear	Coverage: 92.3 %	Color: Brown
	Diameter: 1.53 ± 0.03 mm		Diameter: 2.53 ± 0.10 mm

Electrical Characteristics

Description	Specification
Impedance	50 ± 5 Ω
Conductor Resistance	281 Ω/km 20°C Max.
Insulation Resistance	3000 MΩ/km Min.
Capacitance	95.8 pF/M
Dielectric Strength	AC 1 KV/Minute
Spark Test	2 KV
Nom. Vel. of Prop.	69.5 %
VSWR Test (0~6GHz)	Max 1.3

Physical Characteristics

Description		Specification	
Item		RG-316 (AWG#26)	
Rating Temp Voltage		105°C 30V	
Recognized		UL 1979	
Insulation	Unaged	Tensile Strength	2500 PSI Min. (1.76 Kg / mm²)
		Elongation	200% Min.
	Aged	Tensile Strength	Unaged Min.75% (168HRS×232°C)
		Elongation	Unaged Min.75% (168HRS×232°C)
Jacket	Unaged	Tensile Strength	2500 PSI Min. (1.76 Kg / mm²)
		Elongation	200% Min.
	Aged	Tensile Strength	Unaged Min.75% (168HRS×232°C)
		Elongation	Unaged Min.75% (168HRS×232°C)

Attenuation

Attenuation	10 MHz	100 MHz	1.8 GHz	2.4 GHz	5.2 GHz	6 GHz
dB/100m	10.2	34.1	180	206	315	345
dB/100ft	3.11	10.4	54.87	62.79	96.02	103.64

5.4.2 Measurement Result of RG-316

This type of cable can perform up to 6 GHz according to the measurement result shown in Figure 7.

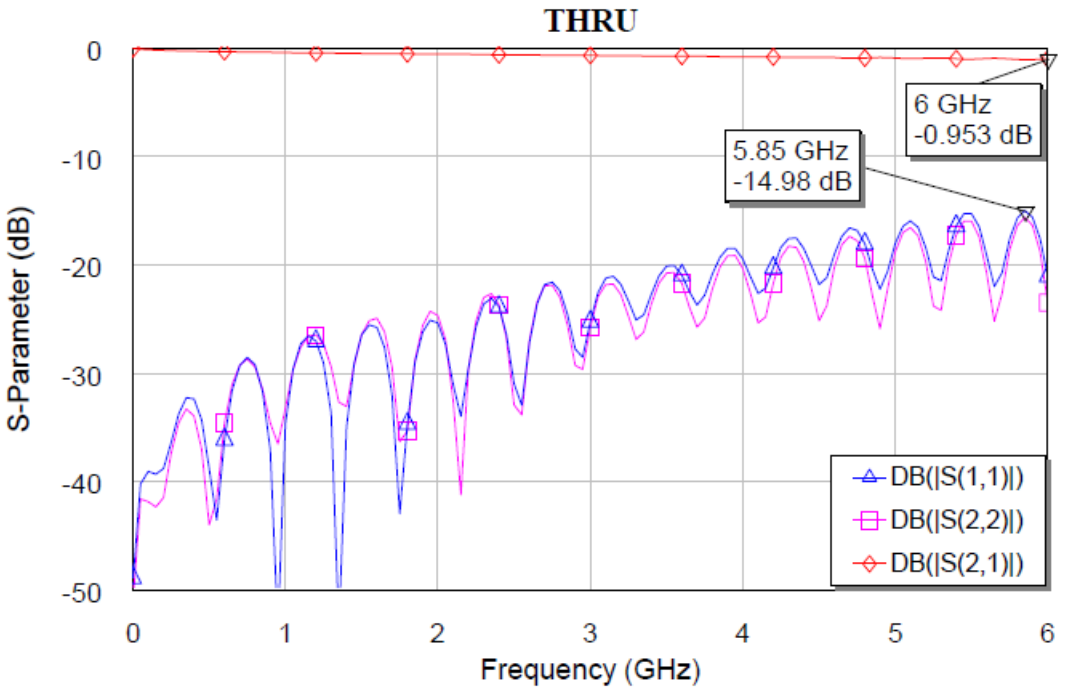


Figure 7 - S-parameter measurement result of RG-316 cable

6 Results

6.1 Straight on PCB (thru)

In this sub-section, the straight on PCB (thru) type (Y-type) of the CMM LF series connectors has been measured using differential signals. The part numbers of the male and the female connectors are 221Y26F22 and 222Y26M16, respectively (shown in Figure 8).

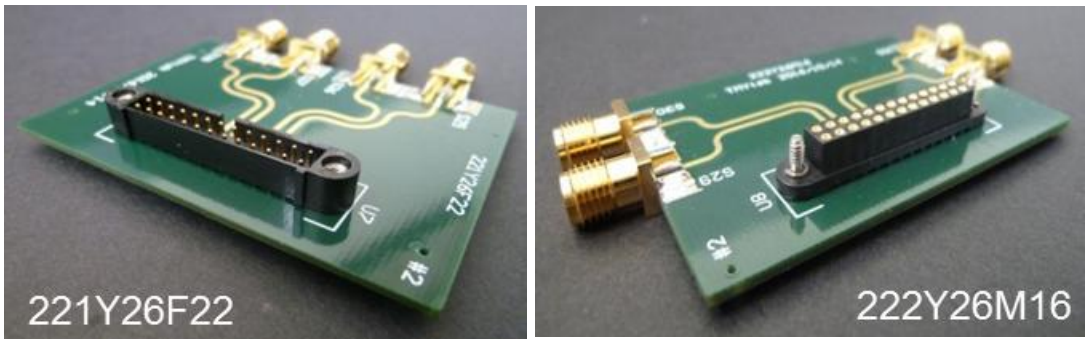


Figure 8 - Male (left) and female (right) straight on PCB (Thru) connectors

According to the measurement result shown in Figure 9, the connectors could work up to 1.2 GHz with a return loss (blue and magenta lines) < -10 dB and an insertion loss = -0.8 dB (the red line). It could also work up to 740 MHz with a return loss < -15 dB and an insertion loss = -0.2 dB. The isolation is better than 30 dB up to 1.3 GHz (shown on Figure 10).

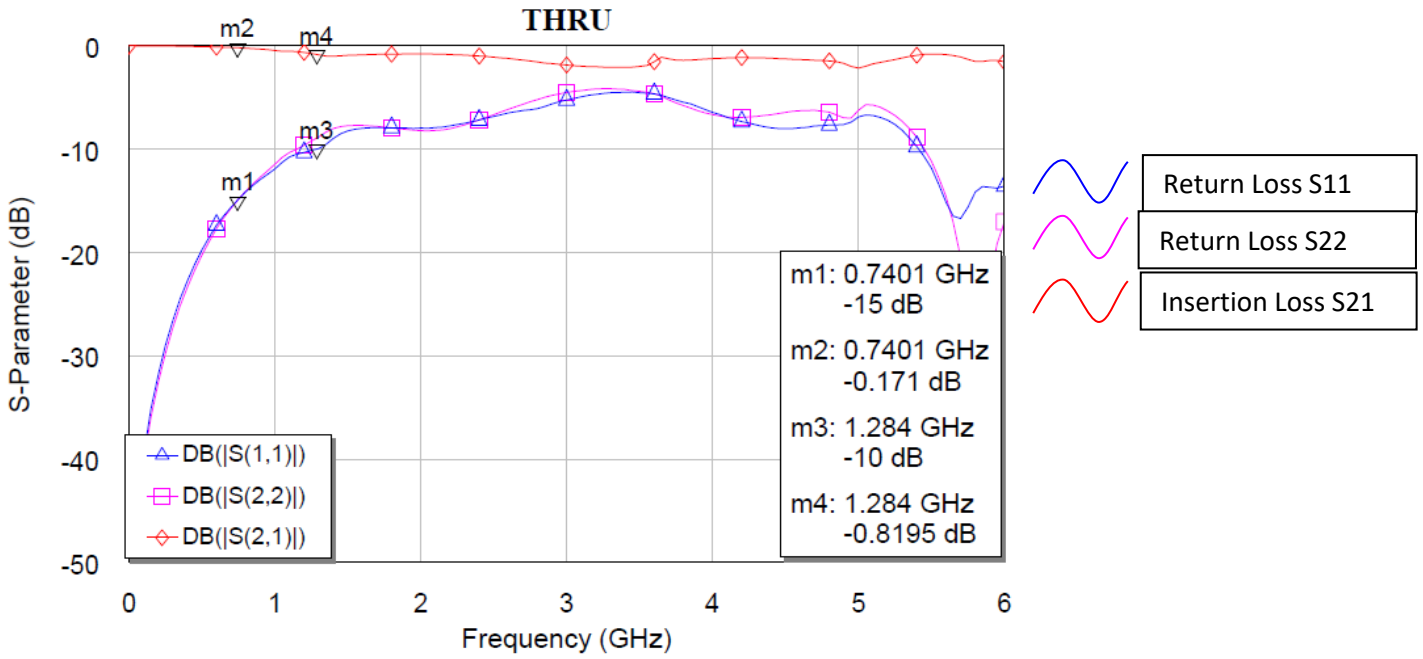


Figure 9 - S-parameter thru performance of the straight n PCB (thru) connector pair

