

Touchstone: Immediate and Long- Term Future

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Agenda

- History – Touchstone as a File Format
- Compatibility Between Versions
- Challenges: Industry Use and Proprietary Variants
- Per Port Impedance
- A Workaround and a Proposal for Touchstone 2.1
- Plans Beyond Touchstone 2.1
- Questions for the Community
- References

Touchstone as a Format

- Touchstone was a microwave simulator by EEsof, Inc. in the 1980s
 - *Later purchased by Hewlett-Packard, and incorporated into Keysight Technologies products, plus others*
- Supports use of an ASCII-text file format to represent network data as scattering or “S-parameters”
- The file format was transferred to IBIS Open Forum management in the early 2000s



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Compatibility Challenges

- Touchstone 1.0 was never published as a specification or standard
- A draft Touchstone 1.1 specification was developed by IBIS in 2002... but also never finalized
 - **The format of the data was untouched**
- The first formal, IBIS-approved specification for Touchstone was Touchstone 2.0 in 2009
 - **The original Touchstone file format is supported and explained there**
 - **Defines the official 1.0 and 2.0 syntax**

Touchstone® File Format Specification

Version 2.0

**Ratified by the IBIS Open Forum
April 24, 2009**

Two Problems Today

- Touchstone 2.0 is not in widespread use
 - Tools seem to support the format, but actual 2.0 files are rarely seen
- Touchstone 2.0's key feature is available in proprietary versions of Touchstone 1.0
 - Independent impedances declared per port

```
[Version] 2.0
# MHz Z MA
[Number of Ports] 1
[Number of Frequencies] 5
[Reference] 20.0
[Network Data]
!freq magZ11 angZ11
100 74.25 -4
200 60 -22
300 53.025 -45
400 30 -62
500 0.75 -89
```

Working theory: Touchstone 2.0 does not include the key features customers want, but adds complexity

Per Port Impedance

- Touchstone's reference default is 50 Ω
 - This originates with coaxial cables for RF
 - This is adequate for most PCB interconnect
- For supplies, smaller references are used
 - 0.01 Ω is the order of magnitude
- Combining signals and supplies into one Touchstone file can cause precision, file size or other issues

How do we provide power-aware Touchstone correctly?

