5-6 Gen 고속 인터페이스 측정 및 De-embedding

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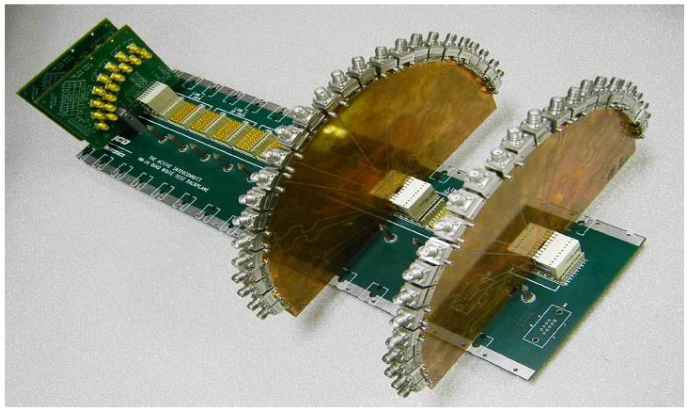
Huwin
R&D
Center

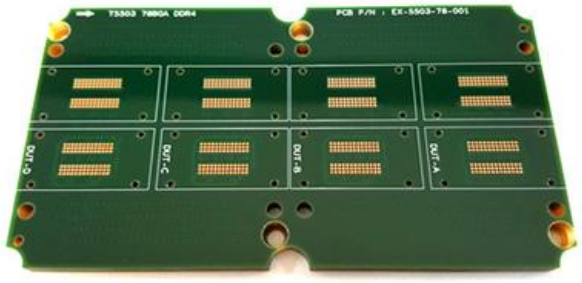
Contents

1) High-speed interface

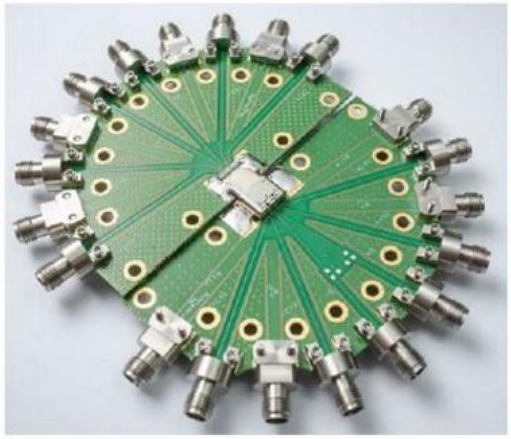
- PCB, Interconnects (including package, connector, cable, etc.)



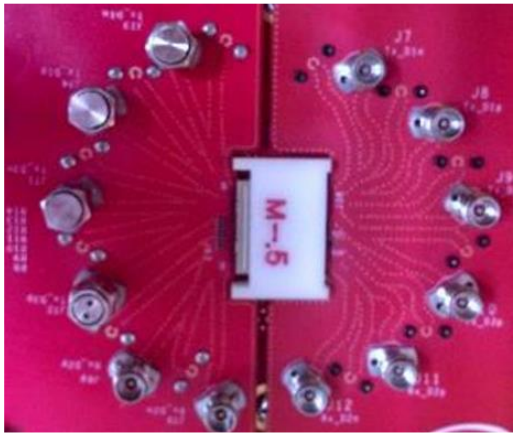
SerDes 채널 (커넥터 + 전송선로)



