S-parameter analysis and conversion using MathWorks tools

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What are we going to talk about today?

- How can I import S-parameters into the MATLAB environment?
- How can I convert single-ended S-parameters to differential S-parameters?
- How can I convert my S-parameters to the time domain and export them for SerDes simulation?
- How can I do Time Domain reflectometry using MATLAB?
- How do I handle S-parameters that are ‘difficult’ to fit?

So why are we talking about S-parameters?

- Channels in high speed serial communication systems are characterized in the frequency domain with S-parameters.

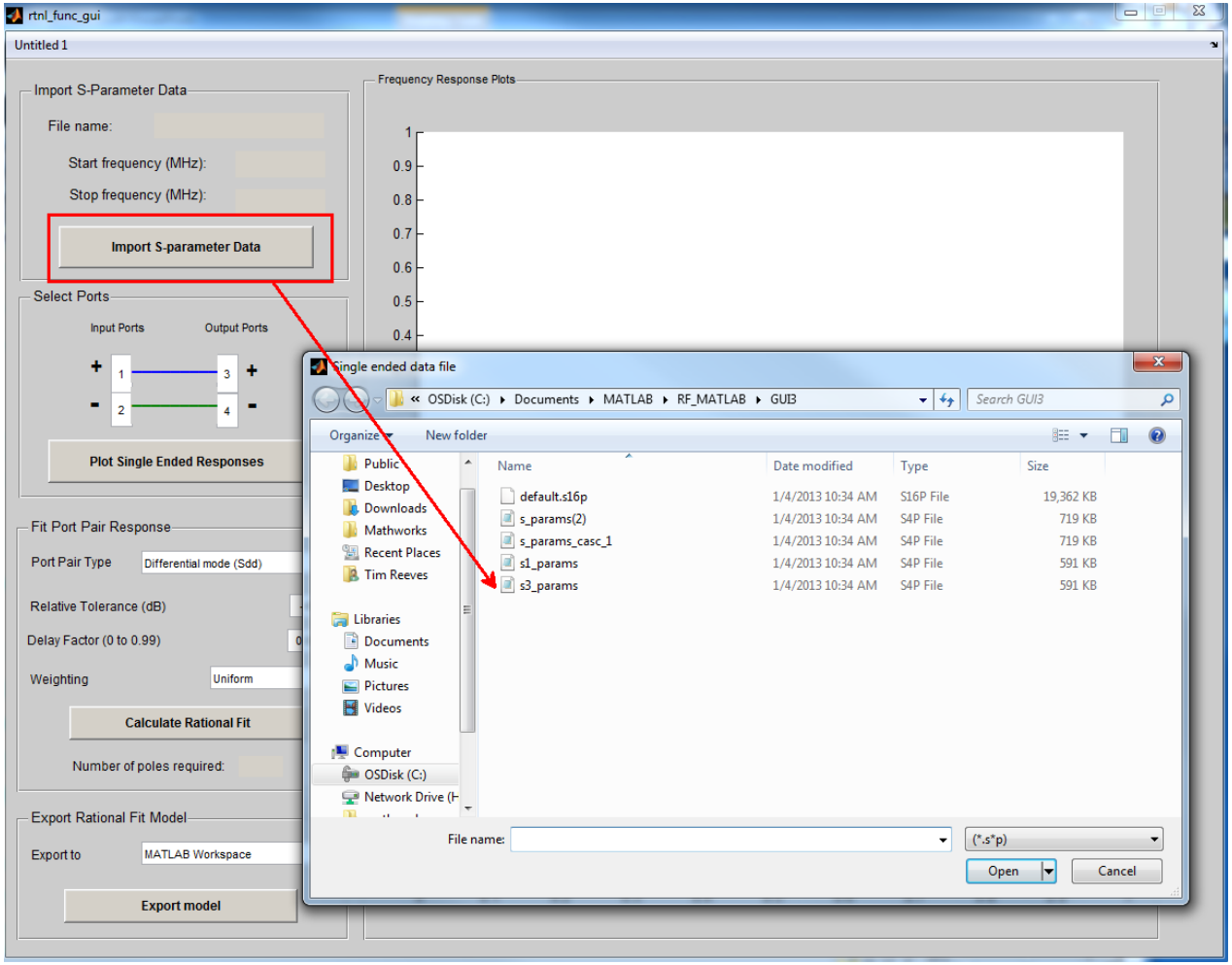
- We need to convert the S-parameters to the time domain so that other components in the transmitter and receiver can be designed and quantitative characterization of the serial communication system can occur.

