

The logo consists of a dark green circle with a white border, containing the letters 'AEM' in white, bold, sans-serif font. The background of the slide features a blurred image of a network switch or server rack with green wavy lines overlaid.

AEM

AEM RJ45 连接硬件测试方案

2020.11.

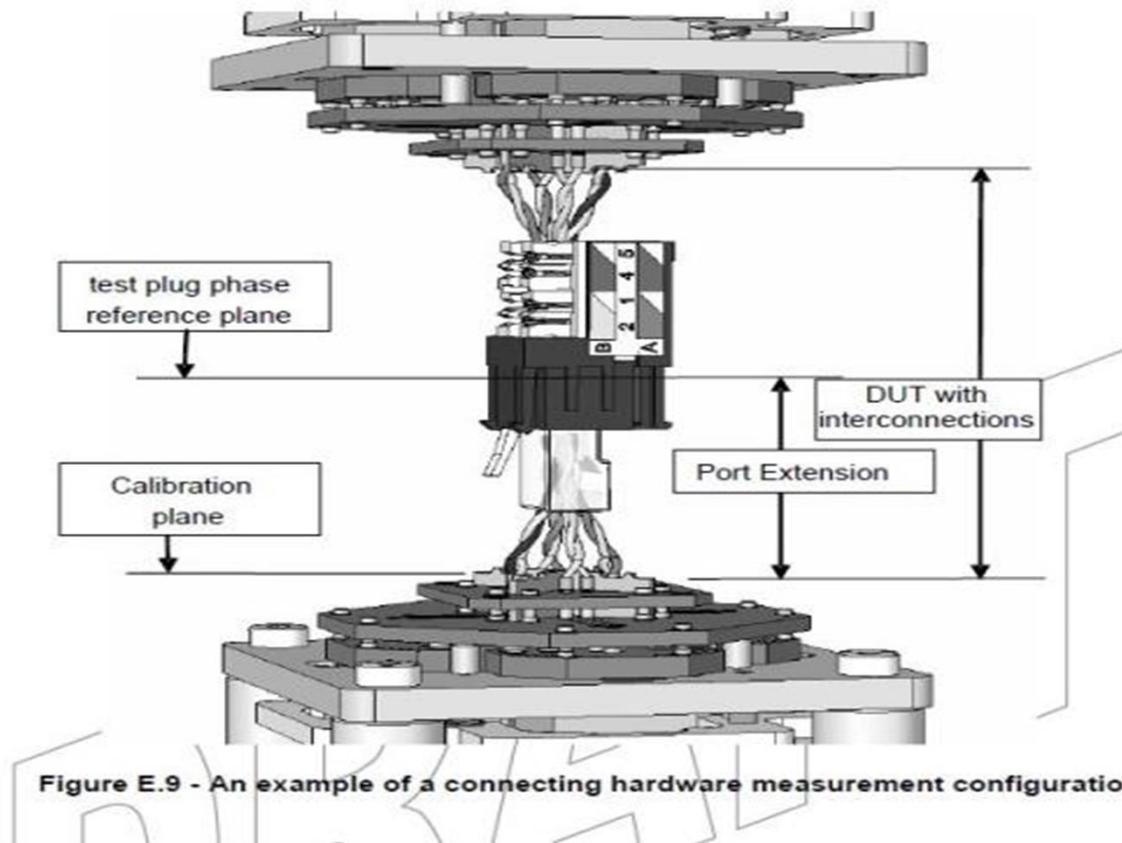
The logo consists of a dark green circle with a white highlight on the top left, containing the letters 'AEM' in white, bold, sans-serif font. The background of the slide features a blurred image of a modern office or laboratory setting with white equipment and a green wavy graphic element that flows across the middle of the page.

AEM

让平凡的劳动更有尊严！

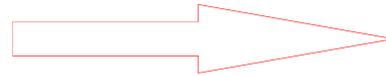
ANSI/TIA-568.2-C 提出的RJ45模块的 测试配置

Figure E.9 shows an example of a connecting hardware measurement configuration.

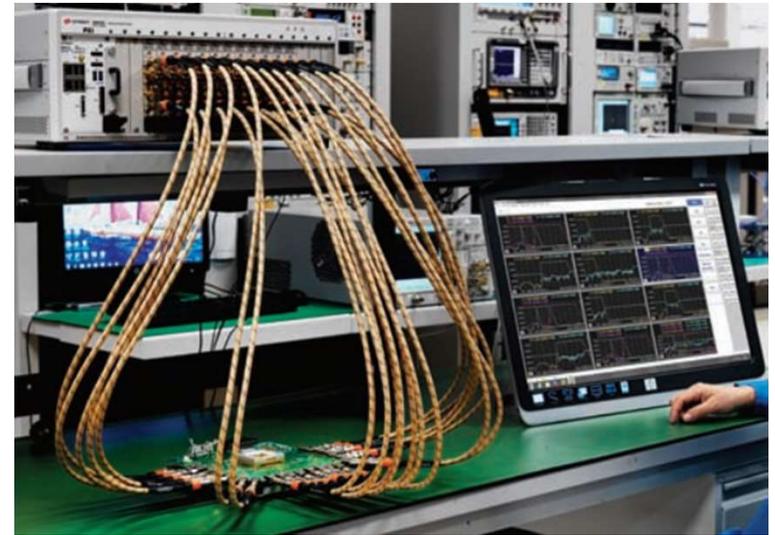
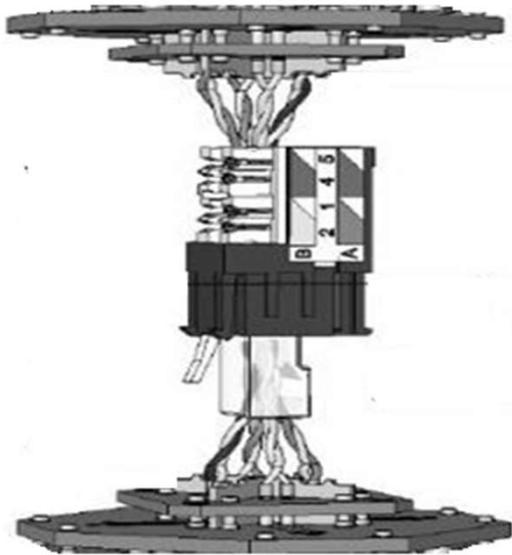


对网络分析仪的要求

被测件 (DUT) 是“双端8通道 (16端口)”



16端口网络分析仪



设备价格高 (\$12000+/通道)

降低网分成本 方案1 —— 2端口网分+开关矩阵

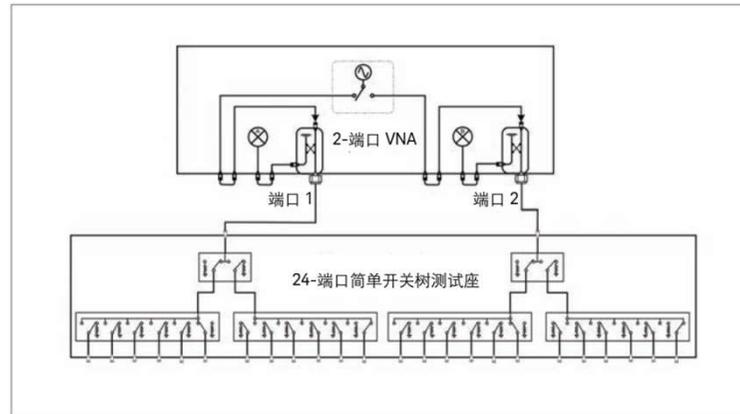
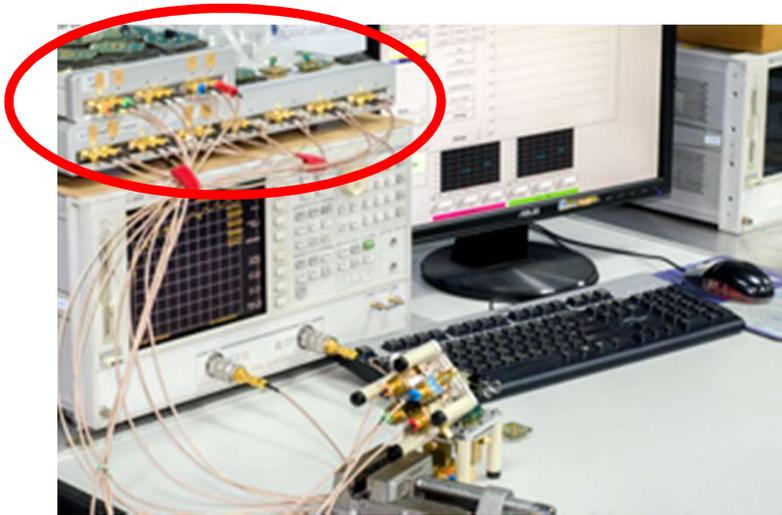
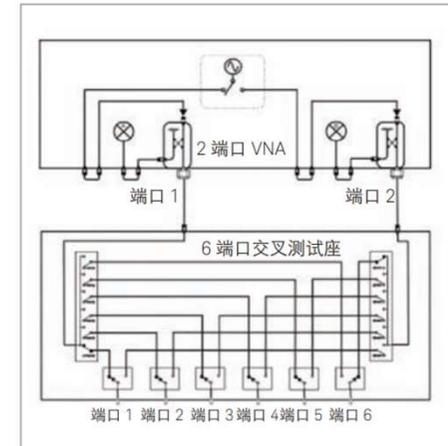


