



*Jmicro Technology*

## **Cal Kit Documentation**

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[www.jmicrotechnology.com](http://www.jmicrotechnology.com)

## Introduction - Obsolete

The PP™CM05 calibration substrate has structures to calibrate for three(3) versions of 5 mil adapter substrates. There are standards for the PP™0501, PP™0502, and PP™0503.

There are three(3) files on the Calibration disk which relate to this calibration substrate.

- 1) CK\_PPALL.20      0-20 GHz Standards
- 2) CK\_PPALL.40      0-40 GHz Standards
- 3) CK\_PPALL.80      0-80 GHz Standards

## Structures used in Cal Kit

Load - fixed 50  $\Omega$  load to ground  
Short - connection to ground through vias.  
Open25 - Open circuit (partially shielded)  
Line0 - 0 psec transmission line  
Line 5 - 5 psec transmission line  
Line10 - 10 psec transmission line  
Line15 - 15 psec transmission line  
Line37 - 37 psec transmission line

### Location of Calibration Structures

Structure	PP™0501	PP™0502	PP™0503
Load	2A	2C	7A
Short	3A	3C	8A
Open25	4A	4C	9A
Line0	6D	8D	10D
Line5	1A	1C	6A
Line10	6C	8C	10C
Line15	1B	1D	6B
Line37	7C/D	9C/D	11C/D

## Structures NOT used in Cal Kit

Offset Load - fixed 50  $\Omega$  load to ground  
Offset Short - connection to ground through vias.  
Offset Open - Open circuit (partially shielded)  
Line42S - 42 psec shorted transmission line

### Location of Calibration Structures

Structure	PP™0501	PP™0502	PP™0503
Offset Load	2B	2D	7B
Offset Short	3B	3D	8B
Offset Open	4B	4D	9B
Line42S	11A/B	-	-

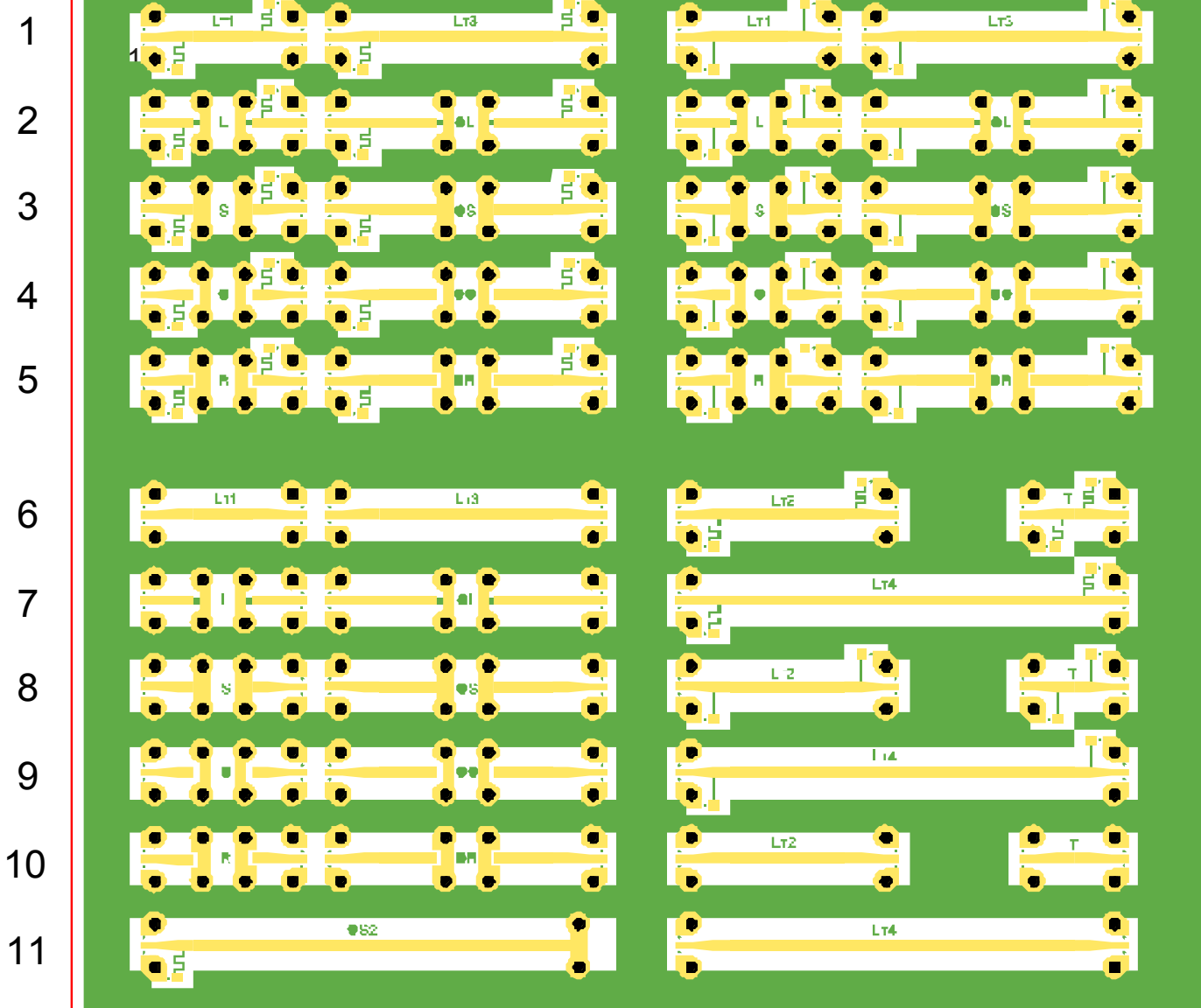
These structures can be used for calibration verification.