반도체 테스트 보드



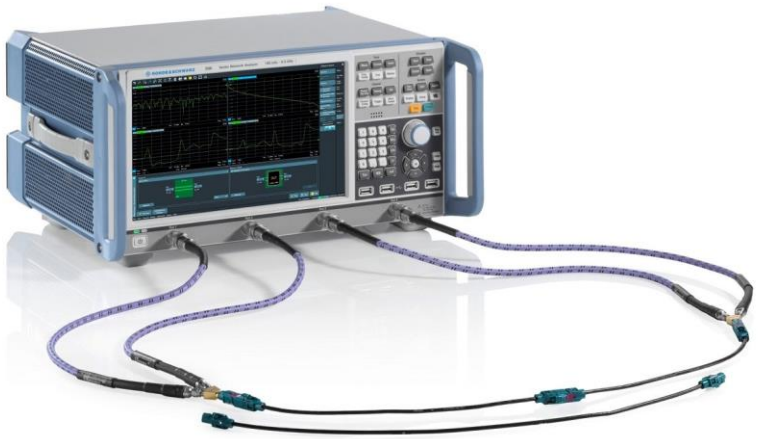
USB Type-C



커넥터

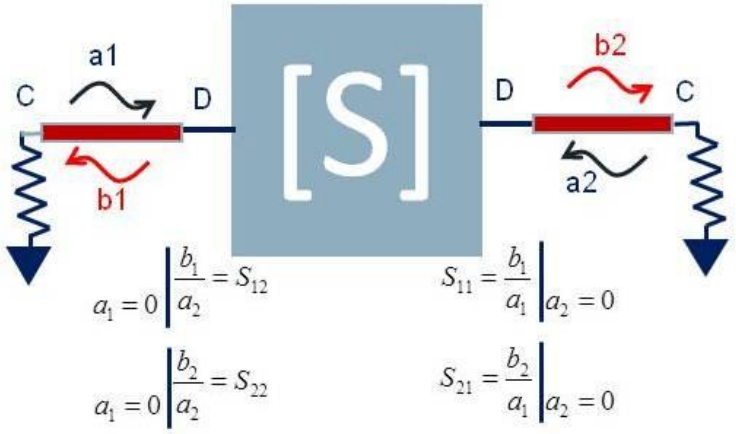
2) 계측기 및 측정

➢ VNA, Probe station등을 이용한 S-parameters 측정 및 변환



Vector Network analyzer

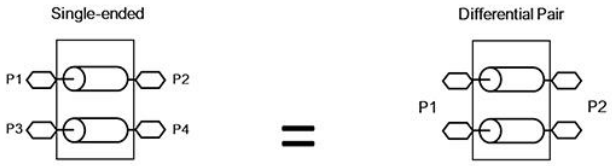
$$b_1 = S_{11}\cdot a_1 + s_{12}\cdot a_2$$
$$b_2 = S_{21}\cdot a_1 + s_{22}\cdot a_2$$
$$a = \frac{V^+}{\sqrt{Zc}} \quad b = \frac{V^-}{\sqrt{Zc}} \quad b = \Gamma \cdot a$$



$$a_1 = 0 \left| \frac{b_1}{a_2} = S_{12} \right. \qquad S_{11} = \frac{b_1}{a_1} \left| a_2 = 0 \right.$$
$$a_1 = 0 \left| \frac{b_2}{a_2} = S_{22} \right. \qquad S_{21} = \frac{b_2}{a_1} \left| a_2 = 0 \right.$$

S-parameters

Probe station with microprobe



Single-ended S-parameters			
IL/RL		NEXT/FEXT	
S11	S12	S13	S14
S21	S22	S23	S24
NEXT/FEXT		IL/RL	
S31	S32	S33	S34
S41	S42	S43	S44

Mixed-Mode			
Differential-Differential		Common-Differential	
SDD11	SDD12	SDC11	SDC12
SDD21	SDD22	SDC21	SDC22
Differential-Common		Common-Common	
SCD11	SCD12	SCC11	SCC12
SCD21	SCD22	SCC21	SCC22

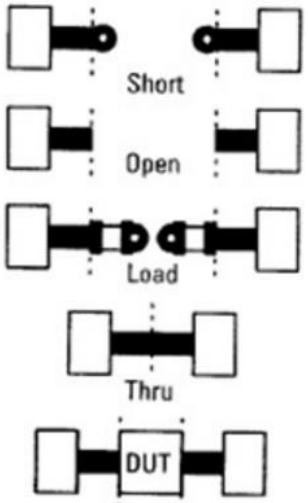
Mixed-mode for differential signaling

2) 계측기 및 측정

- 'VNA + cable' calibration
  - ✓ Calibration method: SOLT (Short-Open-Load-Thru), TRL (Thru-Reflect-Line) 등

Mechanical

E-Cal



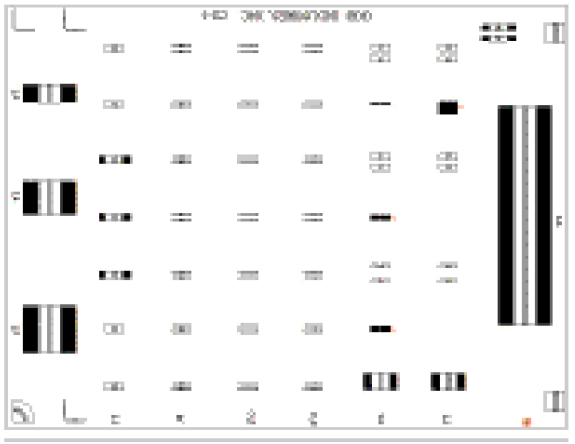
Calibration

2) 계측기 및 측정

➢ Microprobe calibration

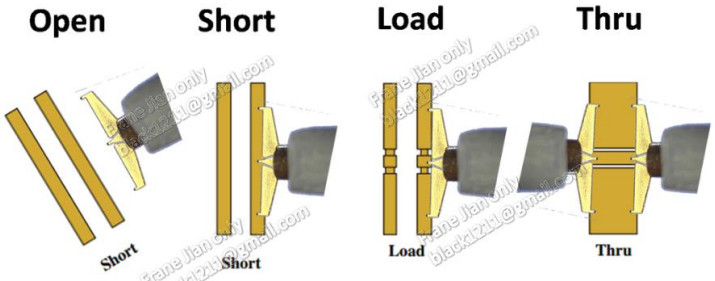
1. Calibration substrate를 이용한 'VNA+cable+microprobe' calibration
2. VNA+cable calibration 후 miroprobe는 test fixtur에 포함하여 de-embedding