Part 1. How can I work with S-parameters using MathWorks tools?

- In this section we are going to cover the MATLAB application that allows you to import, visualize and transform N-port, S-parameters for Signal Integrity analysis.

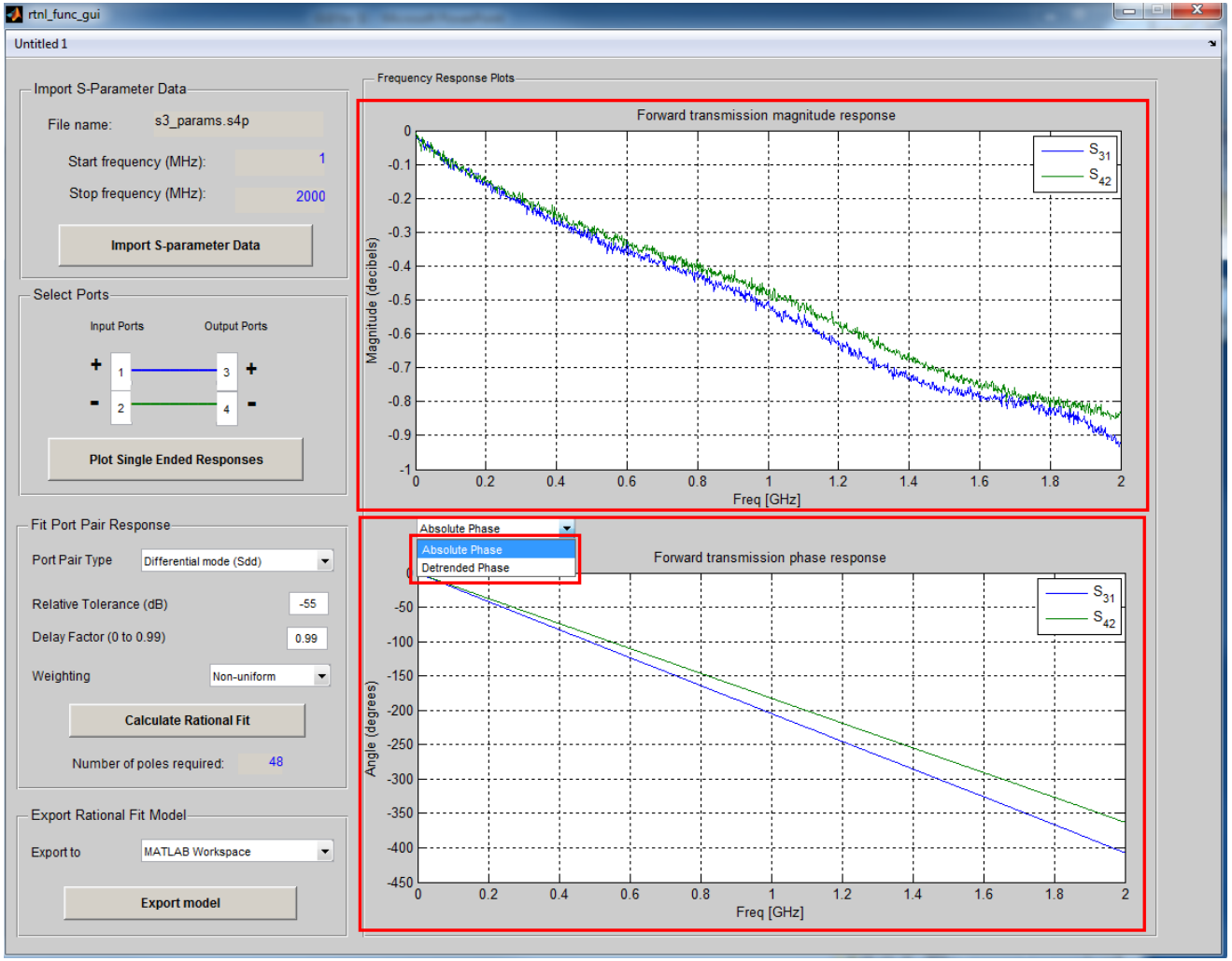
- This allows you to work in a single environment from importing S-parameters to exporting the rational function fit model.

