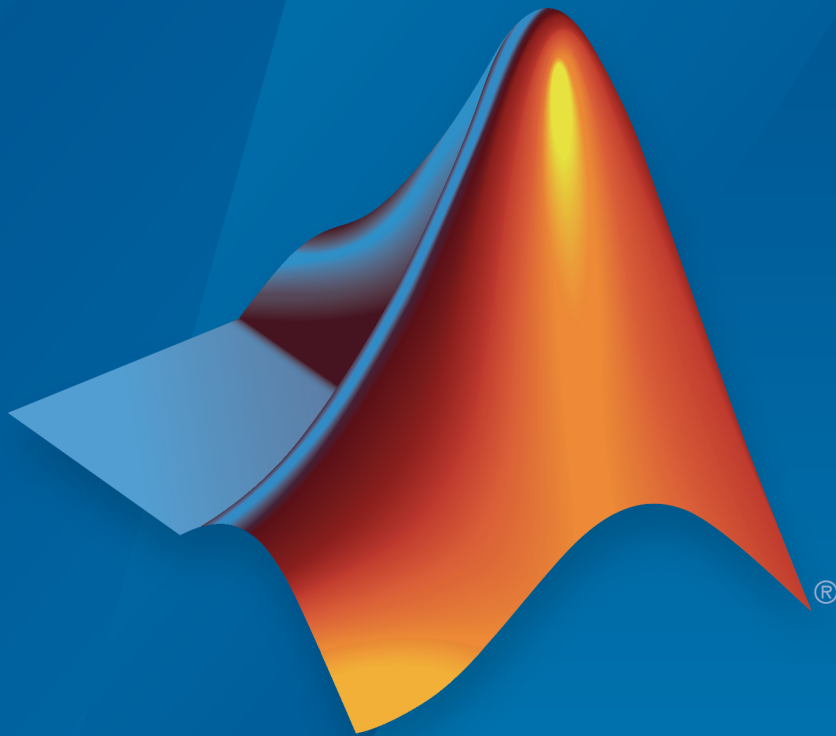


# RF Toolbox™ Release Notes



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### *RF Toolbox™ Release Notes*

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# R2016a

Version: 3.0

New Features

## **RF Budget Analyzer: Analytically compute gain, noise figure, and IP3 for cascaded RF components**

You can use the RF Budget Analyzer app to compute the per-stage and cumulative gain, noise figure, and third intercept point (IP3) for a system of RF elements. Export the computed values to the MATLAB® workspace. Simulate the system using SimRF™. Verify the gain, noise figure, and IP3 using the SimRF testbench simulation. To learn how to use the app, see [Superheterodyne Receiver Using RF Budget Analyzer App](#).

# R2015b

Version: 2.17

New Features

## **LC Ladder Objects: Build different ladder configurations of LC elements and include them in arbitrary networks**

You can use the `lcladder` class to create LC filters, calculate the S-parameters of the filters, and add the filters to an RF Toolbox™ circuit object.

## **Group Delay Calculation: Compute the group delay for networks with arbitrary topologies and for any S-parameter data**

You can use the `groupdelay` function to calculate the group delay of the S-parameters object and these RF network elements: `nport`, `circuit`, and `LC ladder`.

## **rationalfit Function Examples: Learn best practices for fitting S-parameter data**

Use these examples to understand how to improve the quality of `rationalfit` output:

- Using the 'NPoles' Parameter with `rationalfit`
- Using the 'Weight' Parameter with `rationalfit`
- Using the 'DelayFactor' Parameter with `rationalfit`

# R2015a

Version: 2.16

New Features

## **N-Port S-Parameters Circuit Element: Analyze RF networks containing S-parameter components**

You can use `nport` to create a linear `nport` circuit element from Touchstone files and `s-parameter` objects. Use the `add` function to add n-port element to circuit element.

## **T-Parameters Data Object: Store and convert T-parameters data from other formats**

You can create `tparameter` objects from touchstone files, network parameters, and `rfddata.network` objects using the `tparameters data` object function.

## **`rfplot` Improvements: Plot real, imaginary, magnitude, or angle data**

You can now use the `rfplot` function to specify the types of plot such as decibels (default), real, imaginary, absolute, or angle.