Probe station



Calibration substarate

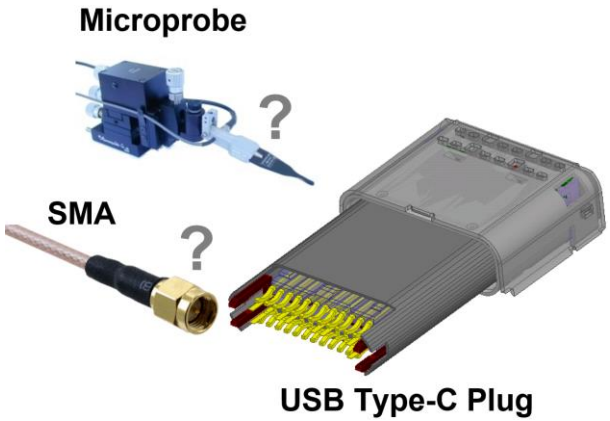
Microprobe



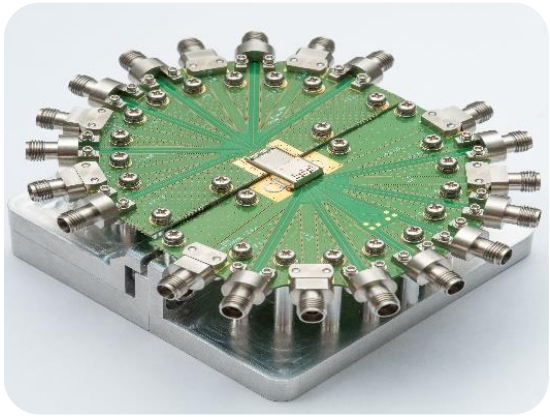
Calibration

3) Test fixture 필요성

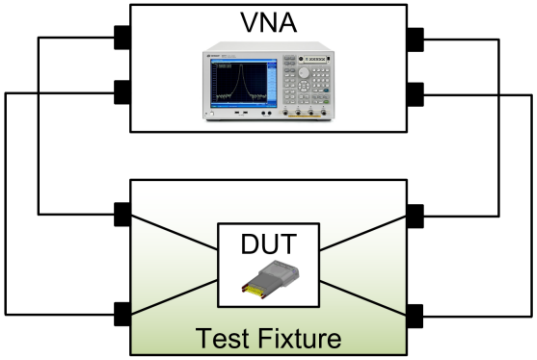
- Microprobe를 이용한 직접 측정이 어려울 경우
- 'Fixture + DUT + Fixture' 구조 설계
- DUT (Devise Under Test) 특성 추출을 위한 De-embedding 적용



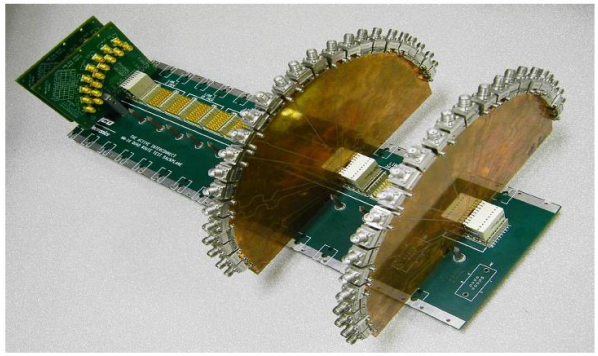
SMA/microprobe로 직접 측정이 어려운 사례



Test fixture 적용 사례-1



Test fixtur를 이용한 DUT 측정 원리



Test fixture 적용 사례-2

2. De-embedding

1) De-embedding 기법 소개

- 1X-Reflect
- 2X-Thru
- Impedance-corrected 2X-Thru
- Direct de-embedding with S-parameter file

2) 2x Thru 기법 소개

- 정확도, 안정성, Fixture 설계등의 측면에서 가장 많이 활용되는 기법
- Thru 구조의 Fixture 설계 후 측정 -> Fixture 단독 S-parameters 추출 가능
  - ✓ TDR의 절반을 gating 후 사용하는 원리
  - ✓ Single/Differential 모두 적용 가능