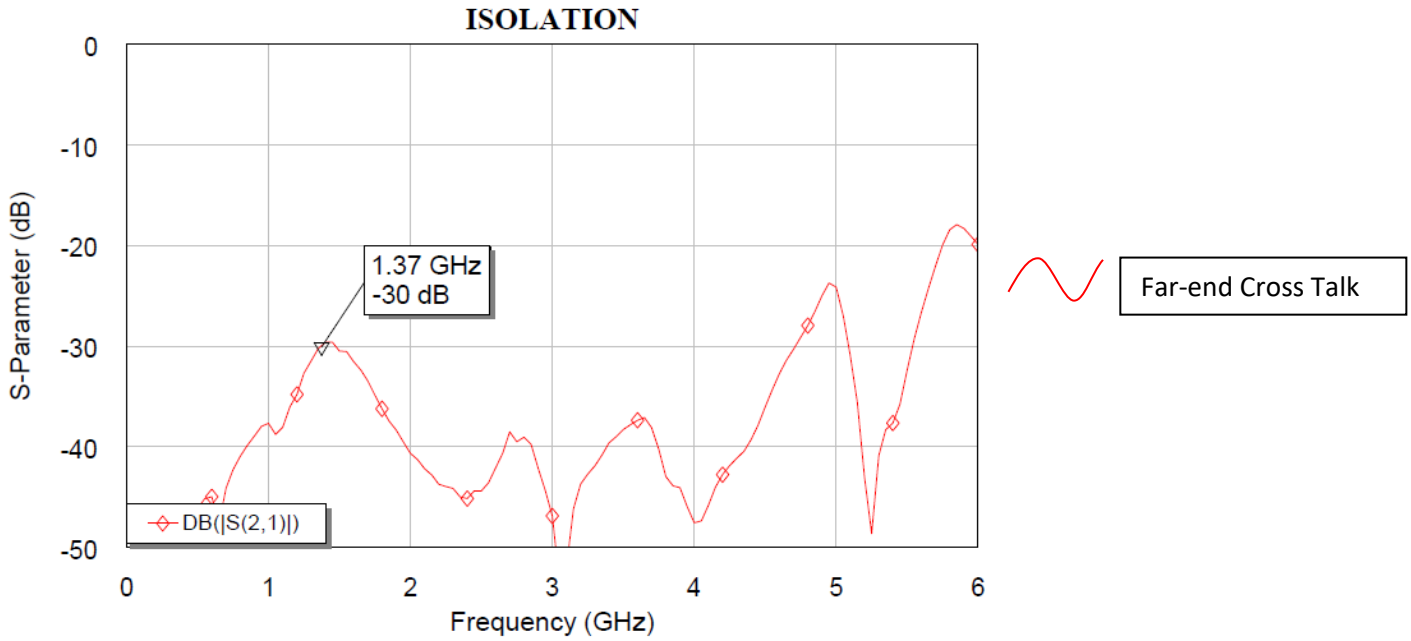


Figure 10 - S-parameter isolation performance of the straight on PCB (thru) connector pair

Connector ref CMM220_LF_Straight on PCB (Y-series): 221Y26F22 & 222Y26M16			
Frequency (MHz)	Insertion Loss (dB)	Return Loss (dB)	Far-end Crosstalk (dB)
10	0.0033	-54.0699	-79.5090
20	0.0019	-51.5362	-74.9772
30	0.0007	-49.5729	-72.0122
50	-0.0013	-46.6180	-68.0467
70	-0.0025	-43.2138	-65.0844
100	-0.0032	-39.7123	-61.9514
200	-0.0087	-31.8548	-55.7266
300	-0.0197	-26.6504	-51.7505
500	-0.0659	-19.7690	-46.1580
700	-0.1443	-15.6055	-44.1151
1000	-0.4520	-11.9134	-37.6735
1500	-0.9038	-8.2333	-30.4959
2000	-0.7811	-7.9560	-40.6410
3000	-1.8404	-5.2447	-46.8717
4000	-1.2362	-6.4291	-47.5567
5000	-2.1526	-6.8716	-24.1400
6000	-1.5328	-13.5722	-19.8968

Eye diagrams of straight on PCB (thru) connectors:

The eye diagram measurements have been performed at three different transfer speeds, which are 1 Gbps, 5 Gbps and 10 Gbps (Figure 11, Figure 12 and Figure 13, respectively). According to the results, the connectors could work up to 10 Gbps with 95% of eye opening. The results are summarized in Table 1.

