SimRF 3.0

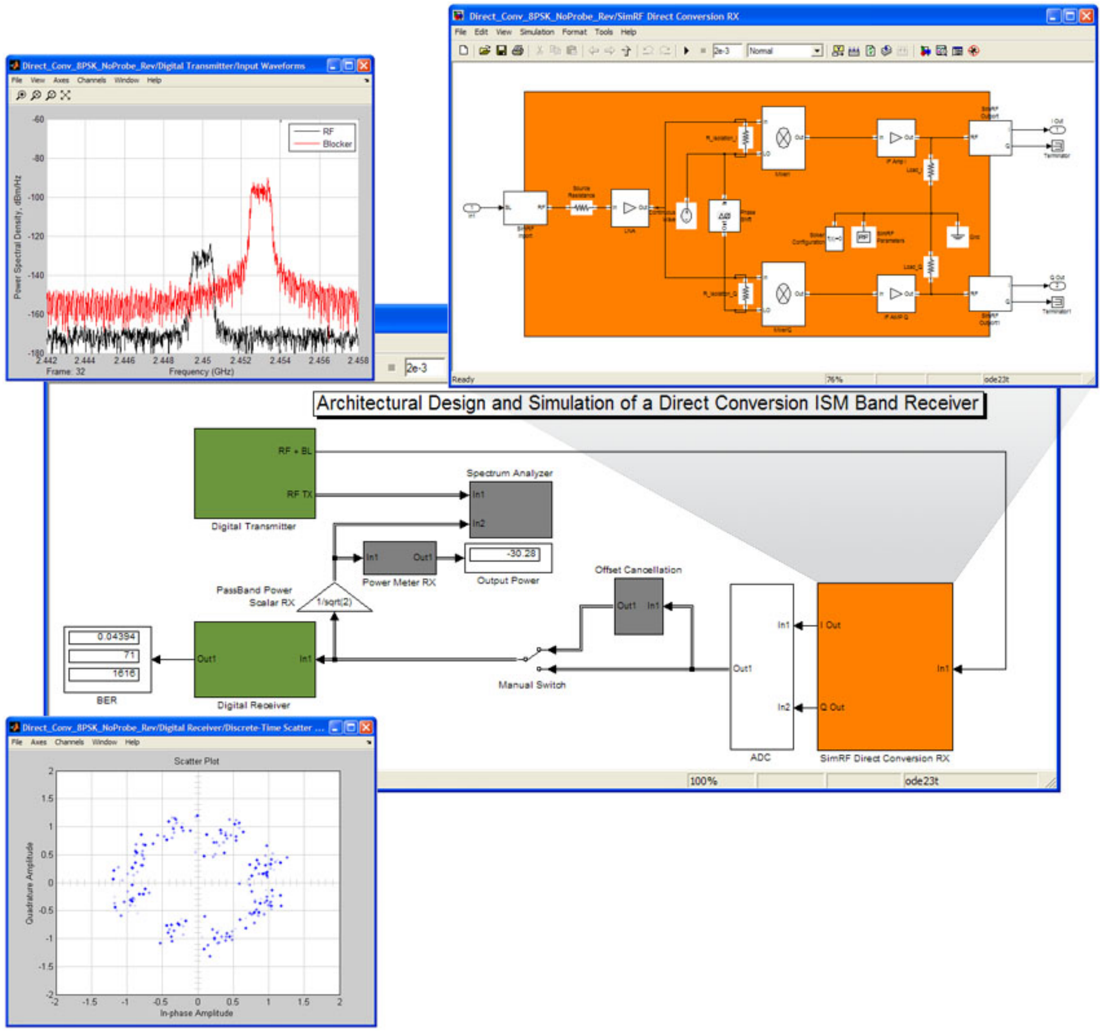
Design and simulate RF systems

SimRF™ provides a component library and simulation engine for designing RF systems. It includes mixers, amplifiers, S-parameter blocks, and other basic blocks for architectural design and modeling of wireless transceivers. You can connect these components arbitrarily to form diverse architectures and to model system-level impairments. SimRF enables simulation of RF gain, noise, and intermodulation distortion commonly attributed to RF amplifiers. It provides circuit envelope technology for simulating RF impairments uniquely associated with mixers, including image rejection, reciprocal mixing, local oscillator phase offsets, DC conversion, and DC offsets. Equivalent baseband technology is also included, enabling fast simulation of single-carrier cascaded systems.

