The Challenge of Correct Modelling and Testing of Advanced High-Speed Multi-Pins Connectors

Prof. L. Martens
Ghent University
Department of Information Technology
Sint-Pietersnieuwstraat 41
9000 Gent
BELGIUM
Tel.: +32-9-264 33 16
Fax: +32-9-264 35 93
e-mail: luc.martens@intec.UGent.be
http://www.intec.UGent.be

UNIVERSITEIT GENT

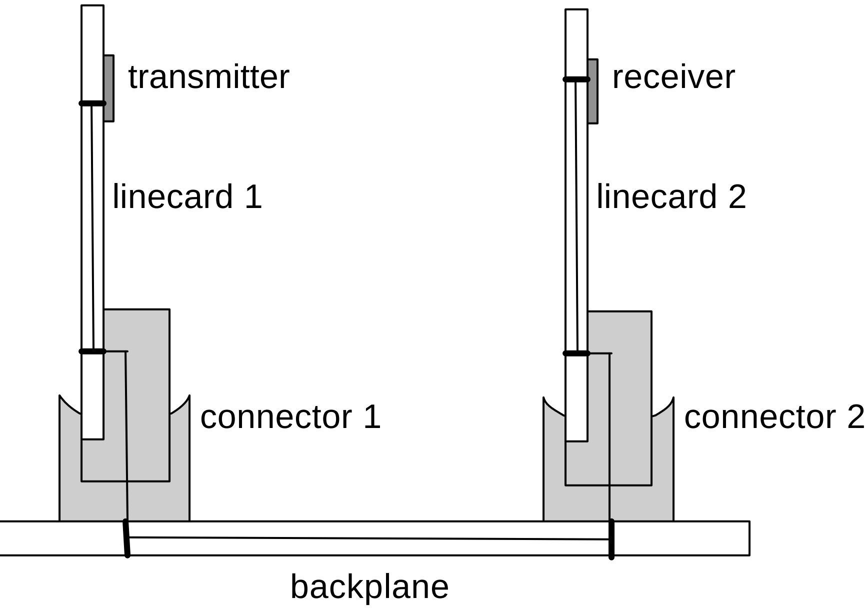
INTEC

Overview

- Configuration of multi-pins backplane connectors
- Challenges of theoretical modelling of multi-pins backplane connectors
- Challenges of experimental characterisation of multi-pins backplane connectors

Multi-pins backplane connector configurations

Connector part of interconnect system



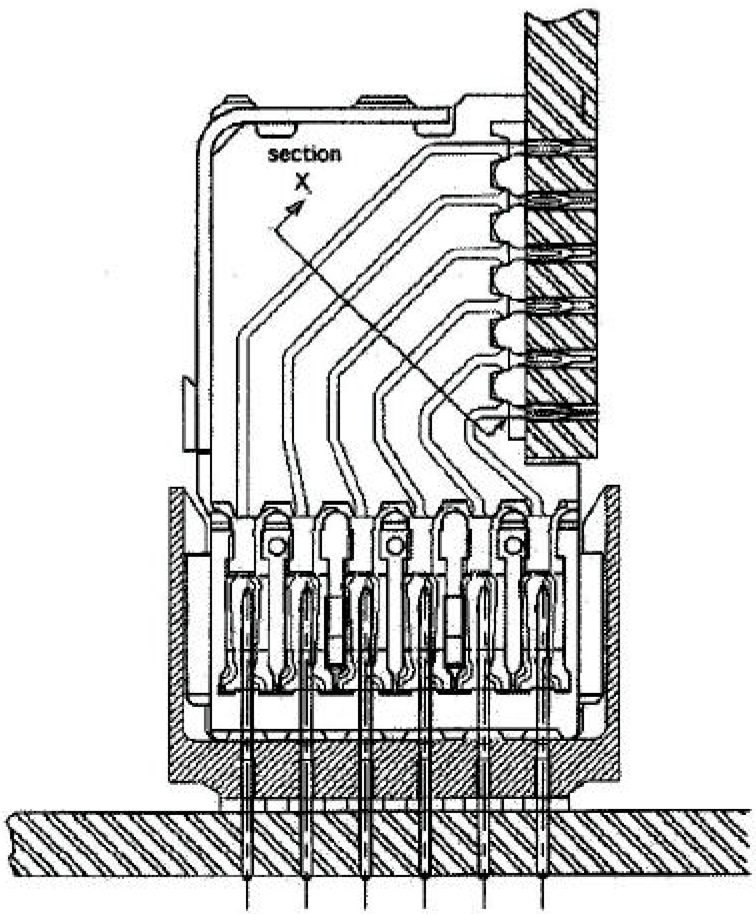
System evaluation based on models of each component; most complex ones:

- IC interconnect
- IC packages
- Backplane connector

Interconnect system

- Chip + package on linecard 1
- Via hole in linecard 1
- Line in linecard 1
- Connector via hole in linecard 1
- Connector pin (female and male part of the connector)
- Connector via hole in backplane
- Line in backplane
- Connector via hole in backplane
- Connector pin (female and male part of the connector)
- Connector via hole in linecard 2
- Line in linecard 2
- Via hole in linecard 2
- Chip + package on linecard 2

Characteristics of multipins backplane connector



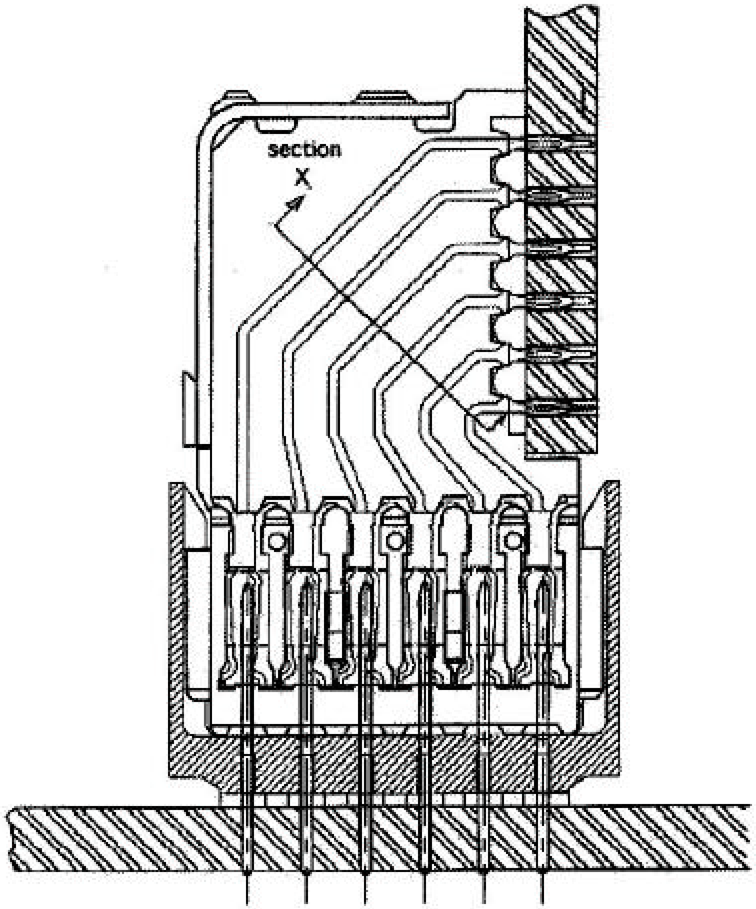
- Complex 3D configuration
- Complex shielding plates
- Large number of pins
- Long structure with small pins

Challenges of theoretical simulation of multi-pins backplane connectors

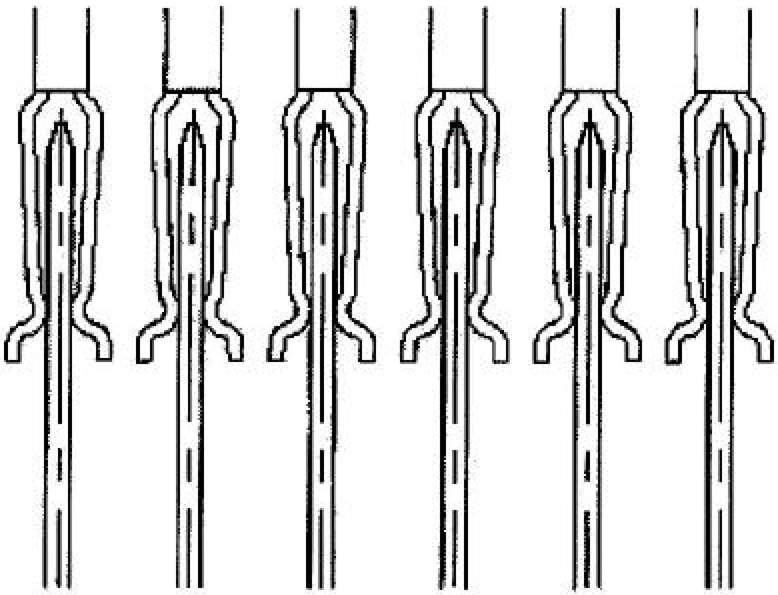
Challenges of modelling of connector

- **Long and small pins and complex configuration make inclusion in Finite Differences tools (such as FDTD) difficult**
- **Linecards (component boards) and backplane board must be included to excite the connector**
- **Ringing due to non-perfect interface between backplane and linecard shields difficult to model**

⇒ Publications of electromagnetic modelling of backplane connectors are scarce



Detail of interface of backplane - linecard pins



- Impedance is changing at interface because of closer distance of pins
- Complex contact region is difficult to implement in modelling tool
- Dependent on the pressure, contact impedance is changing

Challenges of

high-frequency characterisation

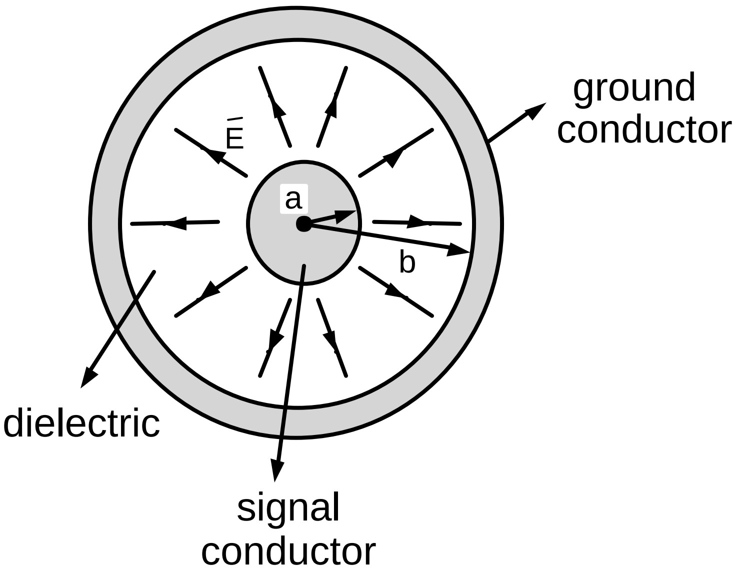
of multi-pins backplane connectors

Challenges

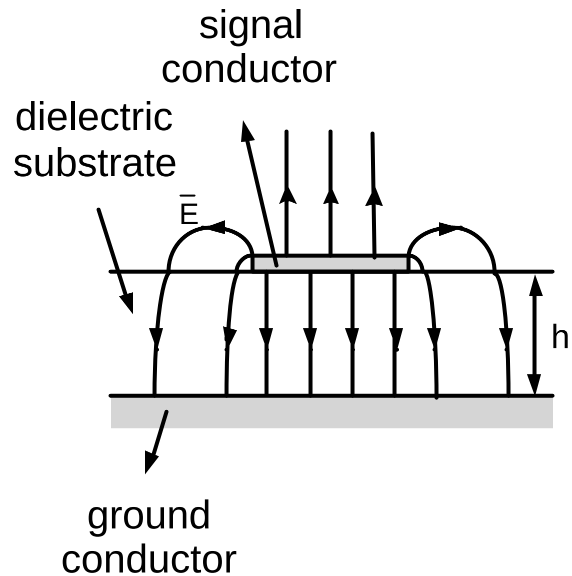
- How to connect multi-pins connectors with high-frequency instruments?
- How to determine S-parameters of a multi-pins backplane connector with a two-port network analyser?
- How to determine the inherent (independent of board configurations) characteristics of the connector?
- How to derive circuit models from S-parameters?

How to connect connector with HF measurement equipment?