How do I import S-parameters?

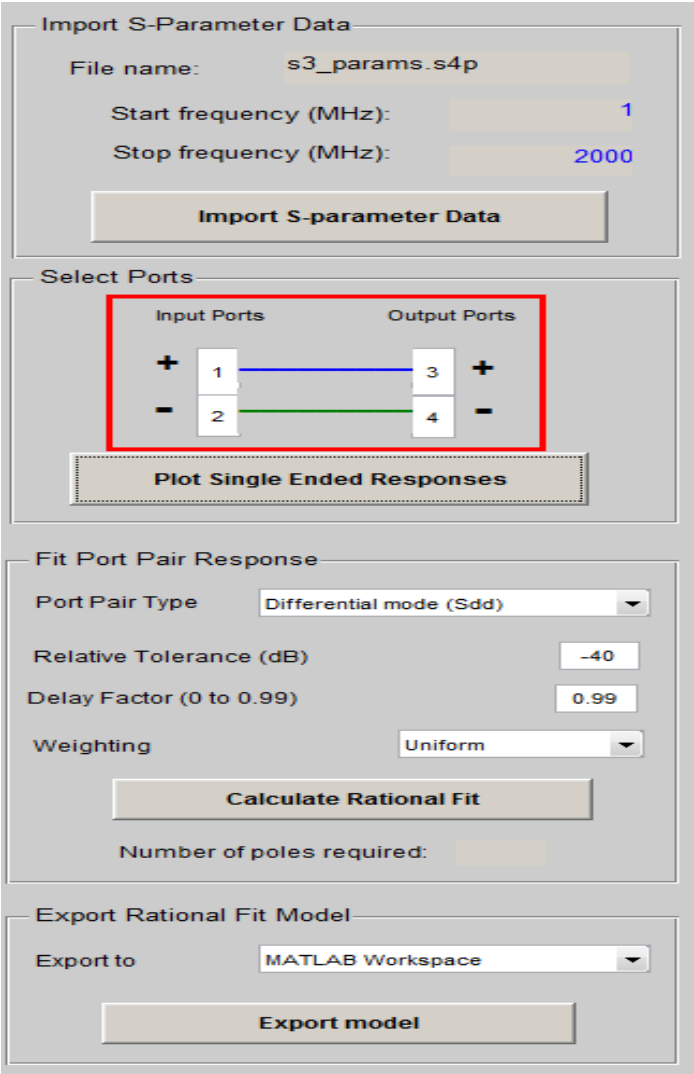


** Has to be at minimum a 4 port data file

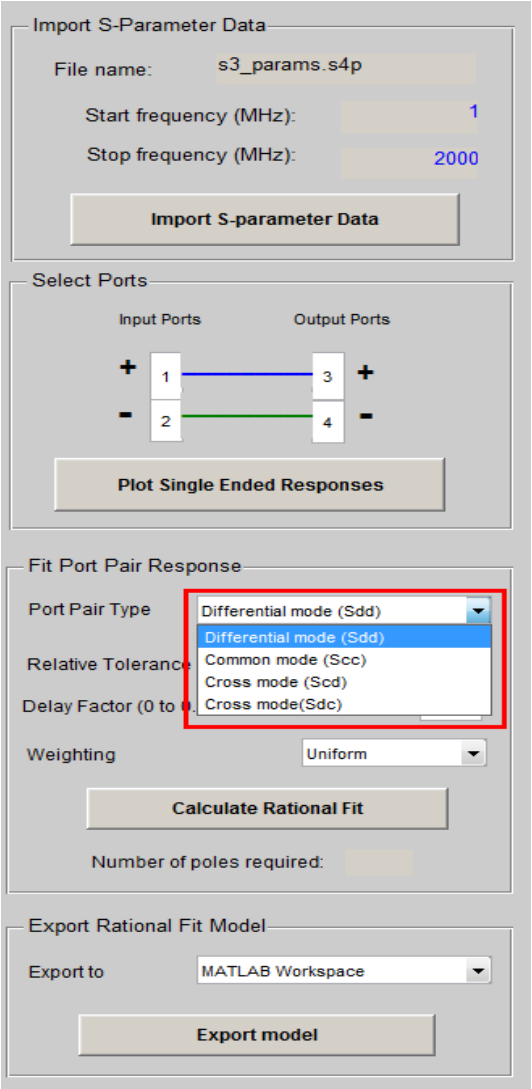
Are there frequency response plots?