SimRF works with Simscape™ to simulate the performance of the RF system defined by the block diagram. Gateways to Simulink® enable signal generation and analysis features found in the recommended Communications Blockset™ and Signal Processing Blockset™, respectively.

Key Features

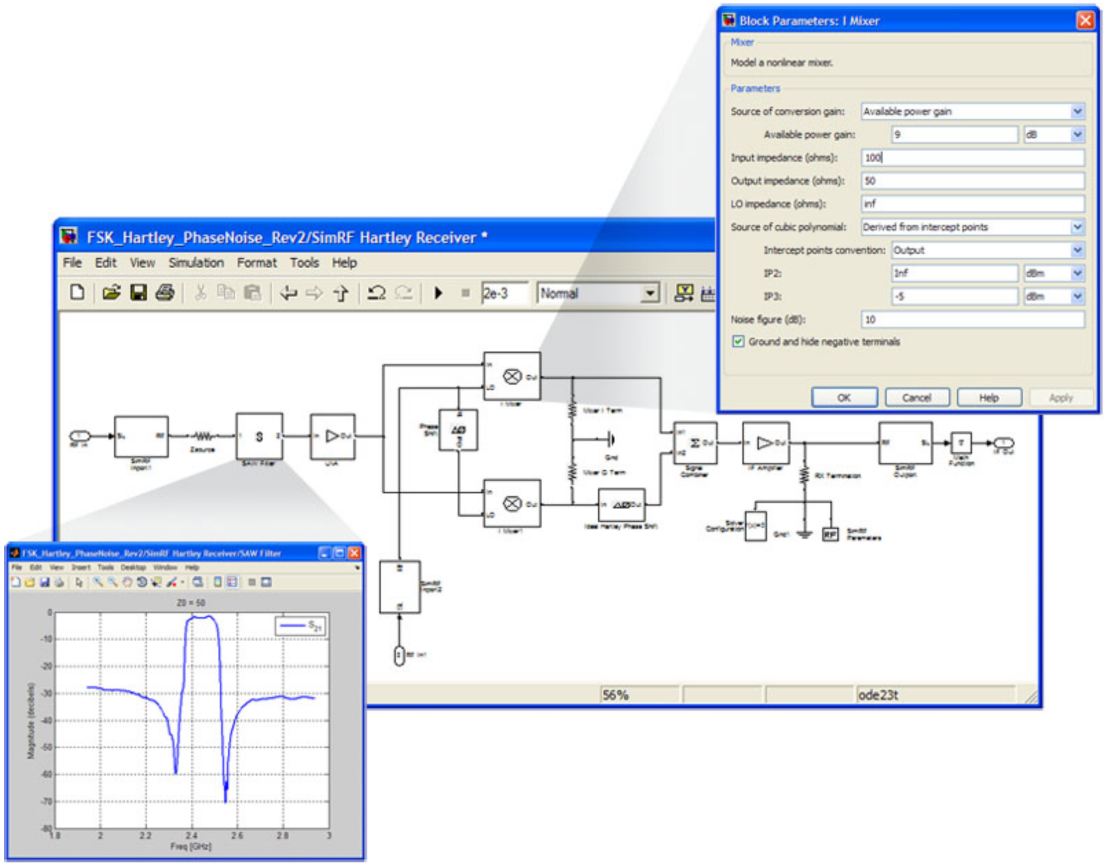
- Multiple carrier-frequency models
- General N-port models and S-parameter data files
- Passive components, including resistors, capacitors, inductors, and general impedance blocks
- Weakly nonlinear 3-port mixers and 2-port amplifiers specified by noise figure, IP2, IP3, and data files
- Intra-model signal probing
- Circuit envelope technology for high-fidelity simulation
- Equivalent baseband technology for fast simulation



Communication system model (middle), SimRF blocks (top right), a spectrum scope display of the input signal and interfering waveform (top left), and constellation diagram of the demodulated output waveform (bottom left). SimRF integrates with Communications Blockset and Signal Processing Blockset to simulate the effects of RF architectures on system performance.