A

B

C

D



**PROBEPOINT™ CM05**  
**CPW-MSTRIP**

JMT0007  
 © 1993

## Introduction

The PP™CM05LX calibration substrate has structures to calibrate for the PP™0503, 5 mil adapter substrates. There are standards for the PP™0503.

There are three(3) files on the Calibration disk for the HP 8510C which relate to this calibration substrate.

- 1) CK\_PPALL.20      0-20 GHz Standards
- 2) CK\_PPALL.40      0-40 GHz Standards
- 3) CK\_PPALL.80      0-80 GHz Standards

## Structures used in Cal Kit

Load - fixed 50  $\Omega$  load to ground

Short - connection to ground through vias.

Open25 - Open circuit (partially shielded)

Line0 - 0 psec transmission line

Line 5 - 5 psec transmission line

Line10 - 10 psec transmission line

Line15 - 15 psec transmission line

Line35 - 35 psec transmission line

### Location of Calibration Structures

Structure	PP™0503
Load	2A
Short	3A
Open25	4A
Line0	4B
Line5	1A
Line10	3B
Line15	1B
Line35	2B

## Structure NOT used in Cal Kit

NA

Unused structures can be used for calibration verification.

A

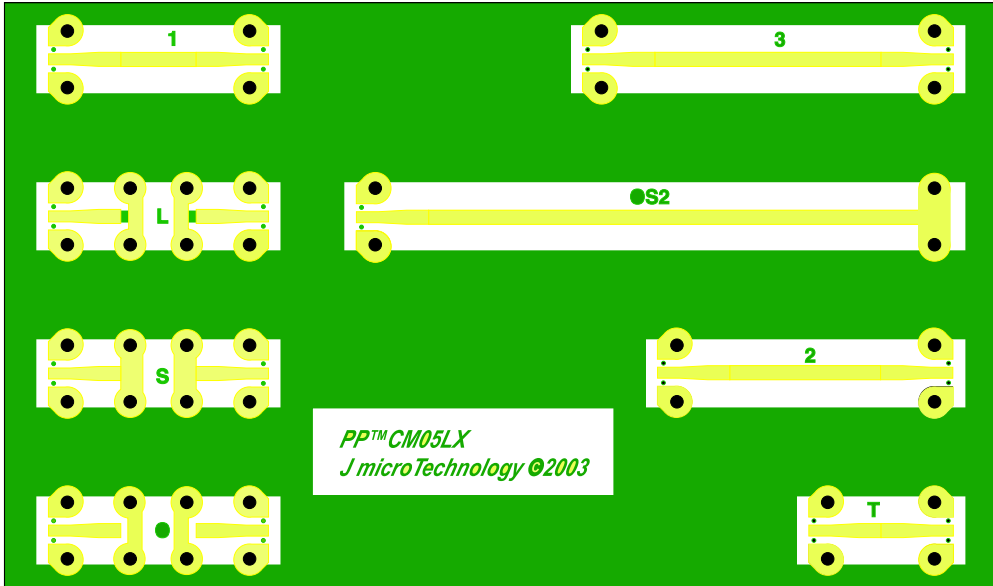
B

1

2

3

4



## Introduction - Obsolete

The PP™CM10 calibration substrate has structures to calibrate for three(3) versions of 10 mil adapter substrates. There are standards for the PP™ 1001, PP™ 1002, and PP™ 1003.

There are three(3) files on the Calibration disk which relate to this calibration substrate.

- 1) CK\_PPALL.20      0-20 GHz Standards
- 2) CK\_PPALL.40      0-40 GHz Standards
- 3) CK\_PPALL.80      0-80 GHz Standards

## Structures used in Cal Kit

Load - fixed 50 Ω load to ground  
Short - connection to ground through vias.  
Open25 - Open circuit (partially shielded)  
Line0 - 0 psec transmission line  
Line 5 - 5 psec transmission line  
Line10 - 10 psec transmission line  
Line15 - 15 psec transmission line  
Line37 - 37 psec transmission line

