A Low-Profile RF Wire-to-Board Connector Design for Millimeter Wave Applications

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TAIWAN TECH NATIONAL TAIWAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

無線通訊與電磁相容技術研發中心
WIRELESS COMMUNICATION AND ELECTROMAGNETIC COMPATIBILITY RESEARCH CENTER

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Harumoto Giken Co., Ltd., Taipei, Taiwan

Harumoto 春源

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MOST 科技部
Ministry of Science and Technology

Introduction

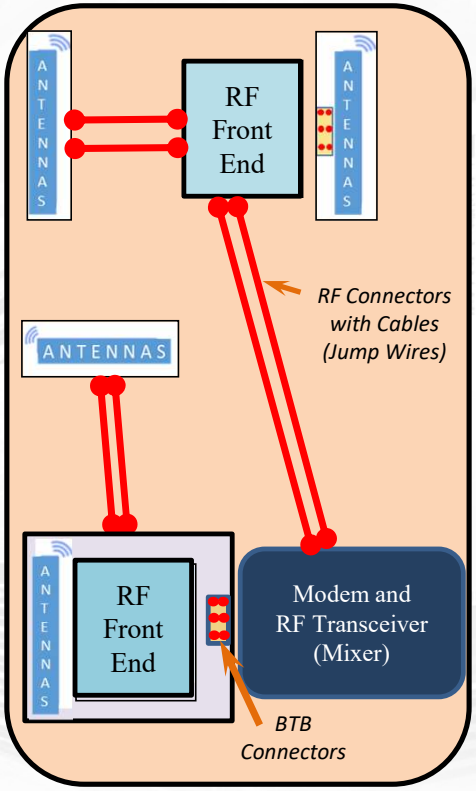
- Nowadays, with the demands for faster speeds, higher capacity, and lower latency, 5G wireless communications and other millimeter wave (mmWave) systems, such as WiGig, become important.
- Due to the broad bandwidth advantage of the millimeter waves, there comes up with a lot of applications, including AR/VR, wireless docking, multimedia streaming, etc.
  - However, the 5G may operate in two millimeter wave bands 28GHz and 38GHz and WiGig operates in an unlicensed band from 57 to 71 GHz.
  - Thus, new RF wire-to-board (WTB) connectors for the connections of the mmWave antenna modules to the modems are requested.
- In this paper, we proposed a low-profile RF connector with total dimensions of only $3.15(L) \times 2.5(W) \times 0.7(T)\ mm^3$.
  - Good comparisons between the simulations and measurements of the S-parameters have been obtained.

WiGig Connector Specifications and Applications

- Specifications

			Spec Items		
Applications			Case 1 (Smartphone)	Case 2 (Laptop)	Case 3 (TV and others)
Mechanical Properties	Coaxial cable	Type	Flexible/Semi Flex		
		Length	150~200mm	500~700mm	700mm
	Mating Height		≤ 0.7mm	≤ 1mm	≤ 1.5mm
	Mating Cycles		≥ 20		
Electrical Properties	TDR Impedance		40~50 Ω for Rise Time 5 ps (10~90%)		
	S_{11}		< −10dB		@70GHz
	S_{21}		< −18dB		

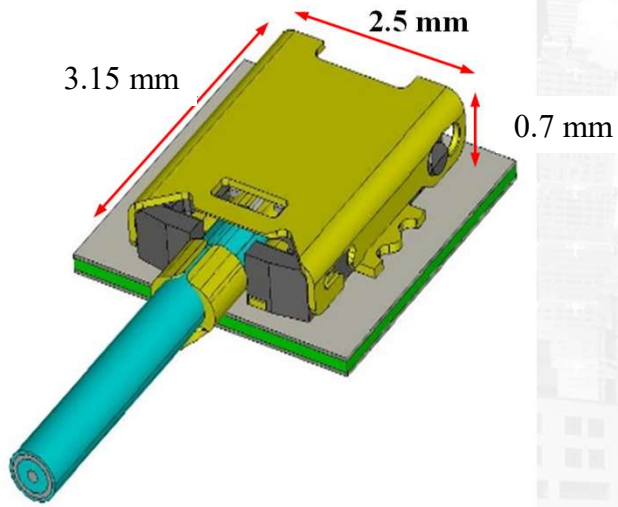
RF Jump Wire Applications



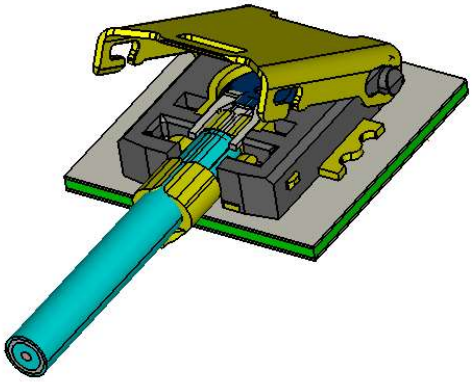
Including a pair of connectors and a 15cm long coaxial cable