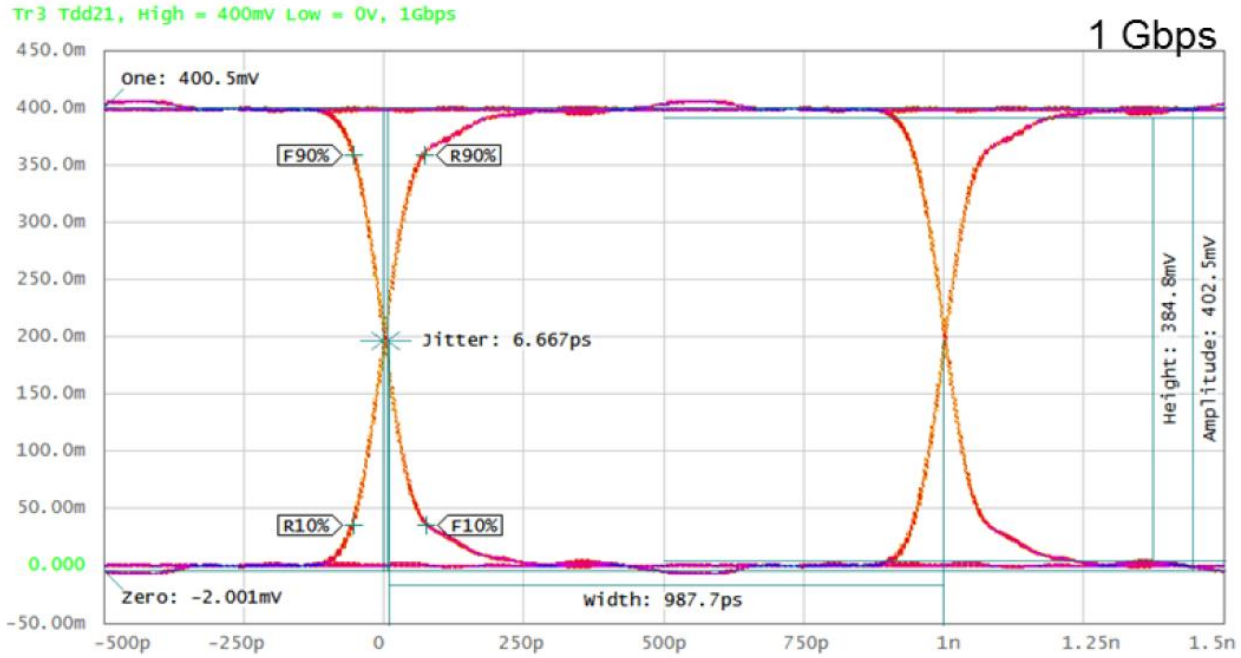


Figure 11 - Eye diagram of the straight on PCB (thru) connector pair at 1 Gbps

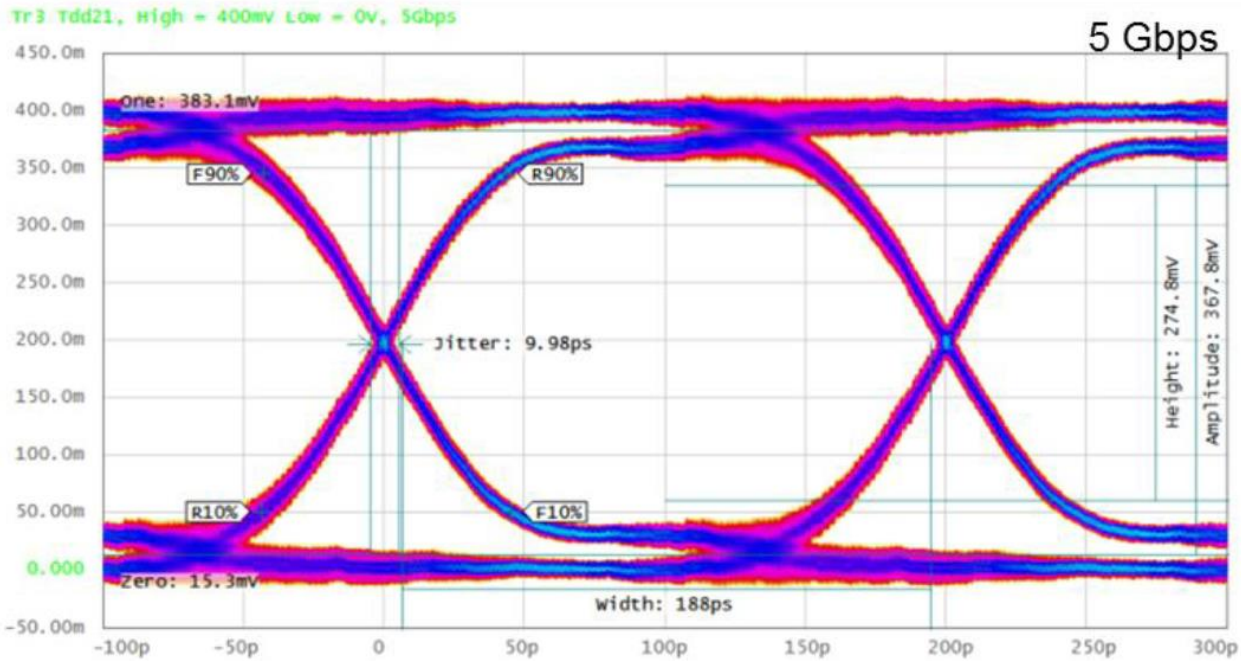


Figure 12 - Eye diagram of the straight on PCB (thru) connector pair at 5 Gbps

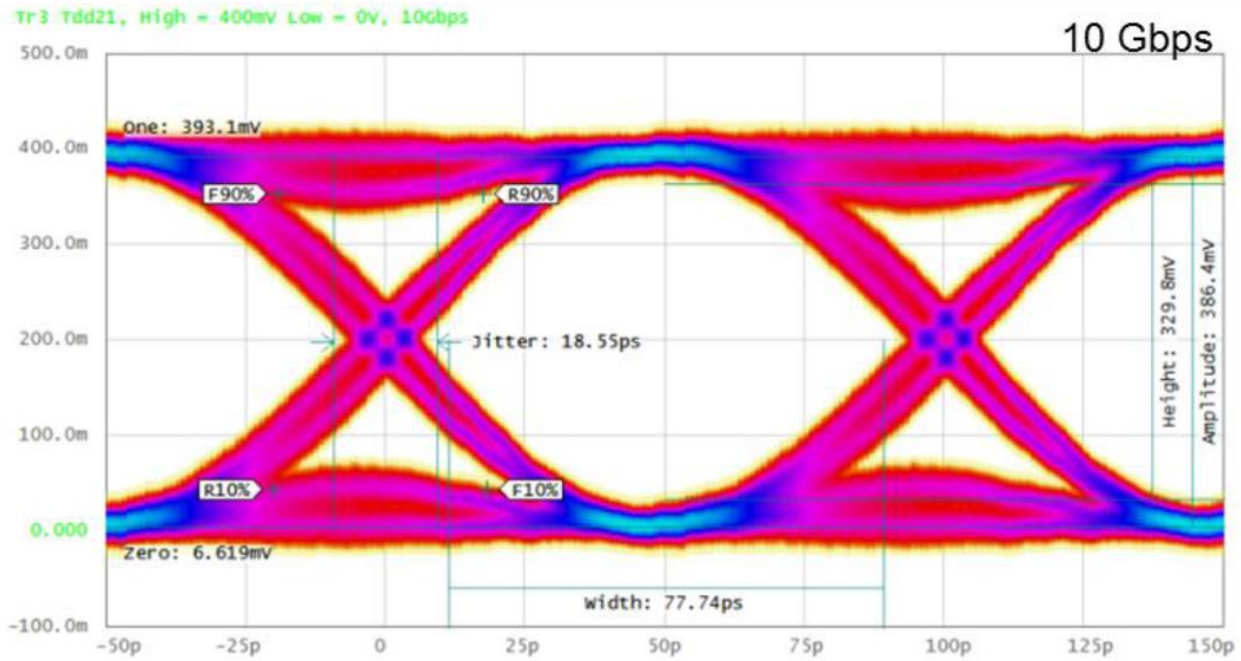


Figure 13 - Eye diagram of the straight on PCB (thru) connector pair at 10 Gbps

Table 1 - Summary of the eye diagram measurement results of the straight on PCB (thru) connector pair

	1 Gbps	5 Gbps	10 Gbps
Fall Time	129.3 ps	87.78 ps	37.39 ps
Jitter RMS	2.051 ps	1.996 ps	3.709 ps
Jitter p-p	6.667 ps	9.98 ps	18.55 ps
Crossing %	49.83%	49.58%	49.77%
Opening Factor	0.9853	0.9157	0.9511
Signal / Noise	68.03	11.86	20.46

6.2 90° on PCB (thru)

In this sub-section, the 90° on PCB (thru) type (V-type) of the CMM LF series connectors has been measured usin differential signals. The part numbers of the male and the female connectors are 221V26F26 and 222V26M21, respectively (shown in Figure 14).

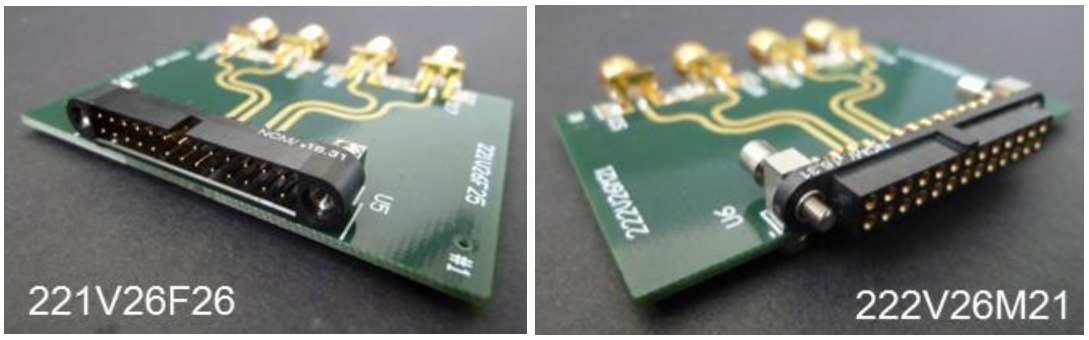


Figure 14 - Male (left) and female (right) 90° on PCB (thru) connectors

According to the measurement result shown in Figure 15, the connectors could work up to 4.4 GHz with a return loss (blue and magenta lines) < -10 dB and an insertion loss of -1.3dB (the red line). It could also work up to 2.5 GHz with a return loss < -15 dB and an insertion loss of -0.4 dB. The isolation is better than 30 dB up to 3.2 GHz (shown on Figure 16).