Coaxial inputs of high-frequency measurement equipment
↔ planar contacts of boards in which connector is fixed



Coaxial input and its electric field

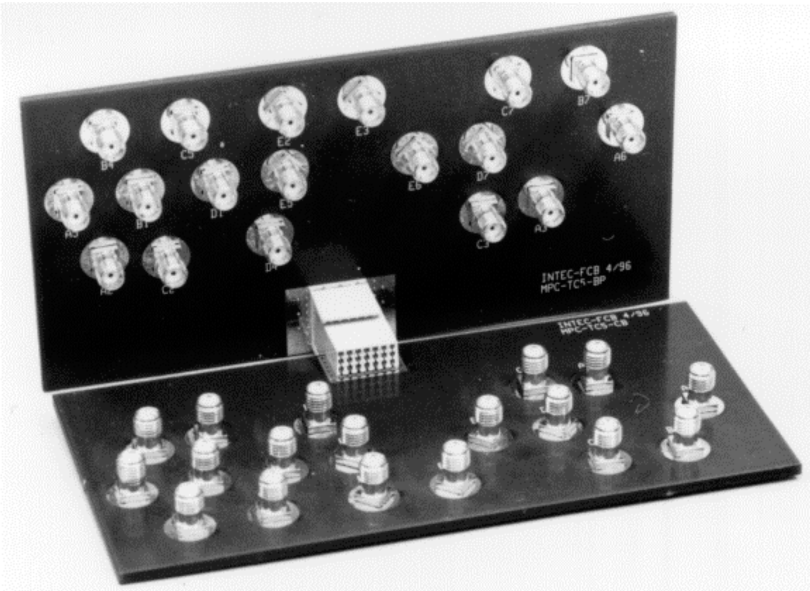


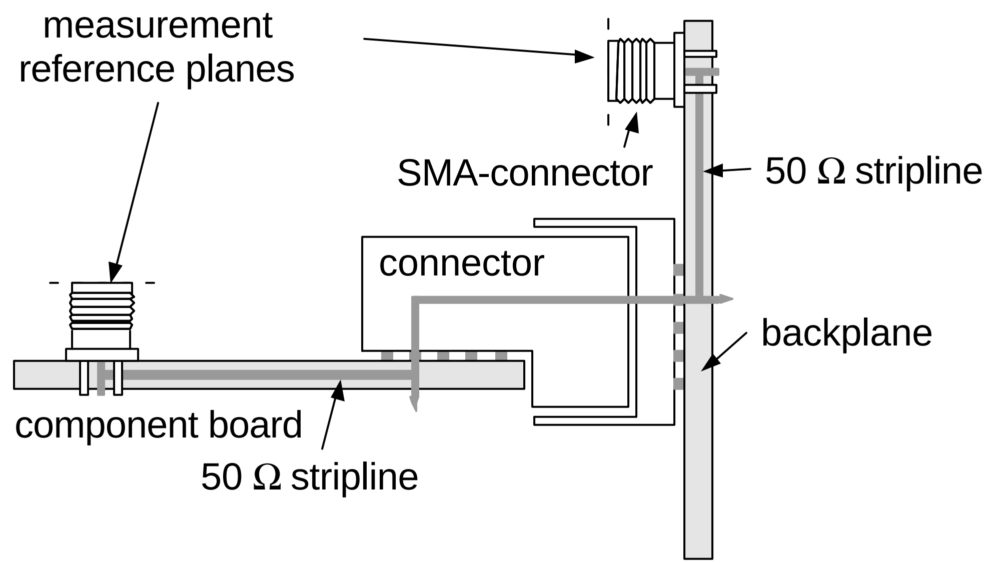
Planar microstrip contact and its electric field

⇒ discontinuity in electric field ⇒ reflections and filtering effect
⇒ impedance controlled transitions needed: test fixtures
or coplanar probes

Connector in a test fixture

Example: PCB-connector test fixture





PROBLEMS

- Besides connector, SMAs and boards are included in the measurements
- SMAs limit bandwidth of measurement
- Test fixture is dedicated to a specific connector

Problem solving

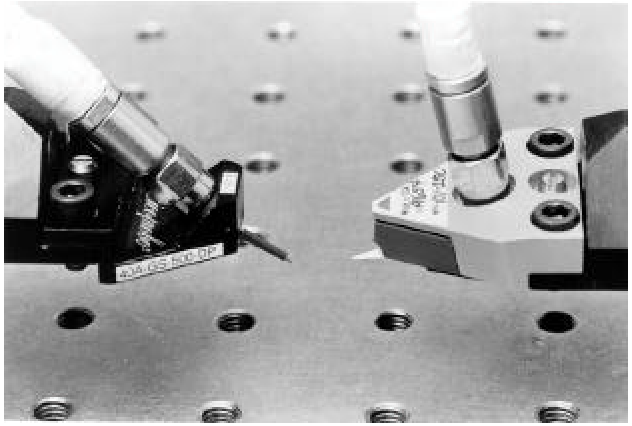
- **Improve bandwidth by replacing one of the SMA connectors with a coplanar probe and use an on-board probing system**

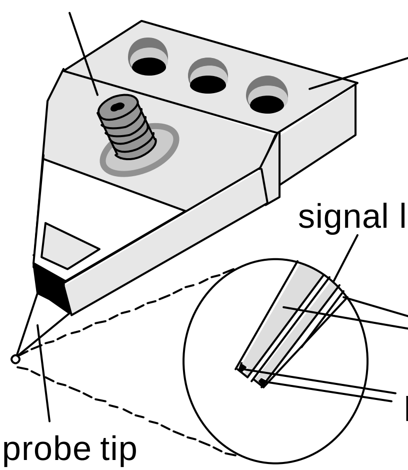
- **De-embed the influence of boards to obtain inherent characteristics of the connector**

Coplanar probes

- **Definition**
  Impedance controlled transition from a coaxial connector to short coplanar lines on a ceramic substrate or to a short thin coaxial cable. The contacts at the end of the lines or of the cable are placed on the pads connected to a planar structure under test

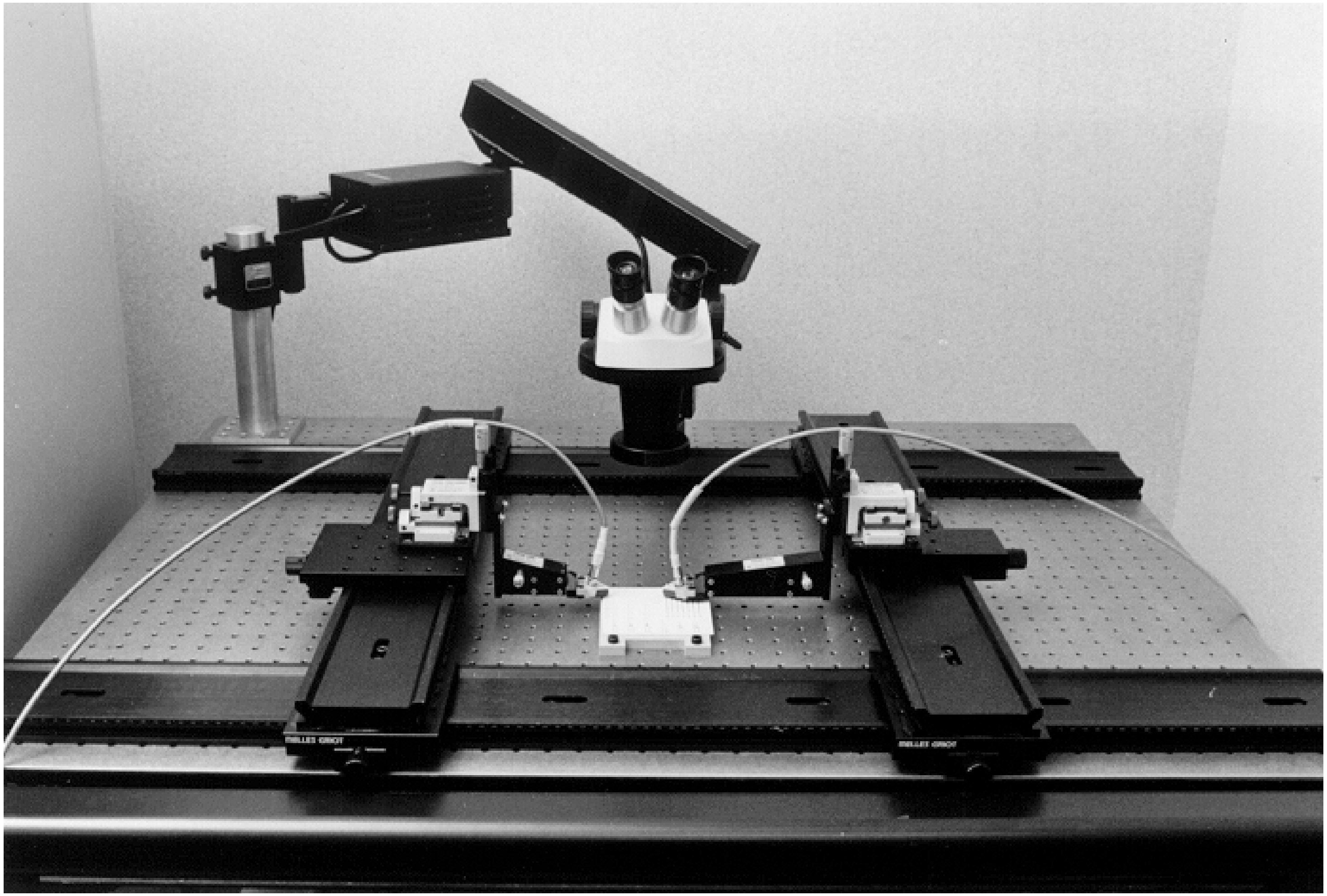
- **Example**





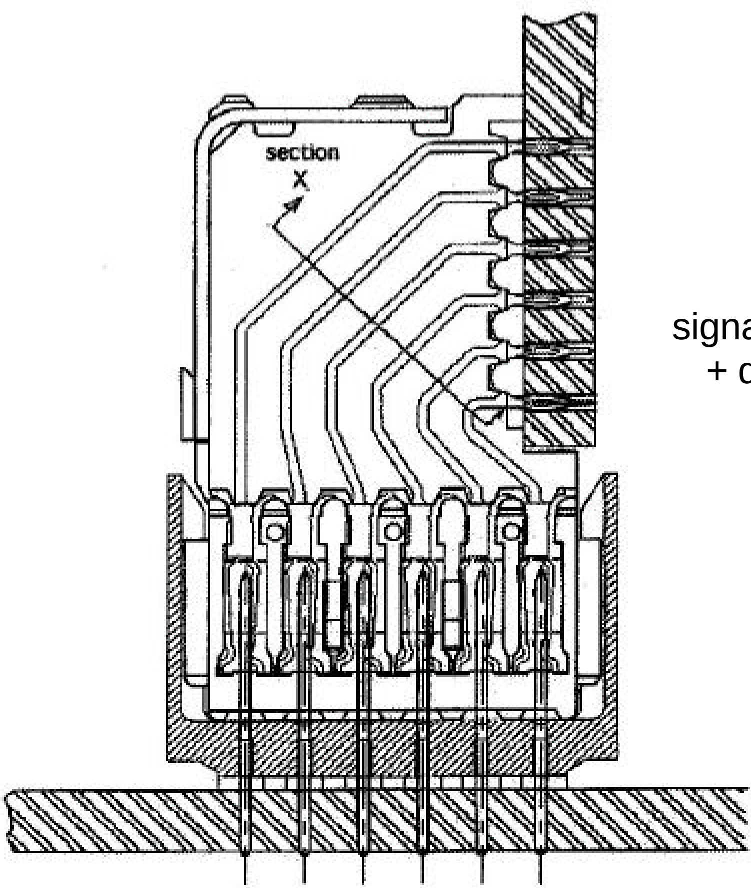
- **Calibration**
  Impedance Standard Substrate (ISS): small alumina substrate containing the standards (thin-film structures)

On-board probing system



How to determine S-parameters of a multi-pins connector with a two-port network analyser?

Network analyser measurements



signal processing
+ display unit

test-set

Connector with N pins
= 2N-port circuit

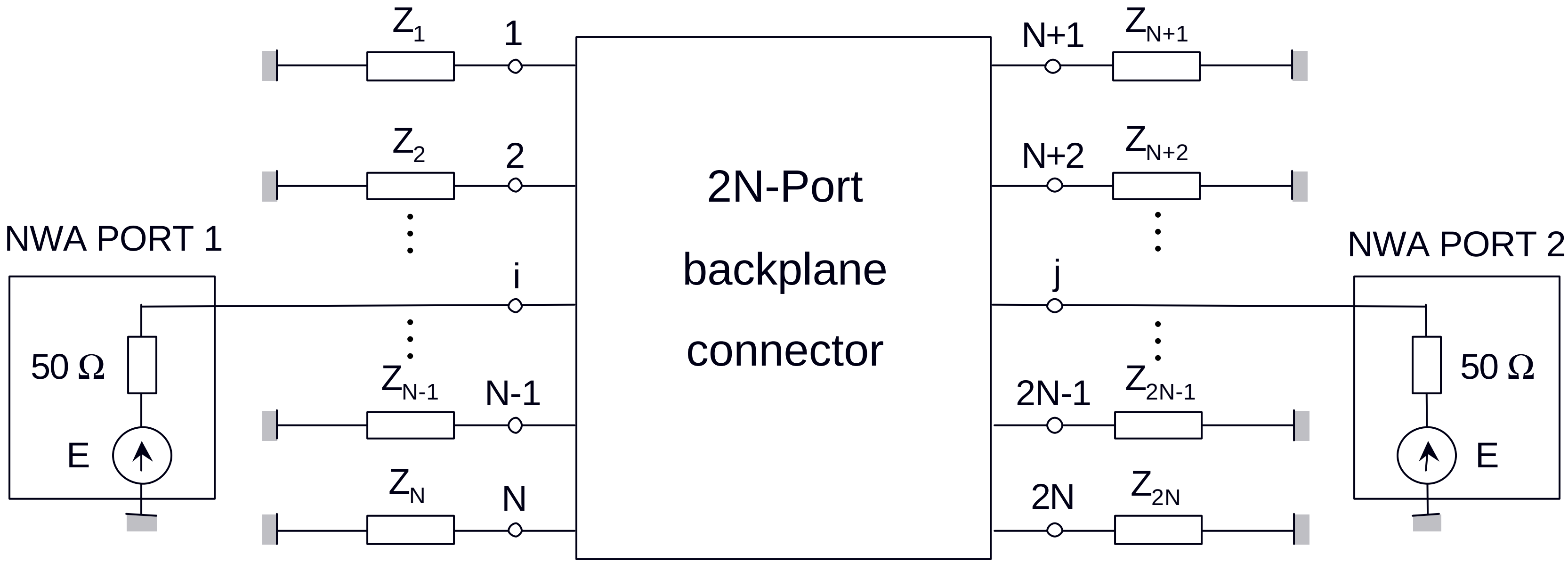
↔

Network analyser with two ports

S-matrix of an N-pins connector

S-matrix with respect to 50 W

→ if perfect 50 Ω at pins available: N(N-1)/2 two-port measurements needed
→ if perfect 50 Ω is not available or can not be realised at the pin inputs: special procedure needed to compensate for the mismatch between 50 Ω reference of the measurement ports and the impedance of the load terminating the rest of the ports



How to determine the inherent characteristics of the connector?