# R2014b

**Version: 2.15**

**New Features**

**Bug Fixes**

## **Gain, noise figure, and IP3 cascade analysis for general RF stages**

You can now compute the `gain`, `noise figure`, `oip3`, and `iip3` of cascaded networks using the `rfchain` object. Display the stage-by-stage results in a spreadsheet format using the `worksheet` method. Visualize the results using the `plot` method.

## **Network parameter object improvements for conversion of any network data object**

You can now convert `rfckt` or `rfdata.data` or `rfdata.network` objects into any network parameter objects including S-parameters, Y-parameters, ABCD-parameters objects.

# R2014a

**Version: 2.14**

**New Features**

**Bug Fixes**

## **General de-embedding function for 2N-port S-parameters**

You can now use the `deembedsparams` function to de-embed 2N-port fixture effects from 2N-port measurements. It supports both three-dimensional S-parameters data and S-parameter objects.

## **N-port Touchstone file writing from any network data object or raw data**

You can use the `rfwrite` function to write Touchstone files from three-dimensional network parameter data or any network parameter object (S-parameters, Y-parameters, Z-parameters, ABCD-parameters, etc.)

## **`rationalfit` function at least six times faster**

The `rationalfit` function now fits a rational model to S-parameter data at least six times faster than previous releases. This responsiveness improves both RF Toolbox command-line behavior and SimRF simulation of S-parameter blocks.

# R2013b

**Version: 2.13**

**New Features**

**Bug Fixes**

## **Additional functions for constructing arbitrary RLC networks**

In R2013b, the following new functions are available:

- resistor, capacitor, inductor, and circuit — Use the basic building functions of an RF circuit to construct RLC networks.
- add — Insert basic RF elements to a circuit.
- clone — Duplicate any existing RF elements or circuits.
- setports — Define node pairs as ports of a circuit.
- setterminals — Map the nodes of a circuit to terminals.

## **S-parameter extraction for arbitrary RLC networks**

The `sparameters` function now includes added functionality that you can use to calculate the S-parameters of RLC networks.

# R2013a

**Version: 2.12**

**Bug Fixes**

**Compatibility Considerations**

## **Improved rationalfit function**

This release introduces additional pole-searching optimizations to the rationalfit function algorithm. Models that the function returns in this release tend to have fewer poles than those in previous releases.

## **Compatibility Considerations**

To constrain the function results across releases and machine architectures, explicitly specify optional parameters such as error tolerance and number of poles when you call the function. Given a data set and corresponding frequencies, the function attempts to calculate a rational function approximation to within a given specification. However, the exact model that the function returns can differ between releases and machines, as the algorithm improves.



# R2012b

**Version: 2.11**

**New Features**

**Bug Fixes**

## **Network parameter interface improvements for faster reading of Touchstone files, plotting, and converting parameters**

New network parameter objects and functions are available, with support for:

- Reading Touchstone files
- Converting network parameters
- Plotting network parameters

Additionally, some functions have been updated to support the new interface. For more information, see RF Network Parameter Objects.

## **Name-value pair syntax for `rationalfit` function**

The `rationalfit` function now supports using name-value pairs for optional input arguments. Name-value pair arguments can be specified in any order and improve readability of code.

# R2012a

**Version: 2.10**

**New Features**

**Bug Fixes**

## New Visualization Option for Intermediate-Frequency (IF) Planning Object

The OpenIF object supports a new interactive, graphical interface for assessing spur information in a mixer chain. You access this interface using the new show method.

## Enhanced S-Parameter Conversion Functions

S-parameter conversion functions have been enhanced to support larger data sets. The following functions now support conversion between parameter sets of  $2N$ -port networks.

- abcd2s
- abcd2y
- abcd2z
- s2abcd
- y2abcd
- z2abcd

The s2simm function now supports mixed-mode conversions for  $N$ -port devices.

The following mixed-mode S-parameter functions now support mixed-mode conversions for  $2N$ -port devices:

- s2scc
- s2scd
- s2sdc
- s2sdd
- simm2s

## New Demos for Signal Integrity Applications

Two new signal-integrity demos are available in this version.