WiGig Connector Design

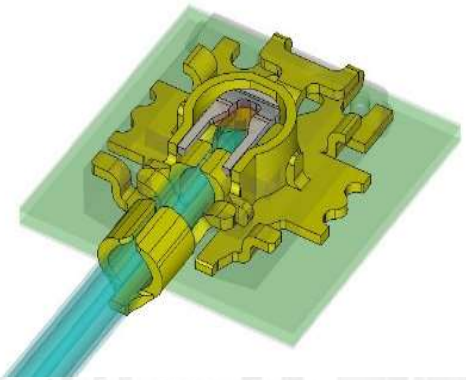
- Connector Structure



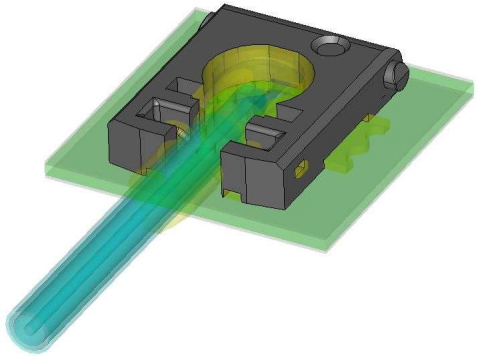
Clamshell



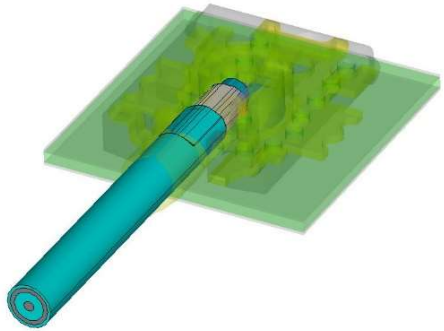
Metal and Metal Dome



Inner Housing

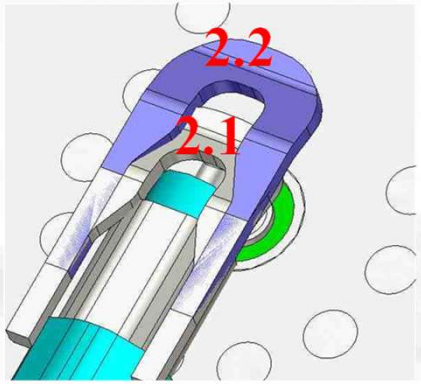


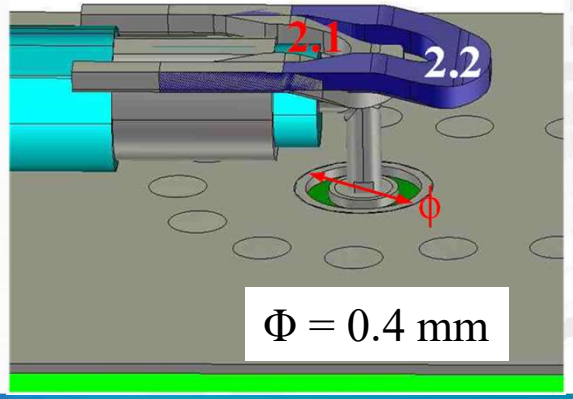
Coaxial Cable

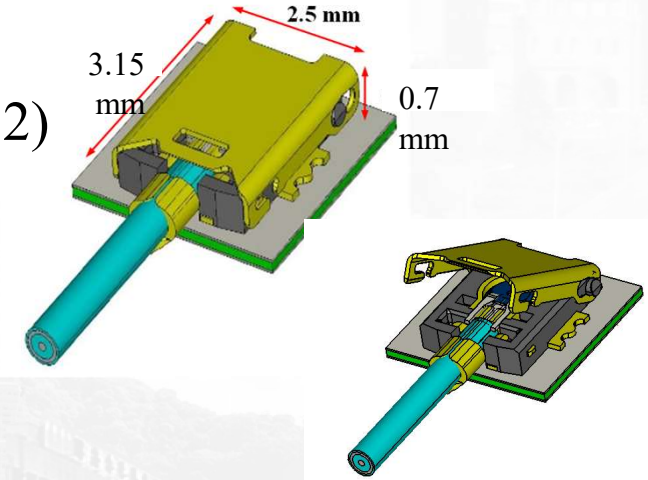


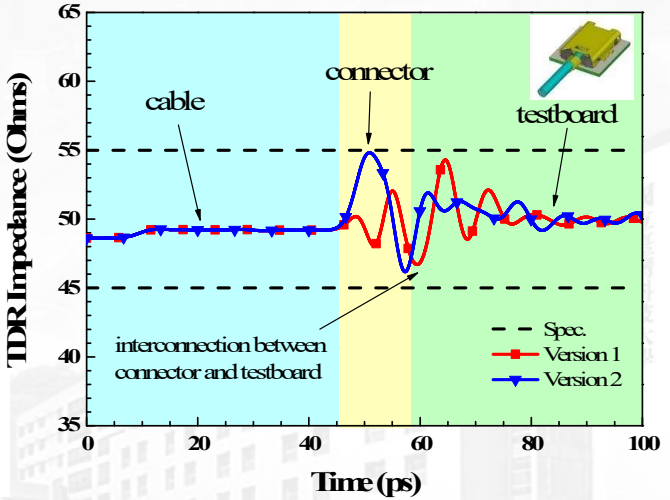
WiGig Connector Simulations

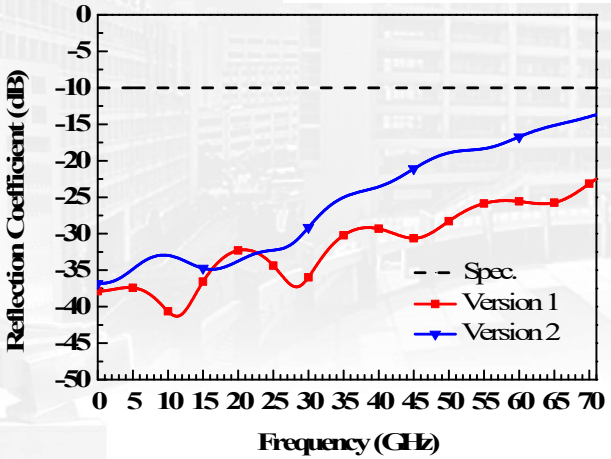
- Original Design (Version 1)
- Manufactured Version (Version 2)