图 2. 配备 24 端口测试座的 2 端口 VNA 示意图

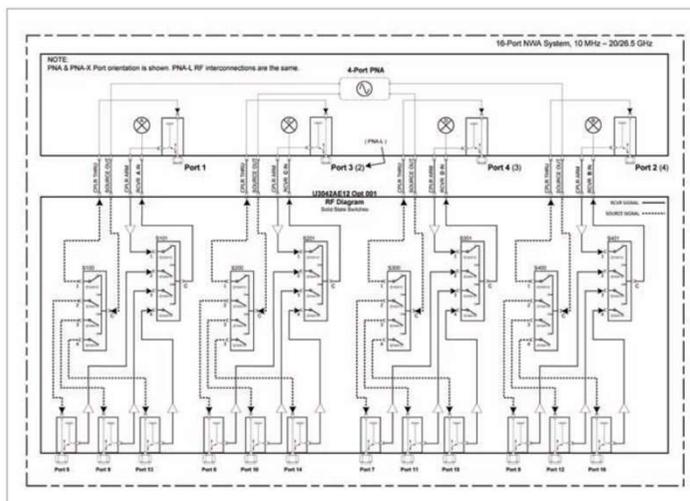
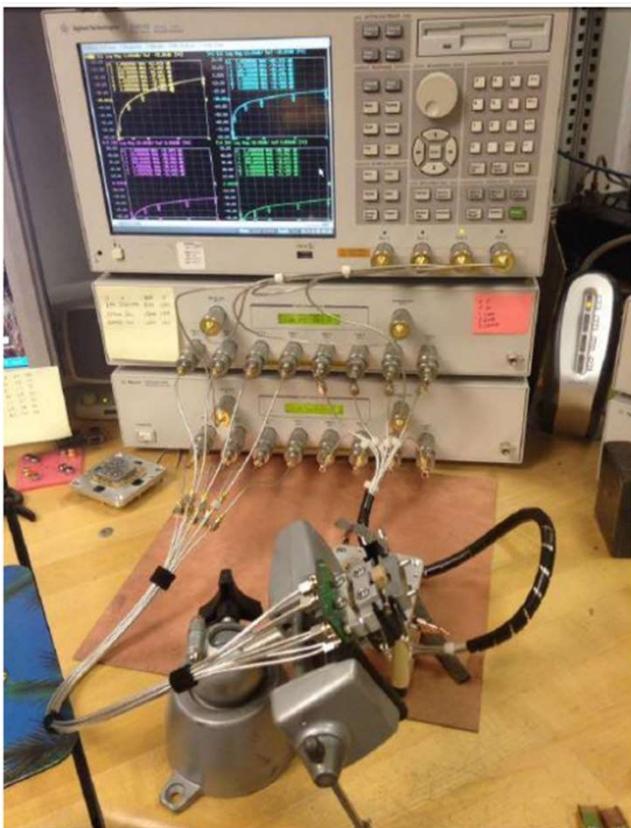