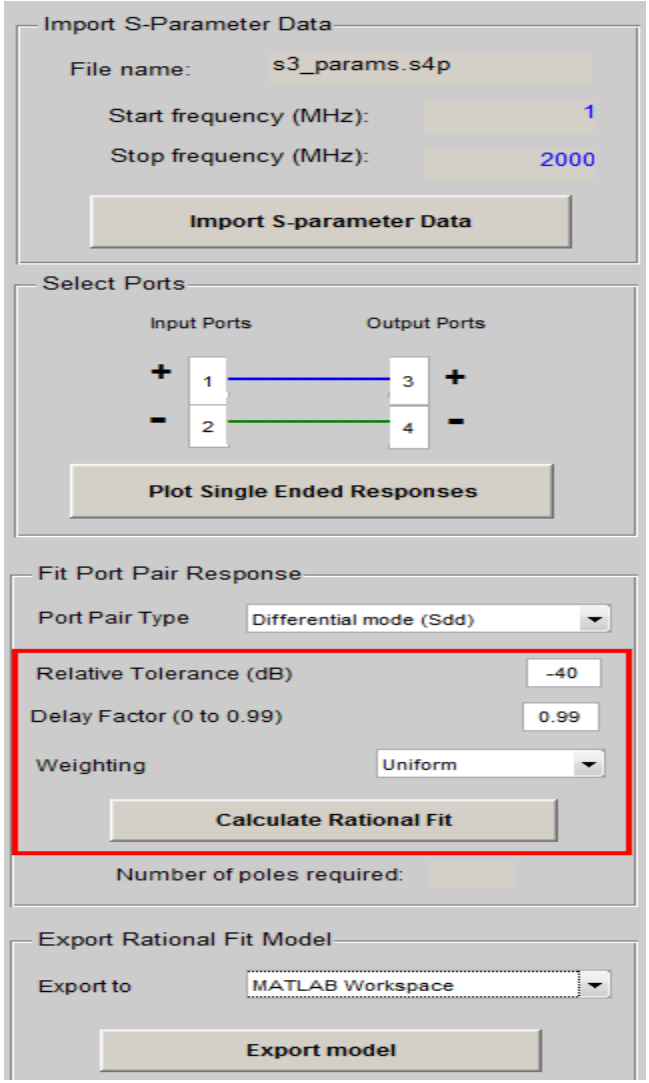
How do I select port pairs for my analysis?