- The Bandpass Filter Response demo describes a procedure for designing and analyzing a simple bandpass filter using `rfckt` objects.
- The MOS Interconnect and Crosstalk demo reproduces Pillage and Rohrer's classic result from "Waveform Evaluation for Timing Analysis".

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## **Enhanced Rational Fitting**

The rationalfit function has improved robustness, speed, and accuracy in this version.



# R2011b

**Version: 2.9**

**New Features**

**Bug Fixes**

**Compatibility Considerations**

## New Intermediate Frequency (IF) Planning Object

The `OpenIF` object supports a new partial workflow for multiband transmitter or receiver design. Use these objects to analyze intermediate frequencies (IFs) that do not produce interference (spurs) in operating bands.

## New Functions for Calculating Transmission Line RLGC Parameters

The `rlgc2s` and `s2rlgc` functions allow you to calculate the per-unit-length RLGC parameters of a transmission line from transmission-line S-parameters.

## Enhanced Rational Fitting

The `rationalfit` function has improved robustness, speed, and accuracy in this version.

## Compatibility Considerations

Some default values of `rationalfit` have changed. For more information, see the function reference page.

## Conversion of Error and Warning Message Identifiers

For R2011b, error and warning messages identifiers have changed in RF Toolbox software.

## Compatibility Considerations

If you have scripts or functions that use message identifiers that changed, you must update the code to use the new identifiers. Typically, message identifiers are used to turn off specific warning messages, or in code that uses a `try/catch` statement and performs an action based on a specific error identifier.

For example, the `rf:rfckt:seriesrlc:setpositive:NotAPositive` identifier has changed to `rf:rftbase:rftbase:setpositive:NotAPositive`. If your code checks for `rf:rfckt:seriesrlc:setpositive:NotAPositive`, you must update it to check for `rf:rftbase:rftbase:setpositive:NotAPositive` instead.

To determine the identifier for a warning, run the following command just after you see the warning:



---

```
[MSG,MSGID] = lastwarn;
```

This command saves the message identifier to the variable `MSGID`.

To determine the identifier for an error, run the following command just after you see the error:

```
exception = MException.last;  
MSGID = exception.identifier;
```

---

**Note:** Warning messages indicate a potential issue with your code. While you can turn off a warning, a suggested alternative is to change your code so it runs warning-free.

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# R2011a

Version: 2.8.1

Bug Fixes



# R2010b

**Version: 2.8**

**New Features**

**Compatibility Considerations**

## Enhanced Rational Function Modeling

An improved algorithm for the `rationalfit` function fits an accurate rational model to passive S-parameter data in less time than in previous versions. In addition, a new parameter specifies the number of iterations `rationalfit` attempts at each value for the number of poles.

## Compatibility Considerations

Default behavior for some parameters have changed:

- The number-of-poles argument `npoles` defaults to a minimum value of 0 in version 2.8, instead of 4, as in previous versions.
- `rationalfit` does not display a wait bar by default in this version. A new `showwaitbar` parameter allows you to specify whether `rationalfit` displays a wait bar.

For more information on using this function, see the `rationalfit` reference page.

## Extended Methods and Parameters for RF Object Visualization

RF Toolbox version 2.8 extends the Plots and Charts methods to include:

- Support for third-order intercept point and transducer power gain parameters, `IIP3` and `Gt`.
- A new method, `table`, for visualizing network data in the Variable Editor.

# R2010a

Version: 2.7

New Features

## Function Added

The `makepassive` function creates passive S-Parameters from any S-parameter array. Use this function to enforce strict numerical passivity on an array of S-parameters that represents a passive device.

## Methods Added

Two new methods for `rfmodel.rational` objects are available:

- The `ispassive` method tests global passivity of an `rfmodel.rational` object.
- The `stepresp` method calculates the response of an `rfmodel.rational` object to a step signal. You can use this function to perform time-domain reflectometry (TDR) and time-domain transmission (TDT) analysis.

## Demo Added

The Modeling a High-Speed Backplane (Part 3: 4-Port S-Parameters to Differential TDR and TDT) demo shows how to perform time-domain reflectometry (TDR) and time-domain transmission (TDT) analysis on network data.



# R2009b

**Version: 2.6**

**New Features**

**Bug Fixes**

## **New Function for Testing Passivity of S-Parameters**

The `ispassive` function checks the passivity of N-port S-parameter matrices.