(b) 配有全交叉开关测试座的 2 端口 VNA 原理图

问题：

- 开关矩阵，校准麻烦
- 仅测单端
- 效率低

降低网分成本 方案2 —— 4端口网分+开关矩阵



(b) 配有 12 端口测试座的 4 端口 VNA 原理图

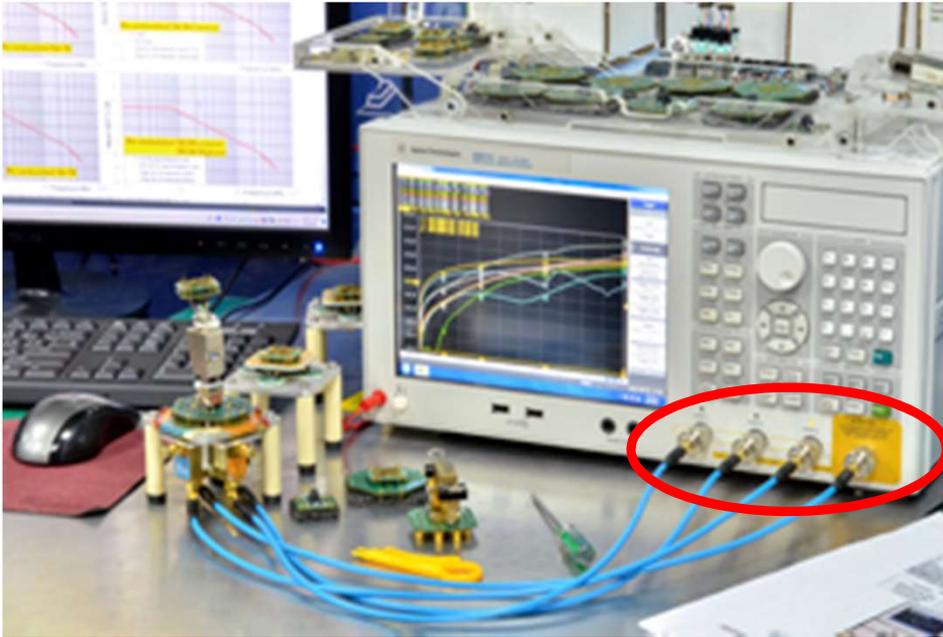
改进

- 支持**双端**/单端测试

问题：

- 开关矩阵，校准麻烦
- **系统成本并不低**
- **效率低**（1个通道/次，依次测试）

降低网分成本 方案3 —— 4端口网分



改进

- 校准相对简单
- 设备成本相对较低

问题：

- 手动转换测试引线，费时、费力
- 效率最低（1个通道/次，依次测试）

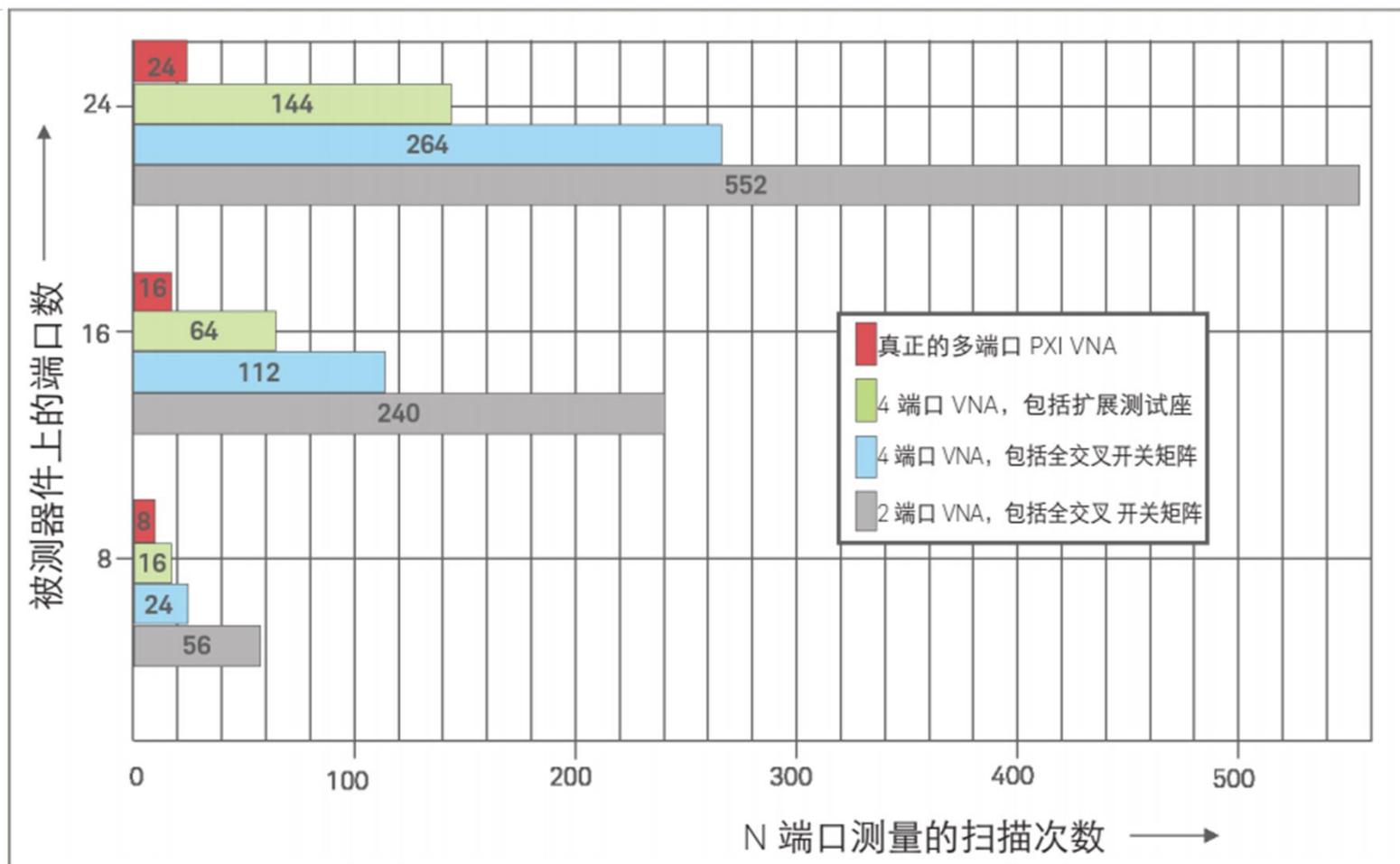


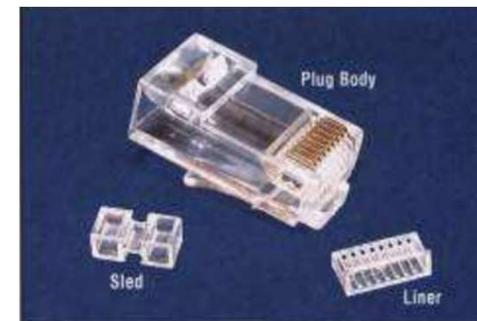
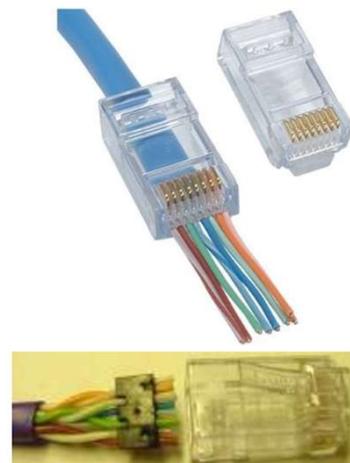
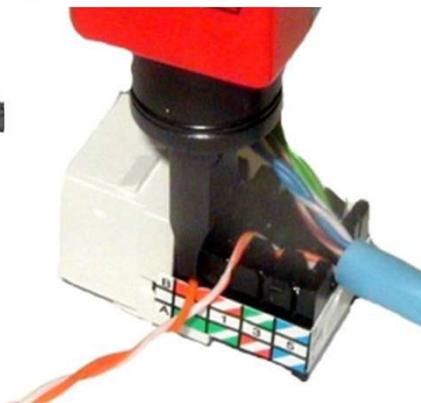
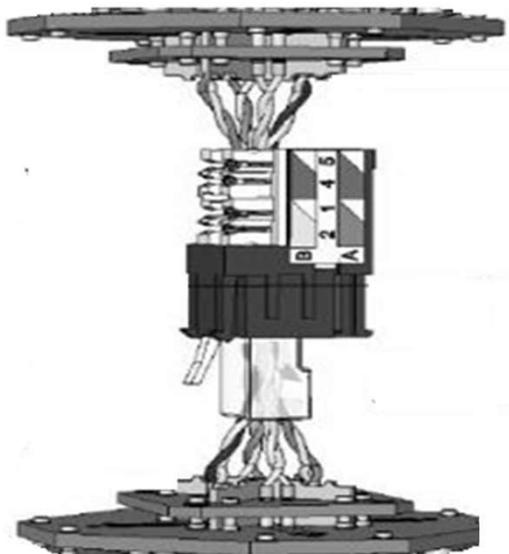
图 9. 真正的多端口解决方案与基于开关的解决方案相比，扫描次数显著减少，测量速度极大加快。

被测件的准备

被测件的准备

1 被测件引线

- 插头/模块均需**手工接线**，**效率低**
- **人为因素**不可避免
- 一致性、可重复性**差**
- 难以**批量测试**



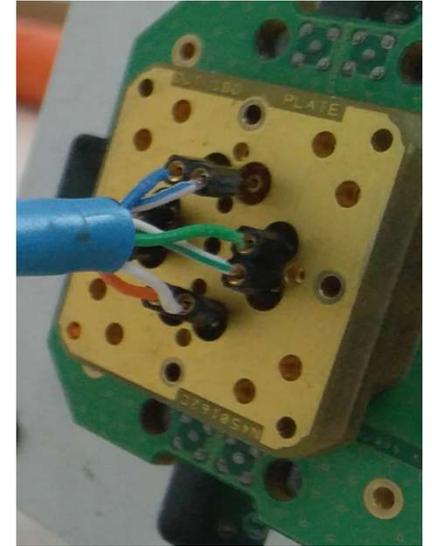
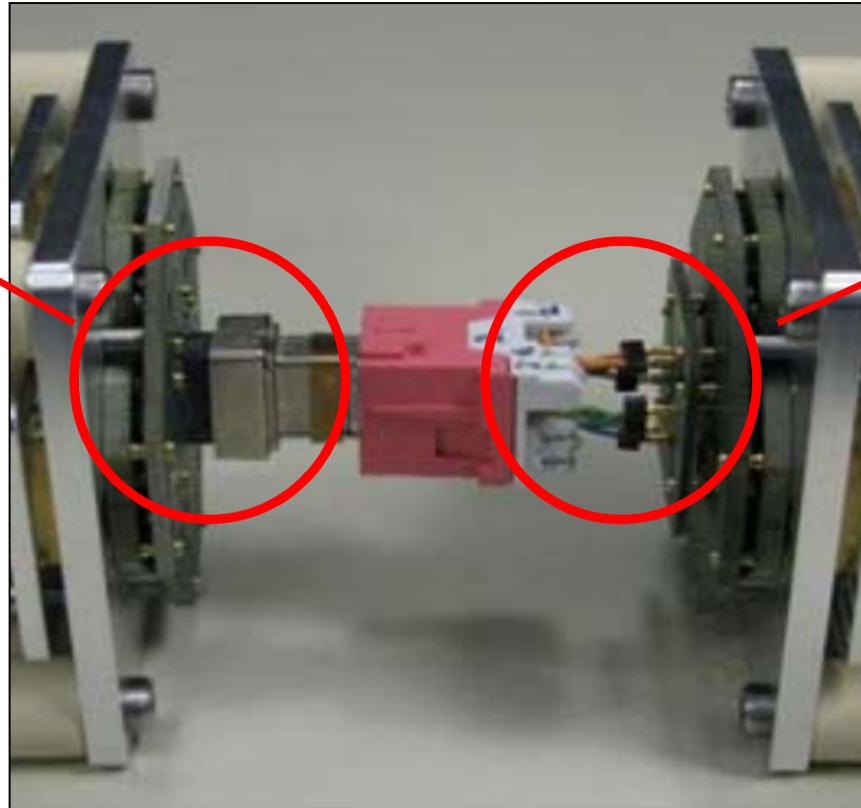
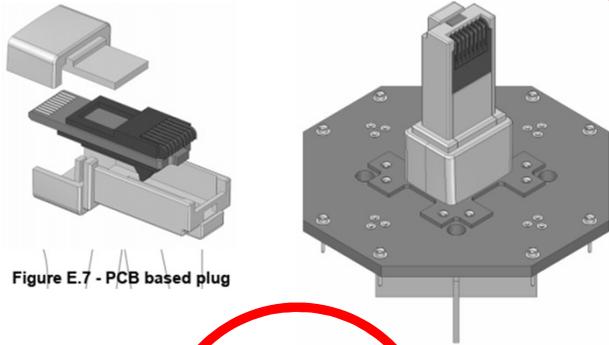
2 与夹具连接

- **手工操作**，**效率低**
- 锡焊，**消耗**夹具配件
- 插接，可能**接触不良**

PCB插头组件 + 模块引出线

优点

- 无需手工接线
- 精度高
- 工效高



缺点

- 手工接线，效率低
- 人为因素不可避免
- 一致性、可重复性差
- 锡焊，消耗夹具配件
- 插接，可能接触不良
- 难以批量测试

AEM公司的解决方案



AEM 网分设备



- 模块化设计
- 测试带宽：0.1MHz~3000MHz
- 单机/双机/多机协同运行
- 16端口（8通道）可无限扩展
- 双端**同时**测试4个通道
- 低成本



