

Subject: About the Compare S-Parameters Tool

Author: John Baprawski; John Baprawski Inc. (JB)

Date: Jan 3, 2019

The Compare S-Parameters Tool uses the data in two S-parameter files to compare their reflection coefficients, transmission characteristics and reverse transmission characteristics.

This tool is one of the many free web-based tools available to use on the web site:

<https://www.serdesdesign.com>

This tool is at the web-site: <https://www.serdesdesign.com/home/compare-sparameters-tool/>

Discussion

A SerDes channel typically is a differential signal transmission channel. A hardware SerDes channel is typically characterized by measuring its N-port S-parameters and is typically a 4-port. The 4-port differential input ports are typically port 1 (+) and port 3 (-). The associated differential output ports are typically port 2 (+) and port 4 (-). The differential characteristic (Port 1 – Port 3 vs. Port 2 – Port 4) is the channel transmission characteristic and the S-Parameter data is versus frequency.

See S-parameter detail in References > [S-Parameter Channel Examples](#).

S-Parameter data inherently is used to represent SerDes system channels, transmit (Tx) or receive (Rx) integrated circuit (IC) input or output analog buffers, IC packaging, and more.

The S-Parameters for an N port device are typically represented with the symbol S_{ij} , where i represents the port of interest with an output wave, and j represents the port with an incident input wave, with i and j being integers in the range 1 to N. Thus, S_{21} means port 2 contains the measured output wave and port 1 has the incident input wave.

Within the Compare S-Parameters Tool, the S-Parameters from two different files can be viewed and compared for their reflection characteristics ($i=j$), transmission characteristics ($i>j$), or reverse transmission characteristics ($i<j$). The characteristics are viewed with magnitude (dB) and phase (deg) versus frequency.

For more detail on the data and graphs available from this web site, see the article: and [Typical Compare SParameters Characteristics and Displays...](#)

Use the tool by following these steps.

Step 1: Define the system.

SerDesDesign.com About_the_Compare_SParameters_Tool

1. Define System

Name	Description	Entry Value(s)	Status	Type	Limits	Comment
SParamFileA	S-parameter file	Channel_25Gbps.s4p Choose File No file chosen		File		Upload a file (Touchstone 1.0 format) or list previously uploaded file.
NumSPortsA	Number of ports	4		Integer	≥ 4	For S-parameter file
InPortPositiveA	Input port + (positive side)	1		Integer	[1, NumSPortsA]	Must be different from the other in and out ports
InPortMinusA	Input port - (minus side)	3		Integer	[1, NumSPortsA]	Must be different from the other in and out ports
OutPortPositiveA	Output port + (positive side)	2		Integer	[1, NumSPortsA]	Must be different from the other in and out ports
OutPortMinusA	Output port - (minus side)	4		Integer	[1, NumSPortsA]	Must be different from the other in and out ports
SParamFileB	S-parameter file B	Channel_25Gbps.s4p.causal.s4p		File	-	List file that was previously uploaded (Touchstone 1.0 format)
NumSPortsB	Number of S-parameter ports	4		Integer	≥ 4	
InPortPositiveB	Input port + (positive side)	1		Integer	[1, NumSPortsB]	Must be different from the other in and out ports
InPortMinusB	Input port - (minus side)	3		Integer	[1, NumSPortsB]	Must be different from the other in and out ports
OutPortPositiveB	Output port + (positive side)	2		Integer	[1, NumSPortsB]	Must be different from the other in and out ports
OutPortMinusB	Output port - (minus side)	4		Integer	[1, NumSPortsB]	Must be different from the other in and out ports

Choose two S-parameter files with file extension sXp where X is an integer in the range [1, 2, 3, 4, 8, 12, ...] where X is a multiple of 4 beyond 12.

List the number of s-parameter ports; NumSPorts should be the same as X; identify the differential input and output pins for each file.

Step 2: Setup the analysis.

2. Setup Analysis

Name	Description	Entry Value(s)	Status	Type	Limits	Comment
AnalysisName	Analysis name	SParametersTest		String		Alpha-numeric characters or underbar - case sensitive - start with alpha character
MeasurementPorts	List of S-parameter ports for measurement	1, 2, 3, 4		Integer array	[1, NumSPorts]	Must not have duplicate ports. Maximum of 4 entries
UnWrapPhase	Unwrap phase vs frequency	1		Integer	[0, 1]	0 = No; 1 = Yes

Set the analysis name; it can remain as the default name.

List up to 4 measurement ports. Let 'i' and 'j' be the S-parameter 'output pin' and 'input pin' respectively. The S_{ii} parameters are reflection coefficients. The S_{ij} parameters with 'i' > 'j' are considered to be transmission coefficients. The S_{ij} parameters with 'i' < 'j' are considered to be reverse transmission coefficients.