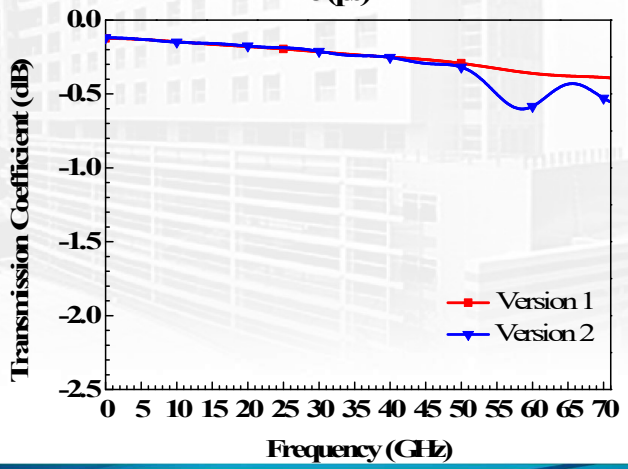






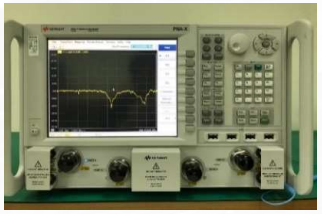




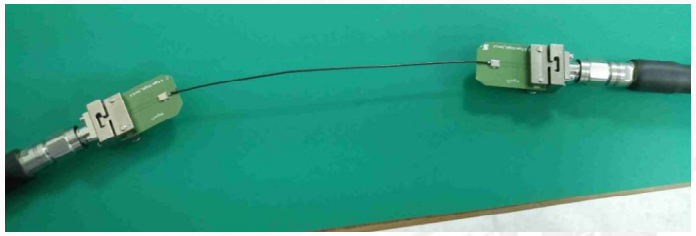


WiGig Connector Measurements

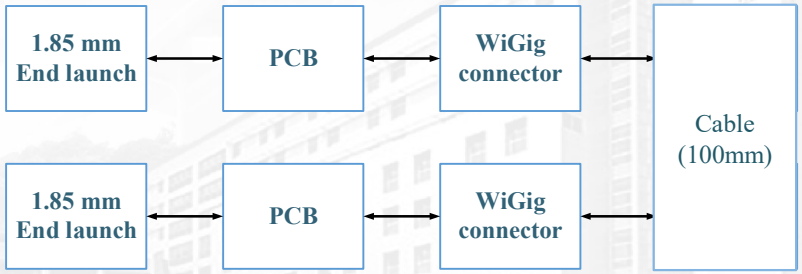
- Measurements of the WiGig Connectors



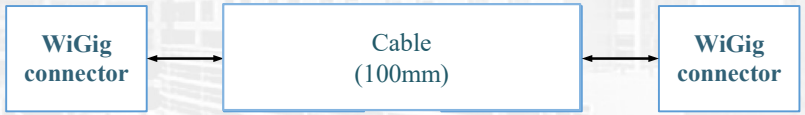
Keysight PNA-X, 10MHz-67GHz



1. Step 1 – Measure with 67GHz Network Analyzer
   - Including a pair of the proposed connectors with the PCB, a pair of the 1.85mm end-launch connectors and a 10cm long cable with an outer diameter of 0.53mm.



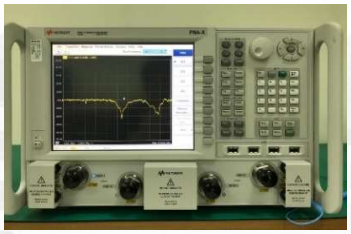
2. Step 2 – Process with PLTS AFR
   - Using Keysight PLTS Automatic Fixture Removal (AFR) to remove the effects of the test boards and 1.85mm end-launch connectors.

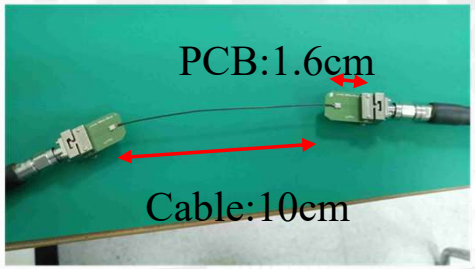


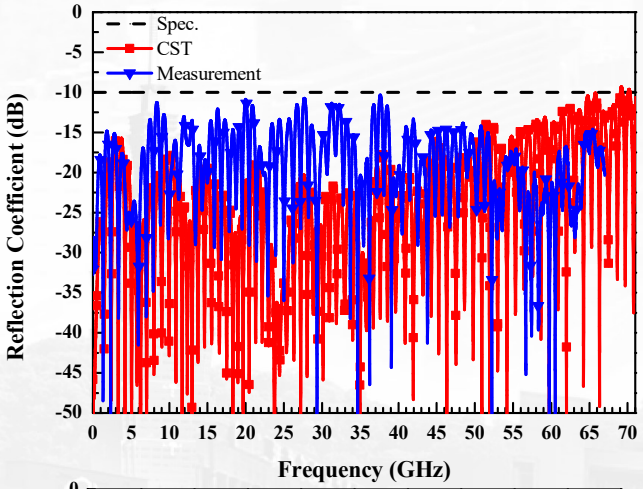
3. Step 3 – Process with PLTS Time Gating
   - Using Keysight PLTS Time Gating to extract results from a single connector.

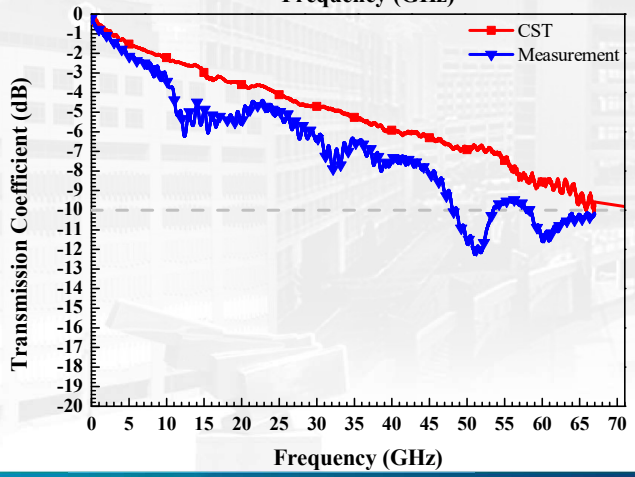
Measurement Results (1/3)