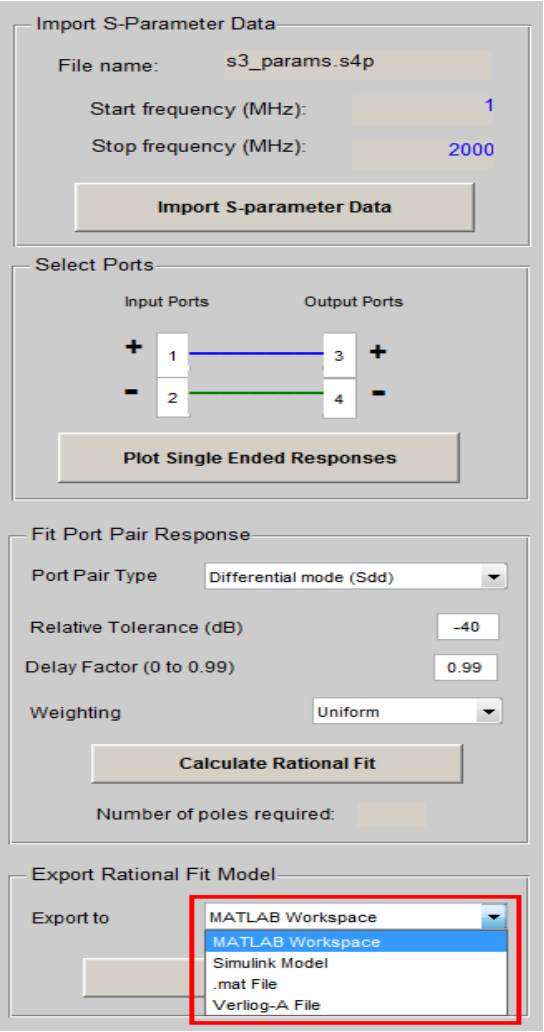
What port pair types can I select?



What options can I set so that I get a good rational fit?