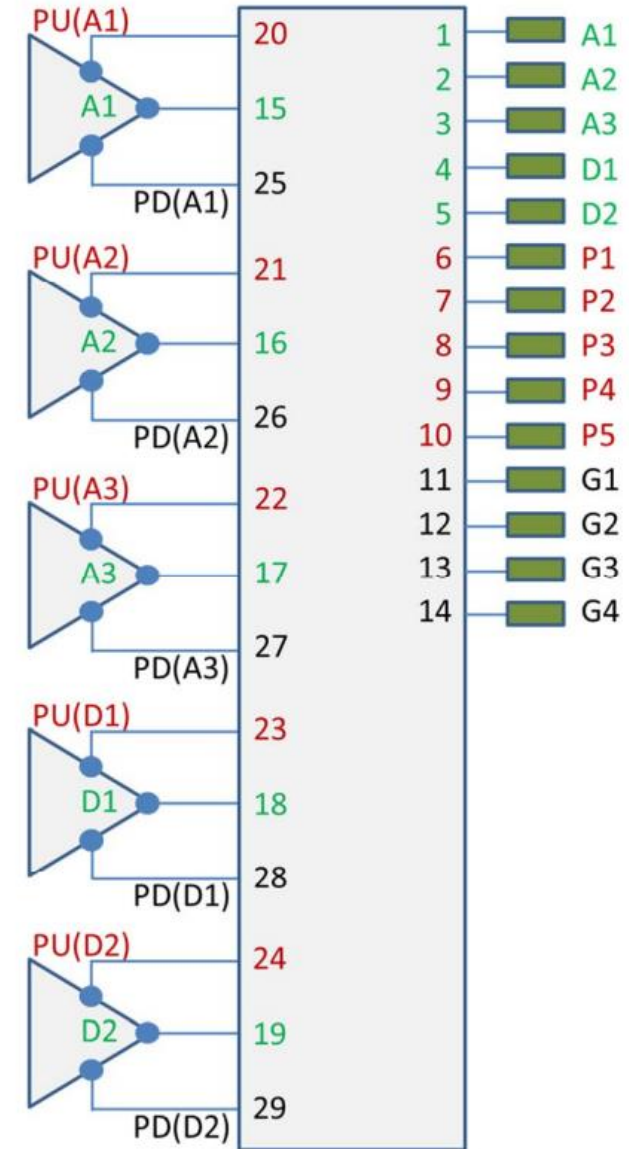


Figure 54 of the IBIS 7.2 Specification

A Workaround and A Proposal

- Touchstone 1.0 supports an option line that includes impedance:
GHz S MA R 50
- Touchstone 2.0 adds an optional [Reference] line to override this
[Reference]
50 75 0.01 0.01
- Proposed Touchstone 2.1 would allow the following for 2.1 and 1.0 files

GHz S MA R 50 75 0.01 0.01

Is this needed? Would this be useful?

Plans for Touchstone Beyond 2.1

- Discussions ongoing regarding Touchstone **3.0**
- Key request # 1
 - Provide port naming and orientation information (explicit input and output)
 - Helps automate connections, but less useful for RF
- Key request #2
 - Support pole-residue or other high-compression format
 - Debate: fitting implies equations defined by the specification

Data Challenge

Rate: 24 GT/s bus
Width: 16 lines (s32p)
= 1024 pairs/freq.

Minimum f: 0 Hz

Maximum f: 12 GHz

Linear step: 10 MHz
= 1200 frequencies
@ 0.2 - 1.2 KB/pair
= 200 - 1400 MB file

Questions for the IBIS Community

- Are these features the most important ones for Touchstone 3.0?
 - If not, which features are most needed?
- Is version control needed for IBIS features that use Touchstone?
 - EMD, IBIS Interconnect, [C Comp Model] can all point to Touchstone files



The IBIS Interconnect Task Group is considering Touchstone 3.0 features – feedback is welcome!

For More Information

- IBIS Interconnect Task Group

- Meets via teleconference on Wednesdays, 8 AM US Pacific Time
- Reflector: freelists.org/list/ibis-interconn
- Documents & Minutes: ibis.org/interconnect_wip/

- References

- Touchstone 2.0: ibis.org/touchstone_ver2.0/

Thank you!

Backup

Example of Combined Signal and Power

```
[Interconnect Model Set]      MT40A1G8SA_DQ_TS2_Sparam
|
[Interconnect Model]          z11b_78b_dq_ts2
```

Touchstone 2.0
8-12 places of precision

```
File_TS      z11b_78b_dq_ts2.ts
Number_of_terminals = 27
```



1	Pin_I/O	pin_name	A7		DM_n_DBI_n_TDQS_t	DM_DBI_TDQS
2	Buffer_I/O	pin_name	A7		DM_n_DBI_n_TDQS_t	DM_DBI_TDQS
3	Pin_I/O	pin_name	C2		DQ0	DQ
4	Buffer_I/O	pin_name	C2		DQ0	DQ
5	Pin_I/O	pin_name	B7		DQ1	DQ
6	Buffer_I/O	pin_name	B7		DQ1	DQ
7	Pin_I/O	pin_name	D3		DQ2	DQ



21	Pin_I/O	pin_name	C3		DQS_t	DQS
22	Buffer_I/O	pin_name	C3		DQS_t	DQS
23	Pin_Rail	signal_name	VDD		VDD	POWER
24	Buffer_Rail	signal_name	VDD		VDD	POWER
25	Pin_Rail	signal_name	VDDQ		VDDQ	POWER
26	Buffer_Rail	signal_name	VDDQ		VDDQ	POWER
27	Pin_Rail	signal_name	VSS		VSS	GND



```
[End Interconnect Model]
|
[End Interconnect Model Set]
```

Example courtesy Micron as publicly available on the IBIS website

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