性能指标



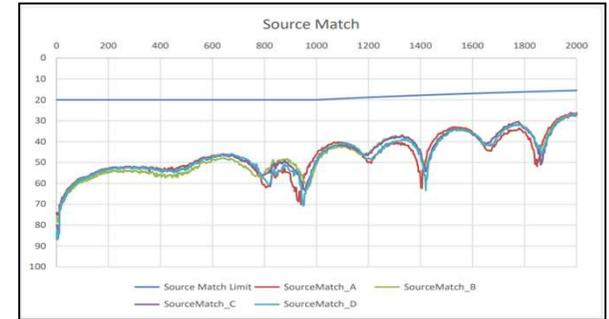
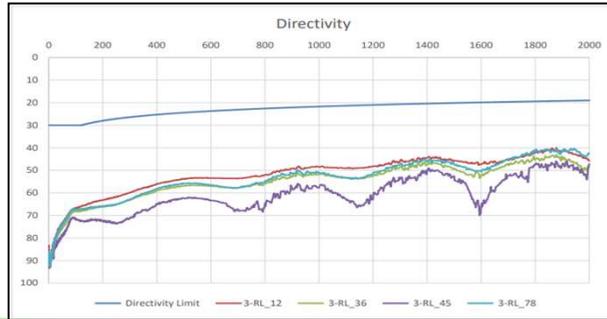
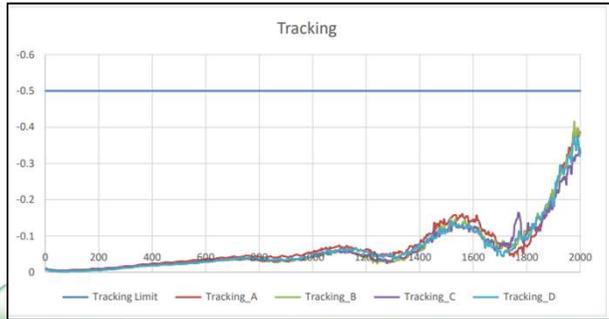
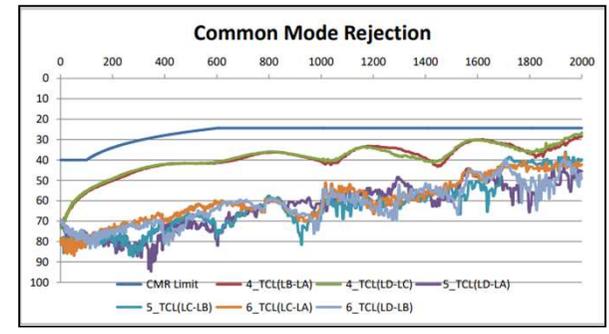
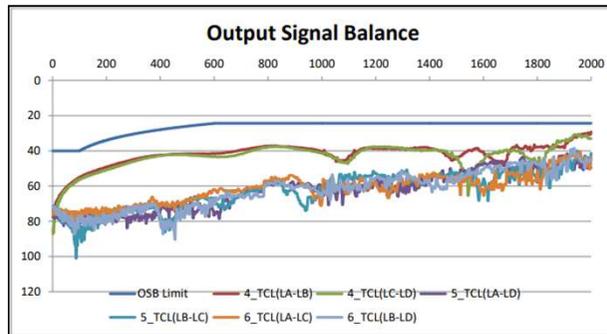
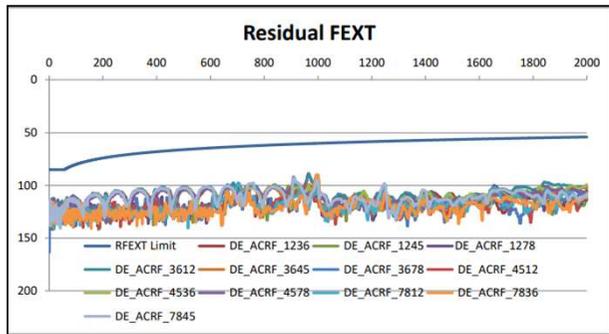
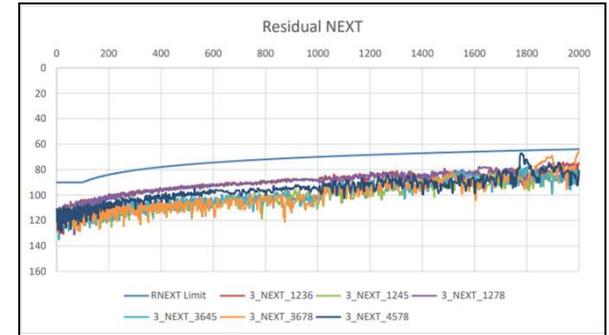
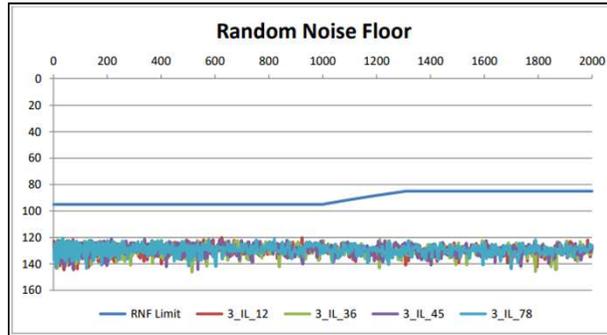
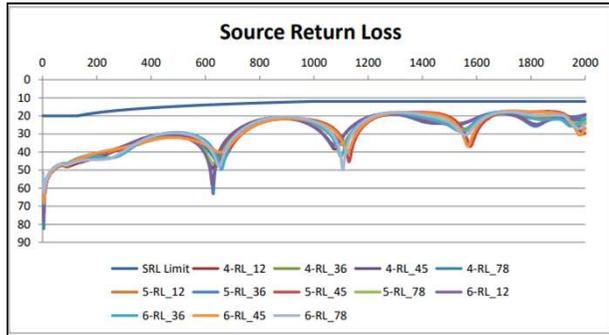
MMVNA-200

- 单机/双机、多机同步运行
- 开放数据接口

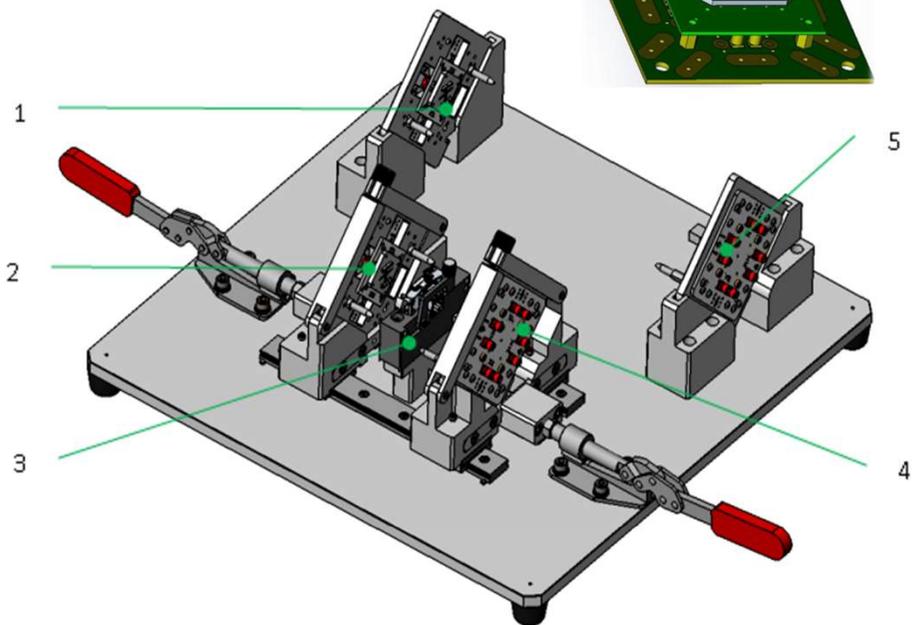
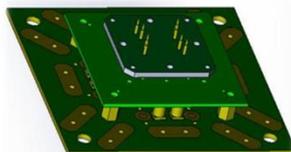
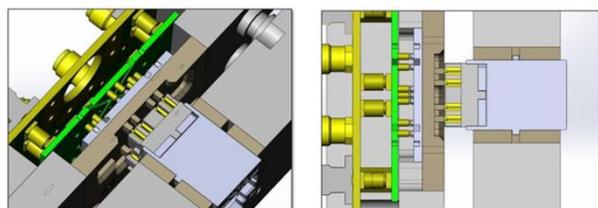
参数	指标
端口数量	8端口（4通道）
扫频起始频率 f_{start}	0.1MHz
扫频停止频率 f_{stop}	3000MHz
频率分辨率	0.1MHz
扫频类型	对数
扫频点数	3350（至3GHz）
输出功率	-60dB
扫频速度	0.3ms/步
测量带宽	$\leq 100\text{Hz}$
串扰本底噪声	快速扫描模式 80dB 慢速扫描模式 110dB
端口参考阻抗（差模）	50 Ω （单端），200 Ω （双端）
端口参考阻抗（共模）	25 Ω
数据校准	可溯源校准套件
平均功能	无
平滑功能	无
功耗	3W
外形尺寸	170mm x 170mm x 55mm