## **Expanded Port-Ordering Schemes for S-Parameter Conversion Functions**

The functions `s2scc`, `s2scd`, `s2sdc`, `s2sdd`, `s2smm`, `s2smm` now support a third commonly-used port-ordering. For more information on using this feature, see the corresponding function reference page.

## **Support for Calculation of Power-Wave Gain for Transfer Functions**

The `s2tf` function can now calculate the power-wave gain of 2-port S-parameters. Calculation in terms of voltage is still the default option.

# R2009a

**Version: 2.5**

**New Features**

**Compatibility Considerations**

## New Functions for Converting 4N-Port S-Parameter Matrices

There are two new functions for converting between 4N-port single-ended S-parameter matrices and 2N-port mixed-mode S-parameter matrices:

- The `s2smm` function lets you convert 4N-port single-ended S-parameters to 2N-port mixed-mode S-parameters. You can view the 2N-port output data to see interactions, such as crosstalk, that are not apparent in the single-ended data. This lets you easily select the ports of interest for further analysis.
- The `smm2s` function lets you convert 2N-port mixed-mode S-parameters to 4N-port single-ended S-parameters.

## Enhanced Dielectric Loss Model in Three Transmission Line Objects

The following objects now provide a more realistic model for dielectric loss:

- `rfckt.coaxial`
- `rfckt.twowire`
- `rfckt.parallelplate`

To specify dielectric loss, you use a new property, `LossTangent`. This property replaces the `SigmaDiel` parameter.

## Compatibility Considerations

Your existing objects with a nonzero value for the `SigmaDiel` parameter no longer model dielectric loss. Instead, the objects issue a warning message and use the default value of zero for the `LossTangent` property when you use the `analyze` method.

## Demos Added

Two new demos show how to design broadband impedance matching networks for RF components:

- `Designing Broadband Matching Networks (Part 1: Antenna)` shows how to design a matching network for an antenna.
- `Designing Broadband Matching Networks (Part 2: Amplifier)` shows how to design a matching network for an amplifier.

# R2008b

Version: 2.4

New Features

## **cascadesparams Function now supports N-port S-parameters**

You can now use the `cascadesparams` function to cascade the S-parameters of an arbitrary number of N-port devices to form a network. The function lets you specify how to connect the ports of each N-port device to the ports of the subsequent N-port device in the cascade. For more information about the function, see the `cascadesparams` reference page.

## **Improvements to the `plotyy` Method**

The `plotyy` method now uses a more intuitive approach when determining how to plot the specified parameters if you do not specify the plot format. For more information about the function, see the `plotyy` reference page.

# R2008a

Version: 2.3

New Features

## Calculation and Plotting Metrics Added

You can now compute and visualize group delay, voltage gain, and stability factor using the `calculate` and `plot` methods.

## Network Parameter Conversion Functions Enhanced

You can now use the `s2sdd`, `s2sdc`, `s2scd`, and `s2scc` functions to perform conversions on network parameters with alternate port arrangements.

## `gammams` and `gammaml` Functions Added

Use the new `gammams` and `gammaml` functions to compute source and load reflection coefficients required for simultaneous conjugate match.

## `z2gamma` Function Added

Use the new `z2gamma` function to convert impedance values to reflection coefficients.

## Demos Added and Updated

A new demo, `Writing a Touchstone File`, shows how to write `rfckt` object data to an industry-standard Touchstone data file.

`Modeling a High-Speed Backplane (Part 2: 4-Port S-Parameters to a Rational Function Model)` now uses the new Communications Toolbox™ eye diagram scope, `commscope.eyediagram`, to plot the eye diagram.

## Command-Line Help Updated

The `help` function returns additional information for objects and packages. The function now includes descriptions of all properties and links to all relevant methods.



# R2007b

Version: 2.2

New Features

## **snp2smp Function Added**

Use the new `snp2smp` function to convert N-port S-parameter data and termination impedances to M-port S-parameters.

## **circle Method Added**

Use the new `circle` method to place circles on a Smith<sup>®</sup> Chart to depict stability regions and display constant gain, noise figure, reflection, and imittance circles.

## **powergain Function Added**

Use the new `powergain` function to compute various power gains of a 2-port network.