Characterisation of connector

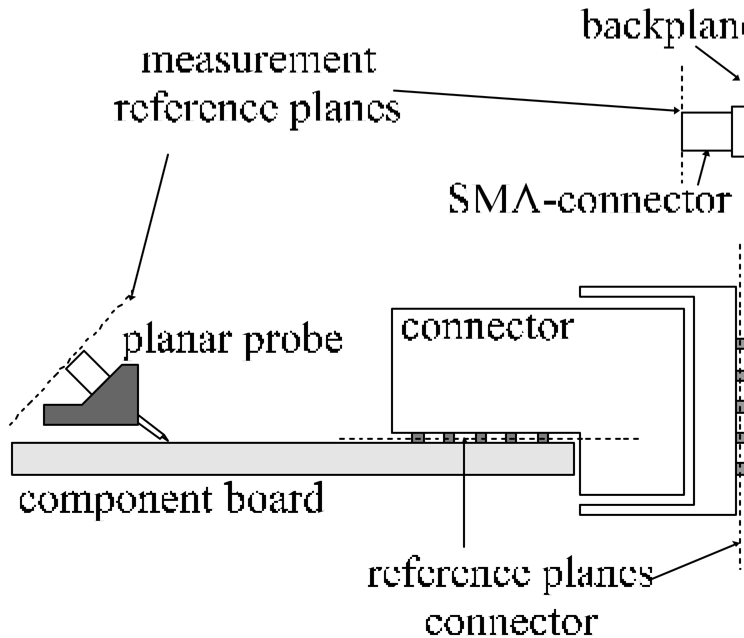
coaxial 2-port calibration

measure test configuration inclusive planar probe, component board,
and backplane (while loading other ports with known impedance)

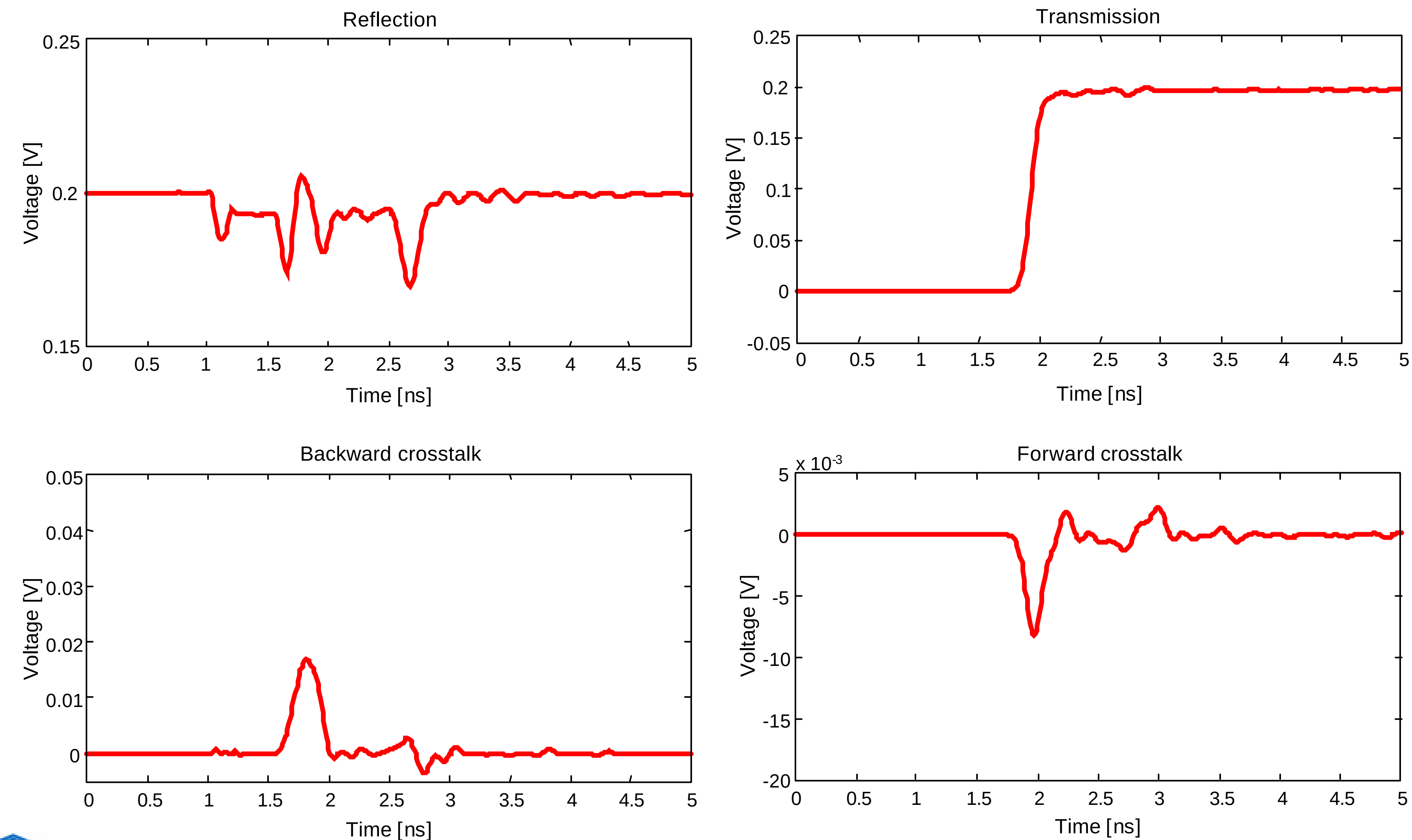
characterise probe, component board and backplane before connector is placed on PCB's

de-embed probe, component board and backplane from measurements

assemble 2N x 2N S-matrix taking into account the non-perfect terminations of the non-measured ports



Characterisation of connector

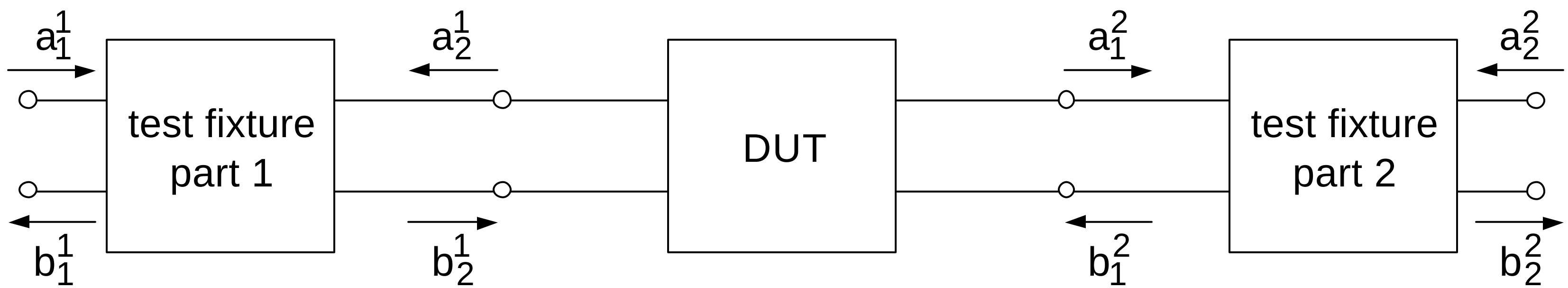


De-embedding

- **Goal**

  To remove reflections and losses due to the test fixture from measured S-parameter data

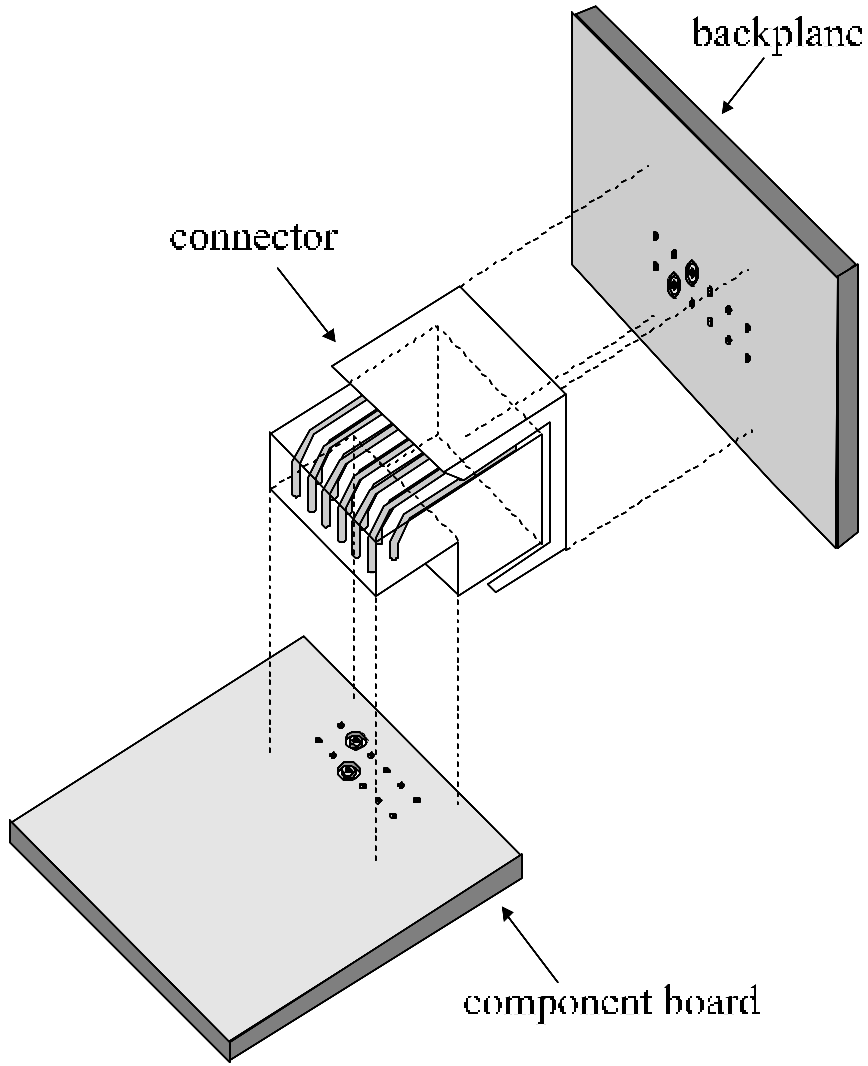
- **Procedure for two-port de-embedding**



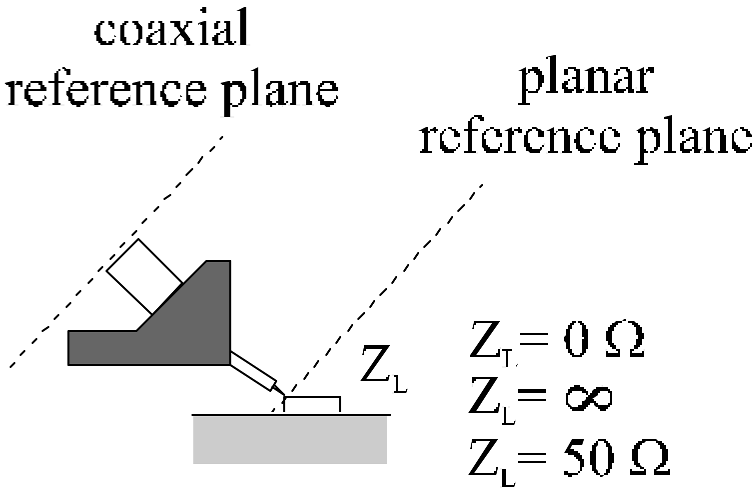
$$\begin{bmatrix} a_1^1 \\ b_1^1 \end{bmatrix} = \bar{\bar{T}}_1 \begin{bmatrix} b_2^1 \\ a_2^1 \end{bmatrix} \qquad \bar{\bar{T}}_{DUT} \text{ or } \bar{\bar{S}}_{DUT} \qquad \begin{bmatrix} a_1^2 \\ b_1^2 \end{bmatrix} = \bar{\bar{T}}_2 \begin{bmatrix} b_2^2 \\ a_2^2 \end{bmatrix}$$

$$\text{measured } \bar{\bar{S}}_{tot} \rightarrow \bar{\bar{T}}_{TOT} = \bar{\bar{T}}_1 \cdot \bar{\bar{T}}_{DUT} \cdot \bar{\bar{T}}_2 \rightarrow \bar{\bar{T}}_{DUT} \rightarrow \bar{\bar{S}}_{DUT}$$

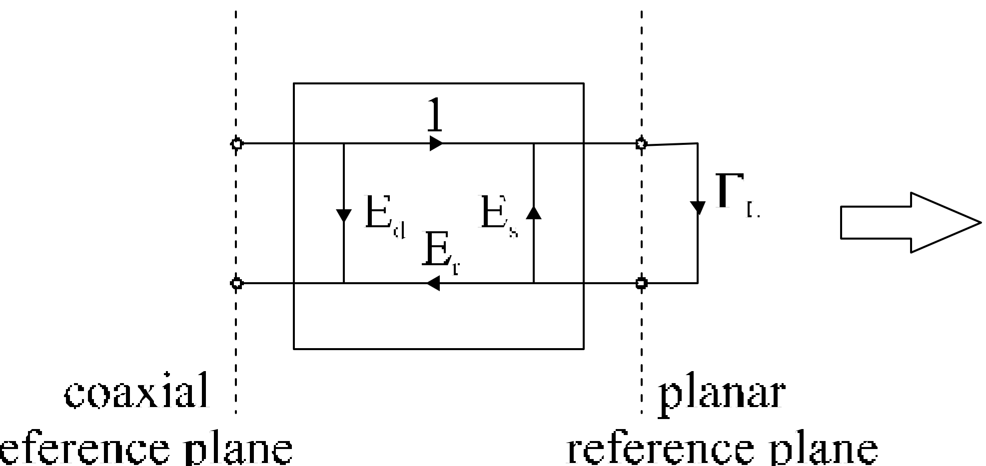
Partitioning of connector, component board and backplane