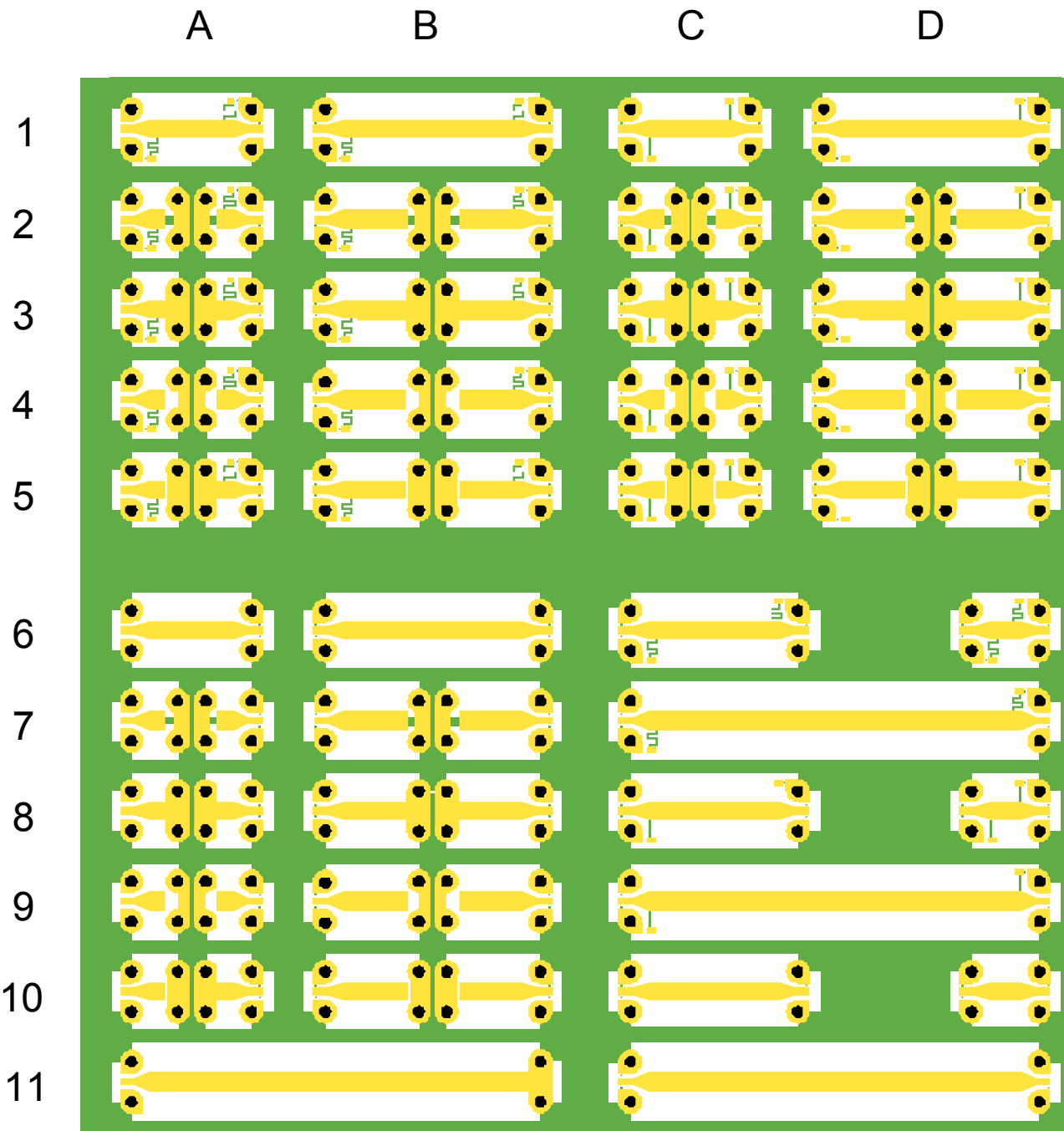
Structure	Location of Calibration Structures		
	PP™ 1001	PP™ 1002	PP™ 1003
Load	2A	2C	7A
Short	3A	3C	8A
Open25	4A	4C	9A
Line0	6D	8D	10D
Line5	1A	1C	6A
Line10	6C	8C	10C
Line15	1B	1D	6B
Line37	7C/D	9C/D	11C/D

## Structures NOT used in Cal Kit

Offset Load - fixed 50 Ω load to ground  
Offset Short - connection to ground through vias.  
Offset Open - Open circuit (partially shielded)  
Line42S - 42 psec shorted transmission line

Structure	Location of Calibration Structures		
	PP™ 1001	PP™ 1002	PP™ 1003
Offset Load	2B	2D	7B
Offset Short	3B	3D	8B
Offset Open	4B	4D	9B
Line42S	-	11A/B	-

These structures can be used for calibration verification.



**PROBEPPOINT™ CM10**  
**CPW-MSTRIP**

JMT0011  
 ©1993

## Introduction

The PP™CM10LX calibration substrate has structures to calibrate for the PP™1003, 10 mil adapter substrates. There are standards for the PP™1003.

There are three(3) files on the Calibration disk for the HP 8510C which relate to this calibration substrate.

- 1) CK\_PPALL.20      0-20 GHz Standards
- 2) CK\_PPALL.40      0-40 GHz Standards
- 3) CK\_PPALL.80      0-80 GHz Standards

## Structures used in Cal Kit

Load - fixed 50  $\Omega$  load to ground  
Short - connection to ground through vias.  
Open25 - Open circuit (partially shielded)  
Line0 - 0 psec transmission line  
Line 5 - 5 psec transmission line  
Line10 - 10 psec transmission line  
Line15 - 15 psec transmission line

### Location of Calibration Structures

Structure	PP™1003
Load	2A
Short	3A
Open25	4A
Line0	4B
Line5	1A
Line10	3B
Line15	2B