- Issue-1
  - ✓ Assymetry ☞ Assymetry 2x Thru option 적용 필요
- Issue-2
  - ✓ Sdc/cd 보상
  - ✓ 2x Thru는 Sdc/cd 성분 '0'으로 가정 ☞ 2x Thru 적용 후 보상 적용
- Issue-3
  - ✓ Impedance correction
  - ✓ 2x Thru fixture와 Fixture+DUT+Fixture간의 Impedance 오차 발생시 적용

3) 결과 평가 방법

- Self de-embedding: |IL| <0.1dB, ∠IL < 1 degree
- TDR check: 2xThru ≈ 'Fixture + DUT + Fixture

3. Test fixture 설계

1) 설계 전략

➢ Single or Differential 선택
✓ Signle-ended 접근 ☞ 결과 신뢰성
✓ X-talk구간 평가 후 최적 선택

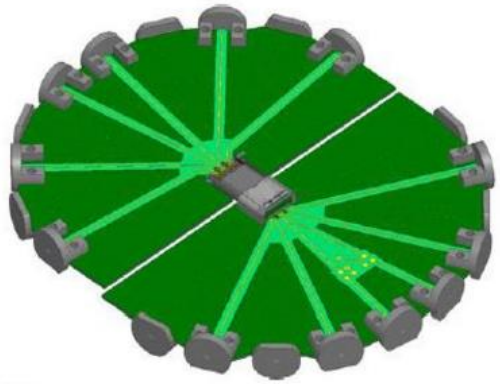
➢ 2xThru와 'Fixture+DUT+Fixture' 동일 조건
✓ PCB/Layer/Transition/SMA등

➢ 2xThru 길이 조건
✓ TDR half gating 안정성 유지를 위한 최소 길이 조건
✓ 2x의 최소 길이 = 1/fmax*3

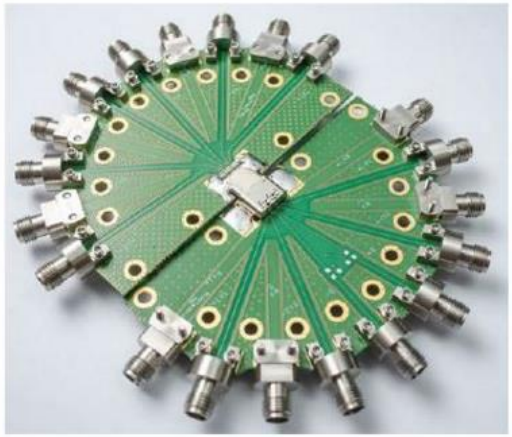
3. Test fixture 설계

1) 설계 전략

- 3D EM simulator (ANSYS HFSS) 를 이용한 설계 및 성능 체크 필수
- ✓ 사전 2xThru de-embedding 테스트 가능

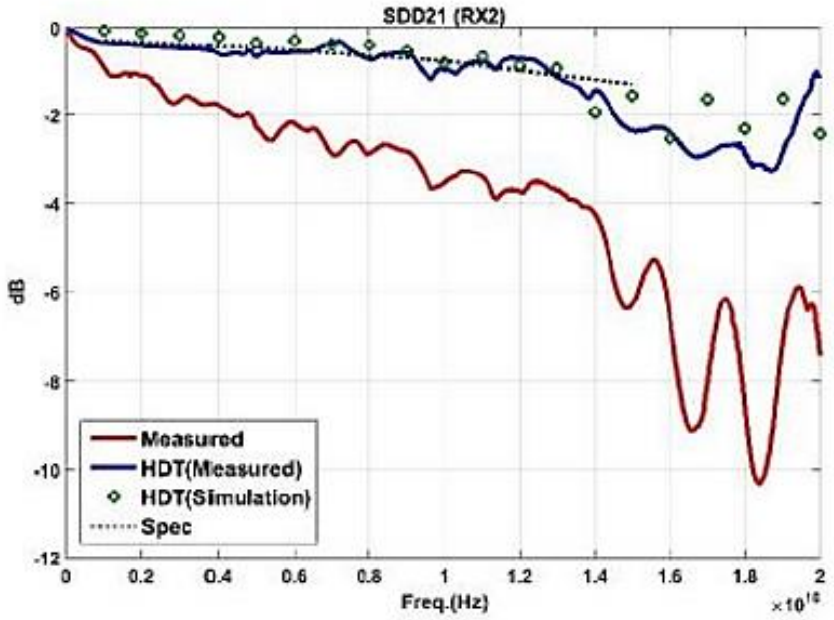


(a)



(b)