测试精度



专用夹具



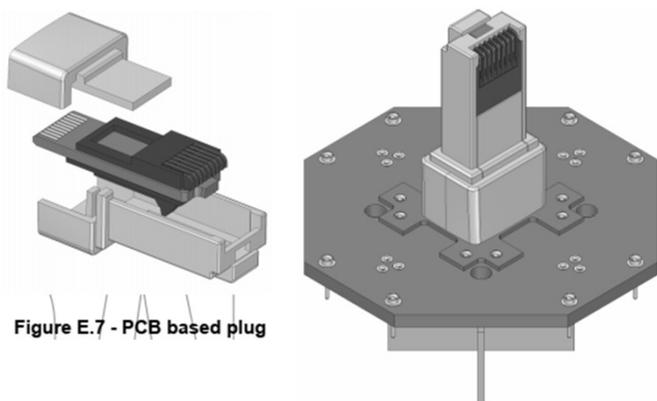
- 弹簧触针设计
- 被测RJ45模块无需卡接引线
- 高工效
- 适于生产线批量测试

序号	名称	功能描述
1	负载-弹簧针终端夹具	用于背向单端测试
2	SMA接口-弹簧针夹具	用于双端测试
3	夹具基座	固定夹具套件和被测RJ45模块
4	SMA接口-PCB测试插头夹具	用于双端测试
5	负载-PCB测试插头终端夹具	用于前向单端测试

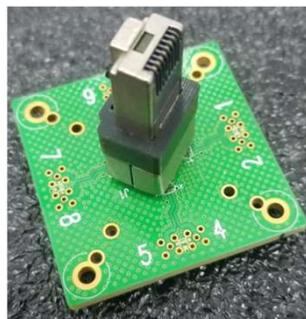


PCB测试插头 夹具

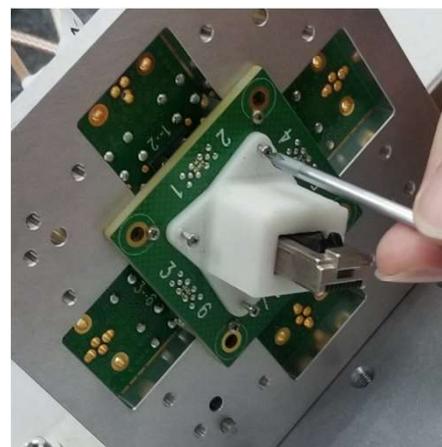
1 测试用插头



2 测试用插头
配套插座和转接PCB



3 插头+插座+PCB



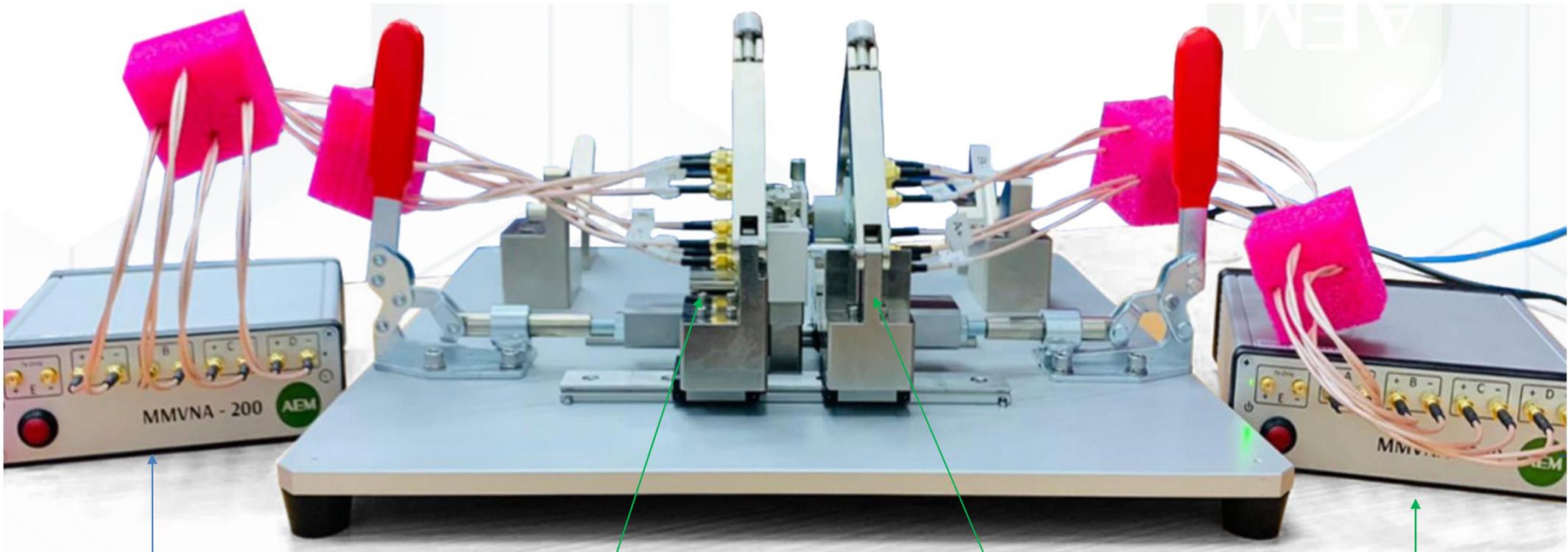
4 安装加固护套



5 完整测试夹具



AEM方案全貌



MMVNA-200 (REMOTE)

SMA -Pogo Jack Fixture

SMA -Plug Jack Fixture

MMVNA-200(MAIN)



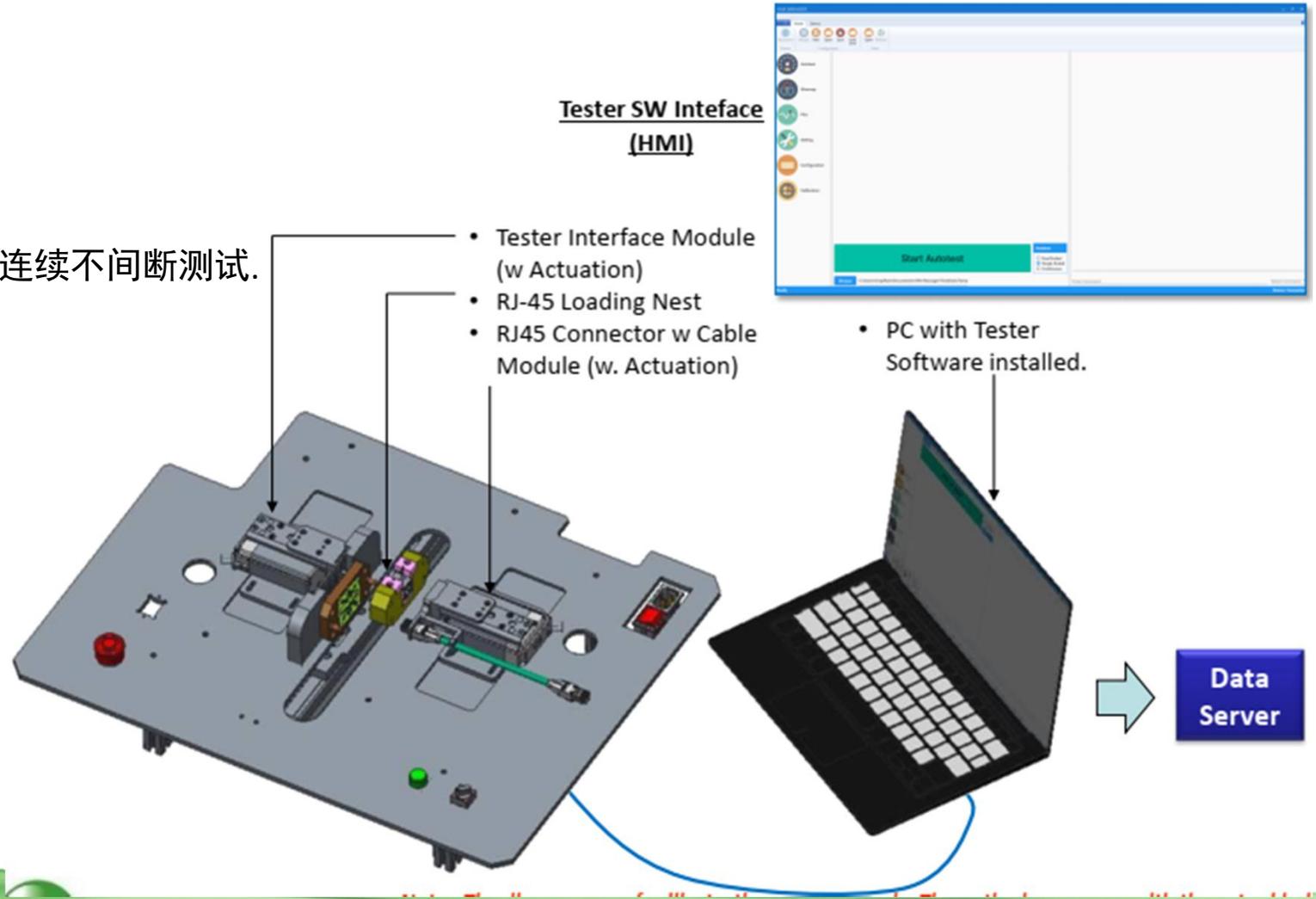
小结

测试成本		测试方案	16端口网分	2/4端口网分+ 开关矩阵	2/4端口网分+ 手动切换	AEM方案
设备成本	设备成本		高	中	低	低
	测试效率		高	中	低	高
人工成本	测试工时		低	中	高	低
	试样准备工时		高	高	高	低
综合成本			很高	高	中	很低