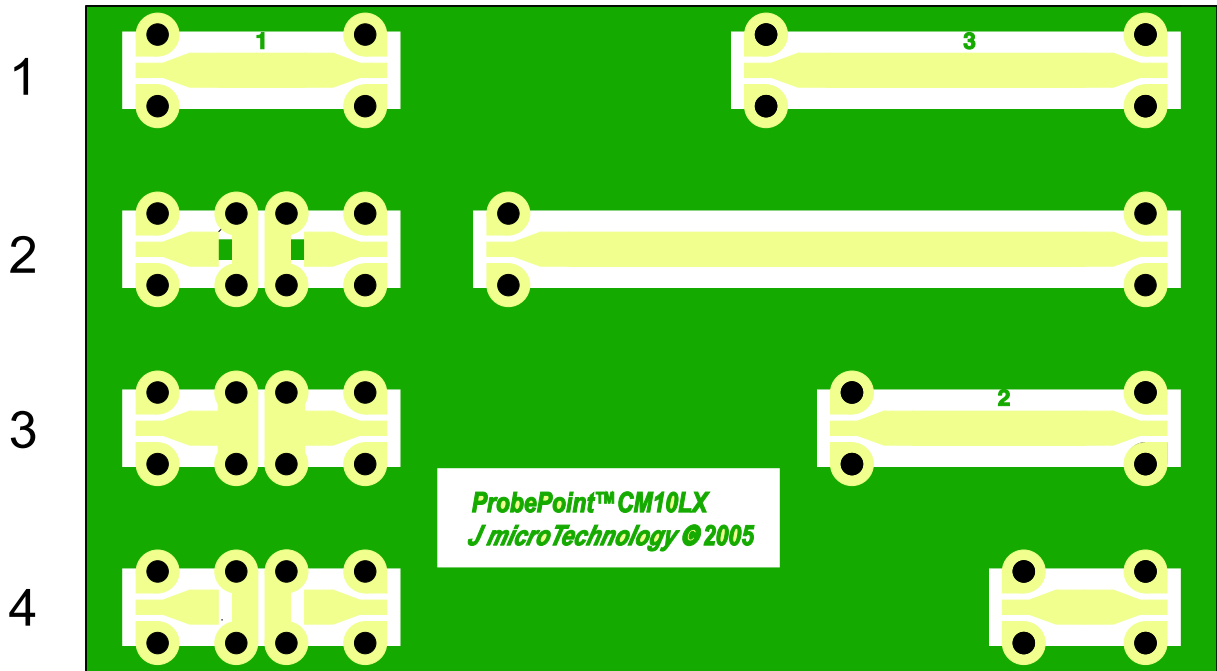
## Structure NOT used in Cal Kit

LineOS2 - shorted transmission line

This structures can be used for calibration verification.

A

B



# Introduction

The PP™CM12 calibration substrate has structures to calibrate for one(1) versions of 10 mil adapter substrates, the PP™1003. The disk files are those used for the PP™CM10.

There are three(3) files on the Calibration disk which relate to this calibration substrate.

- 1) CK\_PPALL.20      0-20 GHz Standards
- 2) CK\_PPALL.40      0-40 GHz Standards
- 3) CK\_PPALL.80      0-80 GHz Standards

## Structures used in Cal Kit

- Load - fixed 50 Ω load to ground
- Short - connection to ground through vias.
- Open25 - Open circuit (partially shielded)
- Line0 - 0 psec transmission line
- Line 5 - 5 psec transmission line
- Line10 - 10 psec transmission line
- Line15 - 15 psec transmission line
- Line37 - 37 psec transmission line

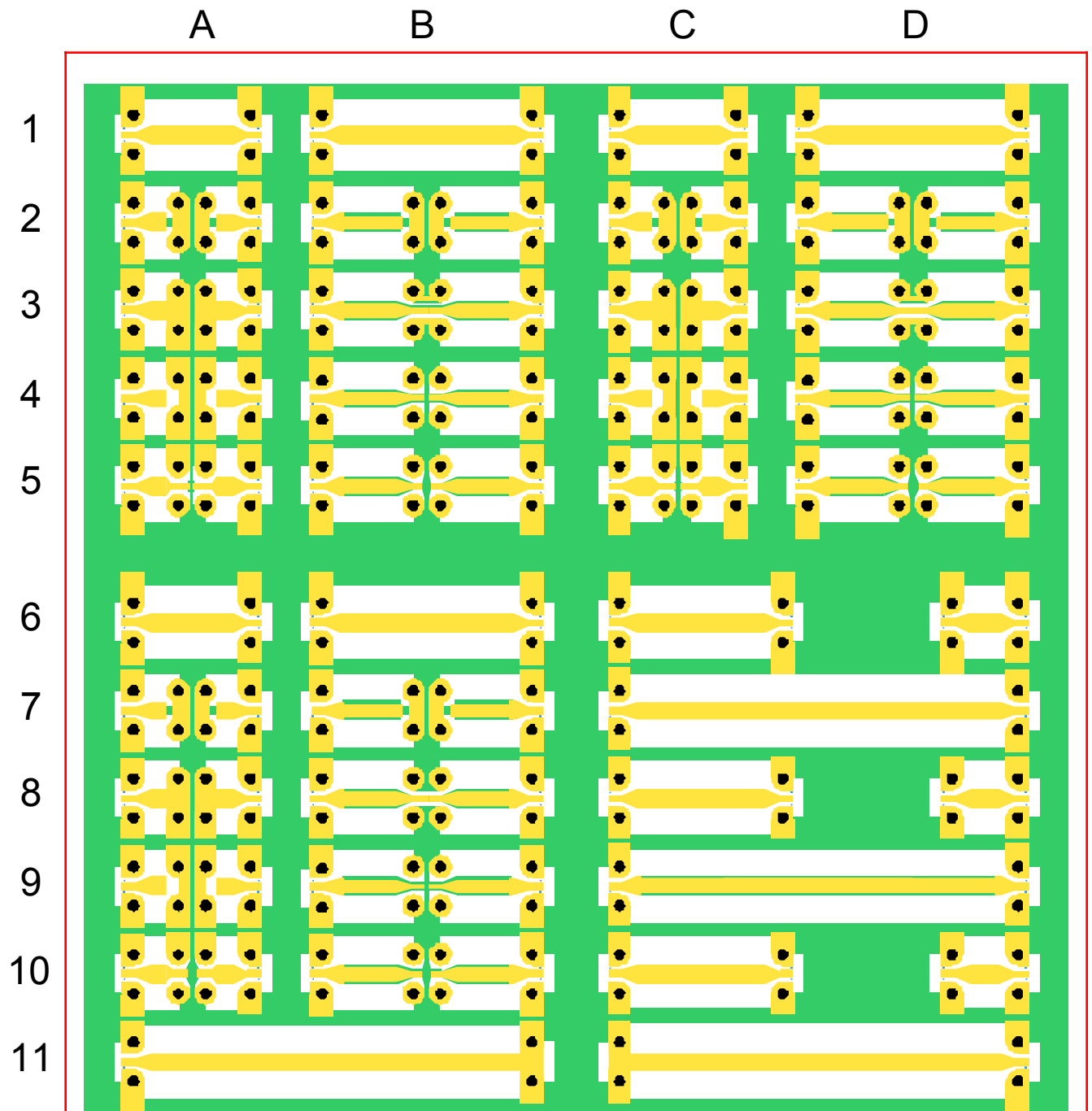
Structure	Location of Calibration Structures		
	PP™ 1003		
Load	2A	2C	7A
Short	3A	3C	8A
Open25	4A	4C	9A
Line0	6D	8D	10D
Line5	1A	1C	6A
Line10	6C	8C	10C
Line15	1B	1D	6B
Line37	7C/D	-	11C/D