Defining RF Components

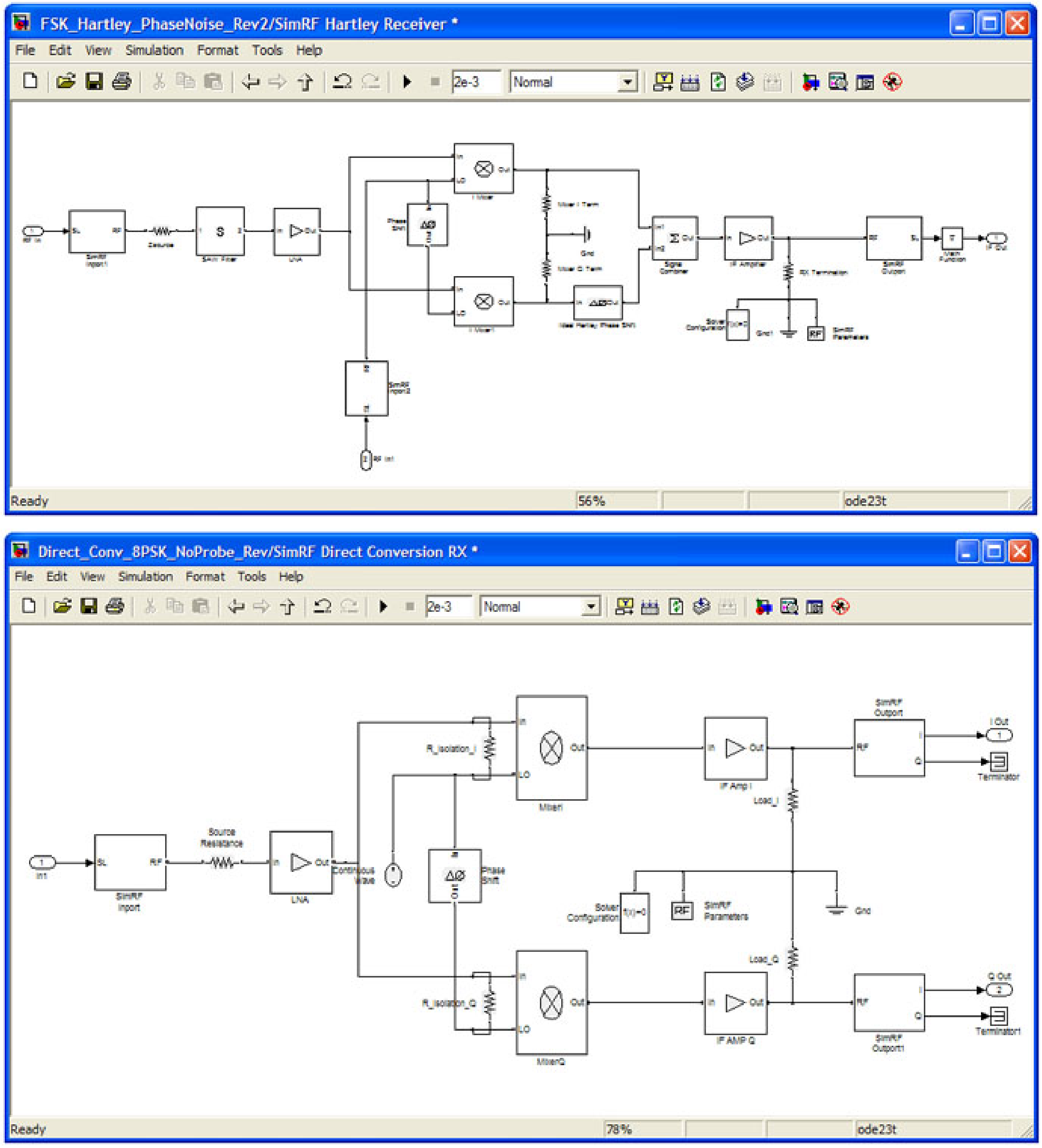
SimRF lets you represent RF amplifiers, mixers, impedances, and filters by specifying physical properties such as resistance, capacitance, and inductance; linear properties such as component gain; and nonlinear properties such as IP2 and IP3, and noise figure. You can also specify linear networks by importing S-parameter data files directly into SimRF models.