- **Step 1**
  - ➢ S_{11} and S_{21} in 10MHz-67GHz



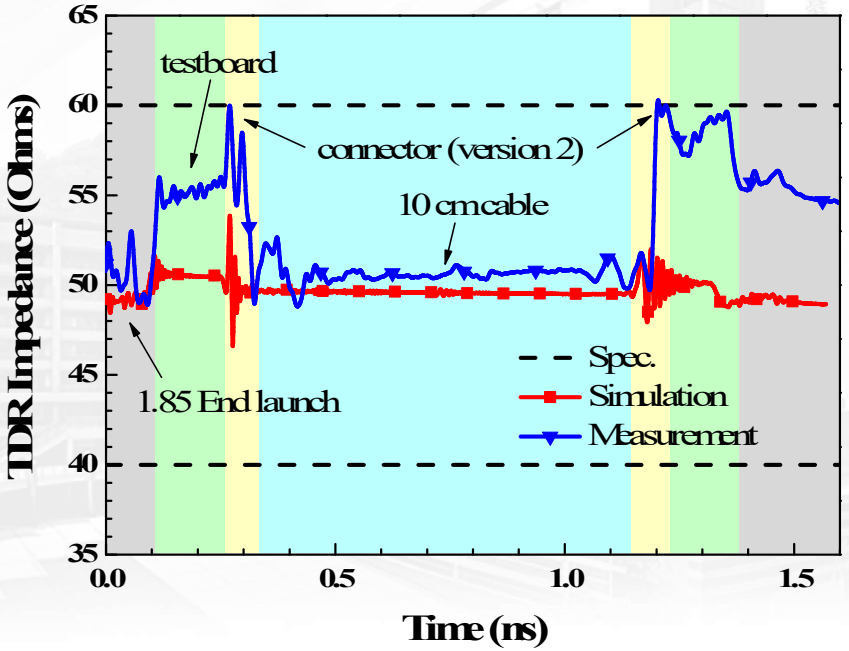






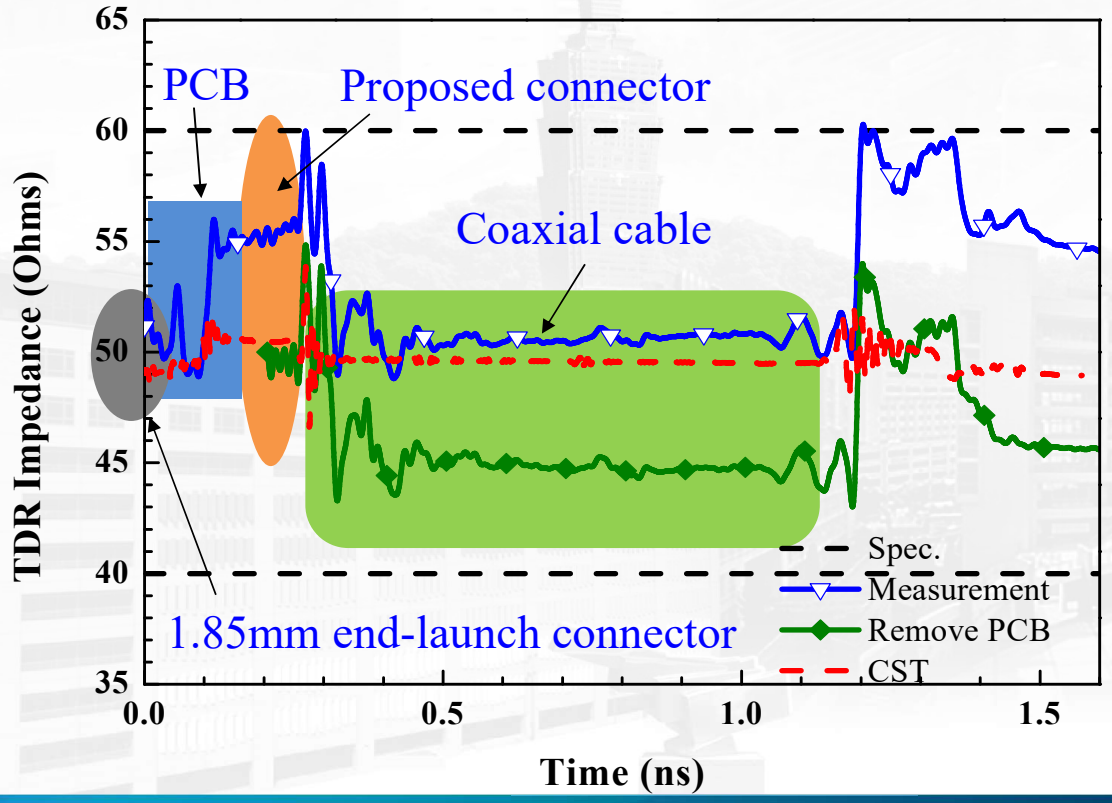
Keysight PLTS

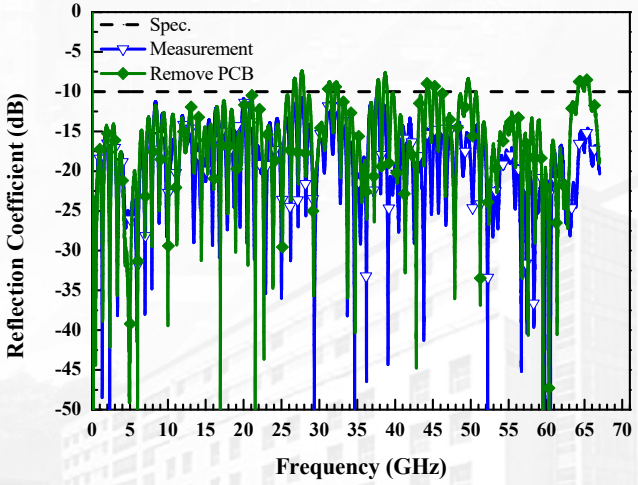
- ➢ Rise time : 5ps

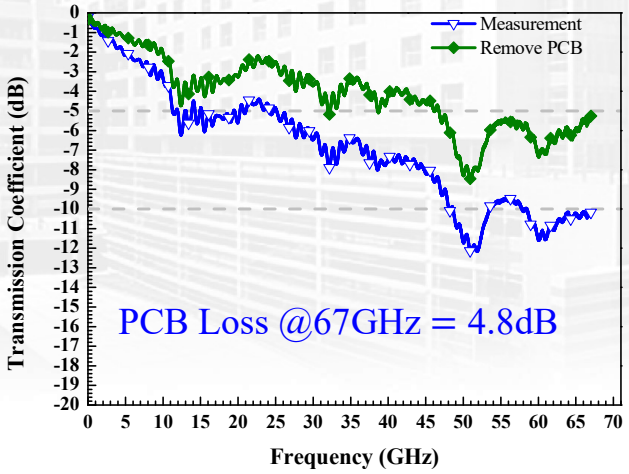


Measurement Results (2/3)