Characterisation of planar probe

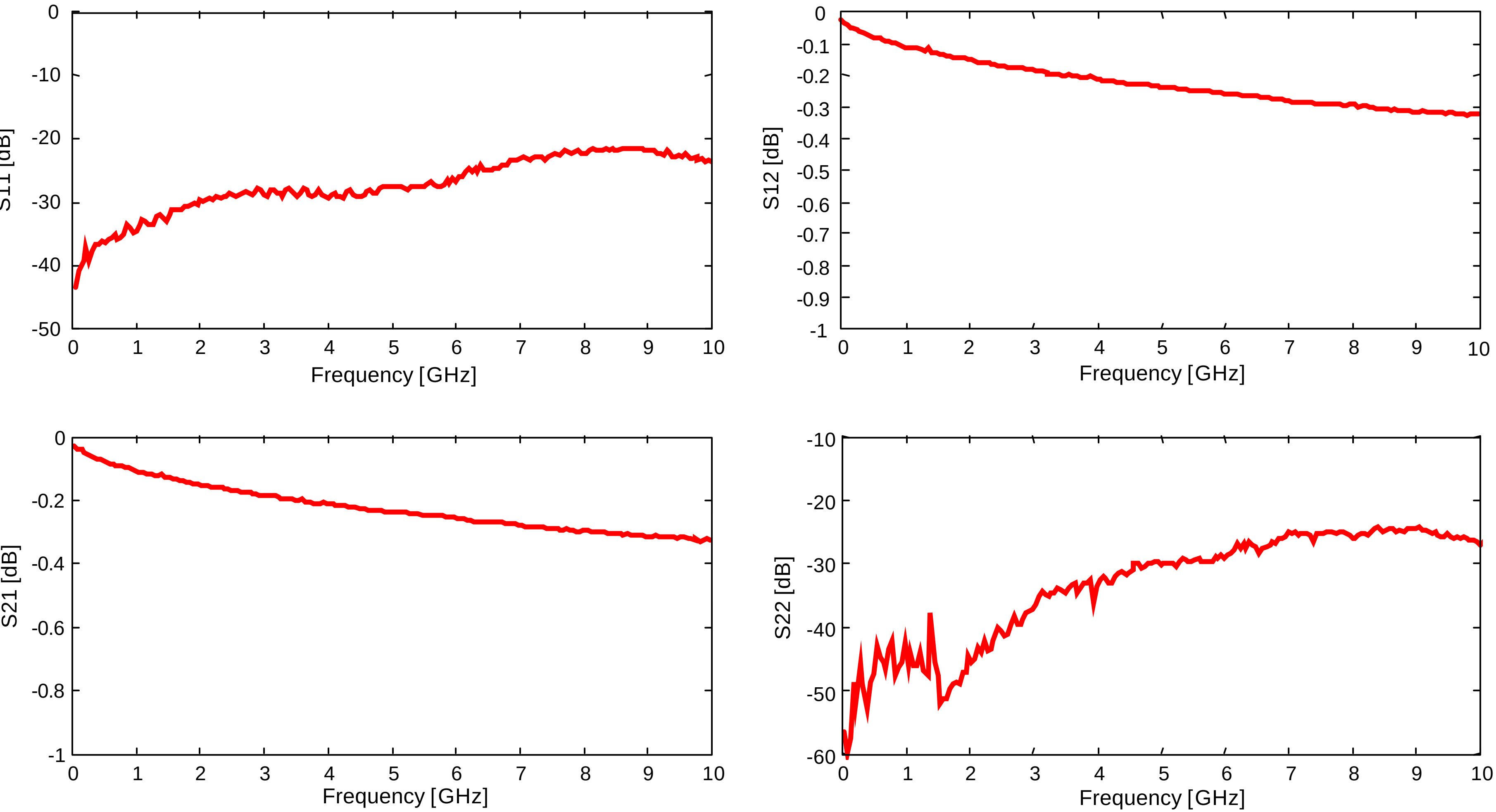


- Perform one-port coaxial SOL calibration
- Perform one-port planar SOL calibration
- Calculate S-parameters probe from error terms of second calibration



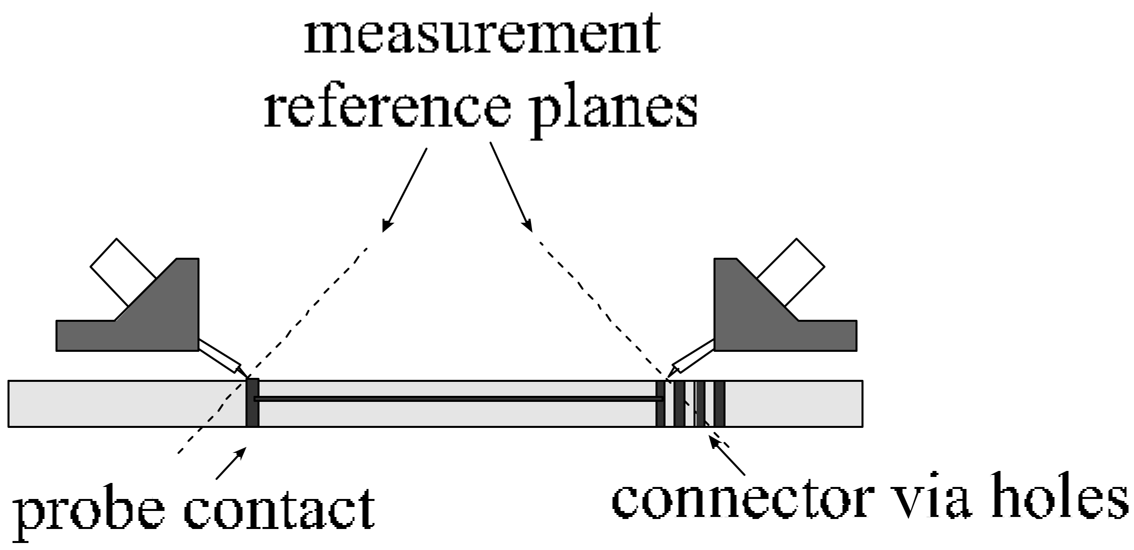
$$S^{probe} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