欲善其事，先利其器
让检测工作更有尊严

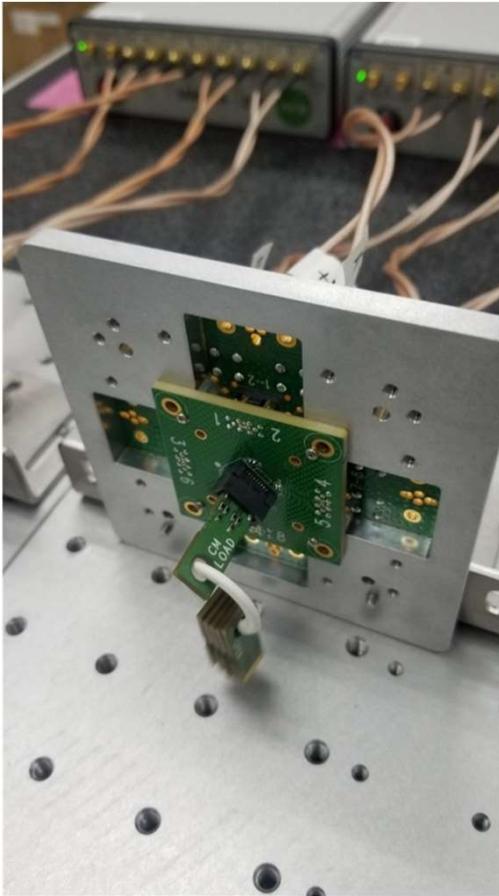
生产线 全自动化 测试方案

- 手动更换 RJ-45 模块.
- 弹簧探针导入测试信号.
- 自动水平接入测试头.
- 3个模块安装位, 往复循环, 连续不间断测试.

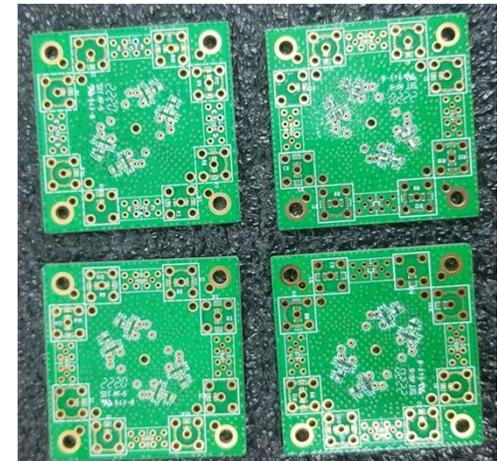
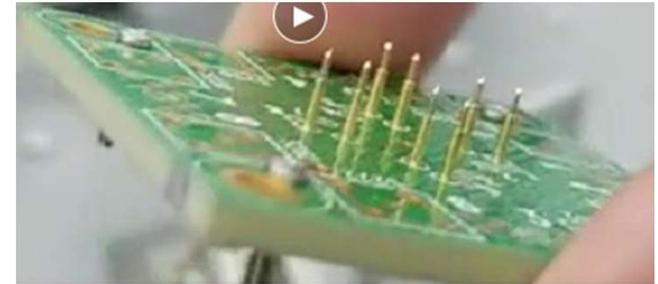


校准

PCB测试插头的校准



弹簧触针夹具的校准



校准件 SHORT LOAD THRU

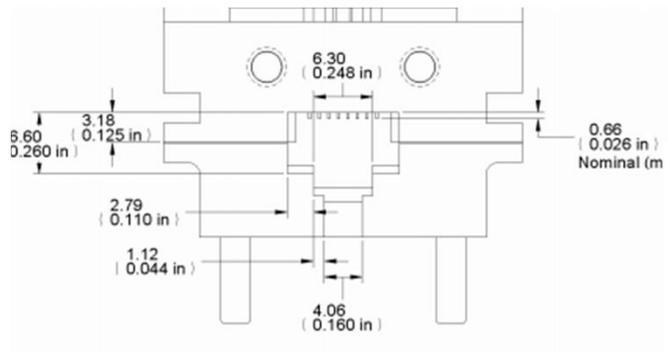


Figure C.20 - Direct fixture mating dimensions, front view

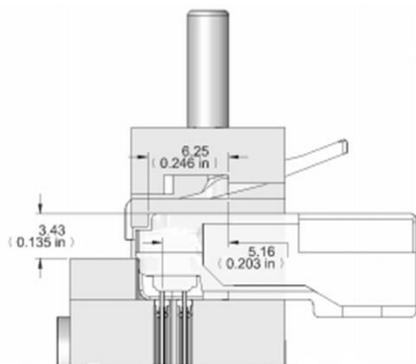


Figure C.21 - Direct fixture mating dimensions, side view

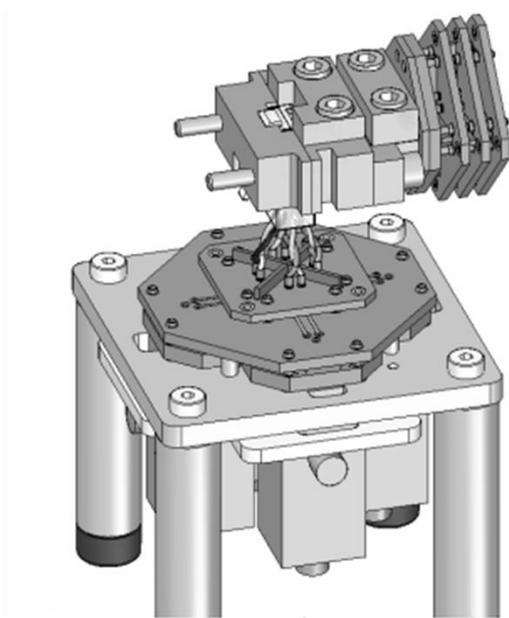


Figure C.24 - Example of a measurement setup for test plug NEXT loss

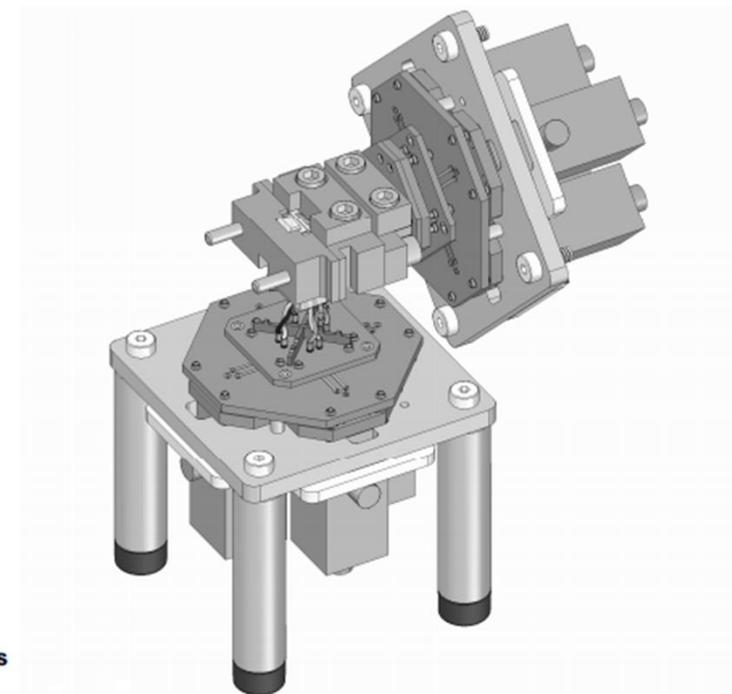


Figure C.25 - Example of a measurement setup for test plug FEXT loss

RL

- ISO/IEC 11801-1:2017 10. 2. 4. 2 Performance requirements
- TIA-568. 2-D 6. 10 Connection hardware transmission performance