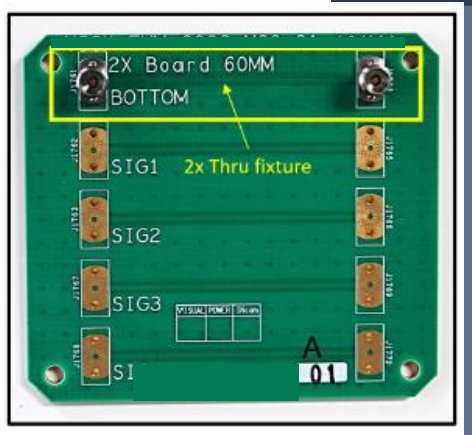
HFSS를 이용한 EM simulation

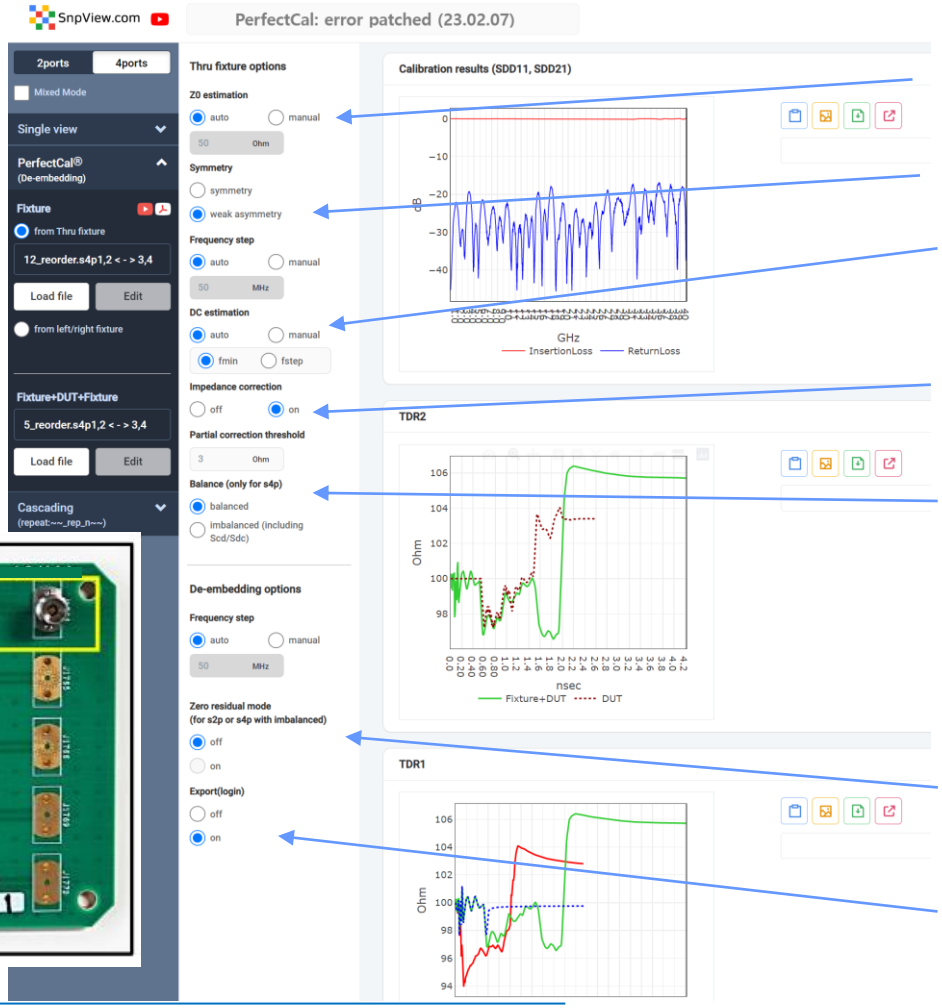


EM simulation결과를 이용한 De-embedding test

1) 반도체 평가 보드의 전송 선로 측정 및 De-embedding

- 3D EM simulation을 이용한 Test fixture 설계
- VNA (up tp 50GHz)를 이용한 S-parameters 측정
- SnpView: Fixture 성능 평가 (IL, TDR) 및 De-embedding (PerfectCal)





Z_0 estimation by auto or manual

Supports weak asymmetry fixture

DC option
: Interpolation, manual 'R' value

Impedance correction
(default: off)