- **Step 2**
  - Remove PCB and1.85mm end-launch connector

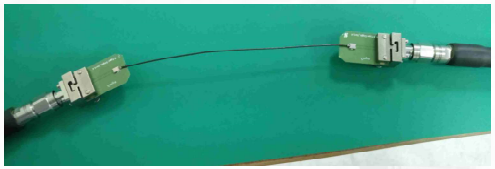


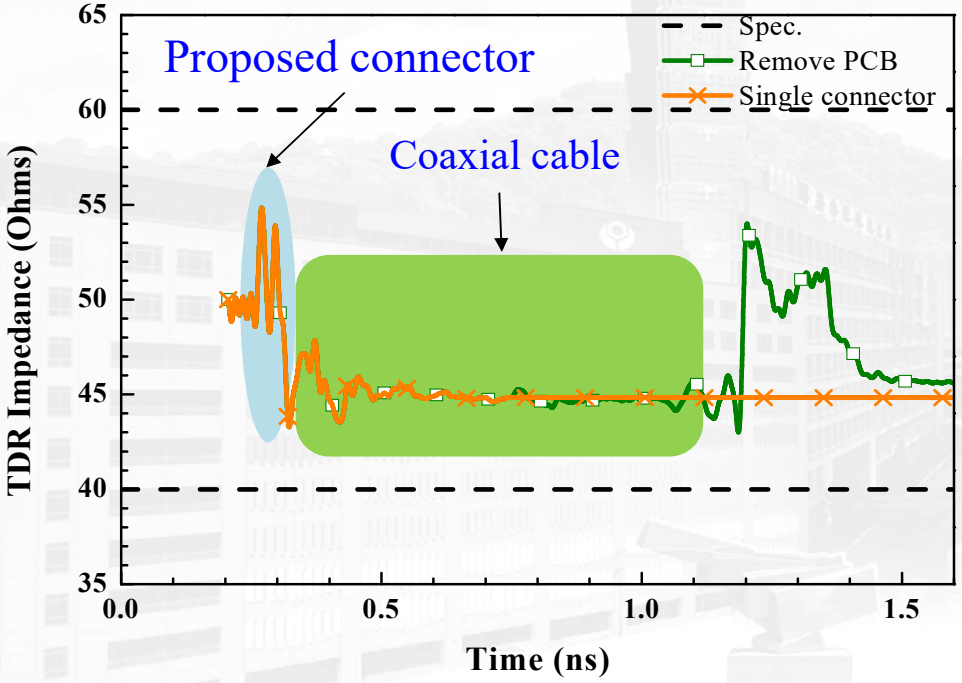


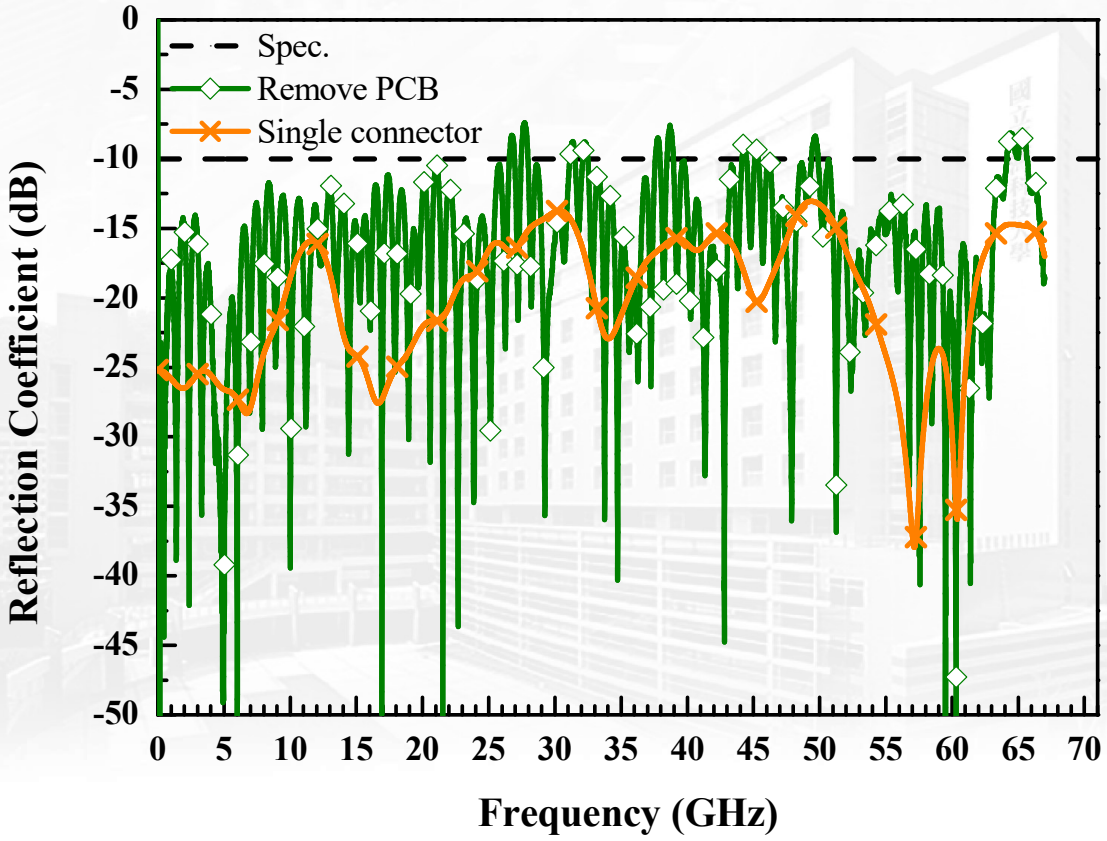


Measurement Results (3/3)

