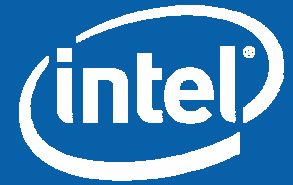


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# **(Re) Introducing Touchstone® 2.0**

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# Introducing Touchstone® 2.0

What is it?

- A revision to Touchstone®, the standard that describes frequency-dependent network data (S-, Z-, etc. parameters)
- A fully backward-compatible update to Touchstone®

Why is it needed?

- The original Touchstone® is ambiguous in several areas
  - Maximum number of ports
  - Definition of “line” and organization of network data
- The original specification did not easily support some applications
  - e.g., network data describing both power planes and signal lines
  - A large reference impedance may introduce numerical errors when applied to the smaller impedances seen in plane measurements

The changes make the format easier to use  
and to integrate with ICM

# Touchstone® 2.0 Key Concepts

## Major Changes from Touchstone®

- Added optional per-port reference impedances
- Added explicit keyword for numbers of ports, frequencies in the file
- Added explicit version control

```
[Version] 2.0
```

```
# GHz S MA R 50
```

```
[Number of Ports] 4
```

```
[Reference] 50 75 0.01 0.01
```

```
5.00000 0.60 161.24 0.40 -42.20 0.42 -66.58 0.53 ...
```

- Removed any limit on the maximum number of ports described
- Removed normalization for non-S-parameter data sets
- Added support for upper- and lower-half matrices

Original Touchstone® files are supported  
as-written under Touchstone® 2.0

# Touchstone® 2.0 Key Concepts

## What Was NOT Included

- No support for mixed-mode S, Y, Z, etc. parameter expressions
  - Differential systems can be easily described with single-ended data
  - Definition of “common” and “differential” ambiguous for > 2 lines
- No support for complex reference impedances
- No support for frequency-dependent reference impedances
  - Most systems can still be mathematically treated to use frequency-independent, real-only references
  - Most simulators use real-only references consistently, but may differ on interpretation of complex impedances

These features are available for inclusion in a Touchstone® 3, if needed

# Touchstone® Major Feature Summary

Feature	Touchstone®	Touchstone® 2.0
Reference impedances	One impedance for all ports	Either one impedance or per-port impedances may be used
Normalization	G-, H-, Y-, Z- parameters are normalized to reference	Data is NOT normalized to the reference
Number of ports	Implied from size of data matrices	Explicitly stated through [Number of Ports]
Number of frequencies	Only known after complete reading of file	Explicitly stated through [Number of Frequencies], [Number of Noise Frequencies]
Version	No version control stated	Specification version is stated under [Version]
Data arrangement	<p>Maximum of four data pairs per line</p> <p>Matrices must be complete (e.g., a 2 port network must include 4 pairs of data plus a frequency point)</p>	<p>No limit on number of data pairs per line; data may be split across multiple lines</p> <p>Matrix data may be reduced into upper- or lower-half formats, assuming symmetry</p>

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# Other Notes & Next Steps

## Technical and Editorial Changes

- To be handled during IBIS Open Forum reviews

## Parser

- Is a standard parser required, as with IBIS and ICM?
- Should this instead be left to the adopting EDA tool vendors?

## Key Comments So Far from the SI-List

- Can mixed mode be added?
- Can unusual order for  $S_{12}$ ,  $S_{21}$  in 2-port networks be changed?

## Next Steps

- Review and comment period through end of February (at minimum)
- Call for vote once all major issues are closed
- GEIA balloting after IBIS vote (PINS has been filed)

**Thanks to Agilent for permission to use the name and to the Interconnect Task Group for their hard work in development!**

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