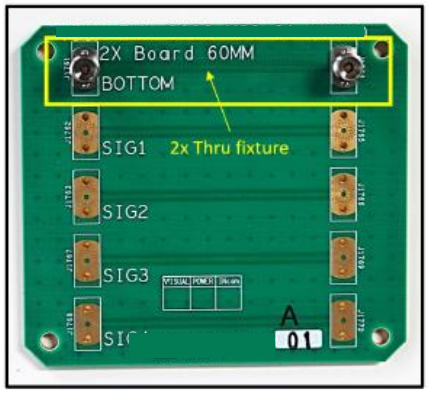
Including Scd/Sdc

No residual after calibration

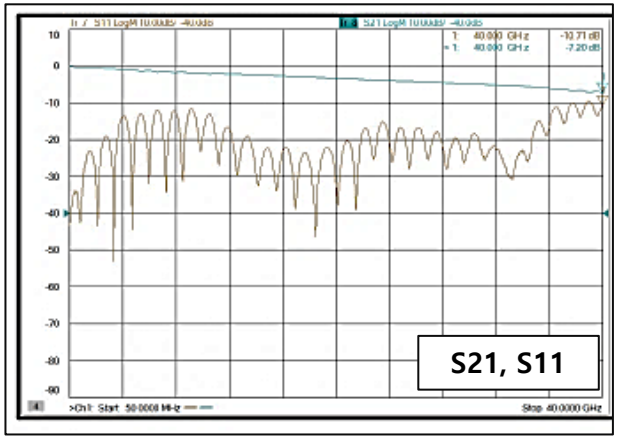
Export results

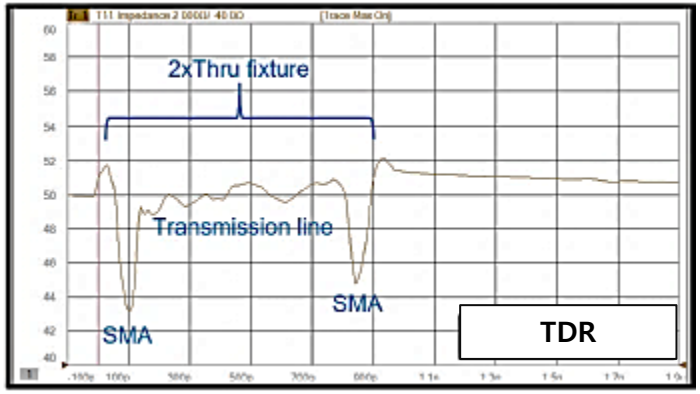
1) 반도체 평가 보드의 전송 선로 측정 및 De-embedding

- ➢ Self de-embedding 검증
- ✓ SnpView PerfectCal로 부터 Fixture S-parameter 적용
- ✓ VNA 적용 후 측정