- Using Keysight PLTS time gating to extract results from a single connector

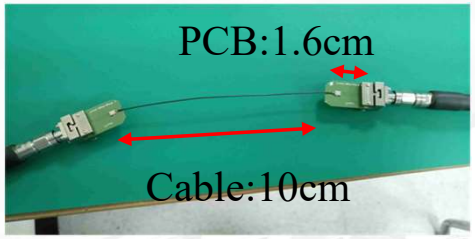


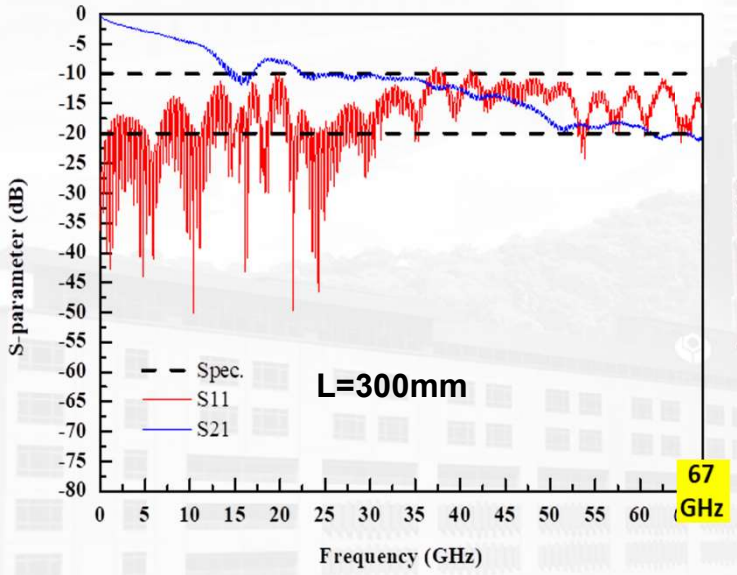


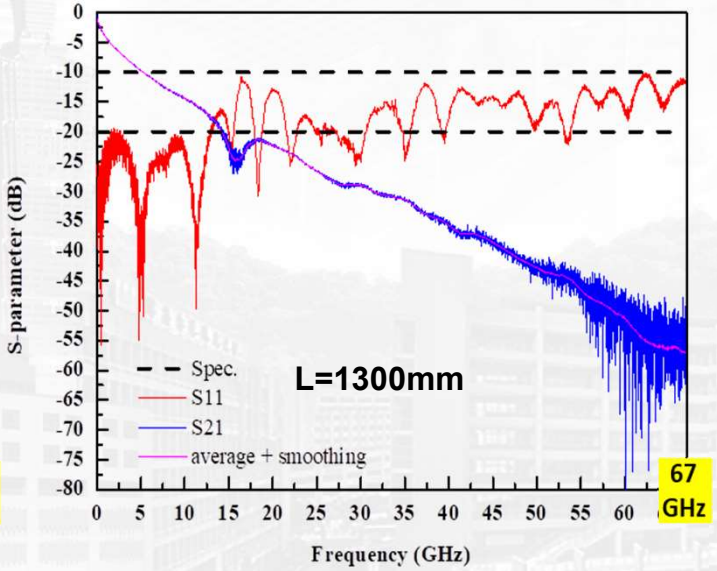


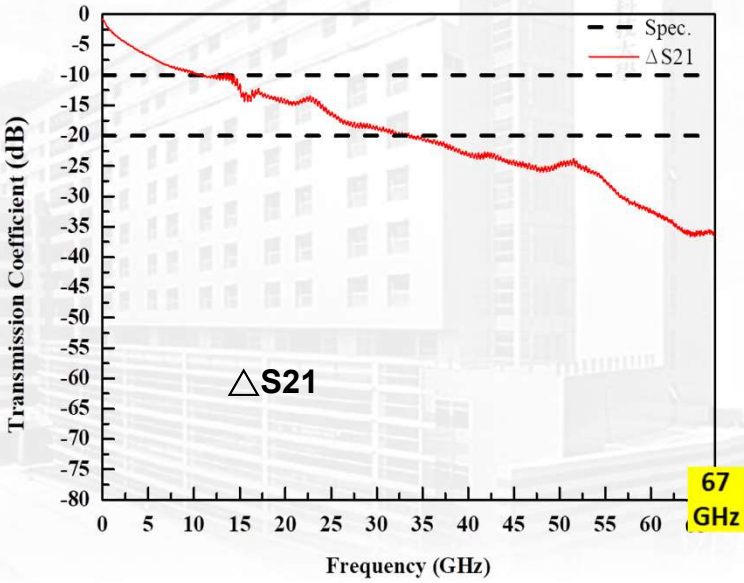
Measurement Results of the OD 0.53mm Cable

- Measuring results from different cable length to obtain cable loss.





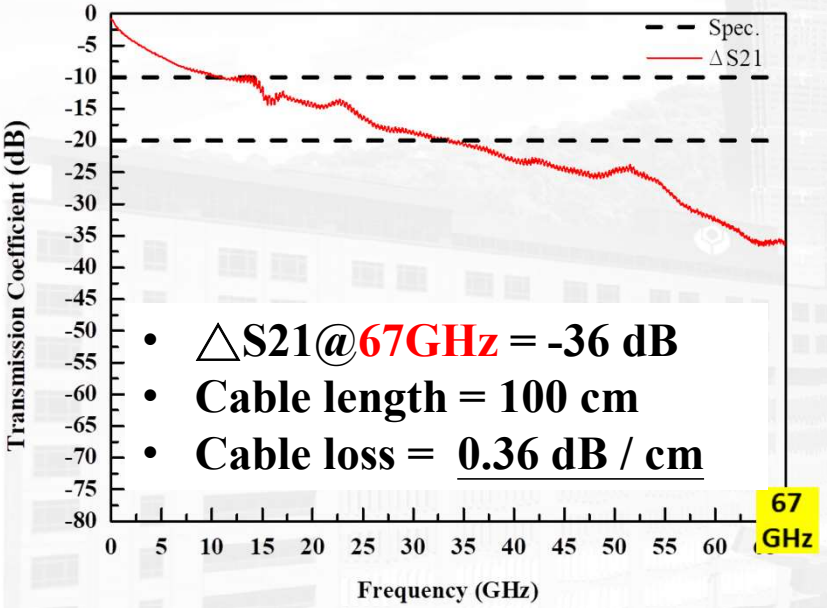


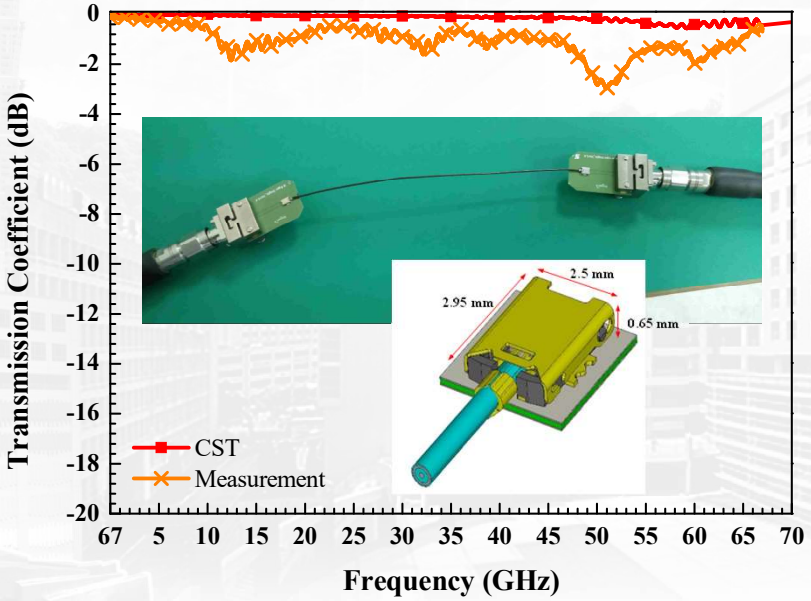


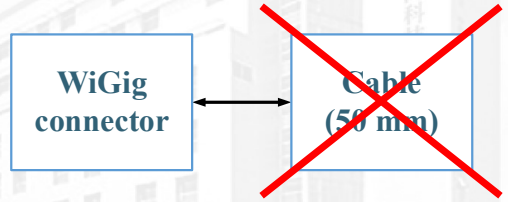
- **△S21@67GHz = -36 dB**
- **Cable length = 100 cm**
- **Cable loss = 0.36 dB / cm**

Single Connector Loss

- Remove cable loss to get the loss of the single proposed connector.
- Compared with simulated results, the proposed connector has additional loss.