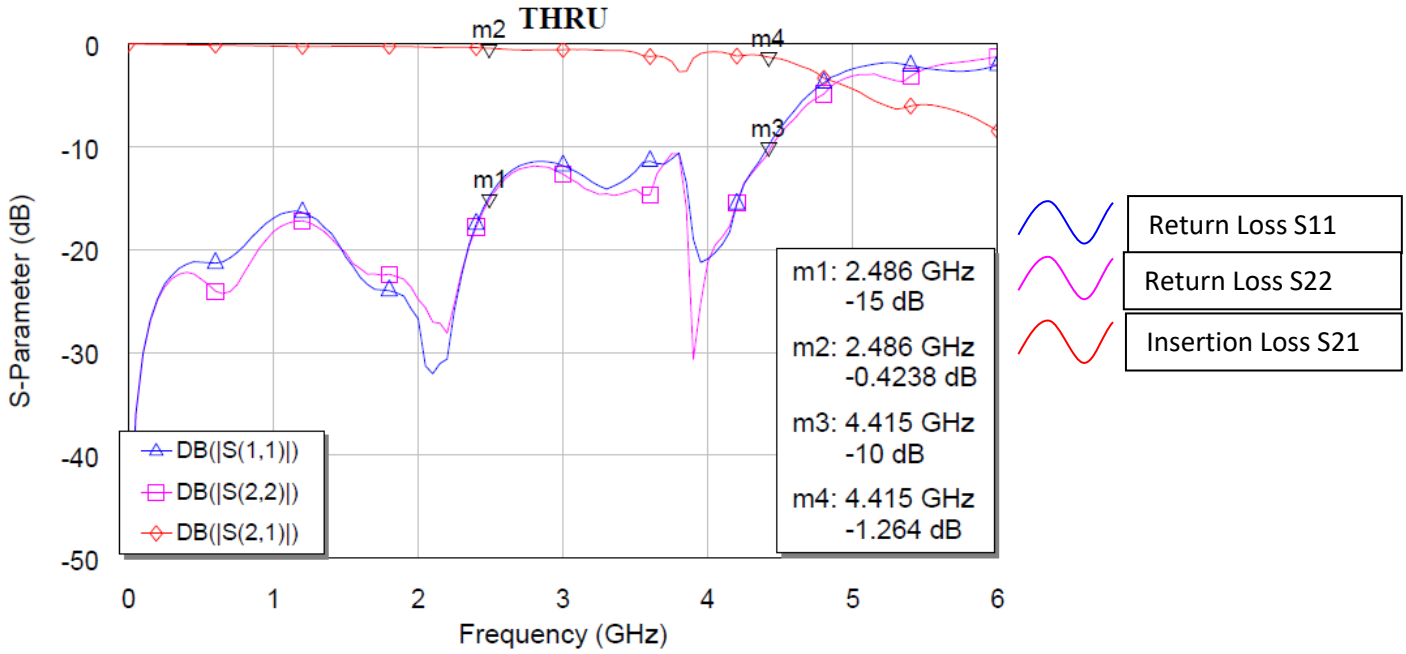


Figure 15 - S-parameter thru performance of the 90° on PCB (thru) connector pair

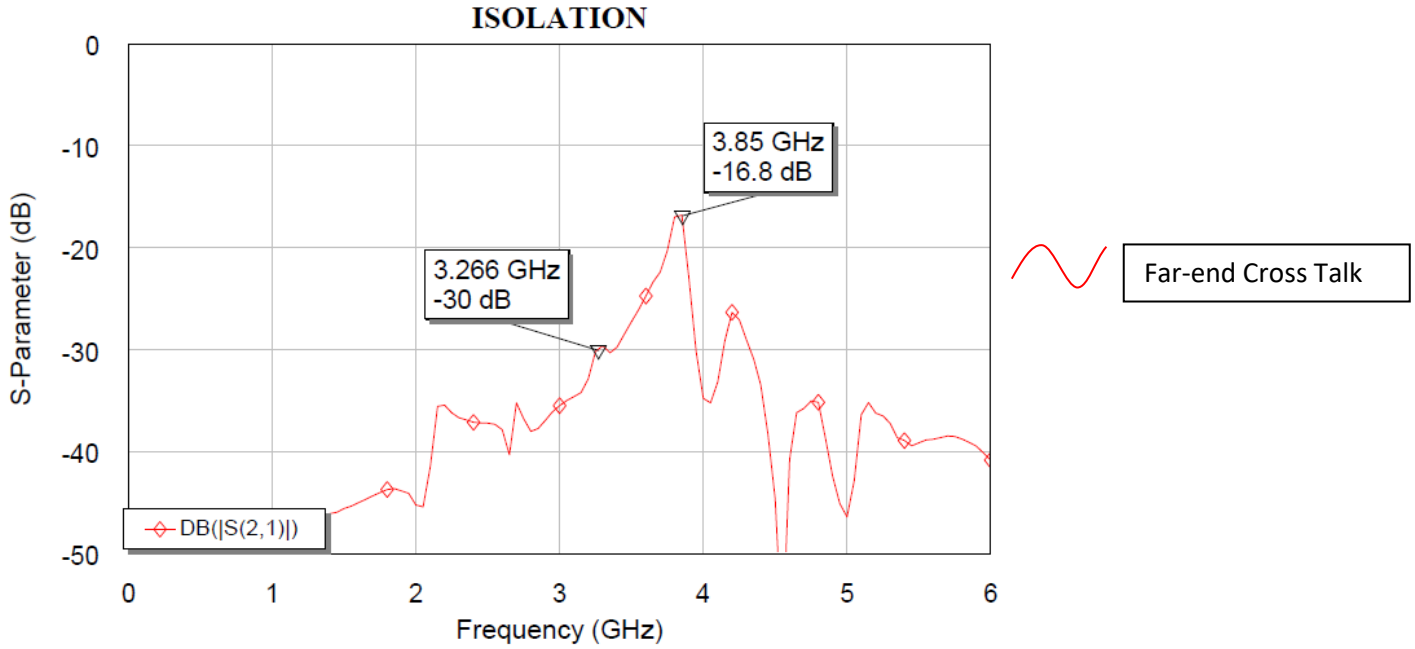


Figure 16 - S parameter isolation performance of the 90° on PCB (thru) connector pair

Connector ref CMM220_LF_90° on PCB (V-series): 221V26F26 & 222V26M21			
Frequency (MHz)	Insertion Loss (dB)	Return Loss (dB)	Far-end Crosstalk (dB)
10	0.0067	-44.4746	-83.7413
20	0.0018	-41.6141	-81.2619
30	-0.0025	-39.3917	-78.9344
50	-0.0090	-36.0977	-75.2968
70	-0.0148	-33.2172	-72.4691
100	-0.0182	-30.1432	-69.4396
200	-0.0425	-24.7709	-63.1798
300	-0.0674	-22.5137	-59.3033
500	-0.1068	-21.2163	-53.9252
700	-0.1363	-20.8189	-50.6214
1000	-0.2177	-16.9649	-47.9897
1500	-0.2535	-20.7220	-45.5814
2000	-0.2871	-26.7326	-45.2314
3000	-0.5551	-11.8461	-35.4960
4000	-0.7954	-20.9064	-34.7777
5000	-4.3903	-2.4284	-46.4097
6000	-8.4744	-2.0647	-40.8340

Eye diagrams of 90° on PCB (thru) connectors:

The eye diagram measurements have been performed at three different transfert speeds, which are 1 Gbps, 8 Gbps and 10 Gbps (Figure 17, Figure 18 and Figure 19, respectively). According to the results, the connector could work up to 8 Gbps with 90% of eye opening. The results are summarized in Table 2.