Characterisation of planar probe

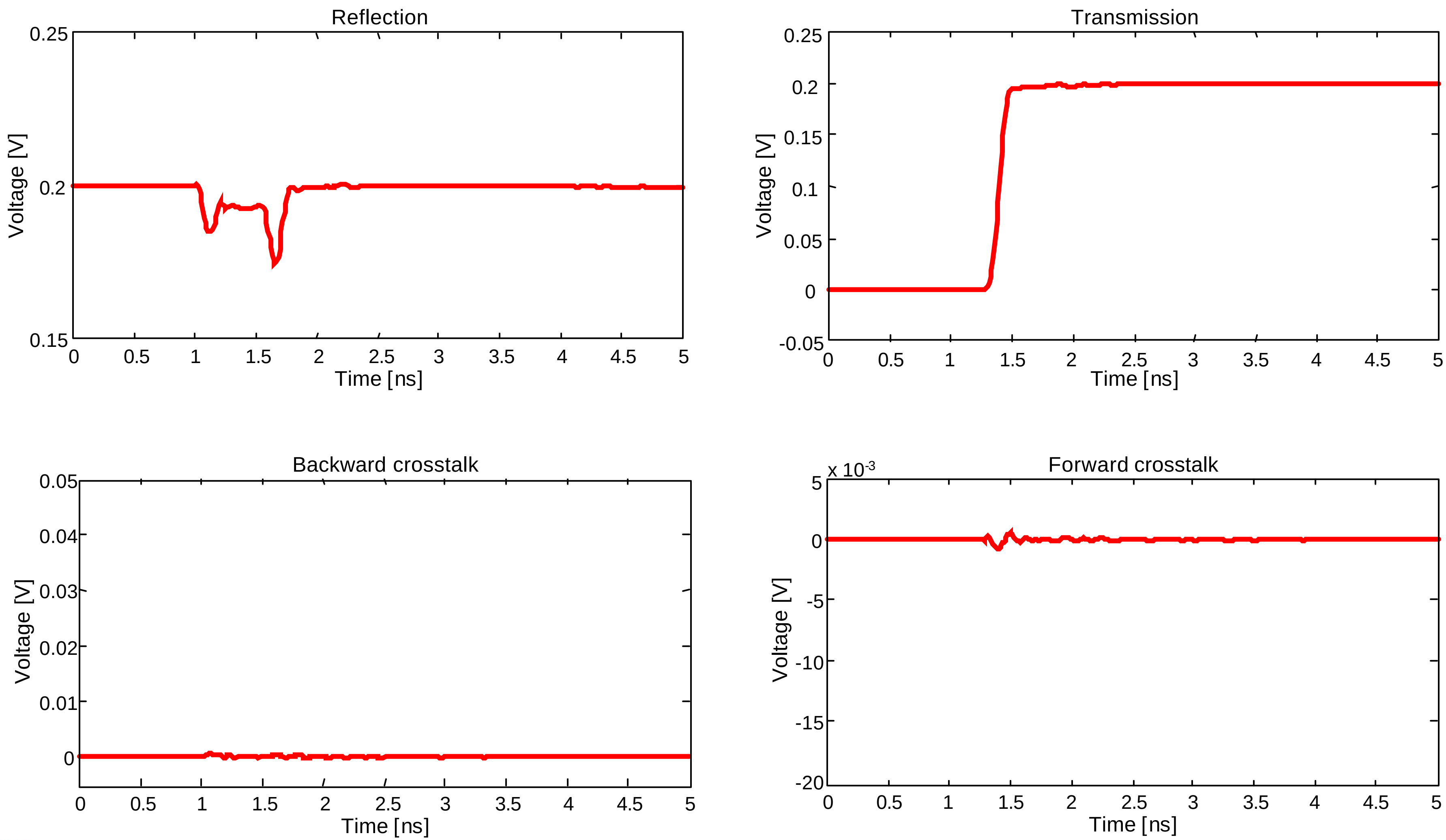


Characterisation of component board

- planar 2-port calibration
- measure S-parameters component board

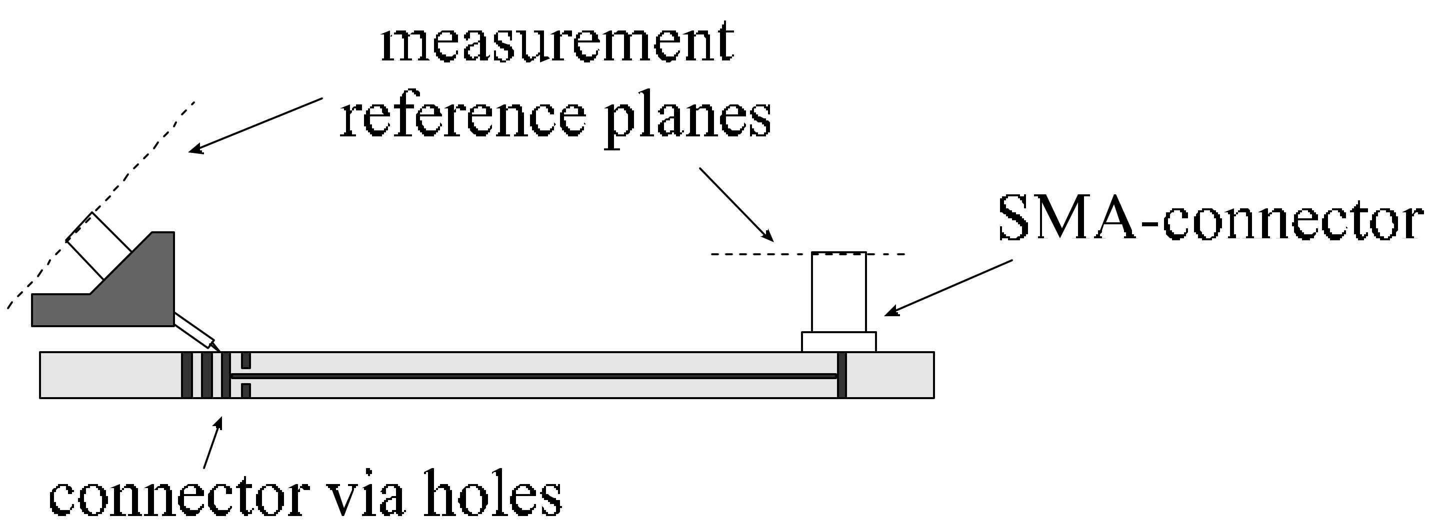


Characterisation of component board

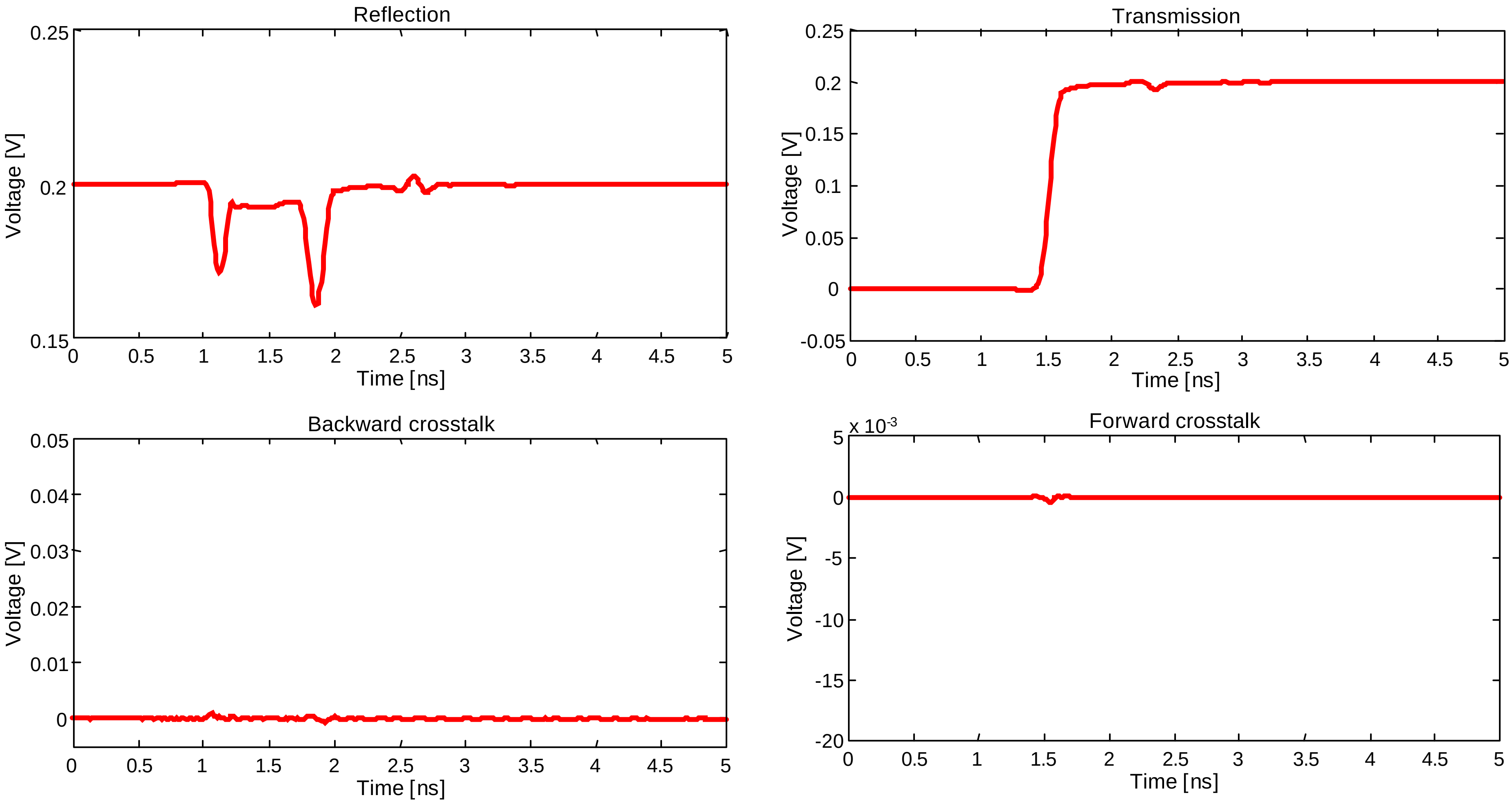


Characterisation of backplane

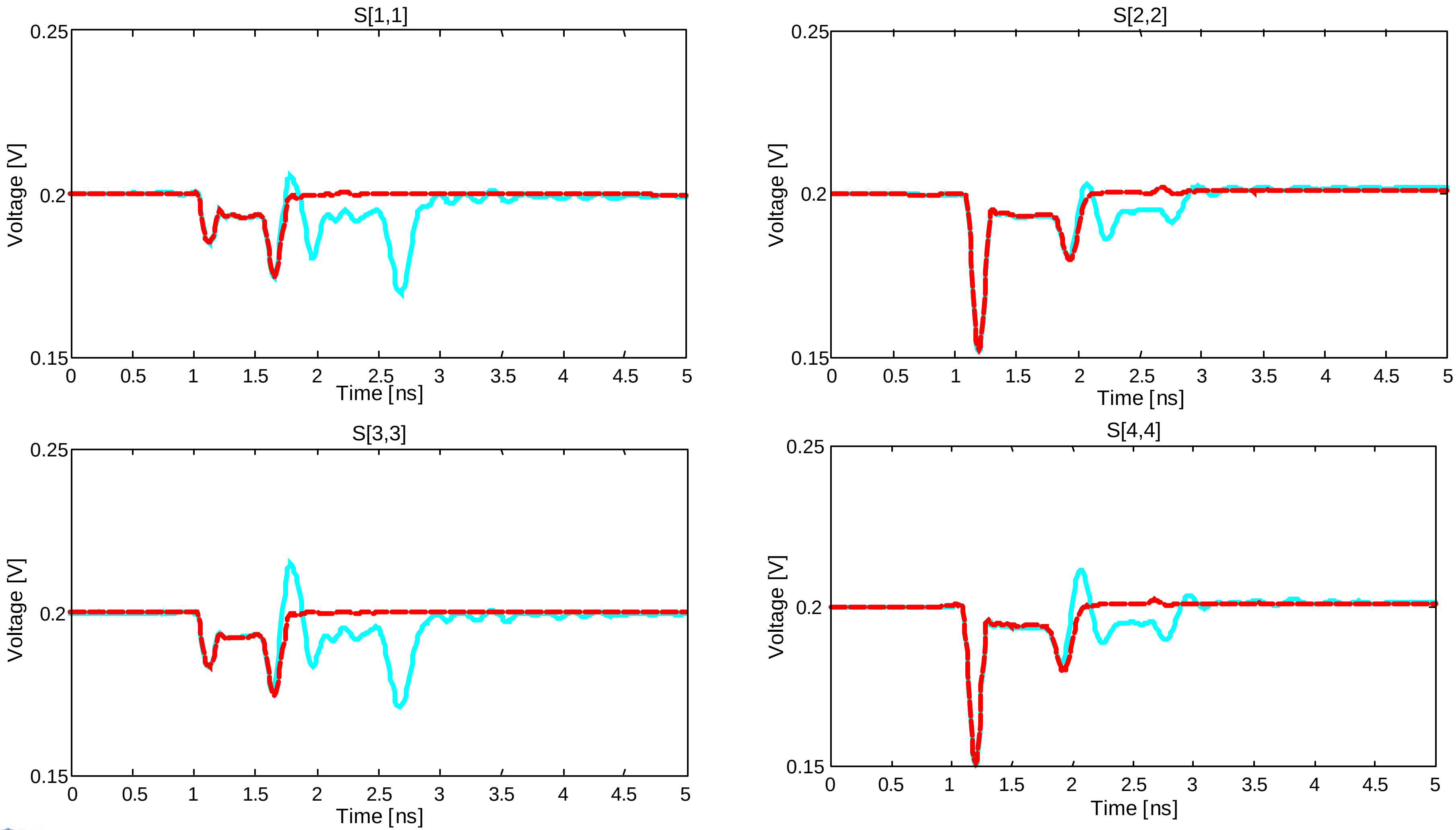
- coaxial 2-port calibration
- measure S-parameters backplane inclusive probe
- characterise probe
- de-embed probe from measurement