## Structures NOT used in Cal Kit

- Offset Load - fixed 50 Ω load to ground
- Offset Short - connection to ground through vias.
- Offset Open - Open circuit (partially shielded)
- Line42S - 42 psec shorted transmission line

Structure	Location of Calibration Structures		
	PP™ 1003		
Offset lossy Load	2B	2D	7B
Lossy Lines	3B	3D	8B
Lossy Lines/attn	4/5B	4/5D	9/10B
Line42S	-	11A/B	11C/D

These structures can be used for calibration verification.



**PROBEPPOINT™ CM12**

**CPW-MSTRIP CALIBRATION**

JMT0012

© 1994

## Introduction

The PP™CM15 calibration substrate has structures to calibrate for two(2) versions of 15 mil adapter substrates. There are standards for the PP™1503 and PP™1505.

There is one(1) file on the Calibration disk which relate to this calibration substrate.

1) CK\_PPALL\_.80 0-80 GHz Standards

## Structures used in Cal Kit

Load - fixed 50  $\Omega$  load to ground

Short - connection to ground through vias.

Open25 - Open circuit (partially shielded)

Line0 - 0 psec transmission line

Line 5 - 5.2 psec transmission line

Line30 - 31.2 psec transmission line

Line83 - 83.2 psec transmission line

Structure	Location of Calibration Structures				
	PP™ 1505/1503		PP™ 1503		
Load	2A	2B	2C	2D	2E
Short	3A	3B	3C	3D	3E
Open25	4A	4B	4C	4D	4E
Line0	8A		9E		
Line5	1A	1B	1C	1D	1E
Line30	5A/B		6D/E		
Line83	9A/B/C/D		8B/C/D/E		

## Structures NOT used in Cal Kit

Loaded Lossy Line - fixed 50  $\Omega$  load to ground

Linelong - PPi1505/PPi1503 transmission line

Structure	Location of Calibration Structures		
	PP™ 1505	PP™ 1503	
Loaded Line	5C/D/E	6A/B/C	7C/D/E
Longline		10A/B/C/D/E	

These structures can be used for calibration verification.

A

B

C

D

E

1



2



3



4



5



6



7



8



9



10



# Standards Definition

Standard	C0 x 10 <sup>-15</sup> F		C1 x 10 <sup>-36</sup> F/Hz <sup>2</sup>		C2 x 10 <sup>-27</sup> F/Hz		C3 x 10 <sup>-45</sup> F/Hz <sup>3</sup>		Fixed or Sliding	Terminal Impedance Ω	Offset			Frequency (GHz)		Coax or Waveguide	Standard Label
	NO.	TYPE	L0 x 10 <sup>-12</sup> H	L1 x 10 <sup>-24</sup> Hz	L2 x 10 <sup>-33</sup> Hz <sup>2</sup>	L3 x 10 <sup>-42</sup> Hz <sup>3</sup>	Delay ps	Zo Ω			Loss GΩ/s	MIN	MAX				
1	OPEN	25									0	50	0	0	999	COAX	OPEN25
2	SHORT	43	160								0	50	0	0	999	COAX	SHORT
3	LOAD							FIXED			0.09	500	0	0	999	COAX	LOAD
4	THRU										5.2	50	4	0	999	COAX	LINE5
5	OPEN	25									0	50	0	0	999	COAX	OPEN25
6	SHORT	43	160								0	50	0	0	999	COAX	SHORT
7	LOAD							FIXED			0.09	500	0	0	999	COAX	LOAD
8	THRU										0	50	0	0	999	COAX	LINE0
9	OPEN										0	50	0	0	999	COAX	OPEN
10	SHORT										0	50	0	0	999	COAX	SHORT
11	THRU										5.2	50	4	10.6	84.6	COAX	LINE5
12	THRU										15.6	50	4	3.5	28	COAX	LINE15
13	THRU										31.2	50	4	1.7	13.8	COAX	LINE37
14	THRU										10.4	50	4	5.2	41.5	COAX	LINE10
15																	
16																	
17																	
18																	
19																	
20																	
21																	
22																	