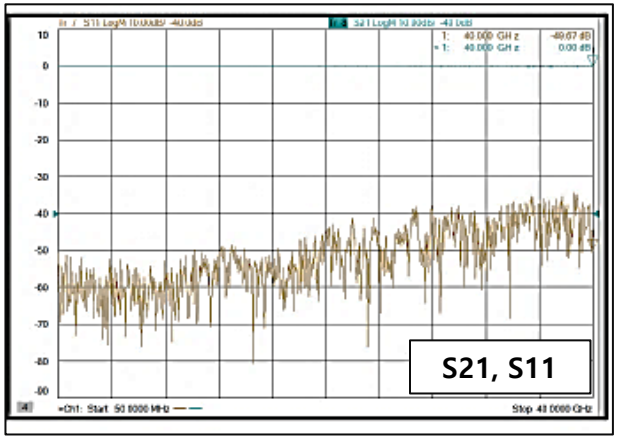


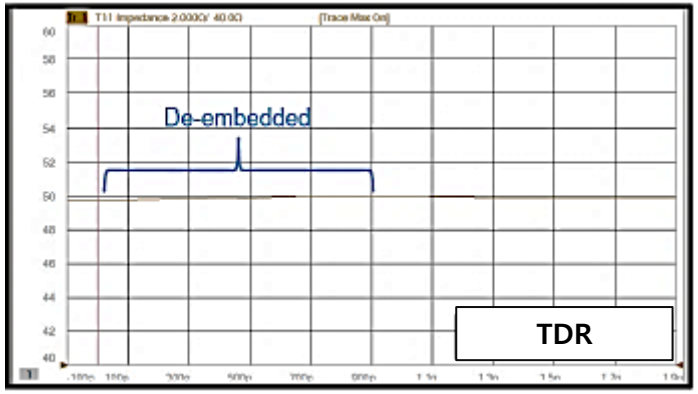
Thru fixture PCB





Before de-embedding

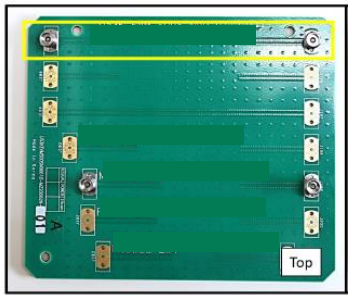




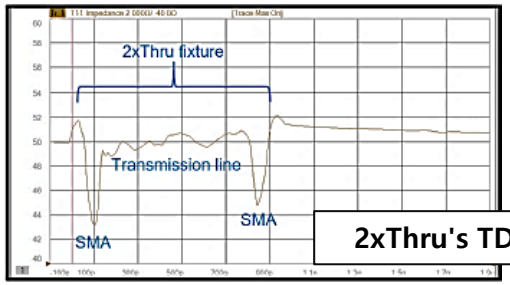
After de-embedding

1) 반도체 평가 보드의 전송 선로 측정/De-embedding

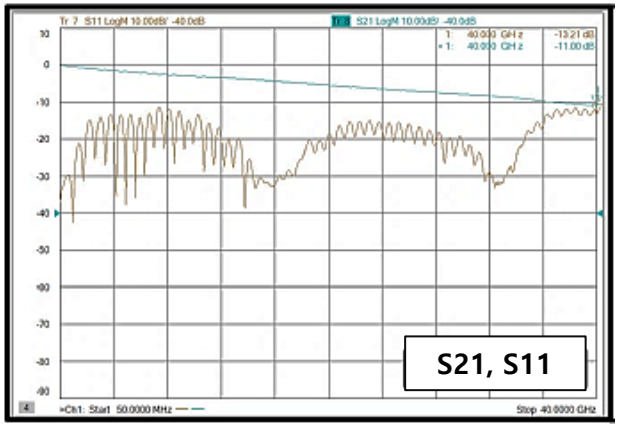
- ➢ 'Fixture+DUT+Fixture'를 이용한 DUT 단독 성능 추출
- ✓ SnpView PerfectCal로 부터 Fixture S-parameter 적용
- ✓ VNA 적용 후 측정

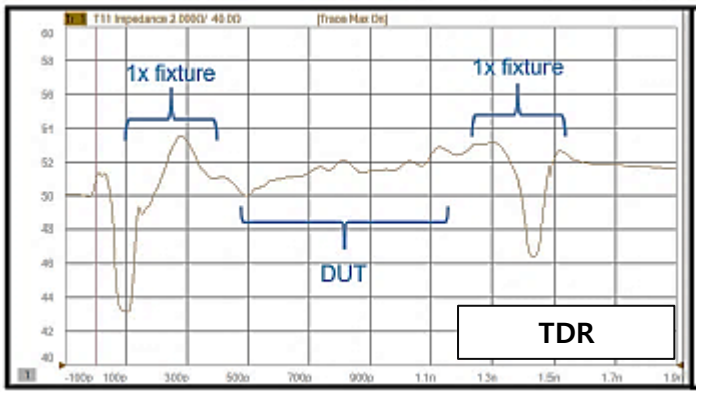


[Fixture + DUT] (Microstrip line)