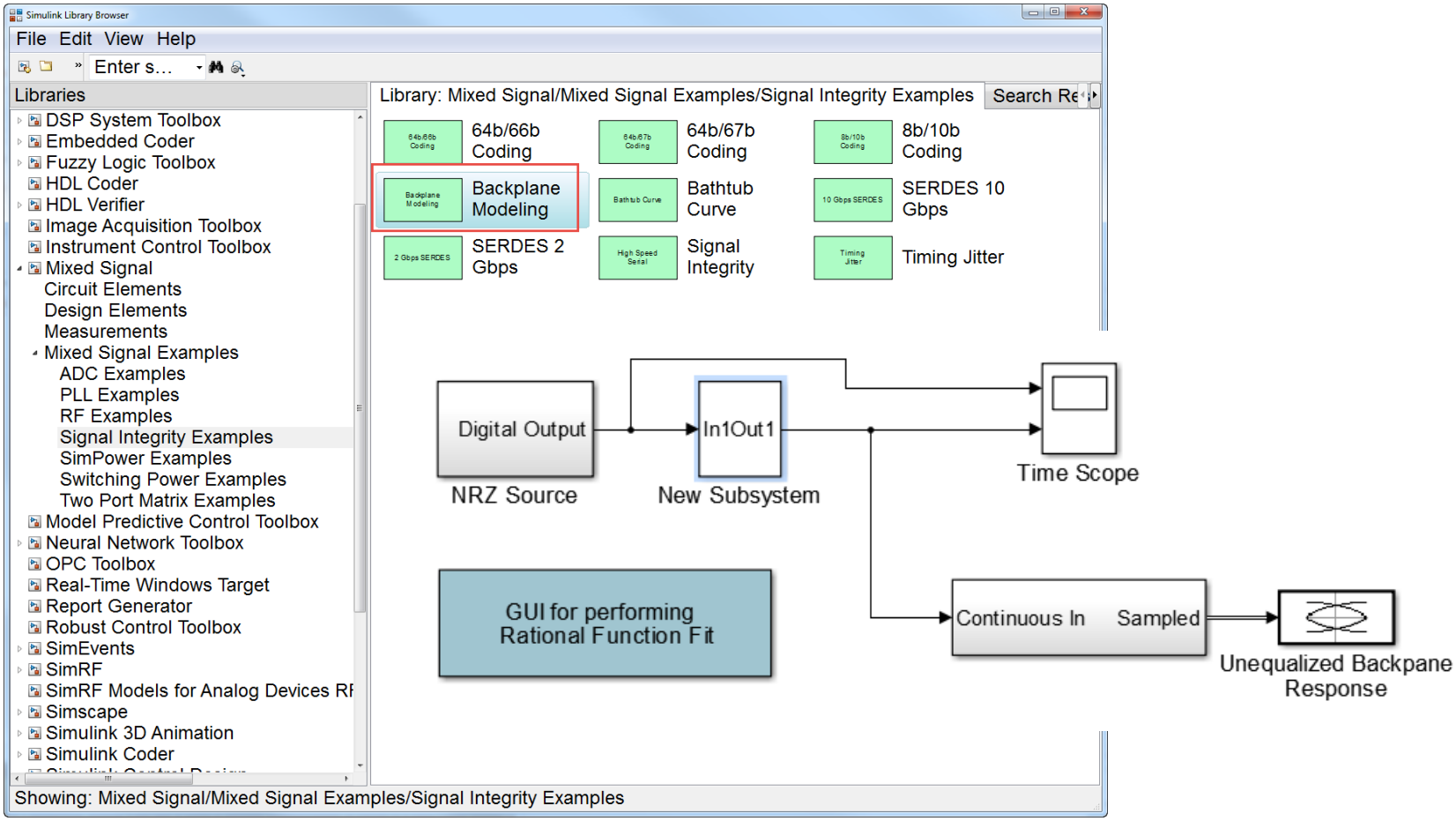


What can I do with the generated Rational Function?



How can I see what the time domain response will look like?

- Mixed Signal Library example



Part 2. How do I handle reflection dependent S-parameters?

- This refers to elements along the S-parameter matrix diagonal as well as elements that characterize isolation.
- For SI analysis these have periodic frequency behavior that is dependent on the transmission line's length.
- Generally these S-parameters are more challenging to fit than transmission S-parameters.

How can you handle reflection S-parameters using RF Toolbox?

- How do we transform S-parameters to the time domain?
  - RF Toolbox function rationalfit
- How is the rational fit converted to the time domain?
  - Transforms to the time domain using state space method
- What is challenging in the use of this function?
  - 7 different internal settings for the function!

What settings are important in the use of rationalfit?

- Let us go through a transmission line example and try to fit the input port reflection characteristic using the rationalfit function
- First we need to define the transmission line
  - We will use the rlcg2s function available from RF Toolbox
  - Need to define the per-unit length parameters such as r, l, c and g.
- The first setting to explore is 'TendsToZero‘ this describes the rationalfit behavior at infinite frequency.
  - Set this to ‘true’ for transmission functions
  - Set this to ‘false’ for reflection functions

How do individual data points impact the rationalfit?

- Often I get asked how much each frequency point impacts the rationalfit.
  - By default the rationalfit function does not let data at each frequency point contribute equally to the fit, it is dependent on the S-parameter value at each frequency point.

- Is this good enough?
  - Yes if the S-parameters don’t differ by orders of magnitude between the absolute minimum and maximum values.
  - So in general this really isn’t good enough.

- You want to adjust the weighting vector, ‘Weight’ setting

Can I select the order of the rationalfit?

- Yes you can!
- The setting ‘NPoles’ will allow you to set a lower and upper bound for the number of poles calculated for approximating the S-parameters.
- I would recommend using a for loop when trying to fit reflection functions.

What about the other settings beside tolerance?

- For the rest of the settings, I would recommend to use the default values when you are trying to fit reflection parameters.

- When fitting transmission parameters set the delayfactor to a non-zero value if the function has a lowpass characteristic.

How do I figure out if I have a good rationalfit?

- The rationalfit setting, ‘Tolerance’ will indicate how good of a fit that you have in the frequency domain.
- Does this mean a bounded time domain response? No
- How can I check the time domain response?
  - Transform the rationalfit into the time domain using timeresp and plotting the output signal
- You may need to go back and change the number of poles that you use for fitting.

What other things should you consider when doing rational function fitting?

- Make sure that you cover the frequency range that is commensurate with the data rate of the system that is being used. I recommend a frequency range up to 8x the data bandwidth.

- Make sure that your S-parameters are passive
  - ispassive and makepassive RF Toolbox functions

- Consider de-embedding or gating so as to reduce the number of poles required for reflection fitting.

What did we talk about today?

- How you can use a MATLAB application that is available in the Mixed Signal Library for transformation of transmission S-parameters into a time domain equivalent.
- A strategy for the use of rationalfit for handling ‘challenging’ S-parameters so as obtain a good rational function fit in both the frequency and time domain.
- How you can check your S-parameter data as well enforce passivity of the data.