

Subject: About the Combine S-Parameters Tool

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The Combine S-Parameters Tool combines the cascade of up to five S-parameter files into one s4p S-parameter file.

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/combine-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 Combine S-Parameters Tool, the S-Parameters from up to five different files can be combined as the cascade of the s4p characteristics. 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 Combine SParameters Characteristics and Displays...](#)

Use the tool by following these steps.

Define the S-parameter files to be cascaded

SerDesDesign.com About_the_Combine_SParameters_Tool

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

Use the 'Choose File' button to upload each of the files to be cascaded.

List the first file in the cascade as 'SParamFileA'.

Each file must have at least 4 ports. These 4 ports are expected to represent a differential channel. List the input and output positive and minus port numbers.

At least SParamFileA must be defined.

If any of the following files are not to be used, then use 'NULL' as the file name.

The default state of this tool lists 'Channel_2Gbps.s4p' as SParamFileA and SParamFileB. NULL is entered for SParamFileC, SParamFileD, and SParamFileE.

Setup the analysis.

Name	Description	Entry Value(s)	Status	Type	Limits	Comment
AnalysisName	Combined filename	Combined_SParameters		String		Alpha-numeric characters or underbar - case sensitive - start with alpha character

Define the name of the resultant combined S-parameter s4p file. This file will be created with:

Run the analysis.

Select to run analysis	Run		Waiting to run
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The S-parameter combining process follows these steps:

- Each S-parameter file has its minimum frequency (fmin), maximum frequency (fmax) and step frequency (fstep) recorded.
- Using the snp file defined reference resistance, the associated s4p data is defined with the other ports terminated in that reference resistance.
- The s4p file is converted to use a 50 Ohm reference resistance.

- For information purpose, the s4p data is reported as passive or not passive. If not passive, then the frequency with the largest passivity violation is reported with its maximum eigenvalue reported.
 - S-parameter passivity is defined at each frequency based on the relationship: $[S]^\dagger[S]$ where $[S]$ is the scattering matrix, and $\dagger$ 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.
- For information purpose, the s4p data is tested for reciprocity with frequency with the maximum reciprocity violation reported along with its maximum difference in dB.
 - S-parameter reciprocity is defined when $S_{ij} = S_{ji}$ for $i \neq j$.
- The maximum minimum frequency is recorded: $f_{min_max} = \max(f_{minA}, f_{minB}, f_{minC}, f_{minD}, f_{minE})$.
- The minimum maximum frequency is recorded: $f_{max_min} = \min(f_{maxA}, f_{maxB}, f_{maxC}, f_{maxD}, f_{maxE})$.
- The minimum step frequency is recorded: $f_{step_min} = \min(f_{stepA}, f_{stepB}, f_{stepD}, f_{stepE})$.
- The minimum step frequency is adjusted such that $f_{step_adj} = (f_{max_min} - f_{min_max})/N_{pts}$ where $N_{pts} = \text{int}((f_{max_min} - f_{min_max})/f_{step_min})$.
- The defined resultant combined S-parameters will have a frequency span defined by f_{max_min} , f_{min_max} and f_{step_adj} .
- Each s4p has its data interpolated for this frequency span.
 - Magnitude is interpolated in dB with a log frequency scale.
 - Phase is in degrees with phase first unwrapped and then interpolated with a linear frequency scale.
- The resultant combined S-parameter s4p file will use a 50 Ohm reference resistance with this port assignment:
 - Port 1 = + differential input.
 - Port 2 = - differential input.
 - Port 3 = + differential output.
 - Port 4 = - differential output.
- For information purpose, the largest passivity and reciprocity violations are reported.
- The name of the combined S-parameter file is reported.

Obtaining the combined S-parameter file.

For Windows:

- The combined S-parameter file will be in the users channel_data directory (C:\SerDesDesign\user-<user_number>\files\channel_data).

For Web-based Linux:

- Use the 'View S-Parameter Tool' to Run with the combined S-parameter file and use the 'Download' button to download to your local computer.
- will be in the users channel_data directory (C:\SerDesDesign\user-<user_number>\files\channel_data).

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