NOTES

not on PP15

not on PP15

Calibration Kit PP™CM/ALL'

Tape File Number 0-20 GHz

## Standards Class Assignments

Class	A	B	C	D	E	F	G	Standard Class Label
S11A	1							OPEN11
S11B	2							SHORT
S11C	3							LOAD
S22A	5							OPEN11
S22B	6							SHORT
S22C	7							LOAD
Forward Transmission	4							LINE5
Reverse Transmission	4							LINE5
Forward Match	4							LINE5
Reverse Match	4							LINE5
Frequency Response	4							LINE5
TRL Thru	8							LINE0
TRL Reflect	9	10						OPEN/SHORT
TRL Line Transmission	3	12						TLINES

Calibration Kit PP™CM'ALL'

Tape File Number 0-40 GHz

## Standards Class Assignments

Class	A	B	C	D	E	F	G	Standard Class Label
S11A	1							OPEN11
S11B	2							SHORT
S11C	3							LOAD
S22A	5							OPEN11
S22B	6							SHORT
S22C	7							LOAD
Forward Transmission	4							LINE5
Reverse Transmission	4							LINE5
Forward Match	4							LINE5
Reverse Match	4							LINE5
Frequency Response	4							LINE5
TRL Thru	8							LINE0
TRL Reflect	9	10						OPEN/SHORT
TRL Line Transmission	3	12	14					TLINES

Calibration Kit PP™CM'ALL'

Tape File Number 0-84.gHz

## Standards Class Assignments

Class	A	B	C	D	E	F	G	Standard Class Label
S11A	1							OPEN11
S11B	2							SHORT
S11C	3							LOAD
S22A	5							OPEN11
S22B	6							SHORT
S22C	7							LOAD
Forward Transmission	4							LINE5
Reverse Transmission	4							LINE5
Forward Match	4							LINE5
Reverse Match	4							LINE5
Frequency Response	4							LINE5
TRL Thru	8							LINE0
TRL Reflect	9	10						OPEN/SHORT
TRL Line Transmission	3	11	12	13				TLINES

Calibration Kit PP™CM15

## Standards Class Assignments

Tape File Number 0-84gHz

Class	A	B	C	D	E	F	G	Standard Class Label
S11A	1							OPEN11
S11B	2							SHORT
S11C	3							LOAD
S22A	5							OPEN11
S22B	6							SHORT
S22C	7							LOAD
Forward Transmission	4							LINE5
Reverse Transmission	4							LINE5
Forward Match	4							LINE5
Reverse Match	4							LINE5
Frequency Response	4							LINE5
TRL Thru	8							LINE0
TRL Reflect	9	10						OPEN/SHORT
TRL Line Transmission	3	11	13					TLINES

# Standards Definition

Standard	C0 x 10 <sup>-15</sup> F	C1 x 10 <sup>-36</sup> F/Hz <sup>2</sup>	C2 x 10 <sup>-27</sup> F/Hz	C3 x 10 <sup>-45</sup> F/Hz <sup>3</sup>	Fixed or Sliding	Terminal Impedance $\Omega$	Offset			Frequency (GHz)		Coax or Waveguide	Standard Label
							Delay ps	Zo $\Omega$	Loss G $\Omega$ /s	MIN	MAX		
NO. 1													
1	Short						0.9	50	0	0	999	COAX	SHORT
2	Open	25					0	50	0	0	999	COAX	OPEN
3	Load				FIXED		0.9	50	0	0	999	COAX	LOAD
4	Thru						5.2	50	4	4	999	COAX	LINE5
5	Sliding Load						0	50		0	999	COAX	
6	Delay						15.6	50	4	4	3.5	28	LINE15
7	Delay						10.4	50	4	4	5.2	41.5	LINE10
8	Delay						31.2	50	4	4	1.7	13.8	LINE37

NOTES





# Test Adapter Substrates Ease The Task of Measuring PHEMT FETs

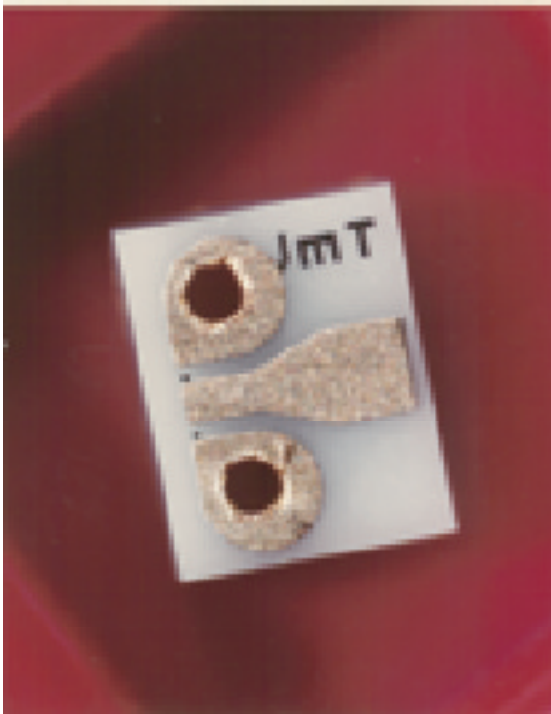


Figure 1 - ProbePoint™ 1003 Adapter Substrate

## Summary

A new method of fixturing microstrip die and other non-coplanar devices is described. An example Pseudomorphic High Electron Mobility Transistor (FET) measurement to 50 GHz is shown along with companion noise parameters to 26 GHz. The direct adapter substrate calibration technique is discussed and verification data shown.