Loss:

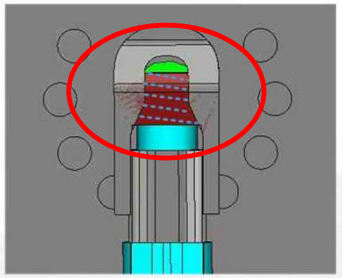
CST@67GHz = 0.45 dB

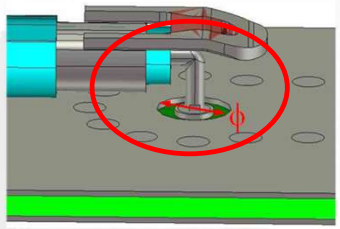
Meas.@67GHz = 0.68 dB

Meas.@51GHz = 2.96 dB

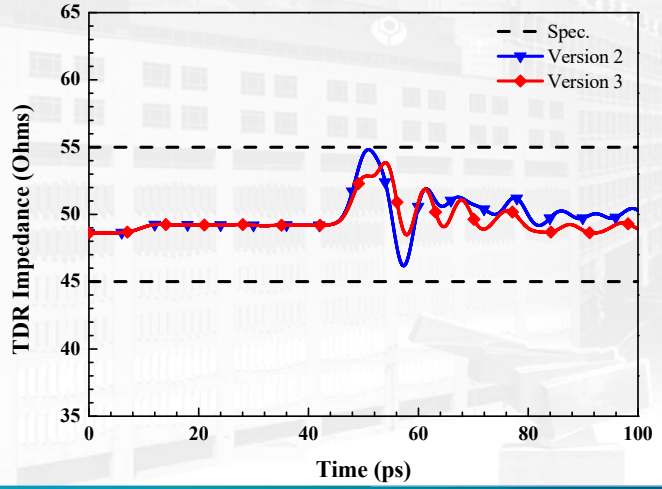
Revised Version

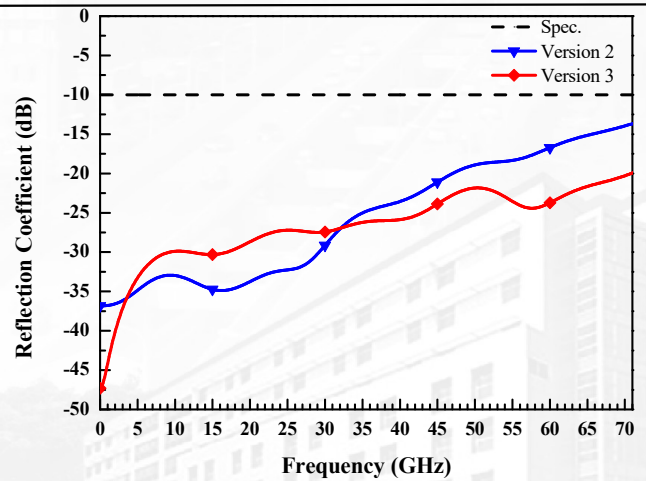
- Version 3
  - Modifying the metal dome and PCB test board