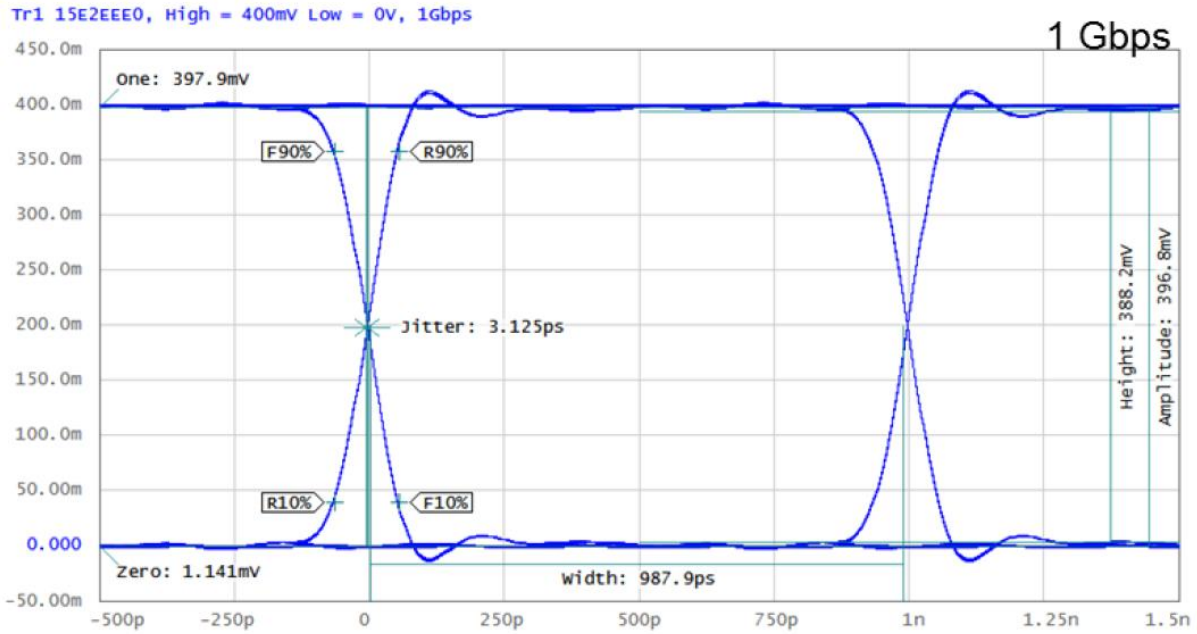


Figure 17 - Eye diagram of the 90° on PCB (thru) connector pair at 1 Gbps

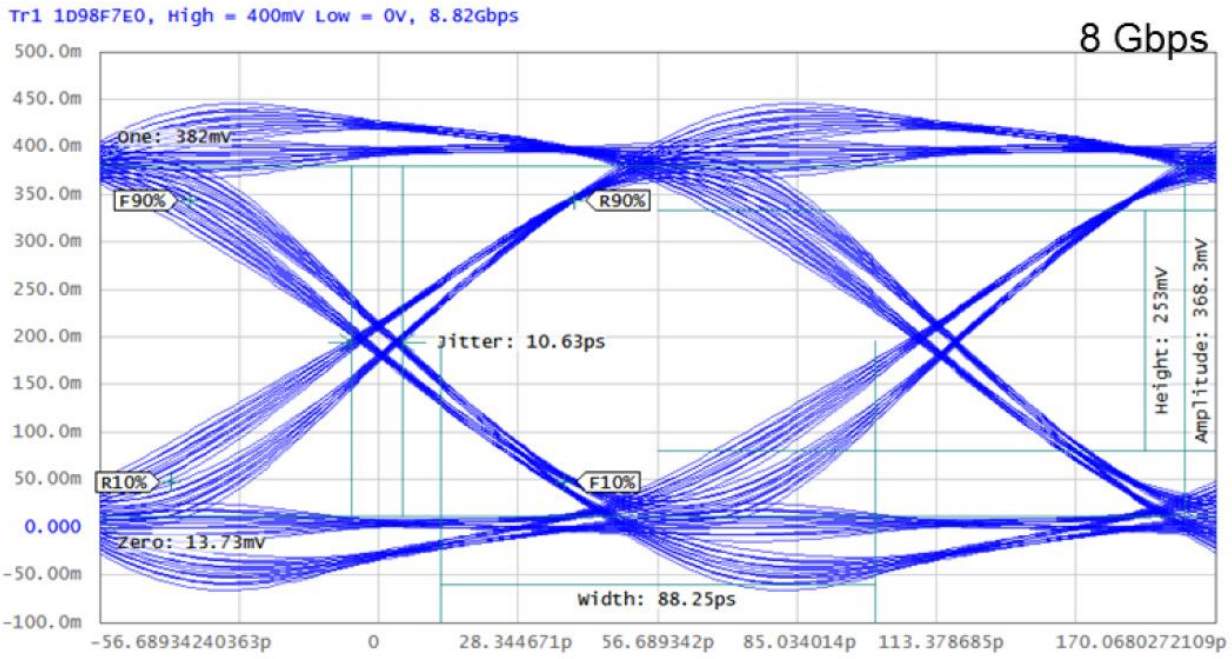


Figure 18 - Eye diagram of the 90° on PCB (thru) connector pair at 8 Gbps

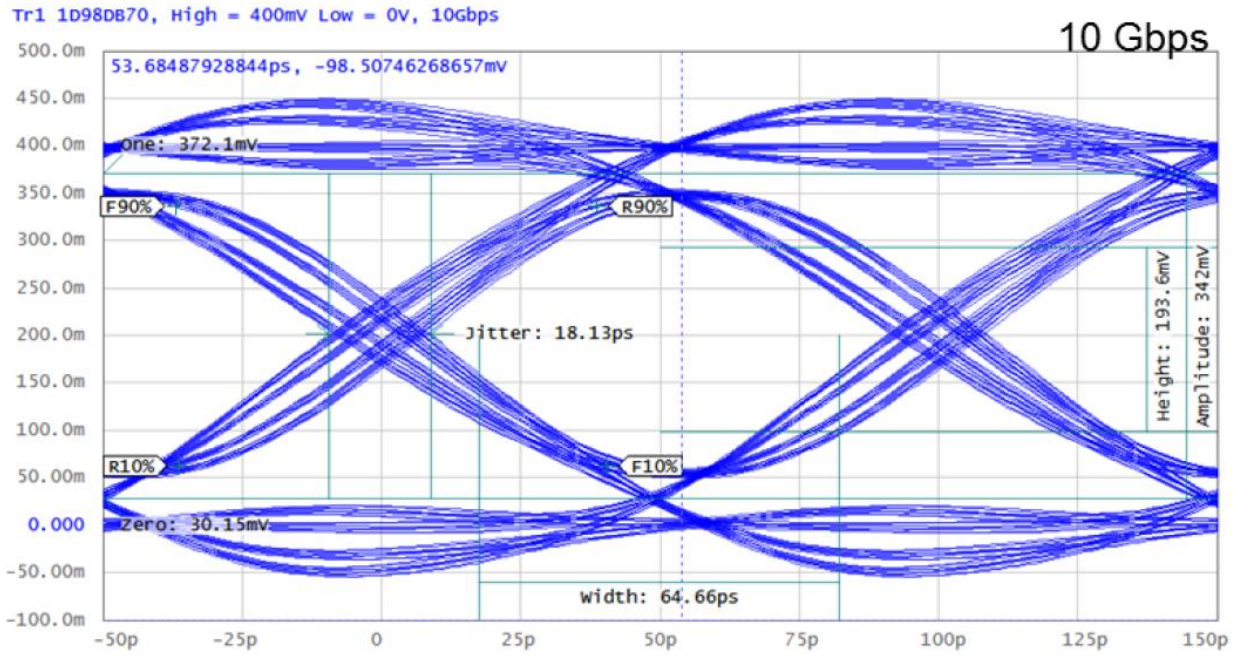


Figure 19 - Eye diagram of the 90° on PCB (thru) connector pair at 10 Gbps

Table 2 - Summary of the eye diagram measurement results of the 90° on PCB (thru) connector pair

	1 Gbps	8 Gbps	10 Gbps
Fall Time	120 ps	75.97 ps	77.22 ps
Jitter RMS	2.009 ps	4.188 ps	5.891 ps
Jitter p-p	3.125 ps	10.63 ps	18.13 ps
Crossing %	50.01%	49.79%	50.81%
Opening Factor	0.9928	0.8956	0.8554
Signal / Noise	138.1	9.582	6.915

6.3 Straight on PCB (SMT)

In this sub-section, the straight on PCB (SMT) type (T-type) of the CMM LF series connectors has been measured using differential signals. The part numbers of the male and the female connectors are 221T26F22 and 222T26M16, respectively (shown in Figure 20).

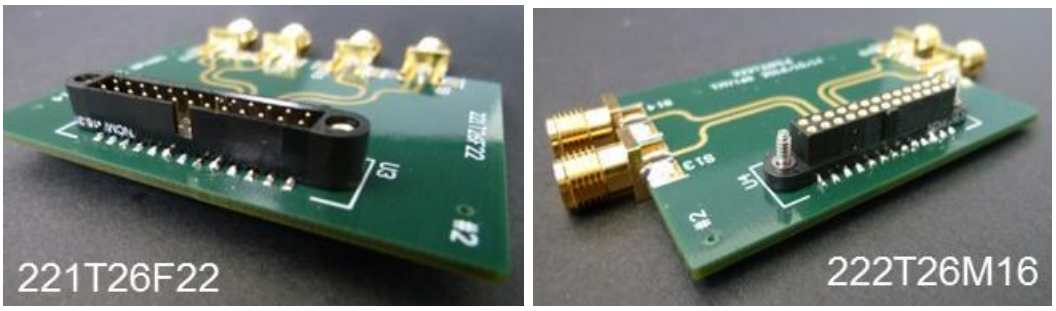


Figure 20 – Male (left) and female (right) straight on PCB (SMT) connectors

According to the measurement result shown in Figure 21, the connectors could work up to 3 GHz with a return loss (blue and magenta lines) < -10 dB and an insertion loss = -0.8 dB (the red line). It could also work up to 1.1 GHz with a return loss < -15 dB and an insertion loss of -0.2 dB. The isolation is better than 30 dB up to 2.7 GHz (shown on Figure 22).

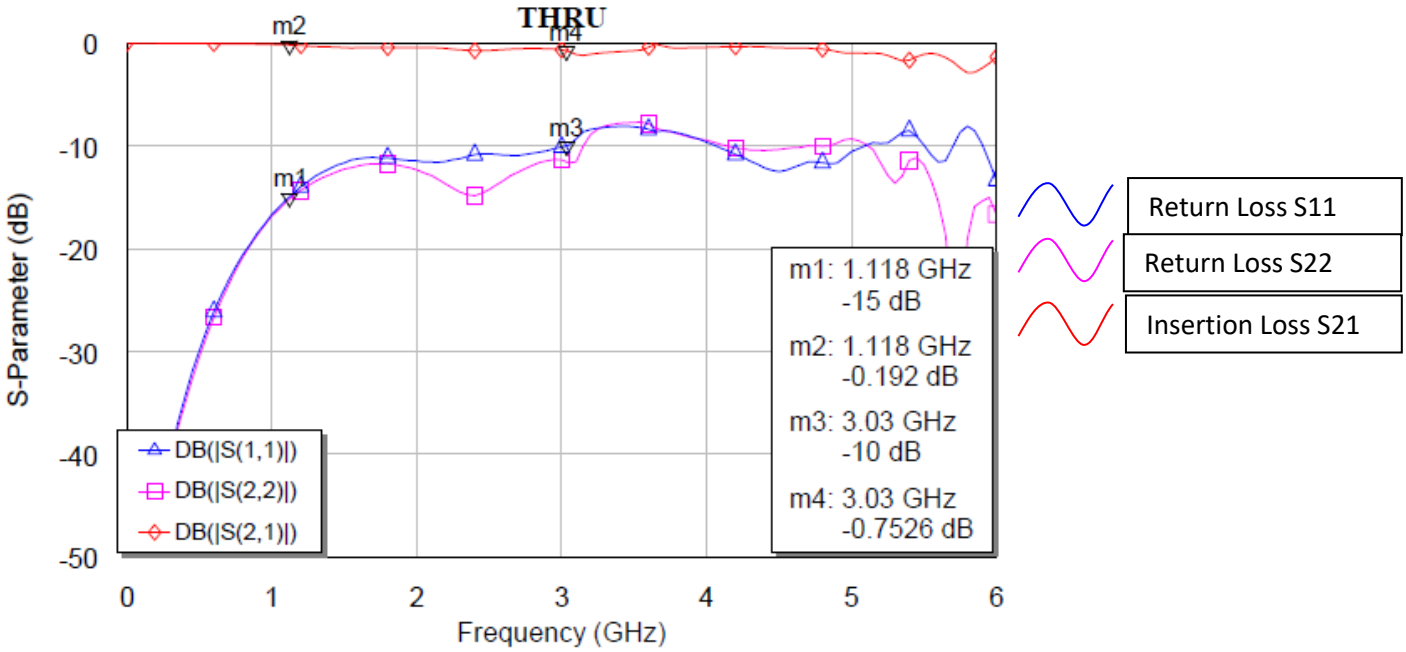


Figure 21 - S-parameter thru performance of the straight on PCB (SMT) connector pair

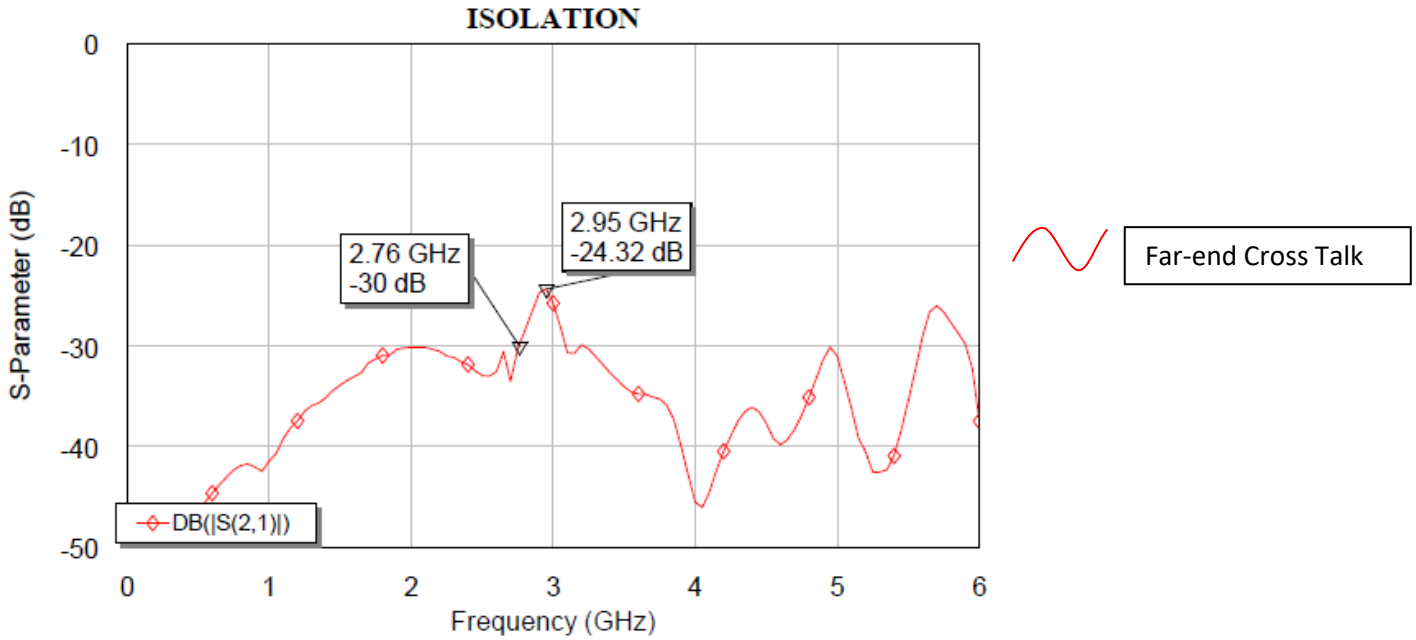


Figure 22 - S-parameter isolation performance of the straight on PCB (SMT) connector pair