## **Smith Chart Enhanced**

The smith method now lets you plot the network parameters of devices with more than two ports on a Smith Chart.

## **Demos Added and Updated**

Modeling a High-Speed Backplane (Part 1: Measured 16-Port S-Parameters to 4-Port S-Parameters) is the new first part of a four-part demo on “Modeling a High-Speed Backplane.” The new demo shows how to extract 4-port S-parameter data from 16-port S-parameter data. The original three parts of the demo are now parts 2, 3, and 4.

The following demos replace the “Designing Impedance Matching Networks” and “Placing Circles on a Smith Chart” demos, respectively, and show how to use the new `circle` method:

- Designing Matching Networks (Part 1: Networks with an LNA and Lumped Elements) uses the available gain design technique to design a low-noise amplifier for a wireless communication system.
- Designing Matching Networks (Part 2: Single Stub Transmission Lines) shows how to design input and output matching networks for an amplifier.

# R2007a

Version: 2.1

New Features

## Agilent P2D and S2D System-Level Verification Model Support Added

The `rfckt.amplifier` and `rfckt.mixer` objects now let you import system-level verification models of amplifiers and mixers, respectively, using data from Agilent® P2D and S2D files.

Use P2D files to specify the following data for multiple operating conditions, such as temperature and bias values:

- Small-signal network parameters
- Power-dependent network parameters
- Noise data
- Intermodulation tables

Use S2D files to specify the following data for multiple operating conditions:

- Small-signal network parameters
- Gain compression (1 dB)
- Third-order intercept point (IP3)
- Power-dependent  $S_{21}$  parameters
- Noise data
- Intermodulation tables

Use the following methods to work with operating condition data after you import a P2D or S2D file into an RF object:

- `setop` — Use this method to set operating condition values or to list all available values.
- `getop` — Use this method to display the selected operating condition values.

## Mixer Spur Analysis Added

You can import an intermodulation table into an `rfckt.mixer` object. The object's `plot` method has a new option for plotting mixer spur data.

## timeresp Method Added

Use the new `timeresp` method of the `rfmodel.rational` object to compute the time response of an `rfmodel` object to a specified input signal. Use this method rather than computing

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impulse response with the `impulse` method and then convolving that response with the input signal because the `timeresp` method generally gives a more accurate output signal for a given input signal.

## Plotting Methods Added

Four new plotting methods provide additional plotting options:

- Use the `ploty` method of the `rfckt` class to create a plot that contains RF circuit object data on both the left and right Y-axes.
- Use the `loglog` method of the `rfckt` class to plot RF circuit object data on a log-log scale.
- Use the `semilogx` method of the `rfckt` class to plot RF circuit object data using a logarithmic scale for the X-axis.
- Use the `semilogy` method of the `rfckt` class to plot RF circuit object data using a logarithmic scale for the Y-axis.

## gamma2z Function Added

Use the new `gamma2z` function to compute input impedance from a reflection coefficient.

## Tab Completion Added

Tab completion is now available in the MATLAB command window for all functions and methods. For more information on tab completion, see the MATLAB documentation.

## Data Tips Added

Data tips are now available for any RF plot. For more information on data tips, see [Data Cursor — Displaying Data Values Interactively](#) in the MATLAB documentation.

## Demos Added and Updated

[Visualizing Mixer Spurs](#) shows how to use the toolbox to perform mixer spur analysis using data from an intermodulation table and then plot the output power spectrum of the desired signal and the undesired spurs.

Modeling a High-Speed Backplane (Part 1: Measured 4-Port S-Parameters to a Rational Function Model) now uses the `timeresp` method to compute the time-domain response of a system characterized by measured data.

Modeling a High-Speed Backplane (Part 2: Rational Function Model to Simulink Model) now includes code that you can use to generate a Simulink model for any `rfmodel.rational` object.

# R2006b

Version: 2.0

New Features

## **S-Parameter Conversion Function Added**

Use the `s2tf` function to convert 2-port scattering parameters into a transfer function that represents the normalized voltage gain of a 2-port network.

## **rfmodel Class Added**

Use objects from the `rfmodel` class to represent components and networks with mathematical equations. The `rfmodel.rational` object stores a rational function model of a component or network.