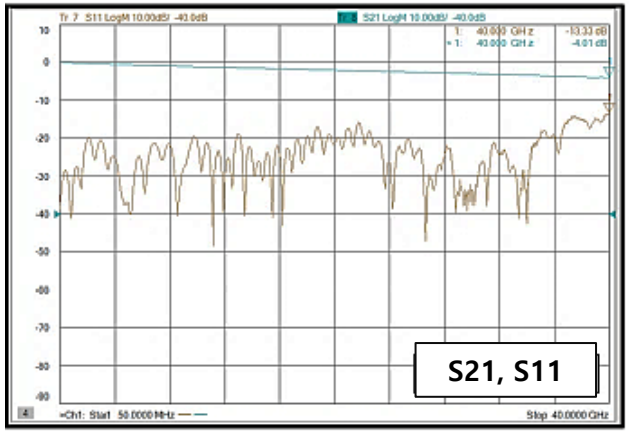


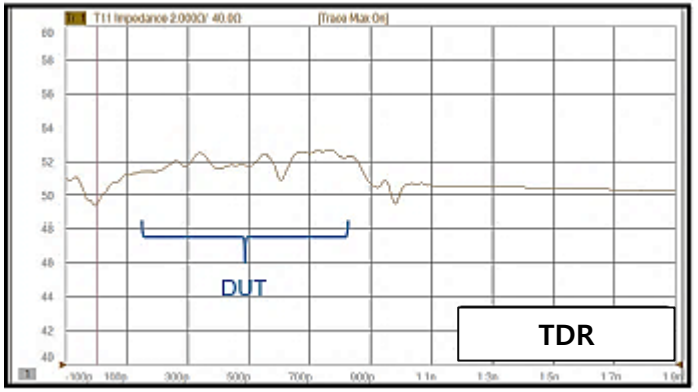
2xThru's TDR





Before de-embedding

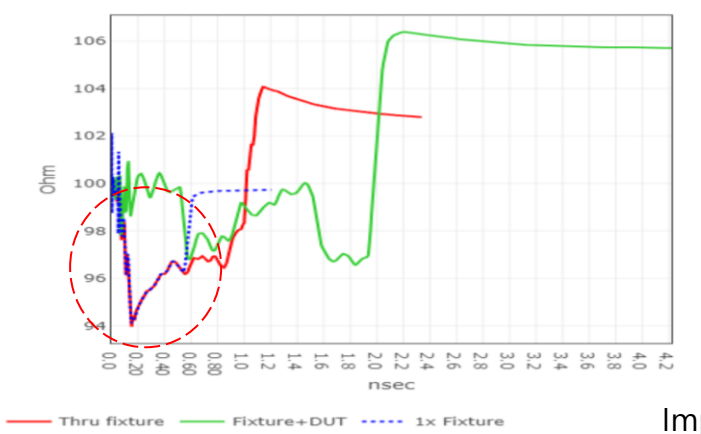


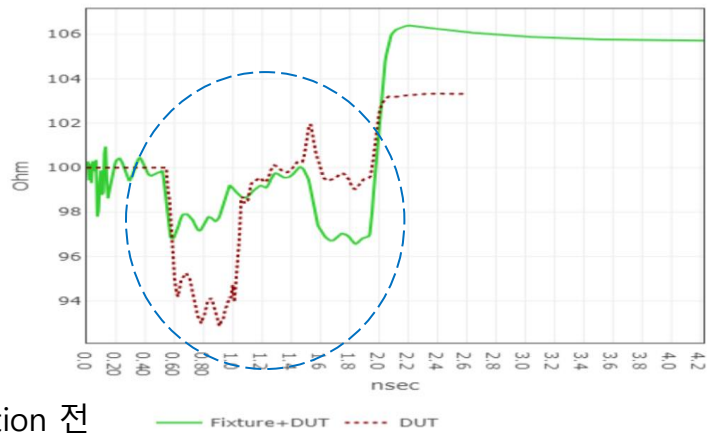


After de-embedding

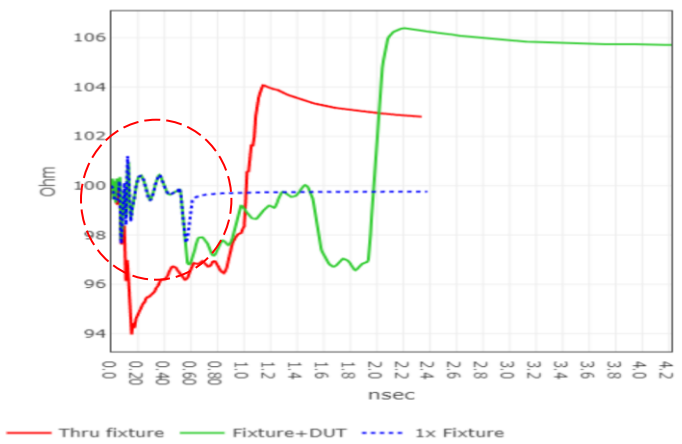
2) 2xThru ≠ 'Fixture+DUT+Fixture' 임피던스 차이 사례

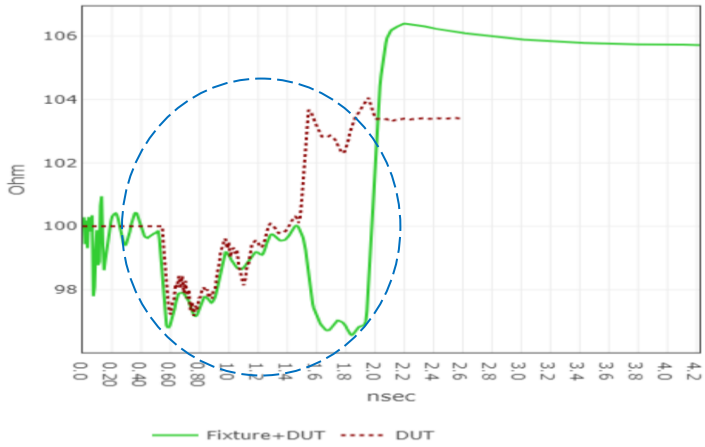
- ➢ SnpView PerfectCal 중 'Impedance Correction' 기능 적용
- ✓ 1x Fixture의 임피던스 특성이 실제 'Fixture+DUT+Fixture'와 동일
- ✓ De-embedding 신뢰성 향상





Impedance correction 전





Impedance correction 후


THANK YOU!