Connector ref CMM220_LF_Straight SMT (T-series): 221T26F22 & 222T26M16			
Frequency (MHz)	Insertion Loss (dB)	Return Loss (dB)	Far-end Crosstalk (dB)
10	0.0025	-60.1228	-79.9002
20	0.0011	-63.9479	-76.4252
30	-0.0001	-70.8463	-73.9151
50	-0.0021	-67.2847	-70.3588
70	-0.0051	-65.4038	-66.2806
100	-0.0088	-60.8849	-62.3146
200	-0.0214	-48.9275	-55.4309
300	-0.0310	-40.5748	-51.5592
500	-0.0419	-29.9368	-46.4870
700	-0.0563	-23.0812	-43.0643
1000	-0.1385	-16.6855	-41.4708
1500	-0.4464	-11.6624	-33.9430
2000	-0.4218	-11.4619	-30.1761
3000	-0.6604	-10.1246	-25.7995
4000	-0.4244	-9.6505	-45.5329
5000	-0.9884	-10.5666	-31.0708
6000	-1.3522	-13.3542	-37.4922

Eye diagrams of straight on PCB (SMT) connectors:

The eye diagram measurements have been performed at three different transfer speeds, which are 1 Gbps, 6 Gbps and 10 Gbps (Figure 23, Figure 24 and Figure 25, respectively). According to the results, the connectors could work up to 10 Gbps with 95% of eye opening. The results are summarized in Table 3.

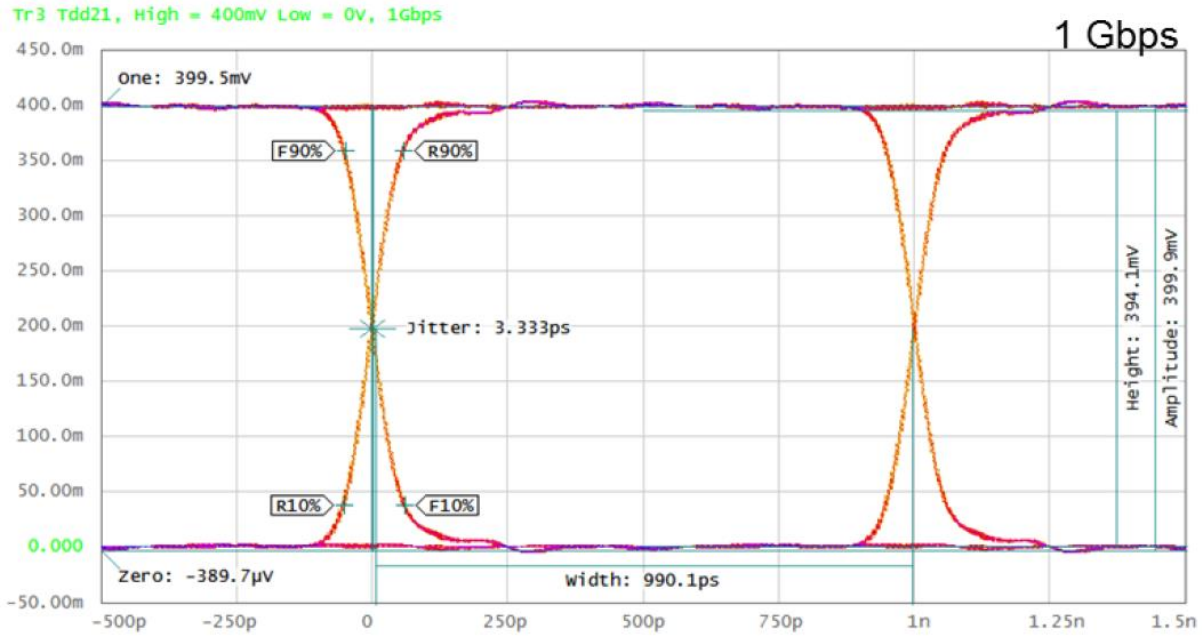


Figure 23 - Eye diagram of the straight on PCB (SMT) connector pair at 1 Gbps

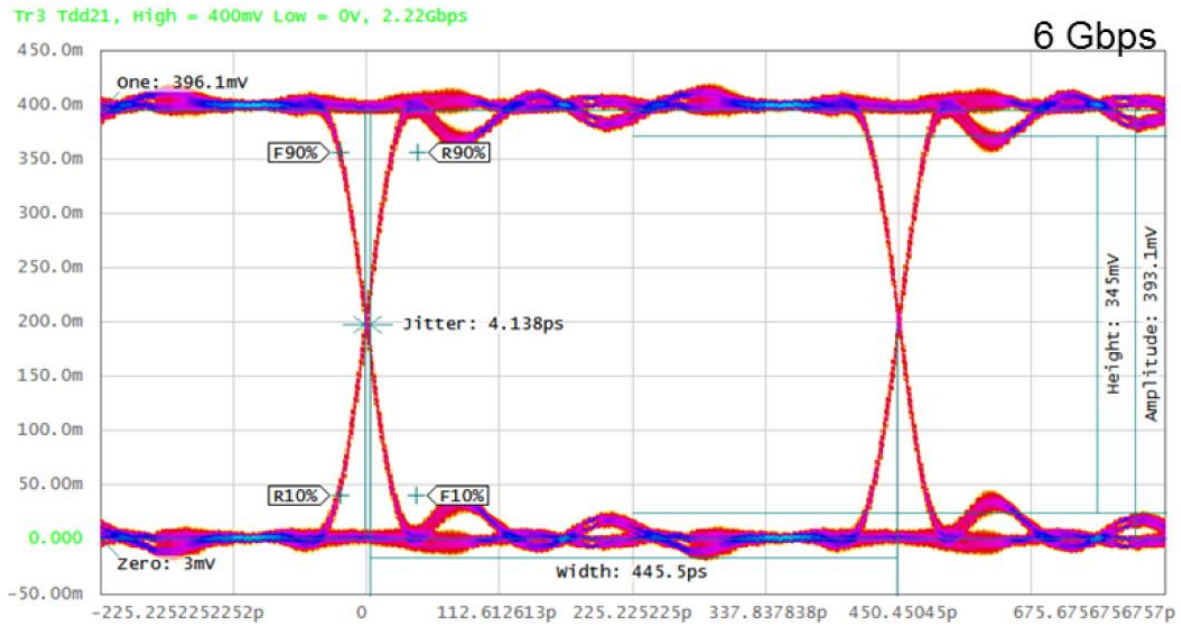


Figure 24 - Eye diagram of the straight on PCB (SMT) connector pair at 6 Gbps

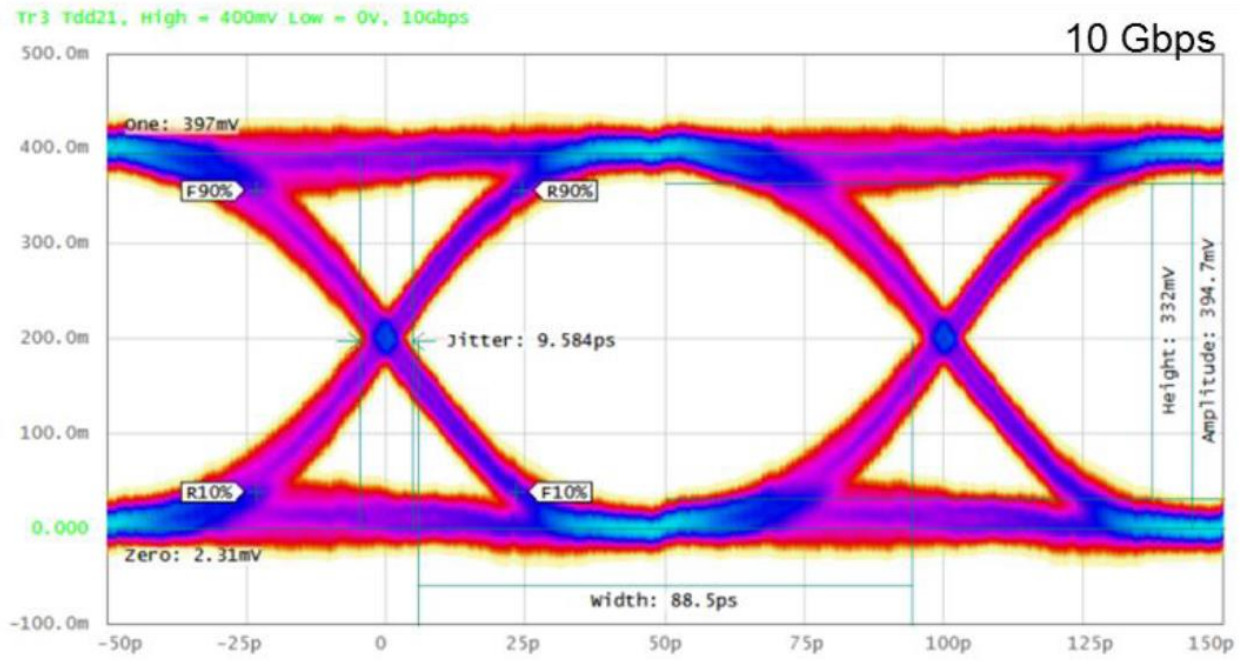


Figure 25 - Eye diagram of the straight on PCB (SMT) connector pair at 10 Gbps

Table 3 - Summary of the eye diagram measurement results of the straight on PCB (SMT) connector pair

	1 Gbps	6 Gbps	10 Gbps
Fall Time	110 ps	64.43 ps	46.58 ps
Jitter RMS	1.643 ps	0.8275 ps	1.917 ps
Jitter p-p	3.333 ps	4.138 ps	9.584 ps
Crossing %	49.96%	49.94%	50.06%
Opening Factor	0.9952	0.9592	0.9471
Signal / Noise	207.4	24.54	18.89

6.4 90° on PCB (SMT)

In this sub-section, the 90° on PCB (SMT) type (R-type) of the CMM LF series connectors has been measured using differential signals. The part numbers of the male and female connectors are 221R26F26 and 222R26M21, respectively (shown in Figure 26).