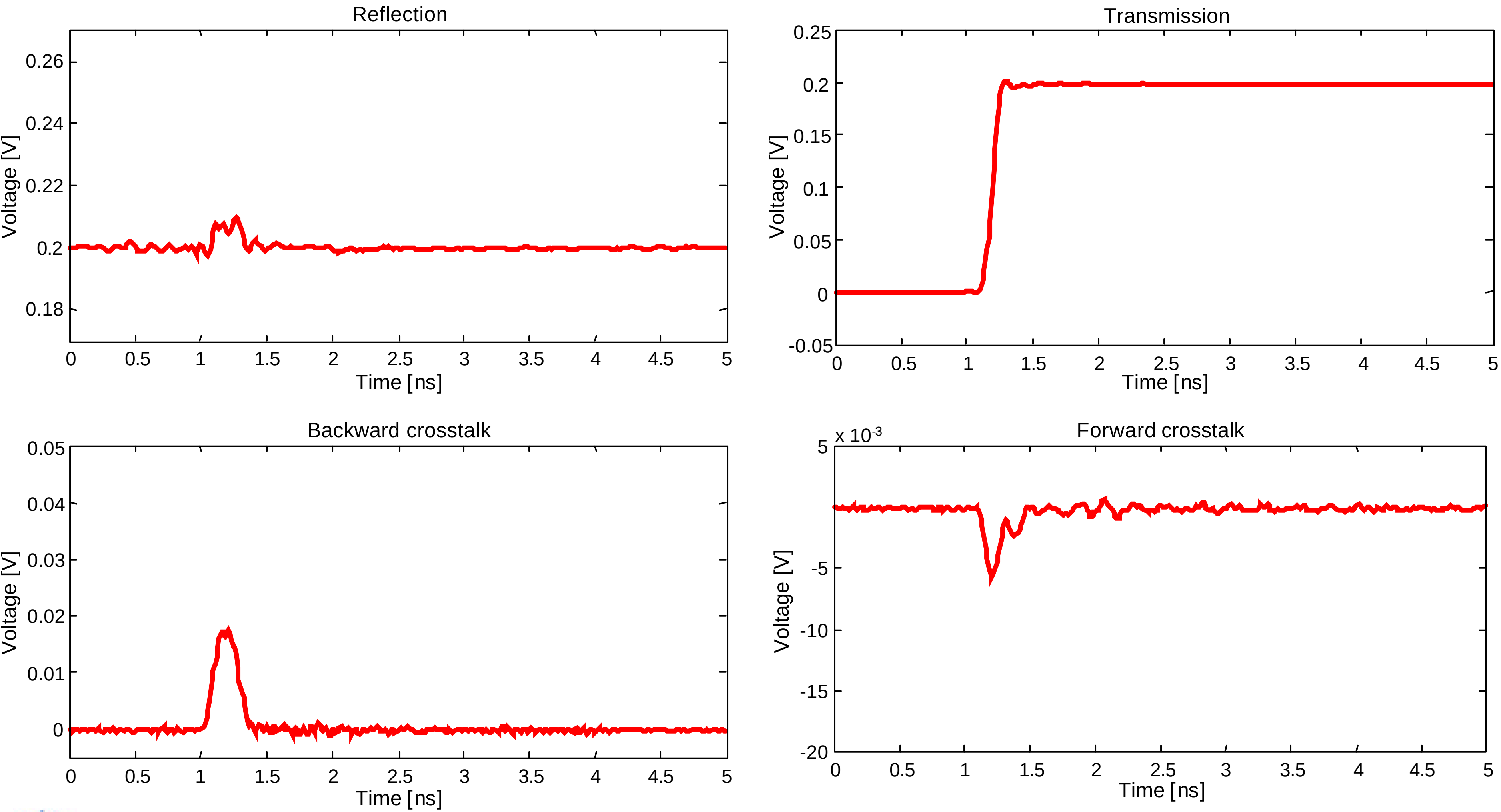
Characterisation of backplane



Comparing connector, component board and backplan

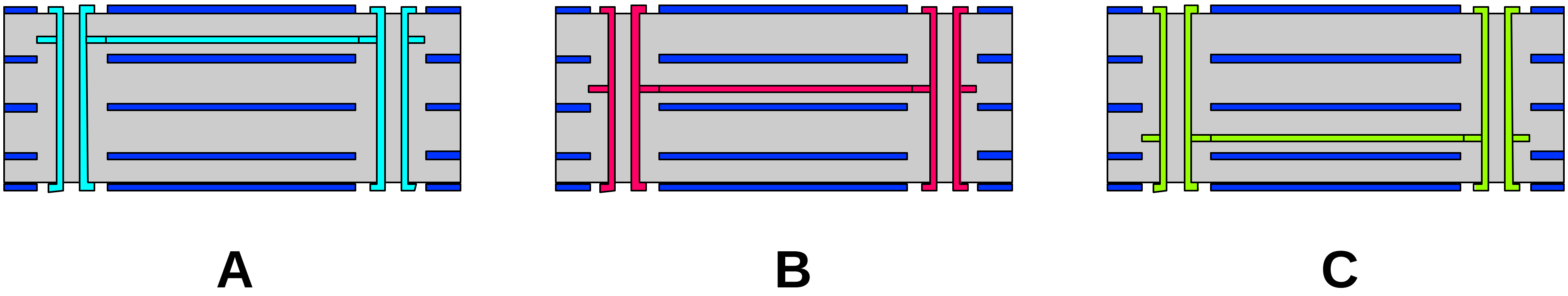


Connector after de-embedding component board and backplane

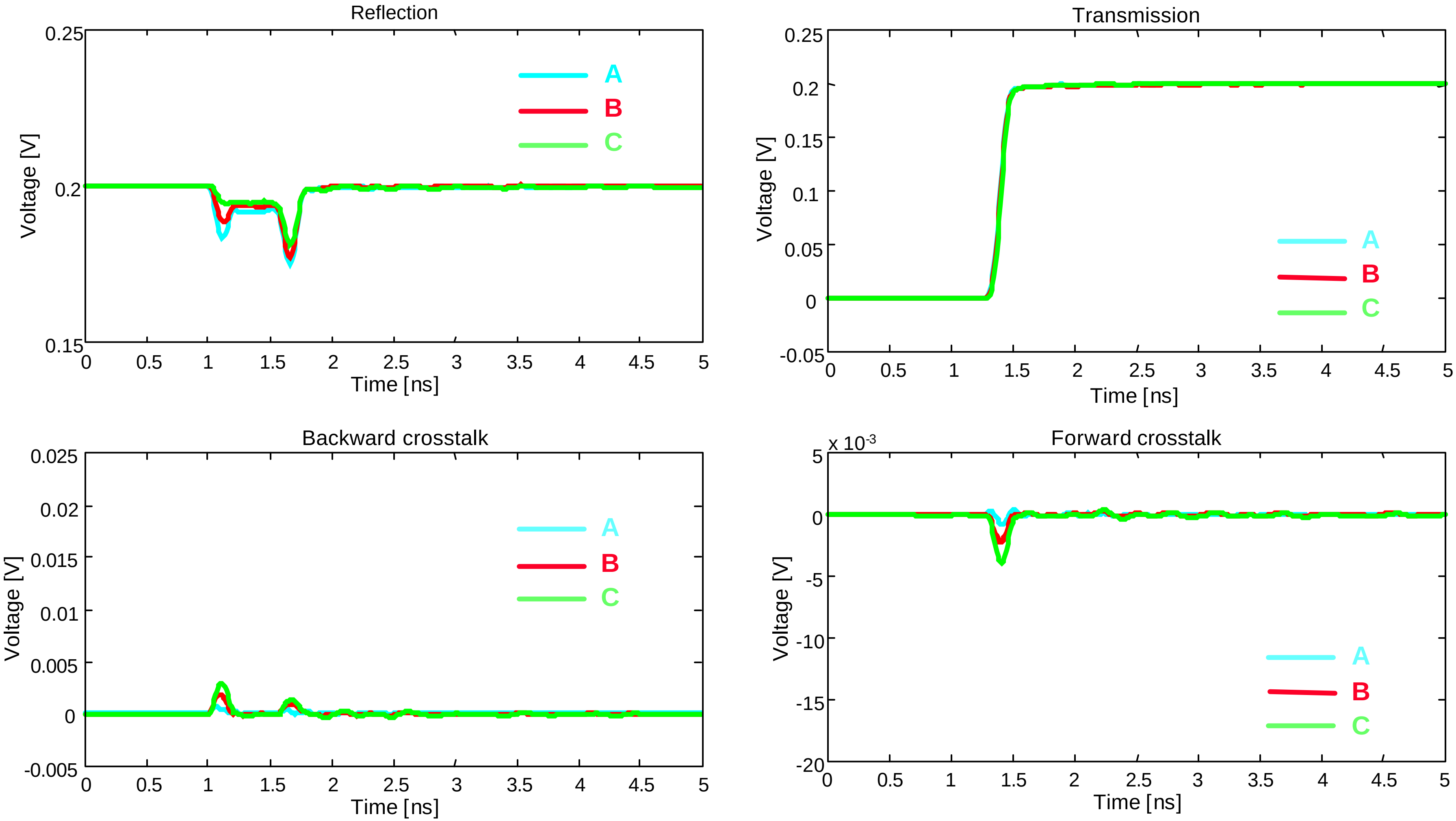


Verification of de-embedding

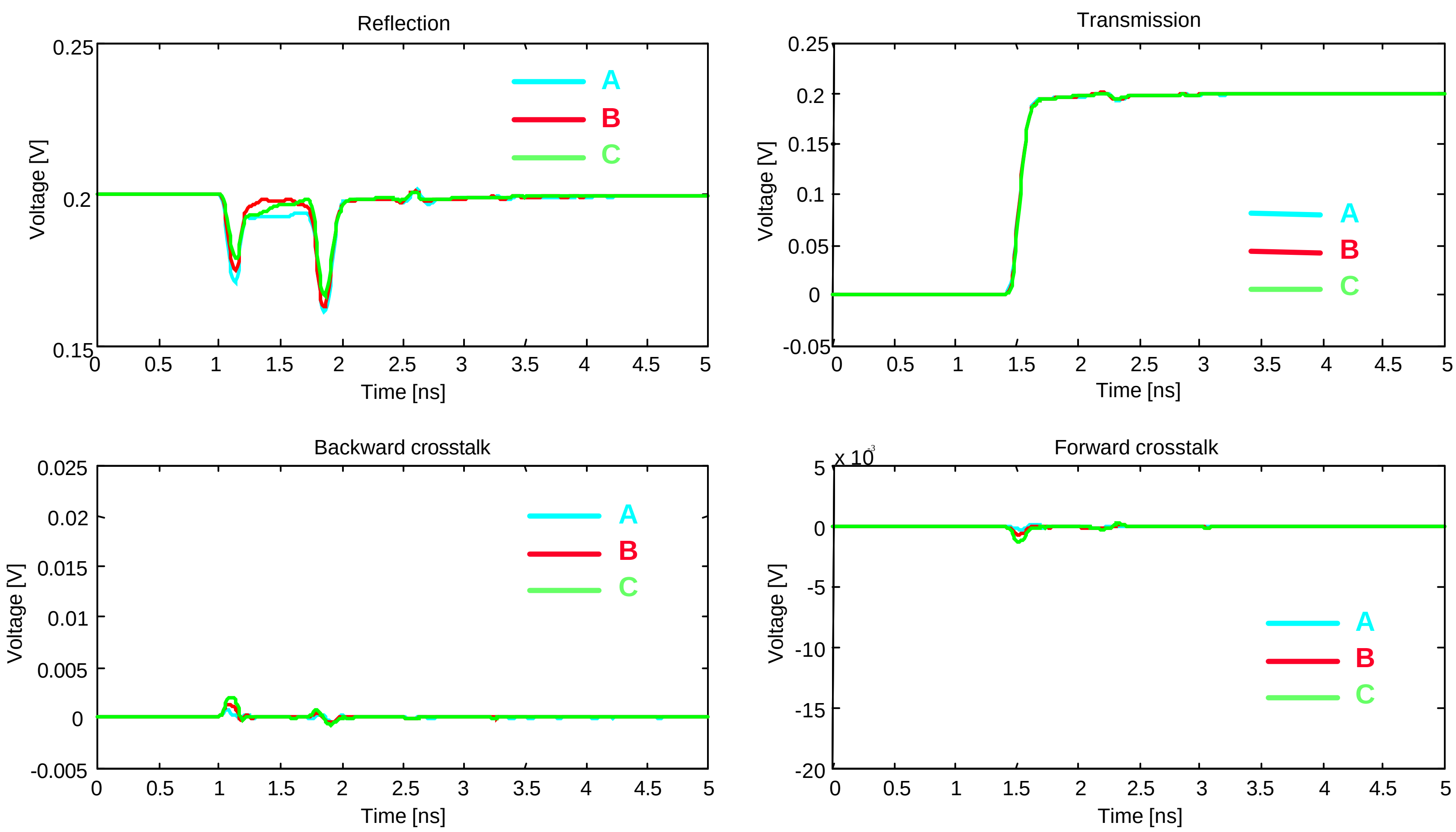
- Connector is mounted on 3 different component boards and backplanes
- All with same signal/ground configuration
- Verification by comparing S-parameters of the connector after de-embedding of component board and backplane



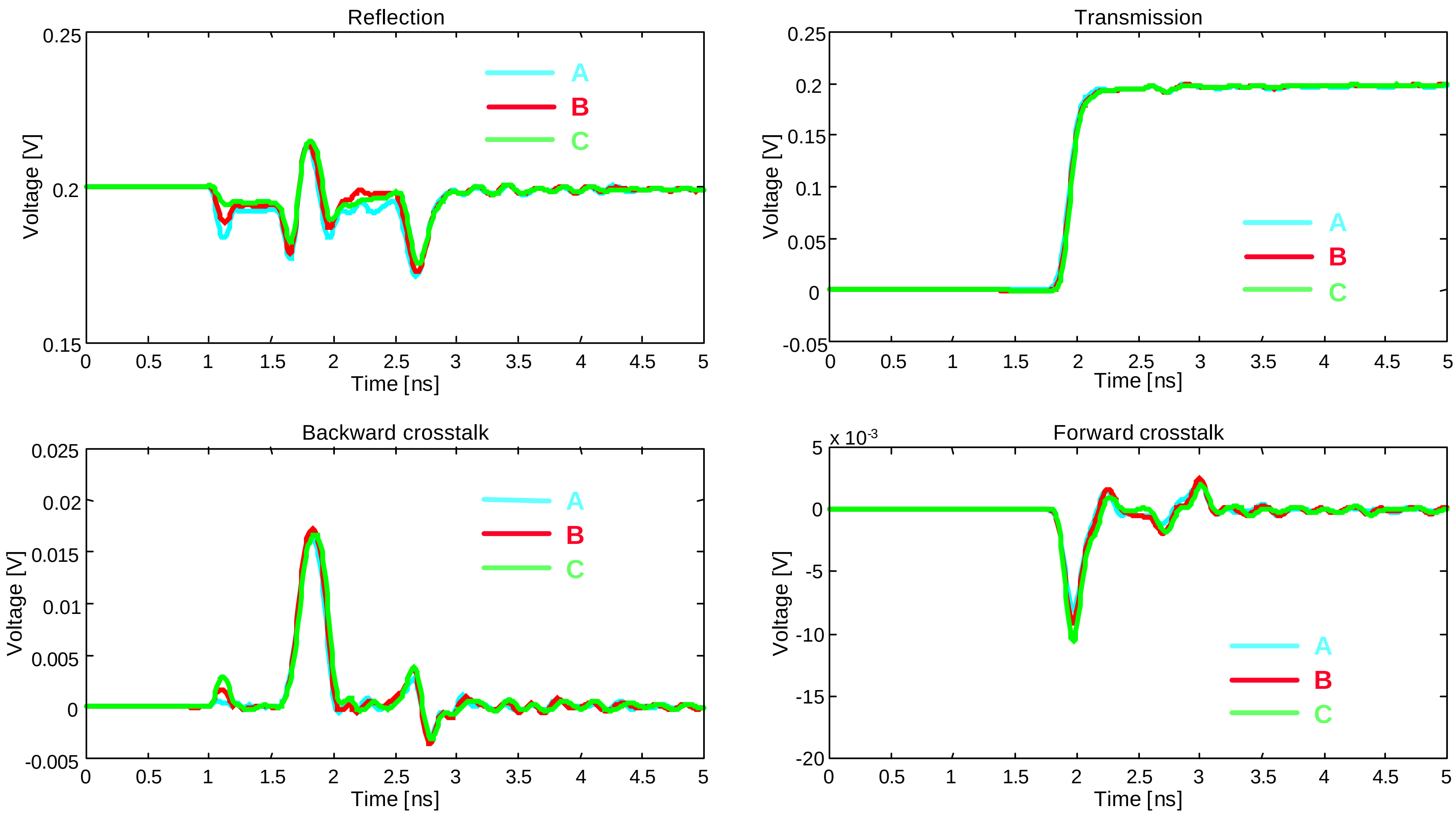
Verification of de-embedding: component board



Verification of de-embedding: backplane

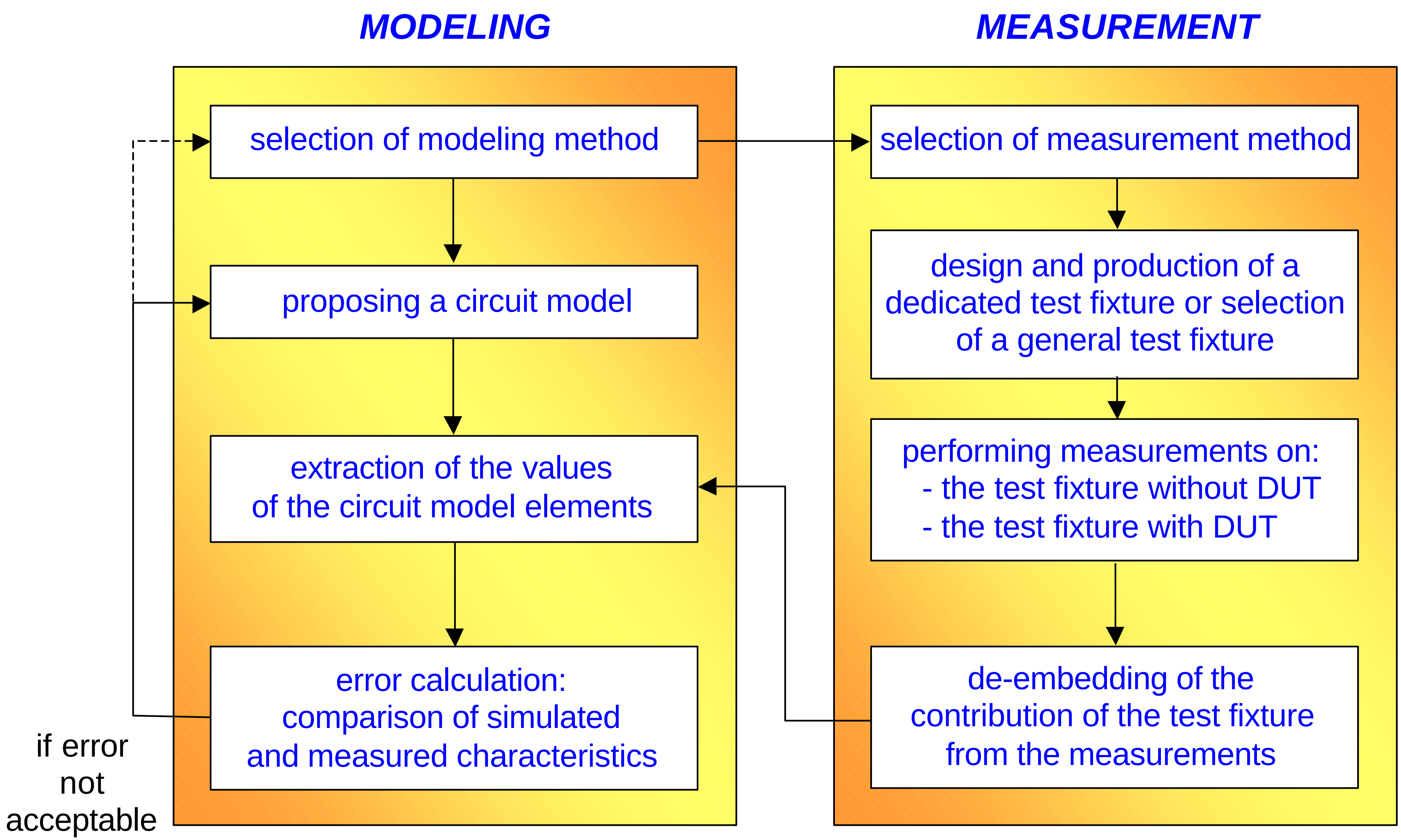


Verification of de-embedding: connector before de-embedding component board and backplane



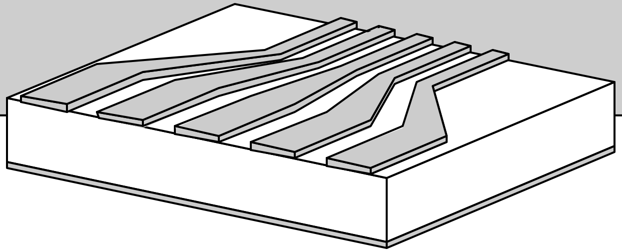
How to derive circuit models from S-parameters?

Flow chart of experimental circuit modelling



Introduction

DUT

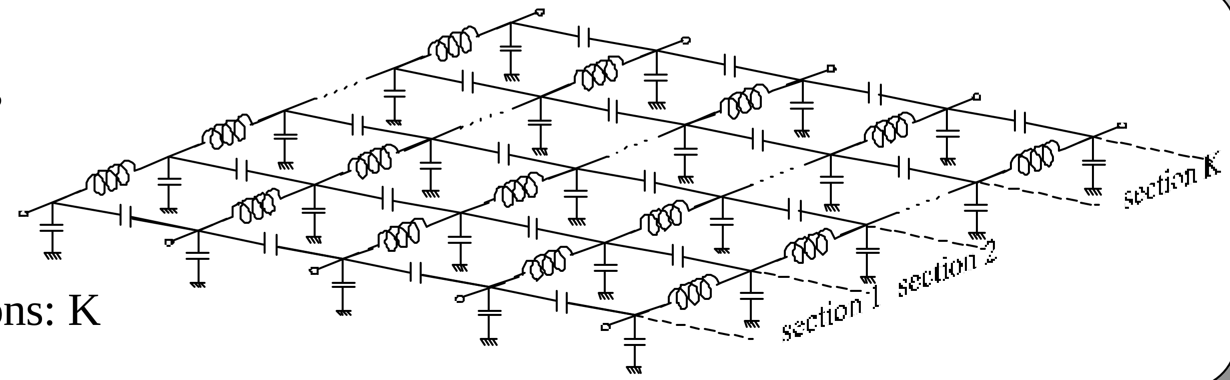


- Large number of coupled conductors
- non-uniform

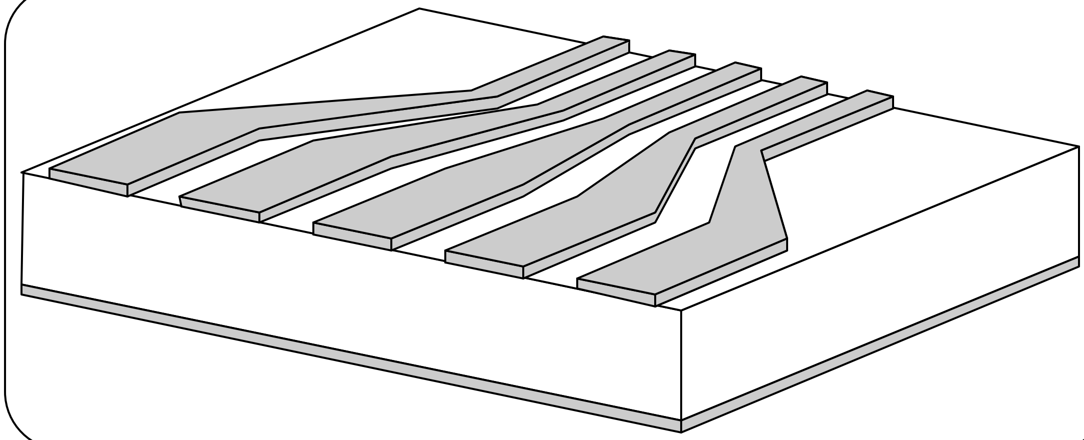
examples: package interconnections, backplane connector, ...