SerDesDesign.com About_the_Compare_SParameters_Tool

The displayed analysis phase results are displayed in degrees and will be the unwrapped degrees when 'UnWrapPhase' is set to '1'.

3. Run the analysis by selecting the 'Run' button.

3. Run Analysis

Select to run analysis	Run		Waiting to run
------------------------	------------------------------------	--	----------------

4. Display the desired results.

1. Passivity check	Open		
Reflection magnitude		Reflection phase	
2. S+in+in	Open	18. S+in+in	Open
3. S+out+out	Open	19. S+out+out	Open
4. S-in-in	Open	20. S-in-in	Open
5. S-out-out	Open	21. S-out-out	Open
Transmission magnitude		Transmission phase	
6. S+out+in	Open	22. S+out+in	Open
7. S+out-in	Open	23. S+out-in	Open
8. S-out+in	Open	24. S-out+in	Open
9. S-out-in	Open	25. S-out-in	Open
Reverse transmission magnitude		Reverse transmission phase	
10. S+in+out	Open	26. S+in+out	Open
11. S+in-out	Open	27. S+in-out	Open
12. S-in+out	Open	28. S-in+out	Open
13. S-in-out	Open	29. S-in-out	Open
Reverse coupling magnitude		Reverse coupling phase	
14. S+in-in	Open	30. S+in-in	Open
15. S+out-out	Open	31. S+out-out	Open
16. S-in+in	Open	32. S-in+in	Open
17. S-out+out	Open	33. S-out+out	Open

Additional Notes and Equations.

For the default files, the analysis log file is displayed here:

```
Compare SParameters setup.
Define_Compare_SParameters: SParamFileA = Channel_25Gbps.s4p, NumSPortsA = 4, InPortPositiveA = 1, InPortMinusA = 3, OutPortPositiveA = 2,
OutPortMinusA = 4, SParamFileB = Channel_25Gbps.s4p.causal.s4p, NumSPortsB = 4, InPortPositiveB = 1, InPortMinusB = 3, OutPortPositiveB = 2,
OutPortMinusB = 4
Setup_Compare_SParameters_Analysis: AnalysisName = SParametersTest, UnWrapPhase = 1, CompareImpulseResponses = 0

Reading S-Parameter file.

For file A = Channel_25Gbps.s4p
S-Parameters reference resistance = 50
S-Parameters has 12801 frequencies with fmin = 1e+07 and fmax = 4e+10.

For file B = Channel_25Gbps.s4p.causal.s4p
S-Parameters reference resistance = 50
S-Parameters has 16385 frequencies with fmin = 0 and fmax = 4.00024e+10.

SA21, SA12 are not recipicol. Max difference is 38.8548 dB at freqA[10439] = 3.26237e+10.
SA31, SA13 are not recipicol. Max difference is 6.20561 dB at freqA[9489] = 2.96557e+10.
SA32, SA23 are not recipicol. Max difference is 45.5311 dB at freqA[11471] = 3.58479e+10.
SA41, SA14 are not recipicol. Max difference is 40.1432 dB at freqA[11709] = 3.65915e+10.
SA42, SA24 are not recipicol. Max difference is 0.289553 dB at freqA[4558] = 1.42502e+10.
SA43, SA34 are not recipicol. Max difference is 30.2431 dB at freqA[11453] = 3.57917e+10.

SB21, SB12 are not recipicol. Max difference is 32.8905 dB at freqB[16196] = 3.95434e+10.
SB31, SB13 are not recipicol. Max difference is 26.8418 dB at freqB[12149] = 2.96625e+10.
SB32, SB23 are not recipicol. Max difference is 43.6793 dB at freqB[15991] = 3.90429e+10.
SB41, SB14 are not recipicol. Max difference is 34.1866 dB at freqB[13806] = 3.37081e+10.
SB42, SB24 are not recipicol. Max difference is 0.58859 dB at freqB[2656] = 6.48477e+09.
SB43, SB34 are not recipicol. Max difference is 28.8727 dB at freqB[15348] = 3.7473e+10.

S-Parameter file A data is passive.

S-Parameter file B data is not passive.
The largest passivity violation occurs for SB at 2.95428e+08 Hz.
The maximum eigenvalue of SS* = 1.08164

Writting Spectrum files.

Exiting Compare SParameters with success; run time = 2 sec.
```

S-parameter passivity is defined at each frequency based on the relationship: $[S]^\dagger[S]$ where $[S]$ is the scattering matrix, and † denotes the conjugation and transposition of a matrix. The calculated passivity measure is the minimum eigenvalue of $[I] - [S]^\dagger[S]$ where $[I]$ is the identity matrix. S-Parameters are passive, if $[S]^\dagger[S]$ is less than or equal to one and are lossless if $[S]^\dagger[S]$ is equal to one.

[Terms & Conditions](#) | [Privacy Policy](#)