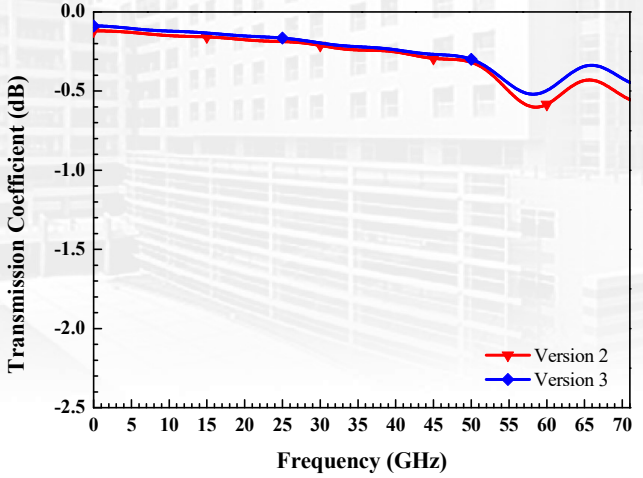




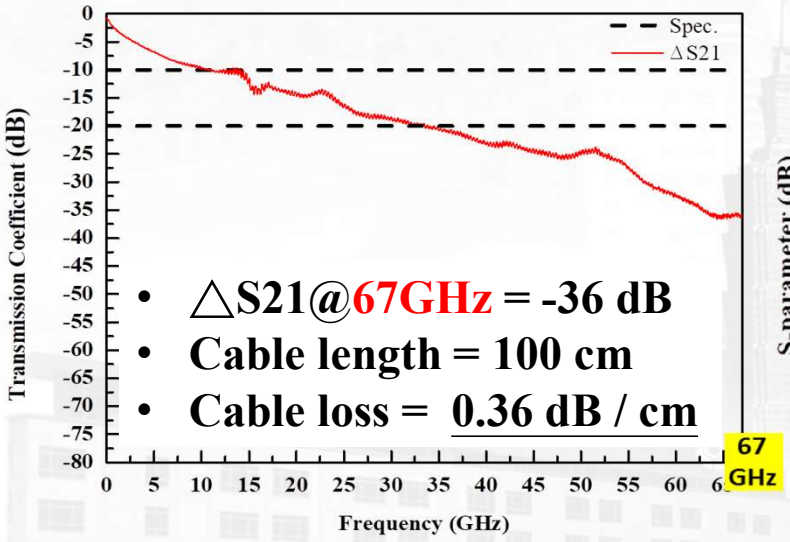
Φ = 0.46 mm



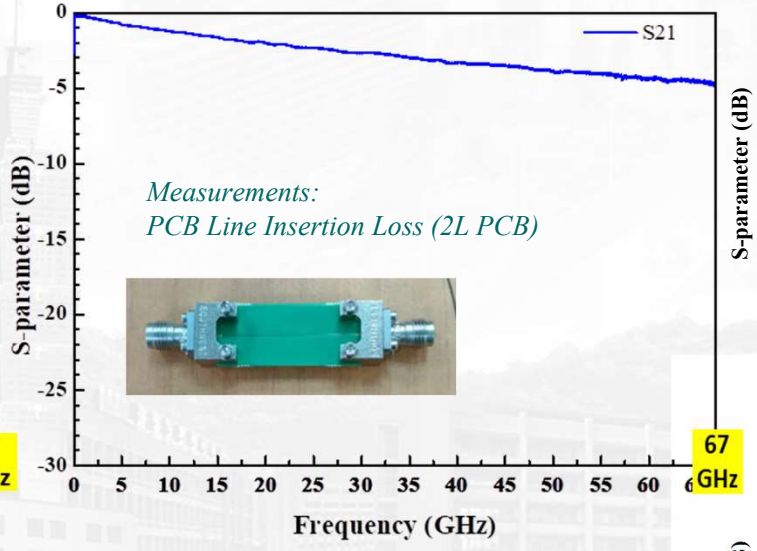




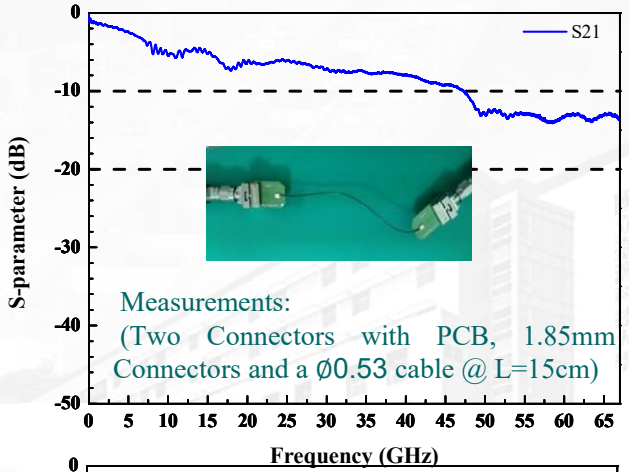
Measurement Results of the Revised Version



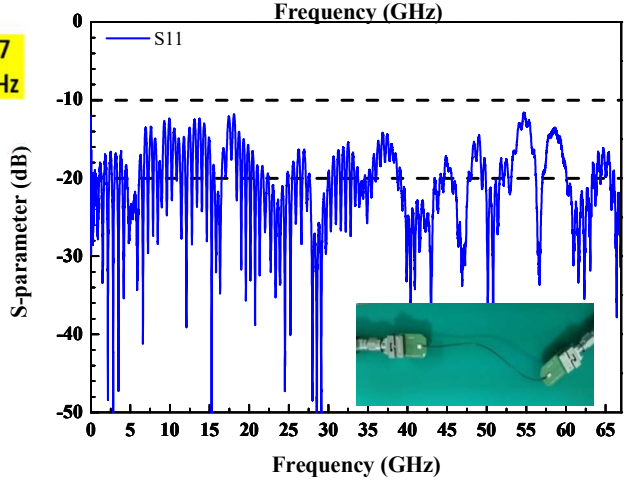
- △S21@67GHz = -36 dB
- Cable length = 100 cm
- Cable loss = 0.36 dB / cm

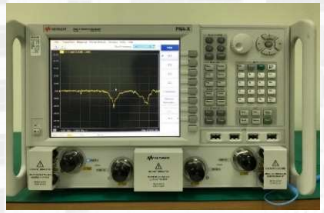


Measurements:
PCB Line Insertion Loss (2L PCB)



Measurements:
(Two Connectors with PCB, 1.85mm Connectors and a Ø0.53 cable @ L=15cm)

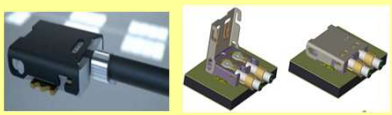
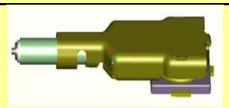
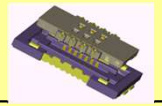
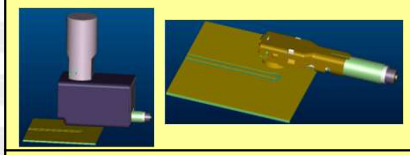
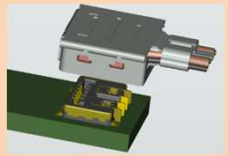




Keysight PNA-X 67GHz

➢ The insertion loss of two LanQ C67 connectors with a 15cm long Ø0.53mm cable is less than 10dB at 67GHz.

RF Connector Product List

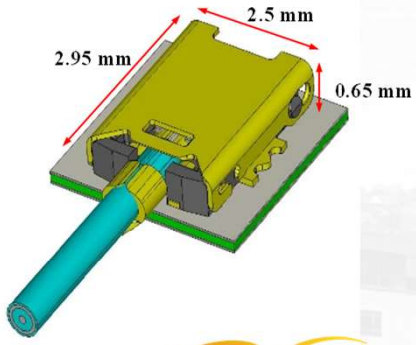
Connector Types		Specifications	
		Data Rate / Frequency	Version
	Clamshell Type RF Connector	67/100GHz	Single Dual
	Rotary Type RF Connector	45/90GHz	Single / Dual
	RF B to B Connector P0.35mm / H0.7mm	45GHz	2 Lines x 7P (6 RF conn.)
	RF Probe	45/90GHz	RF PCBA Test
	1.85mm PCB Mount RF test connector	67GHz	RF Test
	RF W to B Connector P0.35mm / H1.6mm Working Space: 4.4 x 5.3 x 1.6 mm^3	30~50GHz	2 Lines for RF or IF with 5 Lines for Digital and Power

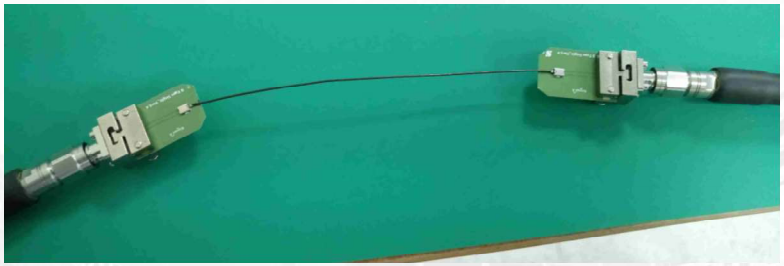
Conclusions

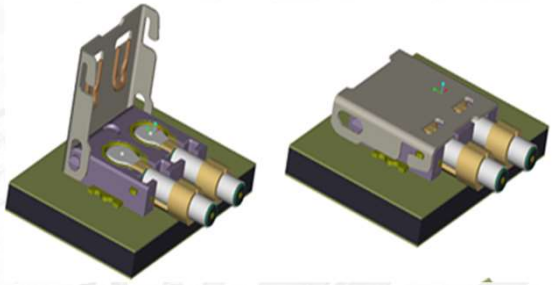
- In this paper, a low-profile RF WTB connector, which has a compact size of 3.15(L) ×2.5(W)×0.7(T) mm^3 is presented.
- The operating frequency of the connector may cover from DC to 70GHz for 5G wireless communications and WiGig applications.
- Currently, some samples in trial runs have been fabricated and tested for verifications.
- More flexible and better designs are expected by applying this RF WTB jump wires in 5G mmWave bands for both the IF and RF connection architectures.

Acknowledgements

- This work was supported in parts by Harumoto Giken Co., and Ministry of Science and Technology, Taiwan.







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Harumoto 春源

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Thank You