## Introduction and Background

The use of coplanar and coaxial microprobes has made many microwave measurements easier and more accurate. However, there are many products, including FETs, MMICs, chip capacitors, chip resistors, chip inductors that are designed for microstrip applications. None of these products have the required signal and ground pads orientation and the required spacing allowing microprobing. These devices will generally be wire bonded into a circuit, so that the wire bond becomes one of the circuit elements. Consequently, it is desired that the measured S-parameters of this device also include the bond wire response. For example, a low noise GaAs FET die will generally be die attached to a metalized ceramic substrate, and the gate, drain, and source are bond wired (using very short double bonds) to the specified pads on the substrate. Note that the bond wire lengths of the test samples must be identical with the specific application.

Until recently, these measurements have been difficult and tedious. A new set of adapters and associated calibration technique makes these measurements straightforward. The adapters, shown in Figure 1, adapt a coplanar probe to microstrip, which connects to the DUT with bondwires. A typical low noise FET application is shown in Figure 2.

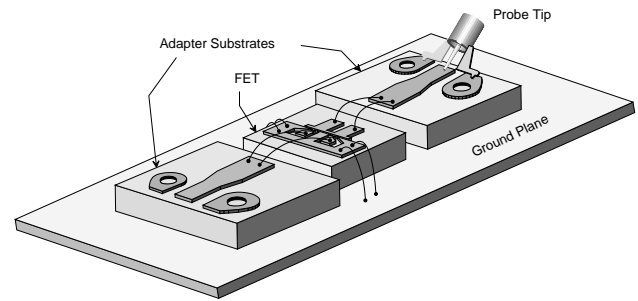


Figure 2. - PHEMT with Adapter Substrate

Double bonds (as used in the actual application) connect the gate and drain metalization to the adapter microstrip. The source metalization is wire bonded to the ground plane, which is common to the entire setup. Any gold metalized conductor works well for the carrier. The DUT dice and the adapter substrates are either attached with silver epoxy or eutectic solder, as required.

## Example Measurements

Microwave semiconductor manufacturers and customers are using the adapters to measure advanced devices. An example use of the adapters is for recent measurements of the low noise Litton Solid State LP7512 PHEMT FETs S-Parameters to 50 GHz, and noise parameter measurements to 26 GHz. The DUTs were set up as shown above in Figure 2. using 10 mil thick adapter substrates. After calibration (described below), excellent data was obtained through 50 GHz. The S-parameter data is shown in Figure 3.

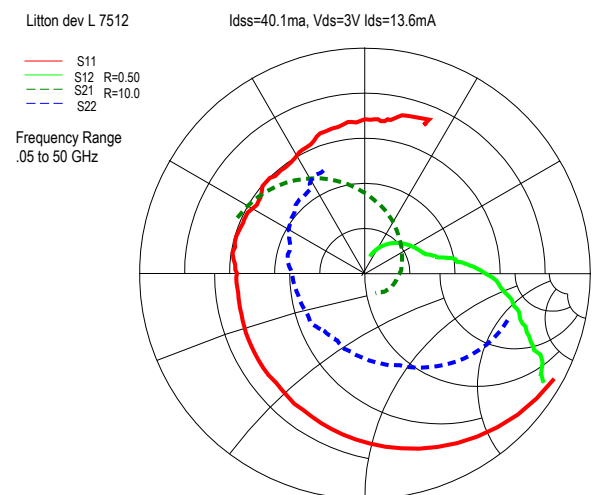


Figure 3. - LP7512 S-Parameters

The measured noise parameter data also looked equally as good and self consistent, particularly for such low noise devices. The quality of the data indicates that both the adapter substrates and the associated calibration techniques were performing properly, comparable to good “on-wafer” data. Important to the quality of the measurements is both the “transition” integrity from the microprobe tip to microstrip bond pad and the calibration precision.

## Calibration

The calibration technique and standards are critical to the correct use of these adapters, particularly above 26 GHz. At lower frequencies, and for less demanding measurements, many people simply calibrate their Automatic Network Analyzer up to the probe tips, as before for on-wafer measurements. Then they move the reference planes out 5.1 ps to compensate for the adapter substrate delay. For more accurate requirements, and beyond 26 GHz, a better method is needed. This is provided by using a TRL calibration technique with the PP CM10 cal substrate. When used together with the cal kit available on floppy disk, the correct direct calibration of the adapter substrates is easily obtained. This technique was used in the above example.

Table 1. PP CM10 - Cal - Kit Description.

Cal Kit File Name	Cal Kit Name	Cal Method	Recommended Min/Max Frequency
CK_SOLT	PP10SOLT	Short, Open, Load, Thru	DC to 10 GHz
CK_LRM	PP10LRM	Line, Reflect, Match	DC to 50 GHz
CK_TRL	PP10TRL	Thru, Reflect, Line	1.5 to 50 GHz

### The calibration technique is easy:

1. Load the TRL cal kit labeled CK\_TRL into the network analyzer; see Table 1. If your Automatic Network Analyzer is not able to read the enclosed disk, a tabular listings for manual data input is available from J microTechnology.
2. Sequentially probe the standards standard identified in Figure 4, stepping through the cal process. It is important to place the probes at the same location with respect to the vias, when probing each calibration structure.
3. Verify the calibration. A one port verification can easily be performed by placing the probes, one at a time, on Line42S (see Figure 4). The response should be a spiral on a Smith chart, similar to Figure 5.