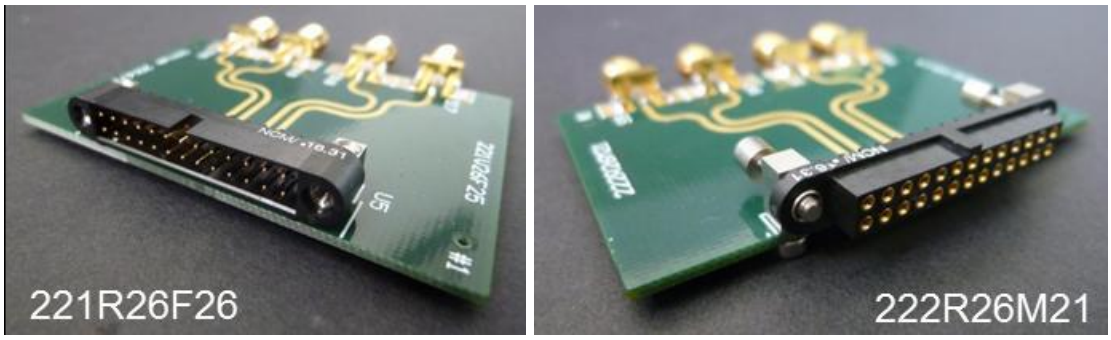


Figure 26 - Male (left) and female (right) 90° on PCB (SMT) connectors

According to the measurement result shown in Figure 27, the connectors could work up to 3.5 GHz with a return loss (blue and magenta lines) < -10 dB and an insertion loss = -1.2 dB (the red line). It could also work up to 3.2 GHz with a return loss < -15 dB and an insertion loss of -0.2 dB. The isolation is better than 30 dB up to 2.7 GHz (shown on Figure 28).

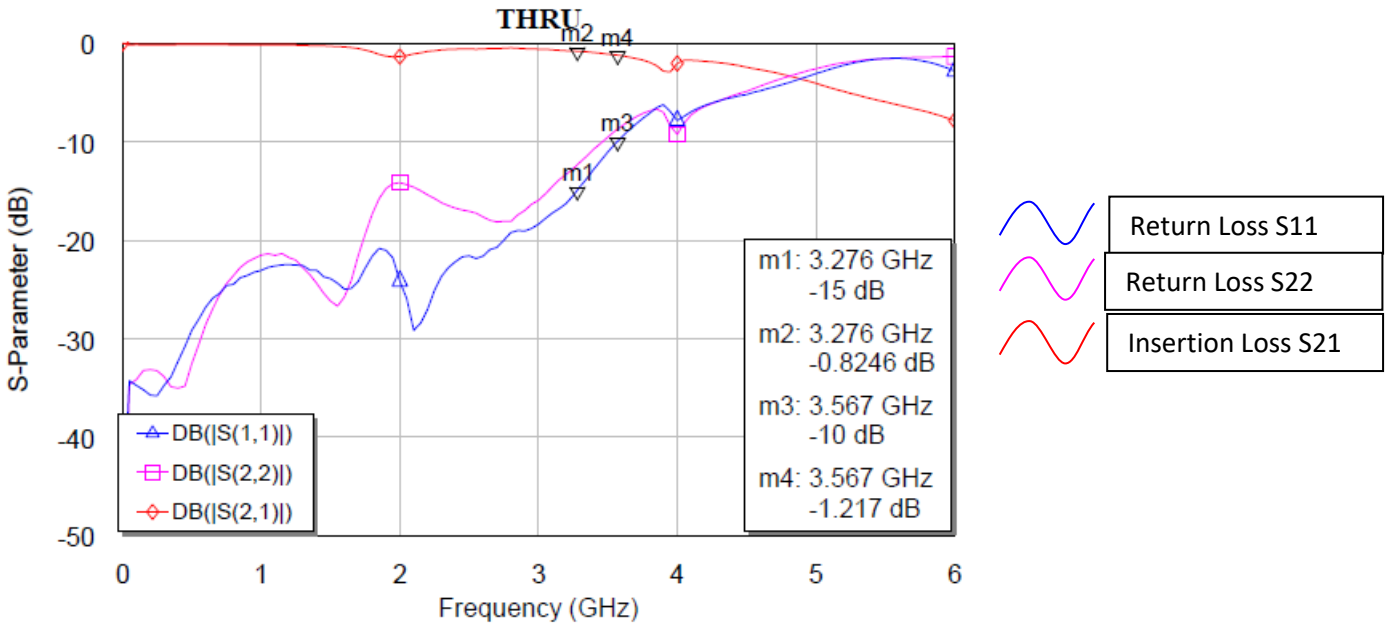


Figure 27 - S-parameter thru performance of the 90° on PCB (SMT) connector pair

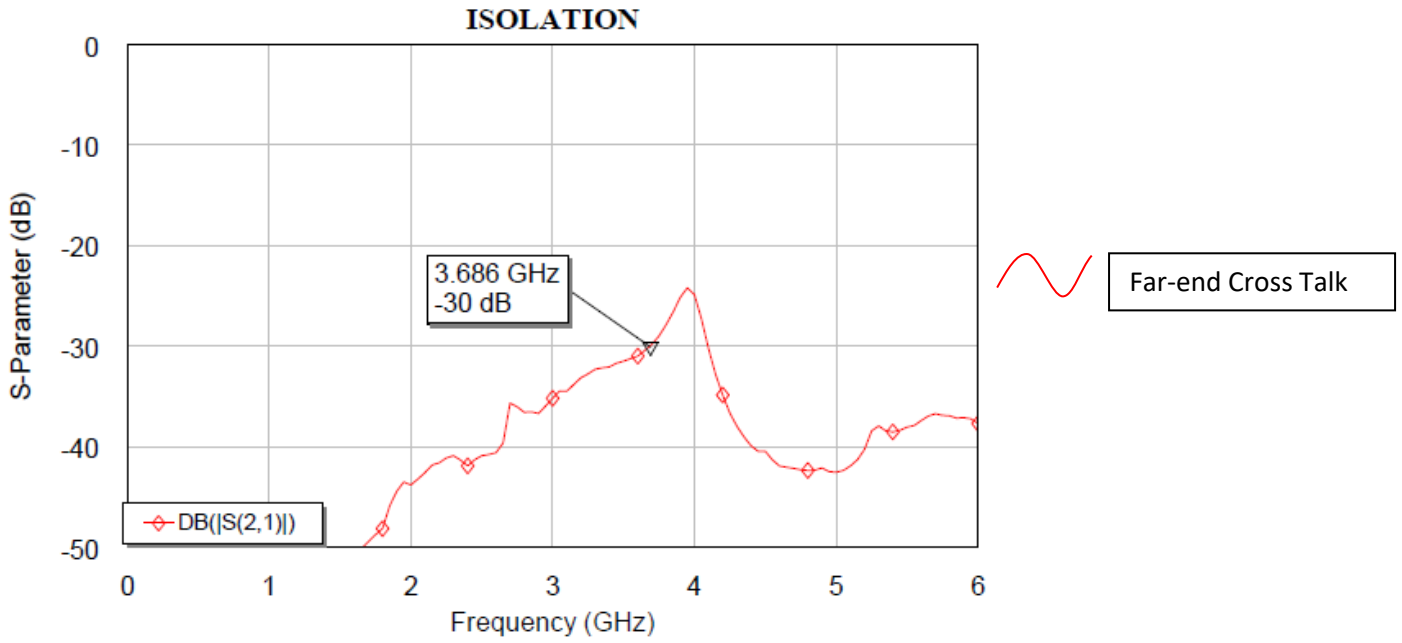


Figure 28 - S-parameter isolation performance of the 90° on PCB (SMT) connector pair

Connector ref CMM220_LF_90° SMT (R-series): 221R26F26 & 222R26M21			
Frequency (MHz)	Insertion Loss (dB)	Return Loss (dB)	Far-end Crosstalk (dB)
10	-0.0352	-42.9958	-83.6045
20	-0.0681	-39.9542	-82.4192
30	-0.1008	-37.6469	-81.3625
50	-0.1656	-34.2770	-79.5494
70	-0.1653	-34.4345	-77.0506
100	-0.1603	-34.7470	-74.2636
200	-0.1689	-35.7535	-68.3540
300	-0.1663	-34.7512	-64.8182
500	-0.1568	-29.1724	-60.1160
700	-0.1566	-25.4055	-56.7962
1000	-0.1891	-23.0861	-53.3379
1500	-0.3028	-23.9030	-50.9605
2000	-1.3566	-24.1547	-43.8183
3000	-0.6042	-18.3751	-35.1927
4000	-2.0520	-7.8550	-24.8717
5000	-4.0722	-3.0983	-42.5620
6000	-7.8536	-2.8265	-37.7019

Eye diagrams of 90° on PCB (SMT) connectors:

The eye diagram measurements have been performed at three different transfer speeds, which are 1 Gbps, 7 Gbps and 10 Gbps (Figure 29, Figure 30 and Figure 31, respectively). According to the results, the connectors could work up to 7 Gbps with 94% of eye opening. The results are summarized in Table 4.