Model of a low-IF Hartley receiver (middle) with a visualization of the S-parameters of the receiver band SAW filter (bottom left) and a graphical interface for setting parameters of the mixer (top right). SimRF blocks are defined by linear and nonlinear specifications, noise figure, and industry-standard Touchstone data files.

Designing RF Subsystems

You can build RF receivers and transmitters by connecting blocks from the SimRF Circuit Envelope component libraries. The signals in these SimRF models are represented as voltages and currents. SimRF signals can be created externally in Simulink and passed into the SimRF models via the SimRF Inport, or signals can be created internally using SimRF sources. Each signal is associated with a carrier frequency that is determined by Inports, for Simulink generated signals, or by the native SimRF signal sources. The set of all carrier frequencies simulated in a SimRF model is defined in the SimRF Parameters block. Loading among blocks can be modeled using internal block impedances or explicitly using circuit elements.



Low-IF Hartley receiver (top) and simple direct conversion receiver (bottom) in SimRF. SimRF enables architectural design of RF subsystems by properly modeling the function, form, and interfaces of RF components.

Each of the nonlinear blocks in SimRF is characterized by IP3 and IP2. Noise associated with three blocks is specified by the noise figure parameter. A noise voltage source in SimRF can be used to inject additional noise into models where noise figure is not applicable or desired. You can author new components to include in your designs using the Simscape modeling language.

In addition to standard RF subsystems, SimRF also includes N-port S-parameter blocks. These blocks read standard Touchstone® .snp files containing measured or simulated component data and enable the user to plot the data post import. Prior to simulation, SimRF applies a general rational function model to the measured S-parameters.