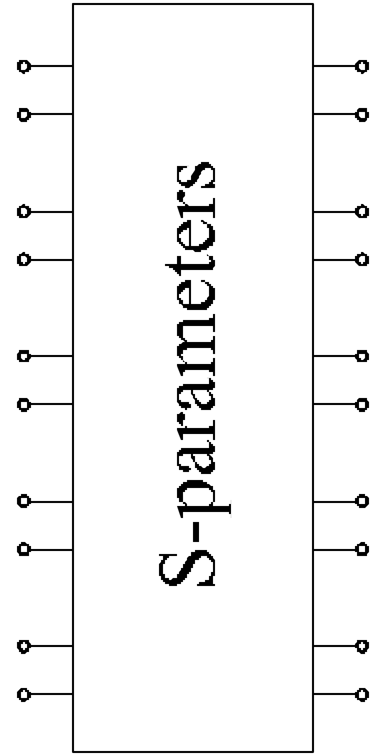
Circuit Model DUT

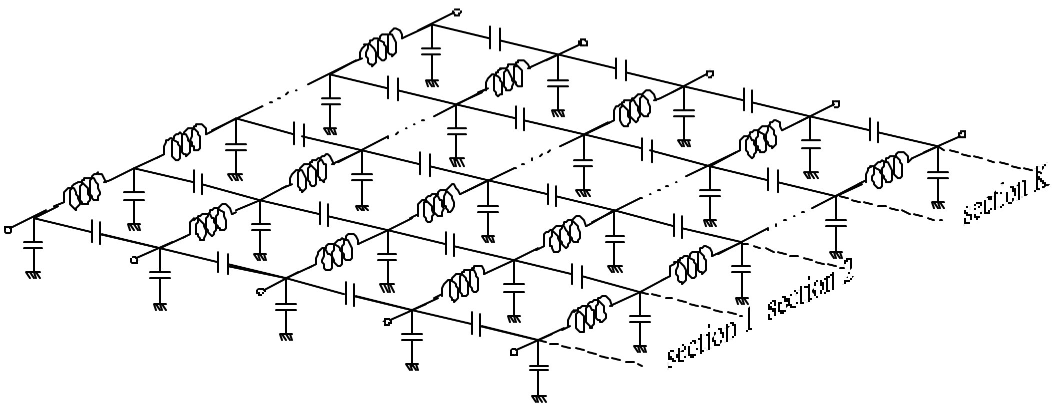
- accurate
- high-frequencies
- topology:



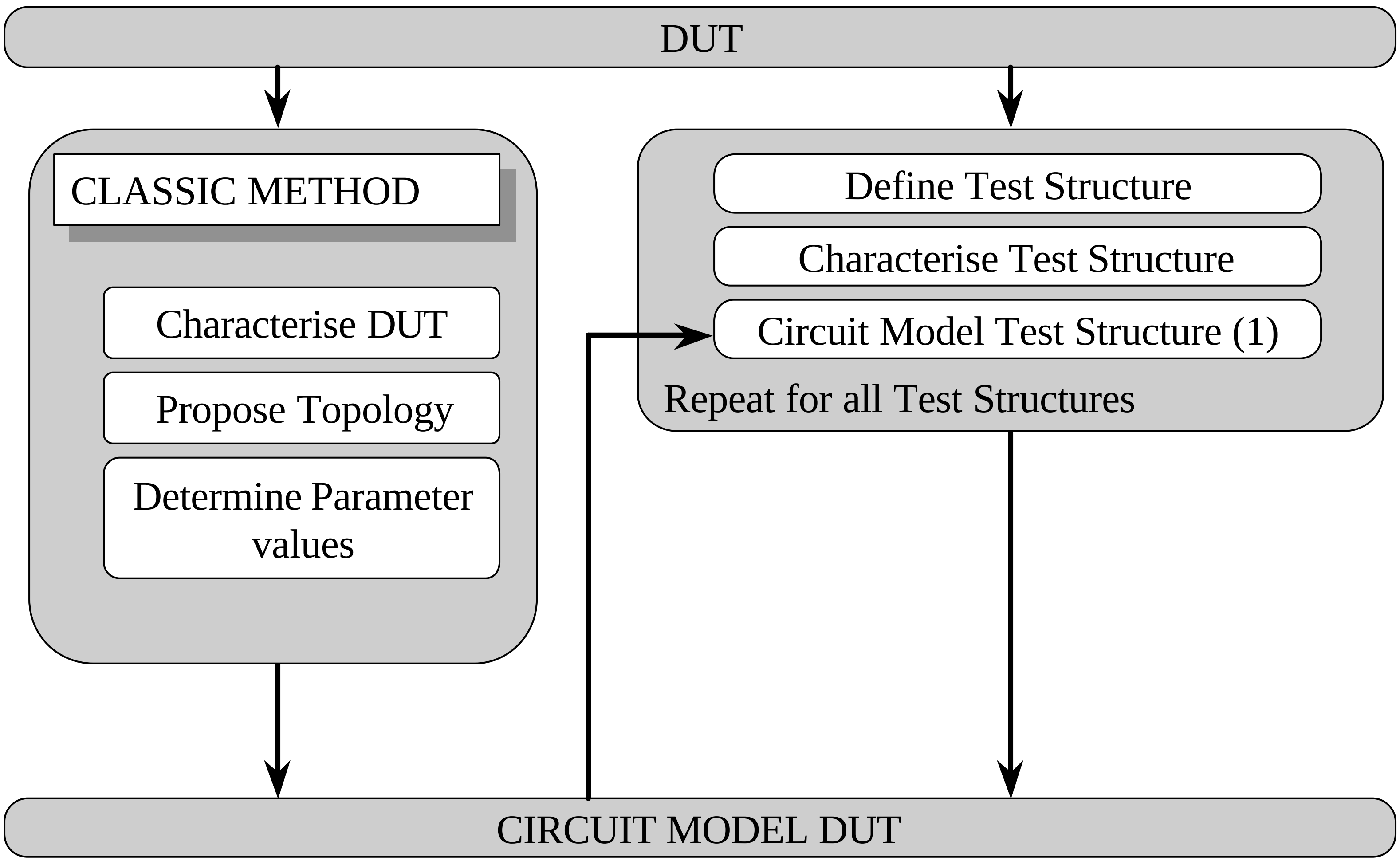
- number of sections: K



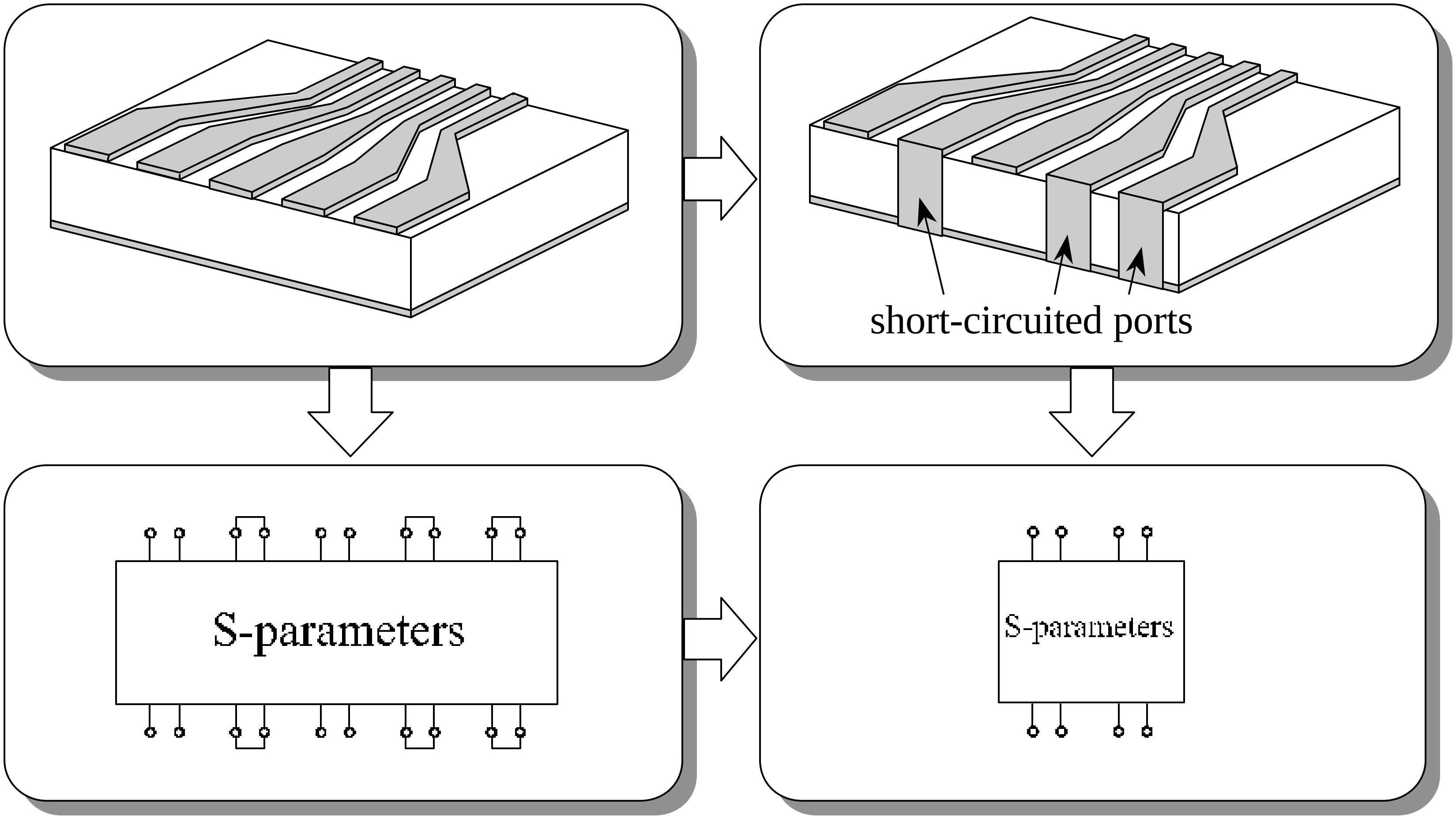

S-parameters


section K
section 1
section 2

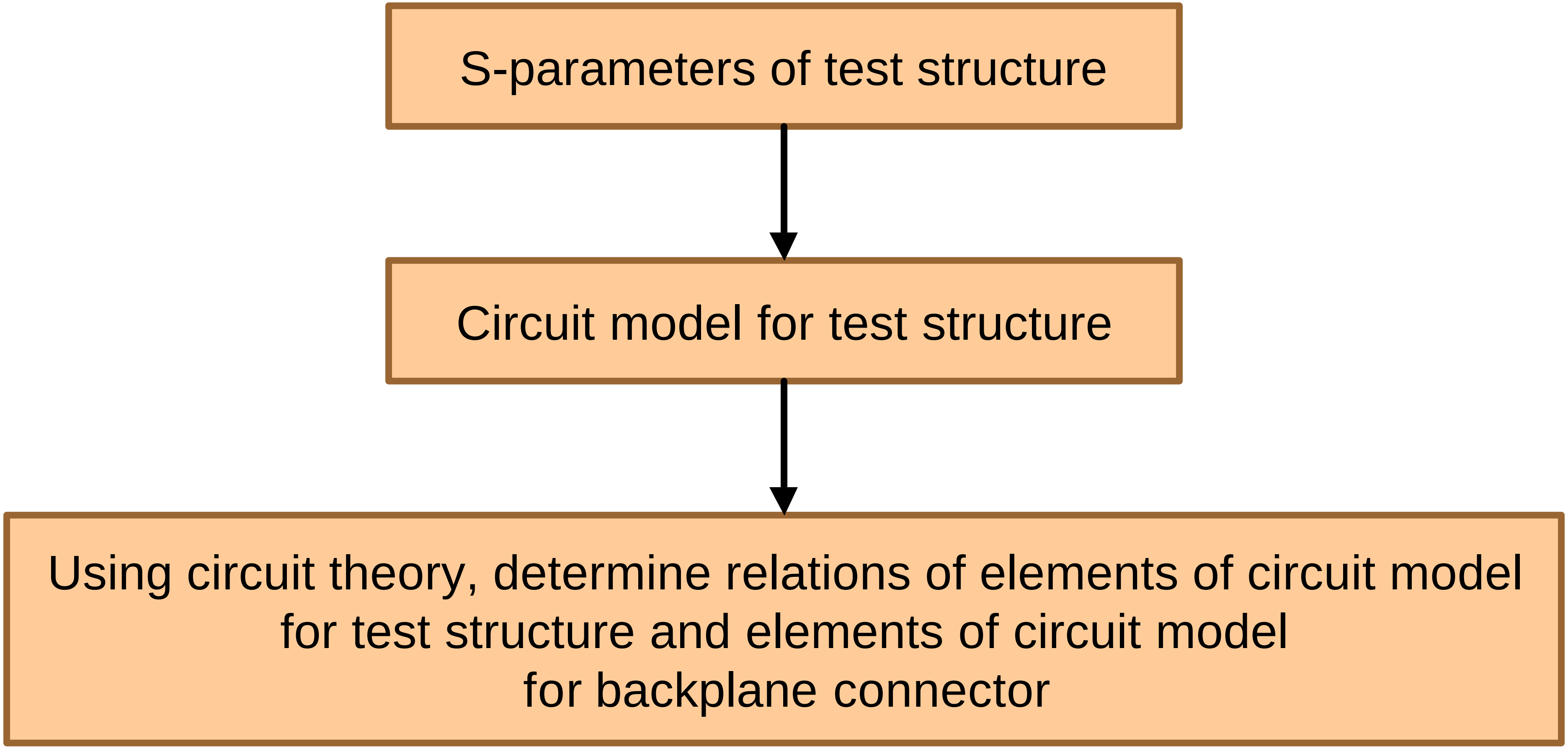
Modeling diagram



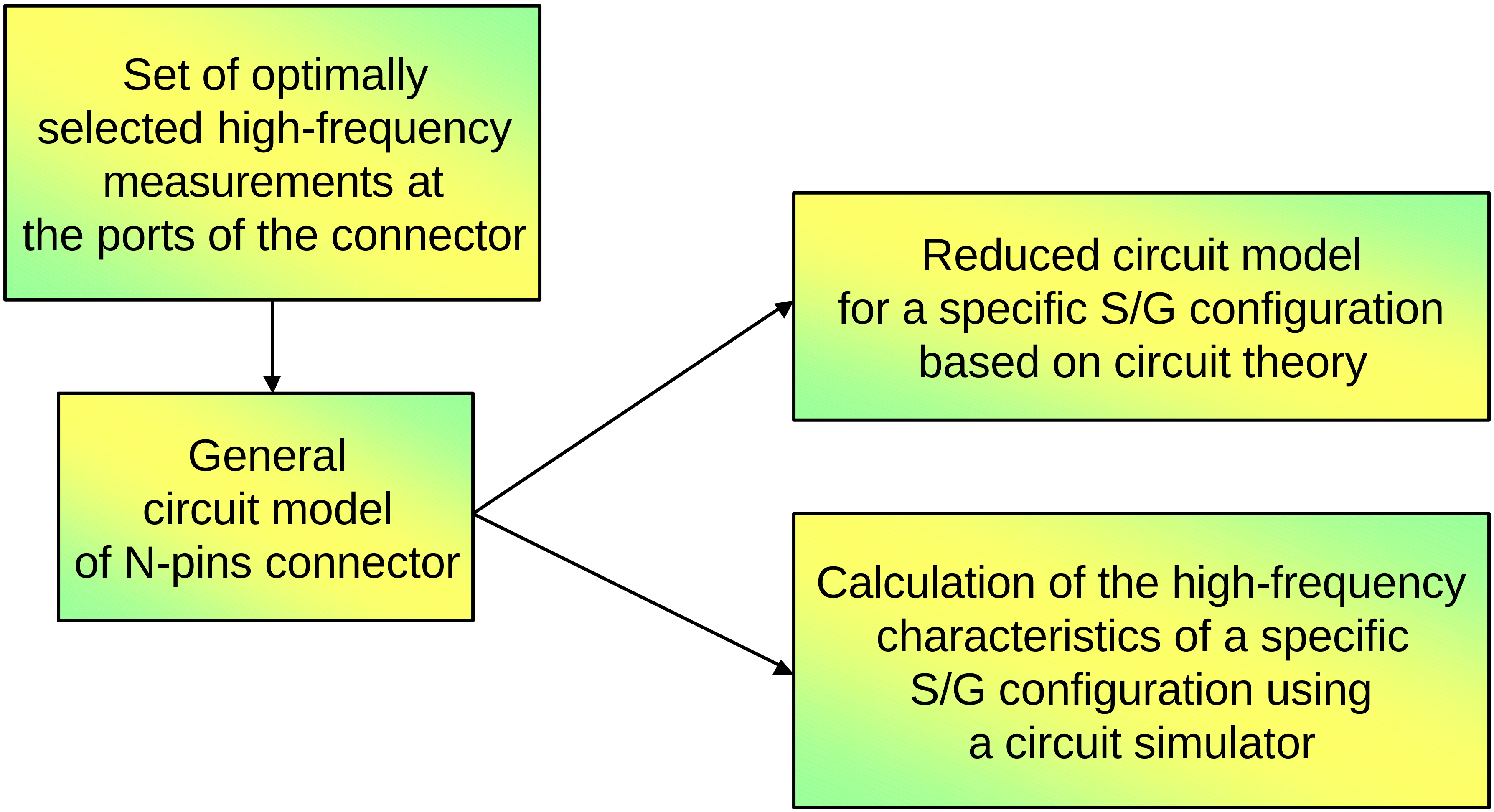
Characterisation test structure



Derivation of elements of circuit model of connecto



S/G configurations



Example: backplane connector

S/G Configurations:

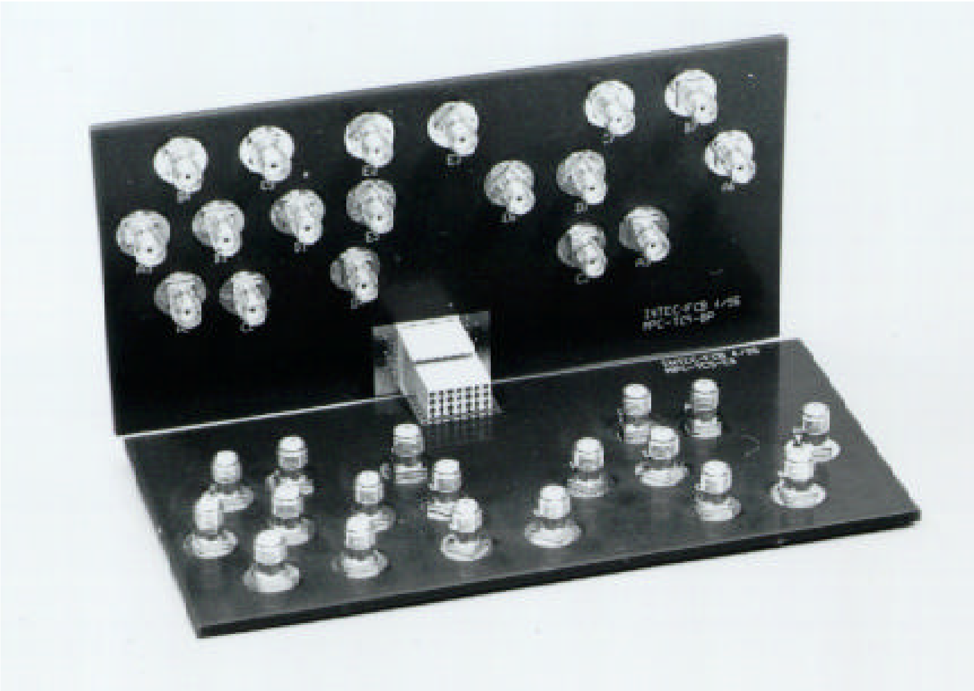
	1	2	3	4	5	6	7
A	X	M	M	X	O	O	X
B	O	X	X	O	X	X	O
C	X	O	O	X	O	O	X
D	O	X	X	O	X	X	O
E	X	O	O	X	O	O	X

Configuration A

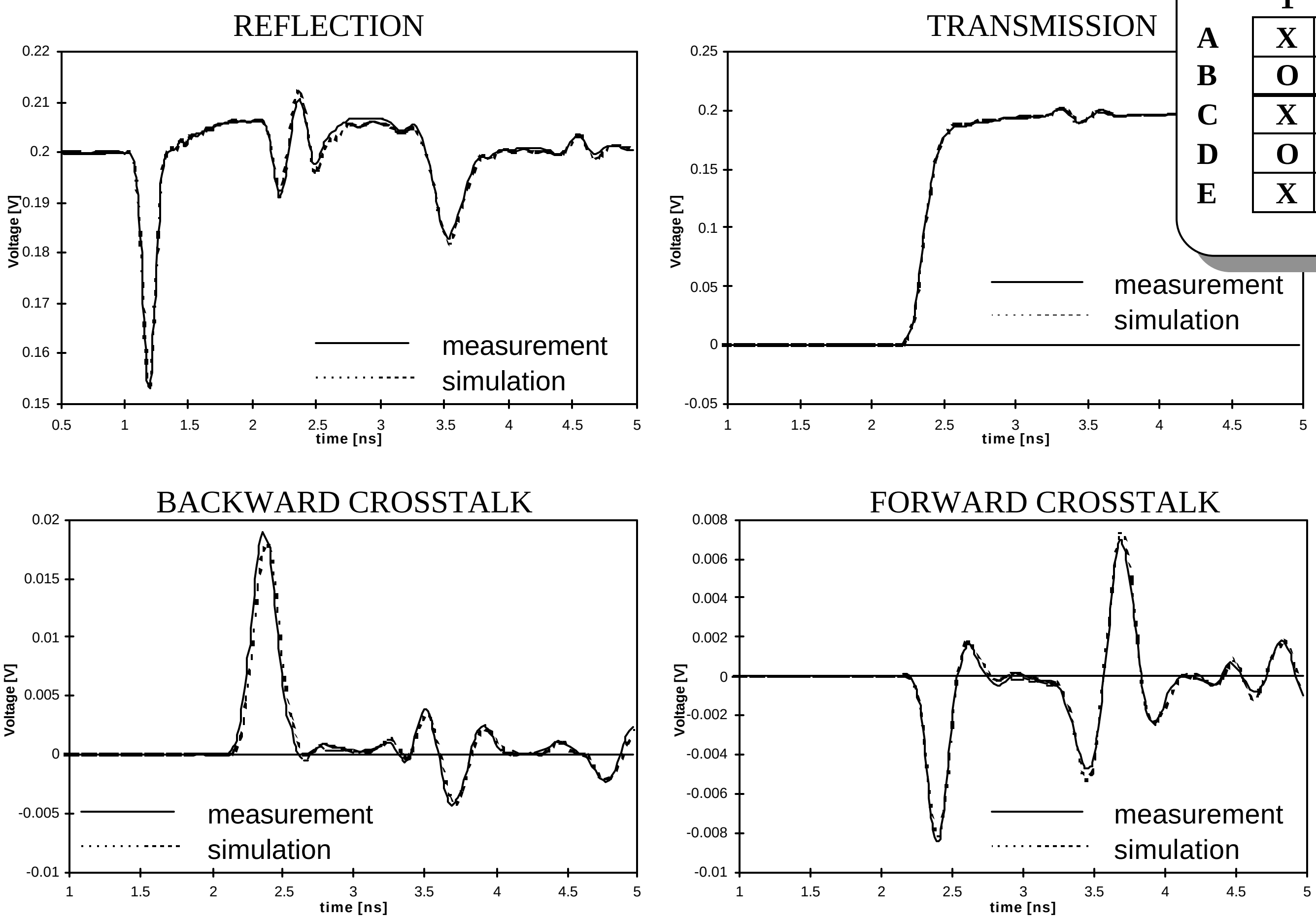
A	O	O	O	O	O	O	O
B	O	O	O	O	O	O	O
C	X	X	X	X	X	X	X
D	M	O	O	O	O	O	O
E	M	O	O	O	O	O	O

Configuration B

O: signal pin
M: monitored signal pin
X: ground pin

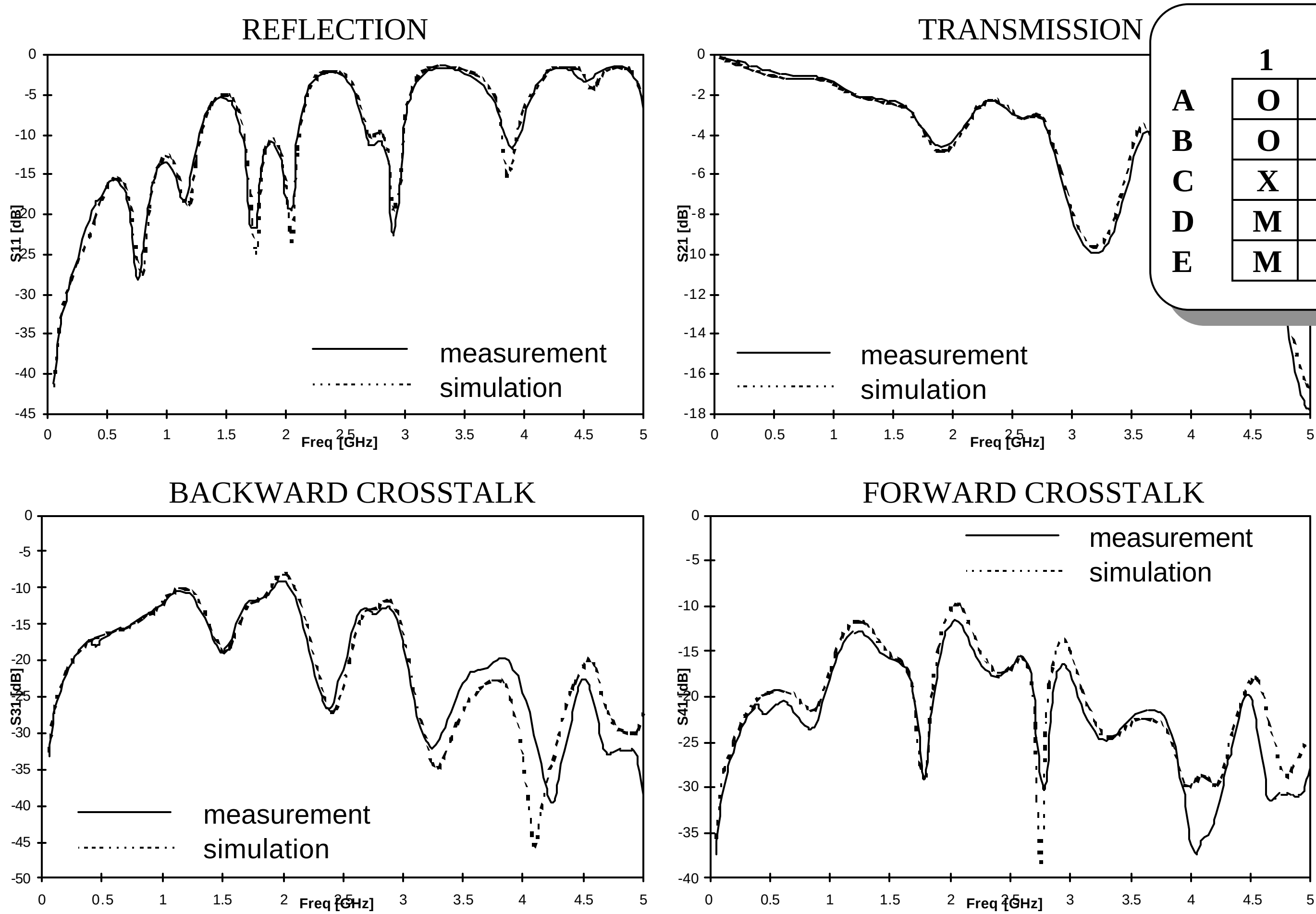


Results: configuration A



	1	2	3	4	5	6	7
A	X	M	M	X	O	O	X
B	O	X	X	O	X	X	O
C	X	O	O	X	O	O	X
D	O	X	X	O	X	X	O
E	X	O	O	X	O	O	X

Results: configuration B



	1	2	3	4	5	6	7
A	O	O	O	O	O	O	O
B	O	O	O	O	O	O	O
C	X	X	X	X	X	X	X
D	M	O	O	O	O	O	O
E	M	O	O	O	O	O	O

More information can be found in:

Experimental High-frequency Characterization of Electronic Packaging

Author: Prof. Luc Martens
Publisher: Kluwer Academic Publishers
ISBN number: 0-7923-8307-9