A two port cal can be verified by placing both probes on Line11 (a total 22.2 ps long line). Be sure to place the probes at the same position relative to the vias as during the cal process. The S11 and S22 response should be well controlled, with the maximum reflection of 30+ dB at 10 GHz, and 20-30 dB at 50 GHz. The delay should be 12 ps (read off the display of the Network Analyzer), demonstrating that the offset calibration is indeed offset by 5.1 ps on each port.

4. Proceed to measure

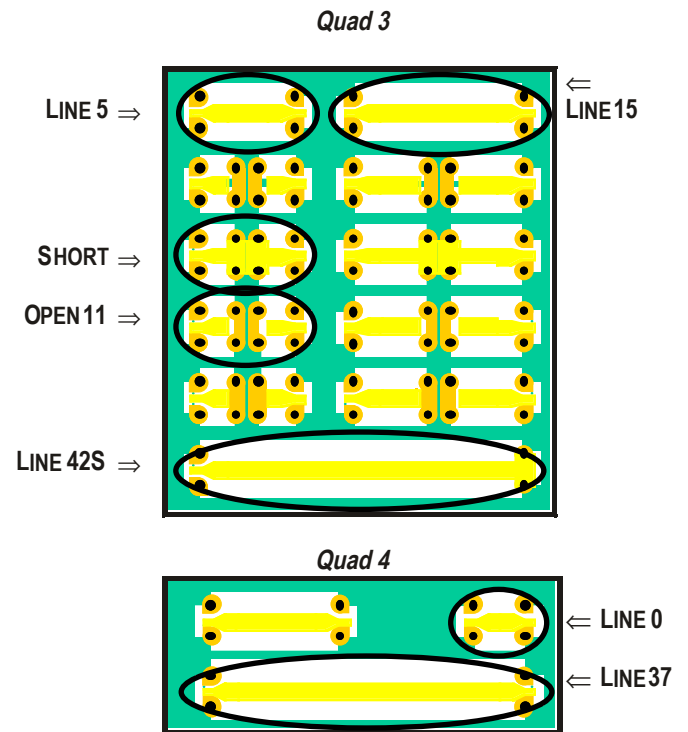


Figure 4 - TRL Calibration Structures on the ProbePoint™ CM10 Calibration Structures Substrate

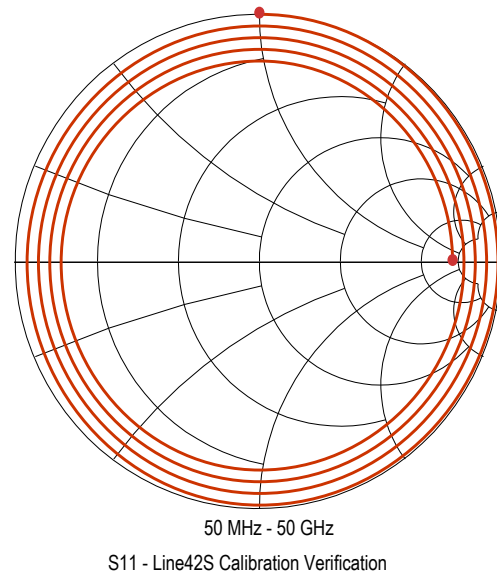
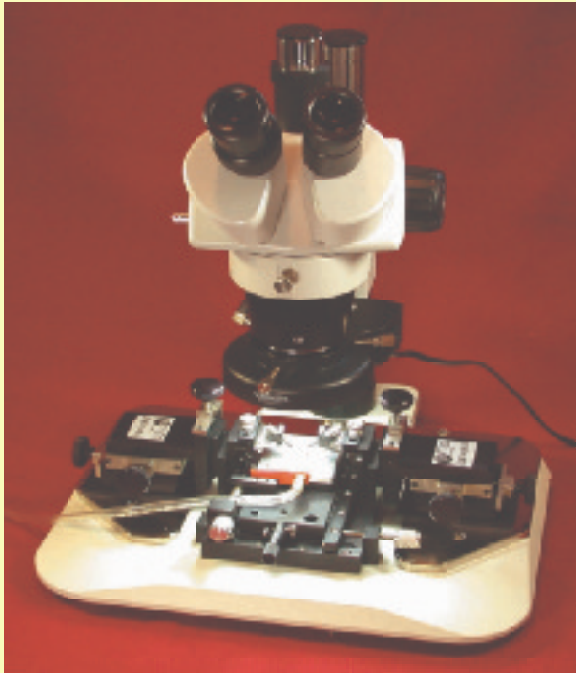


Figure 5 - Calibration Verification

### Closing Discussion

In actual practice, it is relatively easy to get good calibrations to 50 GHz using the TRL methods, much easier than SOLT methods, for example. It is important though to consistently contact each calibration standard at the same position relative to the vias. This same relative position should be used also when performing measurements using the adapters substrates. Physical repeatability is key to achieve electrical repeatability.

J microTechnology, 3744 NW Bluegrass Pl., Portland, OR 97229; (503) 614-9509.



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