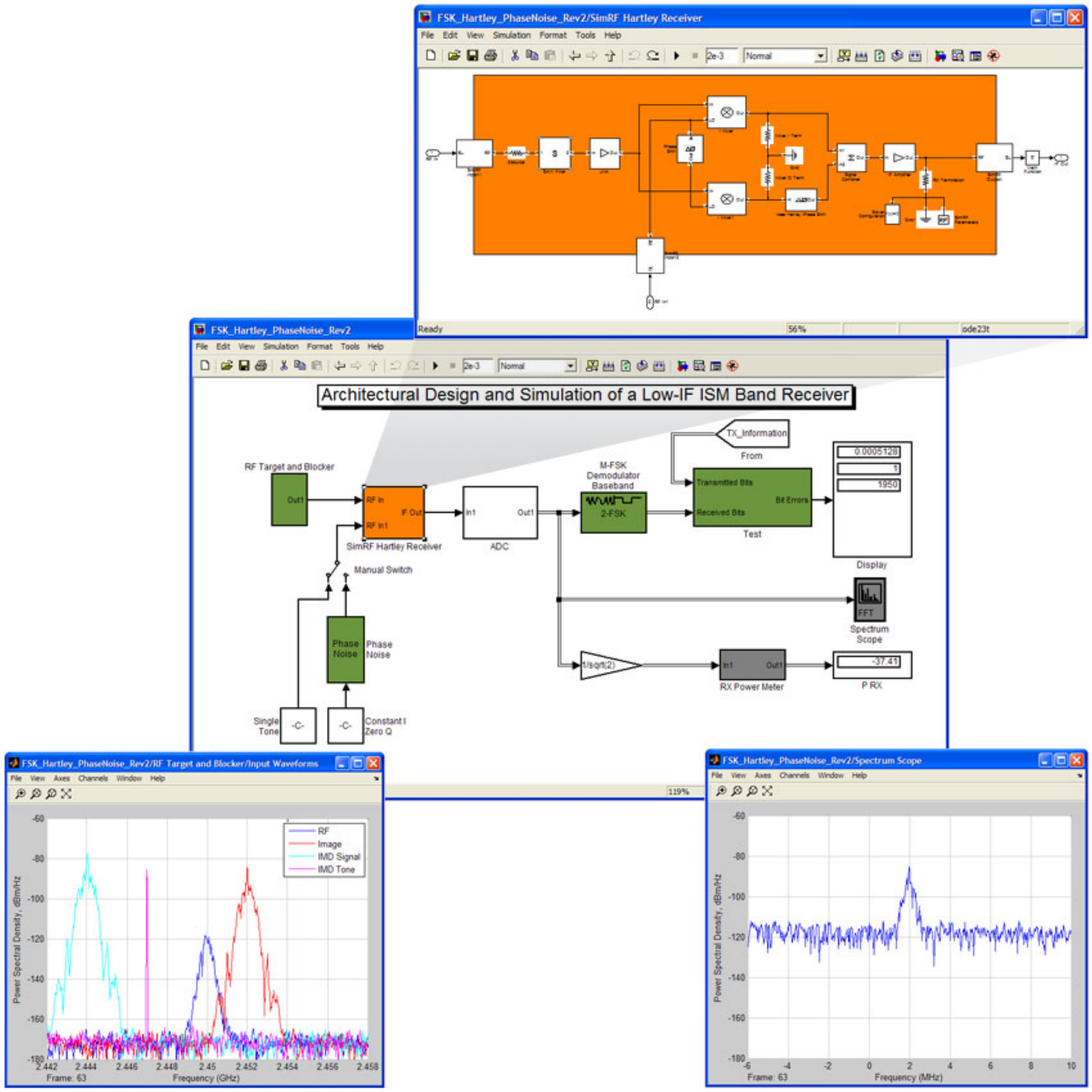
Simulating Wireless Systems Using Circuit Envelope Technology

SimRF integrates with Communications Blockset and Signal Processing Blockset to simulate the effects of RF impairments and architectures on system performance. You can use SimRF to perform what-if analyses with different RF front-end architectures, or commit to a particular architecture and use simulation to develop algorithms to mitigate the RF impairments. For example, with SimRF and Communications Blockset, you could simulate the coexistence of various waveforms in the 2.4 GHz ISM band.

The set of RF impairments enabled by SimRF includes:

- Noise
- Even-order and odd-order intermodulation distortion due to in-band or out-of-band signals
- Spurious signals
- Image effects due to mixing products
- Phase offsets
- I and Q mismatch
- Isolation among blocks
- DC conversion
- DC offset
- Local oscillator phase noise