## **rationalfit Function Added**

Use the `rationalfit` function to fit a rational function to passive data that represents an RF component or network and then store the result in an `rfmodel.rational` object. This type of model is useful to signal integrity engineers, whose goal is to reliably connect high-speed semiconductor devices with, for example, multi-Gbit/s serial data streams across backplanes and printed circuit boards.

## **freqresp and impulse Functions Added**

Use the `freqresp` method of the `rfmodel` class to compute the frequency response of an `rfmodel` object.

Use the `impulse` method of the `rfmodel` class to compute the impulse response of an `rfmodel` object.

## **Support for Exporting Verilog-A Models Added**

Use the `writeva` method of the `rfmodel` class to export a description of an RF component or network for use in a time-domain circuit simulator.

## **Demos Added**

“Modeling a High-Speed Backplane (Part 1: Measured 4-Port S-Parameters to a Rational Function Model)” shows how to use the toolbox to model a differential high-speed backplane using rational functions.



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“Modeling a High-Speed Backplane (Part 2: Rational Function Model to a Verilog-A Module)” shows how to use toolbox functions to generate a Verilog-A module that models the high-level behavior of a high-speed backplane.

“Modeling a Differential High-Speed Backplane in Simulink” shows how to use Simulink to simulate a differential high-speed backplane.



# R2006a

Version: 1.3

New Features

## **S-Parameter Conversion Functions Added**

Use the `s2scc` function to convert 4-port, single-ended S-parameters to 2-port, common mode S-parameters.

Use the `s2scd` function to convert 4-port, single-ended S-parameters to 2-port, cross mode S-parameters.

Use the `s2sdc` function to convert 4-port, single-ended S-parameters to 2-port, cross mode S-parameters.

Use the `s2sdd` function to convert 4-port, single-ended S-parameters to 2-port, differential mode S-parameters.

# R14SP3

**Version: 1.2**

**New Features**

## **extract Function Added**

Use the `extract` function to extract specified network parameters from a circuit or data object and return the result in an array.

## **Circuit Object Added**

Use `rfckt.rlcgline` to construct an RLCG transmission line object.

## **Transmission Line Object Improved**

The new `Freq` property of the circuit object, `rfckt.txline`, is a vector of positive frequencies at which the parameter values are known.

The `Loss`, `PV`, and `Z0` properties of the circuit object, `rfckt.txline`, can now be vectors of line loss, phase velocity, and characteristic impedance values that correspond to the frequencies specified in the `Freq` property.

The new `IntpType` property of the circuit object, `rfckt.txline`, is the interpolation method used to calculate the parameter values between the known frequencies.

## **Touchstone Data File Support Improved**

You can now read data from Touchstone data files that contain comments and spaces between sections of data.

## **Demos Improved**

The demos have new documentation and can be accessed using an improved interface.

## **Command Window Help for Functions That Act on Circuit Objects Added**

You can access help for functions that act on circuit objects by using the syntax `help functionname` at the MATLAB command prompt.

# R14SP2

**Version: 1.1**

**New Features**

## Plot Figures Integrated into the RF Tool GUI

In earlier versions, a plot figure would appear in a separate window after clicking the **Plot** button. In this version, plot figures are integrated into the GUI itself.

## Five Objects Added

These objects can be used to store rfdata such as network parameters, noise figure, power, IP3, and spot noise.

## Three Circuit Objects Added

Use `rfckt.delay` to model delay lines, `rfckt.hybridg` to model hybrid G connected networks, and `rfckt.passive` to model RF passive networks.

## Methods Added

The new `write` method allows saving of RF network data into files for all `rfckt` objects.

The new methods, `read` and `restore`, read and restore data for `rfckt.datafile`, `rfckt.amplifier`, and `rfckt.mixer`.

## Method Enhanced

The `analyze` method now takes three additional optional inputs for the load, source, and reference impedances.

## Functions Added

The functions `stabilitymu` and `stabilityk` calculate the stability factors  $\mu$  and  $k$ .

The functions `h2g` and `g2h` convert between hybrid G and hybrid H parameters.

## General Enhancements

It is now possible to create the objects `rfckt.amplifier` and `rfckt.mixer` from a MATLAB variable.



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The frequency-dependent NF and IP3 data types were added to the AMP format.