$$28-20\lg(f/100)=28-20\lg(f)+40=68-20\lg(f)$$

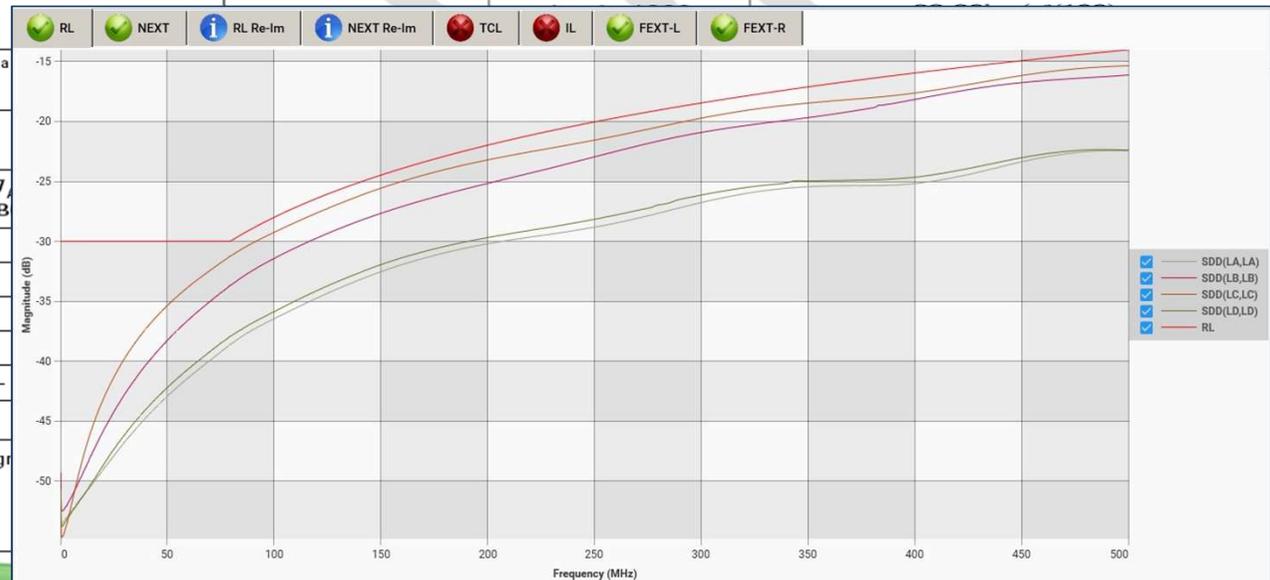
Table 121 - Connecting hardware return loss

	Frequency (MHz)	Return loss (dB)
Category 3	$1 \leq f \leq 16$	n/s
Category 5e	$1 \leq f \leq 31.5$ $31.5 < f \leq 100$	30 $20-20\lg(f/100)$
Category 6	$1 \leq f \leq 50$ $50 < f \leq 250$	30 $24-20\lg(f/100)$
Category 6A	$1 \leq f \leq 79$ $79 < f \leq 500$	30 $28-20\lg(f/100)$

Table 99 – Return loss

Frequency MHz	Minimum return loss ^a dB				
	Connector category				
	5	6	6 _A	7	7 _B
$1 \leq f \leq 100$	$60 - 20 \lg(f)$	-	-	-	-
$1 \leq f \leq 250$	-	$64 - 20 \lg(f)$	-	-	-
$1 \leq f \leq 500$	-	-	$68 - 20 \lg(f)$	-	-
$1 \leq f \leq 600$	-	-	-	$68 - 20 \lg(f)$	-
$1 \leq f \leq 1000$	-	-	-	-	68 -
$1 \leq f \leq 2000$	-	-	-	-	-

^a Return loss at frequencies that correspond to calculated values of minimum requirement of 30,0 dB.
^b Calculated values below 10,0 dB revert to a 10,0 dB plateau.
^c Calculated values below 12,0 dB revert to a 12,0 dB plateau.



IL

- ISO/IEC 11801-1:2017 10. 2. 4. 2 Performance requirements
- TIA-568. 2-D 6. 10 Connection hardware transmission performance

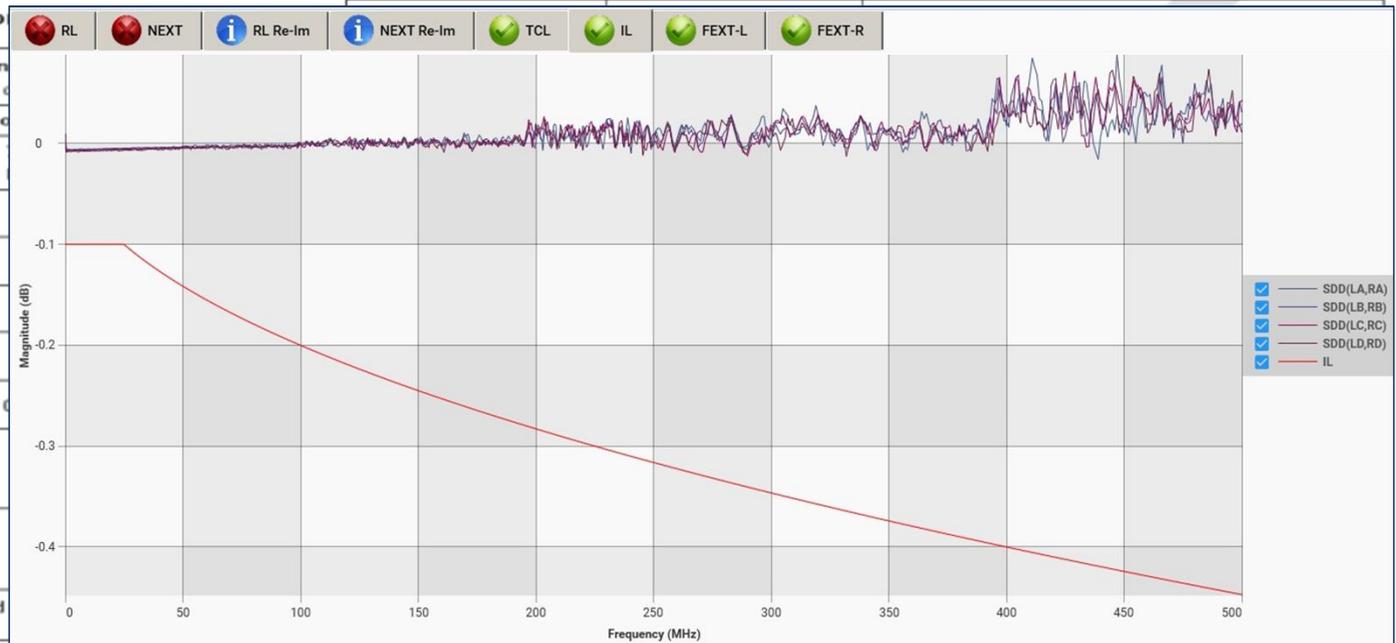
Table 123 - Connecting hardware insertion loss

	Frequency (MHz)	Insertion loss (dB)
Category 3	$1 \leq f \leq 16$	$0.10\sqrt{f}$
Category 5e	$1 \leq f \leq 100$	$0.04\sqrt{f}$
Category 6	$1 \leq f \leq 250$	$0.02\sqrt{f}$
Category 6A	$1 \leq f \leq 500$	$0.02\sqrt{f}$

Table 101 - Insertion loss

Frequency MHz	Maximum insertion loss (dB)			
	5	6	6A	7
$1 \leq f \leq 100$	$0.04\sqrt{f}$	-	-	-
$1 \leq f \leq 250$	-	$0.02\sqrt{f}$	-	-
$1 \leq f \leq 500$	-	-	$0.02\sqrt{f}$	-
$1 \leq f \leq 600$	-	-	-	$0.02\sqrt{f}$
$1 \leq f \leq 1000$	-	-	-	-
$500 \leq f \leq 2000$	-	-	-	-
$1000 \leq f \leq 2000$	-	-	-	-

^a Insertion loss at frequencies that correspond to calculated requirement of 0,1 dB maximum.