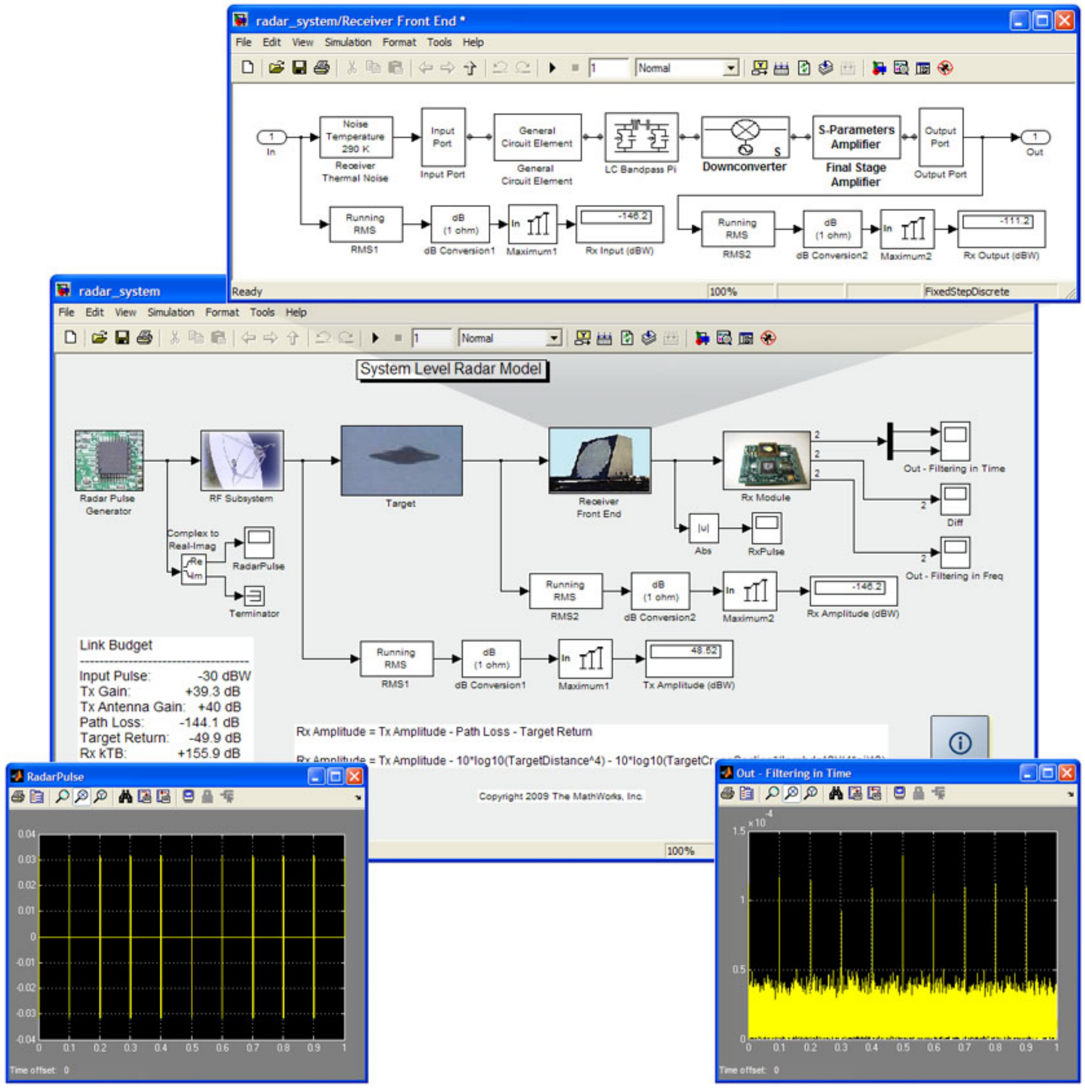
The probing capabilities of SimRF enable you to track the effects of these impairments through the model.



System-level model of an ISM-band receiver in SimRF (middle), low-IF Hartley receiver subsystem model (top), a spectrum display of the input signals to the receiver (left), and a display of the received signal at the receiver output. Ideal phase shifters for image cancellation with input signals are generated by SimRF. Impairments analyzed in this model include interference, odd-order intermodulation distortion, image effects, local oscillator phase noise, and quantization noise.

Simulating Wireless Systems Using Equivalent Baseband Technology

SimRF includes equivalent baseband blocks for fast simulation of single-carrier communication systems. The equivalent baseband technology is best suited for superheterodyne systems where out-of-band interference is of secondary importance and where simulation speed is paramount. Presently, transmission line models are supported only by the equivalent baseband technology.



Radar system model, including a radar pulse generator (bottom left), an RF transmitter subsystem (middle), a Simulink representation of a moving target (bottom right), and an RF receiver and receive module (RX module) (top). The model is typical of a radar system used for target position and velocity detection.

Resources

Product Details, Demos, and System Requirements
www.mathworks.com/products/simrf

Trial Software
www.mathworks.com/trialrequest

Sales
www.mathworks.com/contactsales

Technical Support
www.mathworks.com/support

Online User Community
www.mathworks.com/matlabcentral

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