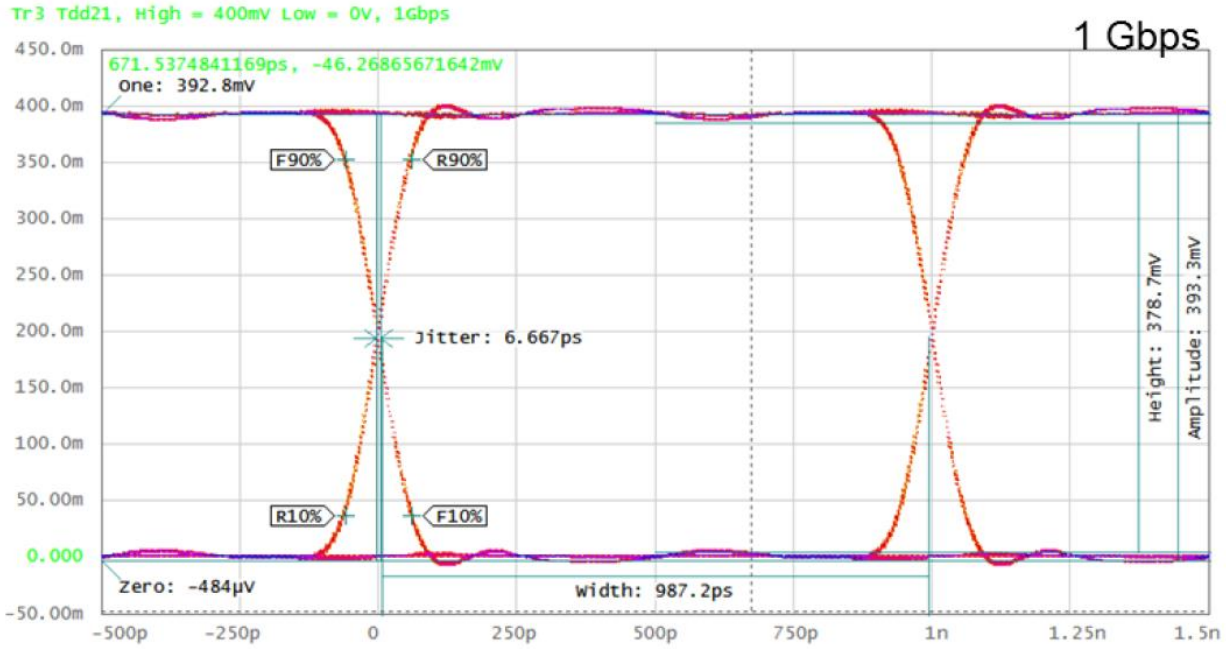


Figure 29 - Eye diagram of the 90° on PCB (SMT) connector pair at 1 Gbps

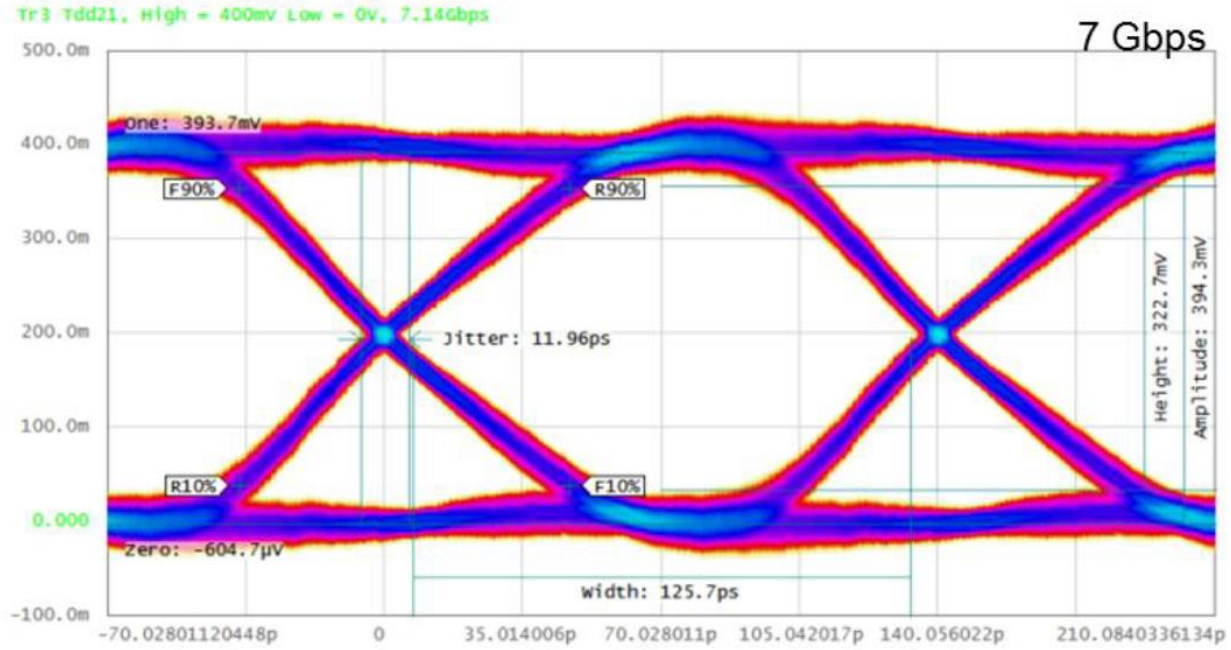


Figure 30 - Eye diagram of the 90° on PCB (SMT) connector pair at 7 Gbps

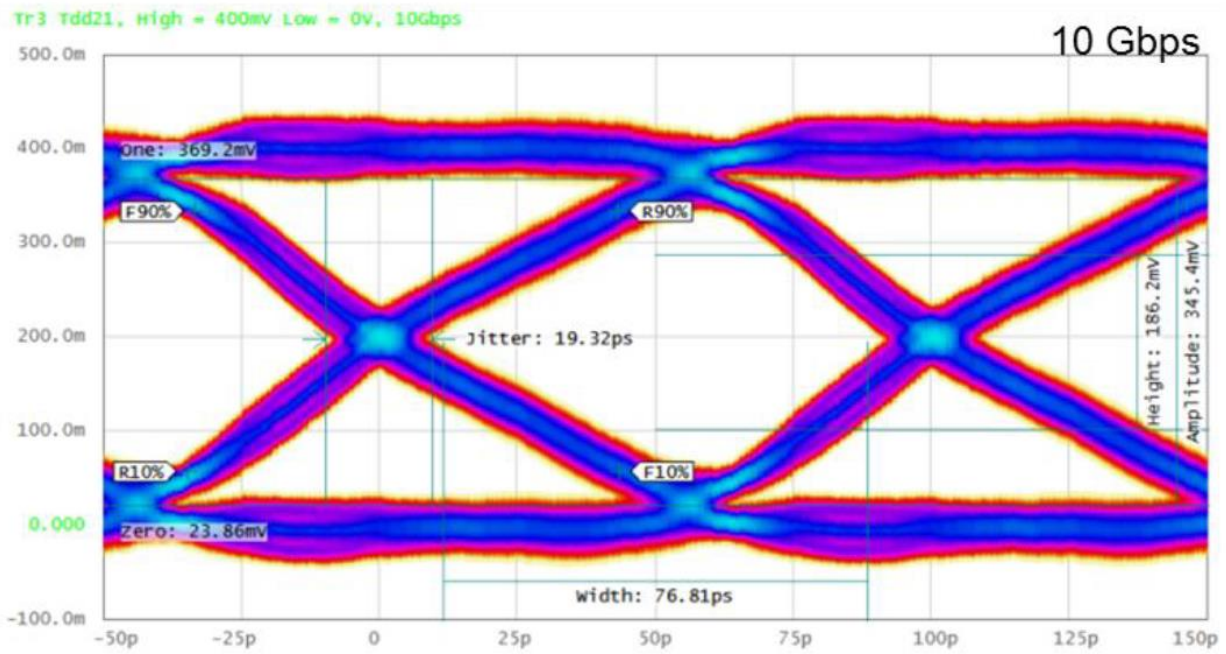


Figure 31 - Eye diagram of the 90° on PCB (SMT) connector pair at 10 Gbps

Table 4 - Summary of the eye diagram measurement results of the 90° on PCB (SMT) connector pair

	1 Gbps	7 Gbps	10 Gbps
Fall Time	120 ps	83.66 ps	76.72 ps
Jitter RMS	2.13 ps	2.391 ps	3.865 ps
Jitter p-p	6.667 ps	11.96 ps	19.32 ps
Crossing %	49.86%	49.62%	50.64%
Opening Factor	0.9876	0.9394	0.8463
Signal / Noise	80.8	16.51	6.508