NEXT

- ISO/IEC 11801-1:2017 10.2.4.2 Performance requirements

- TIA-568.2-D 6.10 Connection hardware transmission performance

Table 125 - Connecting hardware NEXT loss

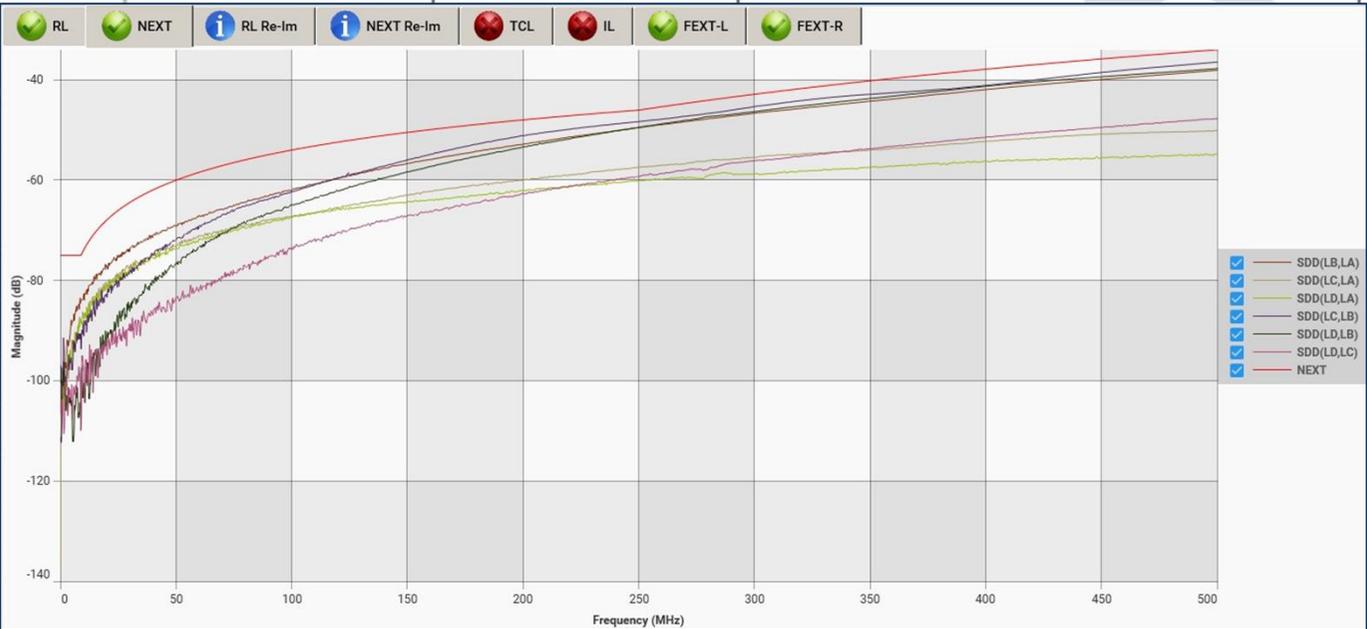
	Frequency (MHz)	NEXT loss (dB)
Category 3	$1 \leq f \leq 16$	$34 - 20\log(f / 16)$
Category 5e	$1 \leq f \leq 100$	$43 - 20\log(f / 100)$
Category 6	$1 \leq f \leq 250$	$54 - 20\log(f / 100)$
Category 6A	$1 \leq f \leq 250$ $250 < f \leq 500$	$54 - 20\log(f / 100)$ $46.04 - 40\log(f / 250)$

Table 103 - Near-end crosstalk

Frequency MHz	Category		
	5 ^a	6 ^a	6A ^a
$1 \leq f \leq 100$	$83 - 20\log(f)$	-	-
$1 \leq f \leq 250$	-	$94 - 20\log(f)$	$94 - 20\log(f)$
$250 < f \leq 500$	-	-	$46.04 - 30\log(f/250)$
$1 \leq f \leq 600$	-	-	-
$600 < f \leq 1000$	-	-	-
$500 \leq f \leq 2000$	-	-	-
$1000 \leq f \leq 1600$	-	-	-
$1600 \leq f \leq 2000$	-	-	-

^a NEXT at frequencies that correspond to calculated value requirement of 75,0 dB.

^b NEXT at frequencies that correspond to calculated value requirement of 80,0 dB.



FEXT Loss requirement in TIA and ISO

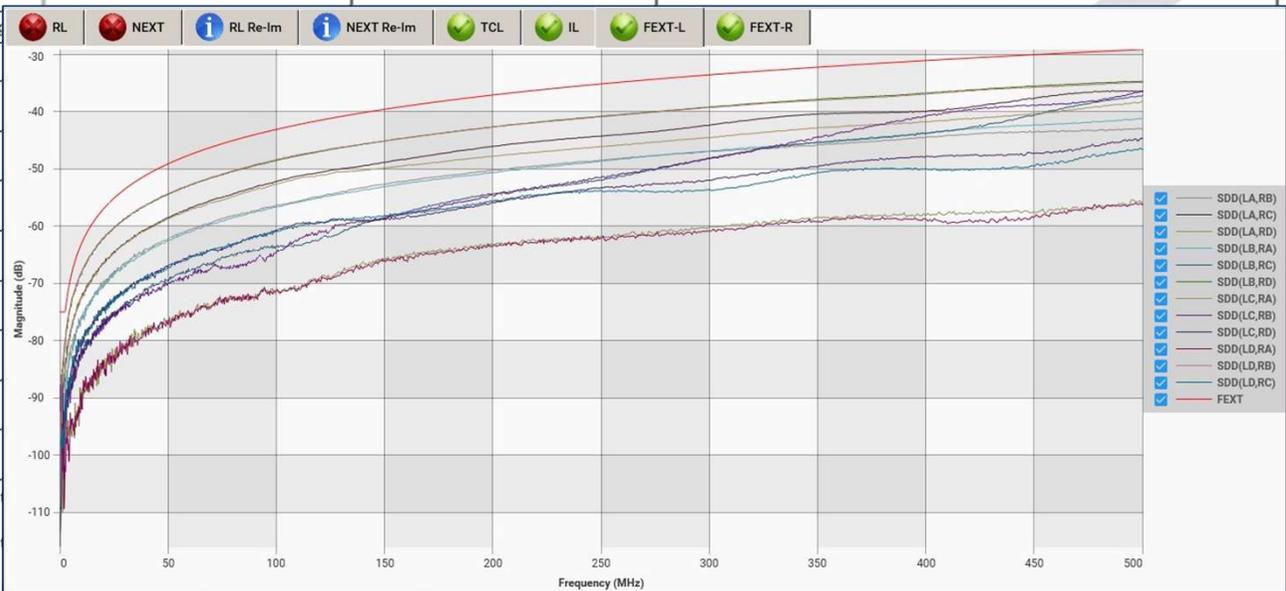
ISO/IEC 11801-1:2017 10.2.4.2
 Performance requirements
 TIA-568.2-D 6.10 Connection hardware
 transmission performance

Table 129 - Connecting hardware FEXT loss

	Frequency (MHz)	FEXT loss (dB)
Category 3	$1 \leq f \leq 16$	n/s
Category 5e	$1 \leq f \leq 100$	$35.1 - 20\log(f / 100)$
Category 6	$1 \leq f \leq 250$	$43.1 - 20\log(f / 100)$
Category 6A	$1 \leq f \leq 500$	$43.1 - 20\log(f / 100)$

Table 107 - Far-end crosstalk (FEXT)

Frequency MHz	Minimum FEXT ^c dB				
	Connector category				
	5 ^a	6 ^a	6A ^a	7 ^a	
$1 \leq f \leq 100$	$75.1 - 20\log(f)$	-	-	-	
$1 \leq f \leq 250$	-	$83.1 - 20\log(f)$	-	-	
$1 \leq f \leq 500$	-	-	$83.1 - 20\log(f)$	-	
$1 \leq f \leq 600$	-	-	-	$90 - 15\log(f)$	
$1 \leq f \leq 1000$	-	-	-	-	
$1 \leq f \leq 2000$	-	-	-	-	
$1000 \leq f \leq 1600$	-	-	-	-	
$1600 \leq f \leq 2000$	-	-	-	-	



^a FEXT at frequencies that correspond to calculated values of greater requirement of 75,0 dB.
^b FEXT at frequencies that correspond to calculated values of greater requirement of 80,0 dB.
^c For connectors, the difference between FEXT and ACR-F requirements are used to model ACR-F performance for links and channels.

TCL

- ISO/IEC 11801-1:2017 10.2.4.2 Performance requirements

- TIA-568.2-D 6.10 Connection hardware transmission performance

Table 133 - Connecting hardware TCL

	Frequency (MHz)	TCL (dB)
Category 3	$1 \leq f \leq 16$	n/s
Category 5e	$1 \leq f \leq 100$	n/s
Category 6	$1 \leq f \leq 250$	$28 - 20\log(f/100)$
Category 6A	$1 \leq f \leq 500$	$28 - 20\log(f/100)$

Table 116 - Transverse conversion

Frequency MHz	Minimum transverse conversion			
	5 ^a	6 ^a	6 _A ^a	68 ^b
$1 \leq f \leq 100$	$66 - 20\log(f)$	-	-	-
$1 \leq f \leq 250$	-	$68 - 20\log(f)$	-	-
$1 \leq f \leq 500$	-	-	$68 - 20\log(f)$	-
$1 \leq f \leq 600$	-	-	-	68 -
$1 \leq f \leq 1000$	-	-	-	-
$1 \leq f \leq 2000$	-	-	-	-

^a TCL at frequencies that correspond to calculated values of requirement of 50,0 dB.

^b TCL at frequencies that correspond to calculated values of requirement of 40,0 dB.



Thanks