Agilent SystemVue
W1905 Radar Model Library

Advanced Simulation Blockset for Radar System Architects

The **W1905 radar model library** provides over 35 highly-parameterized primitive blocks and higher-level reference designs that can be used to create a working radar system. It is especially useful for pulsed-doppler (PD) radar architectures. The blockset, and its example workspaces, serve as algorithmic and architectural reference designs to verify radar performance under different signal conditions, target and radar cross section (RCS) scenarios, clutter conditions, jammers and environmental interferers, and different receiver algorithms. Fixed-point effects can also be observed with the optional W1903 fixed-point library.

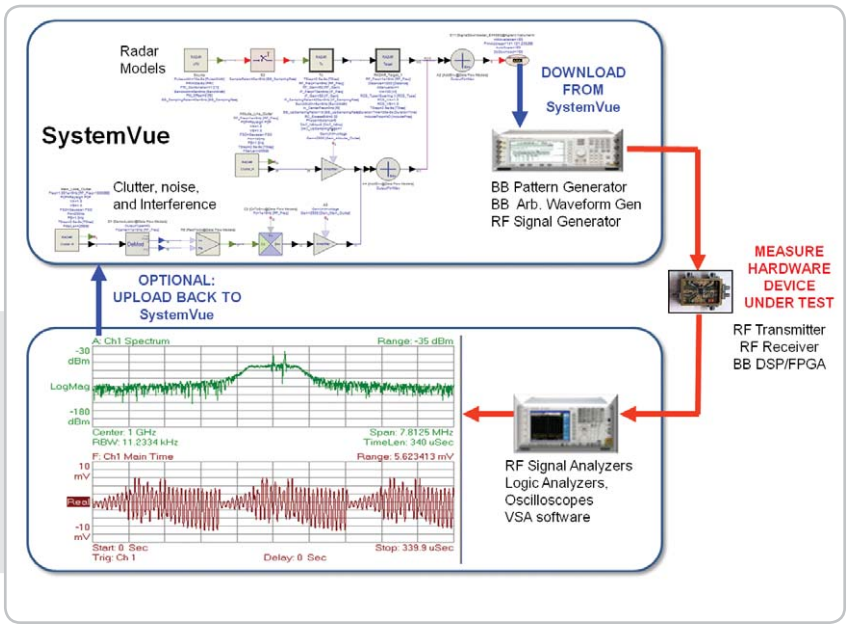

Figure 1. SystemVue can be used to study architectures and then download degraded reference waveforms to test equipment with known amounts of interference, clutter and impairments, in order to test receiver algorithms and hardware.

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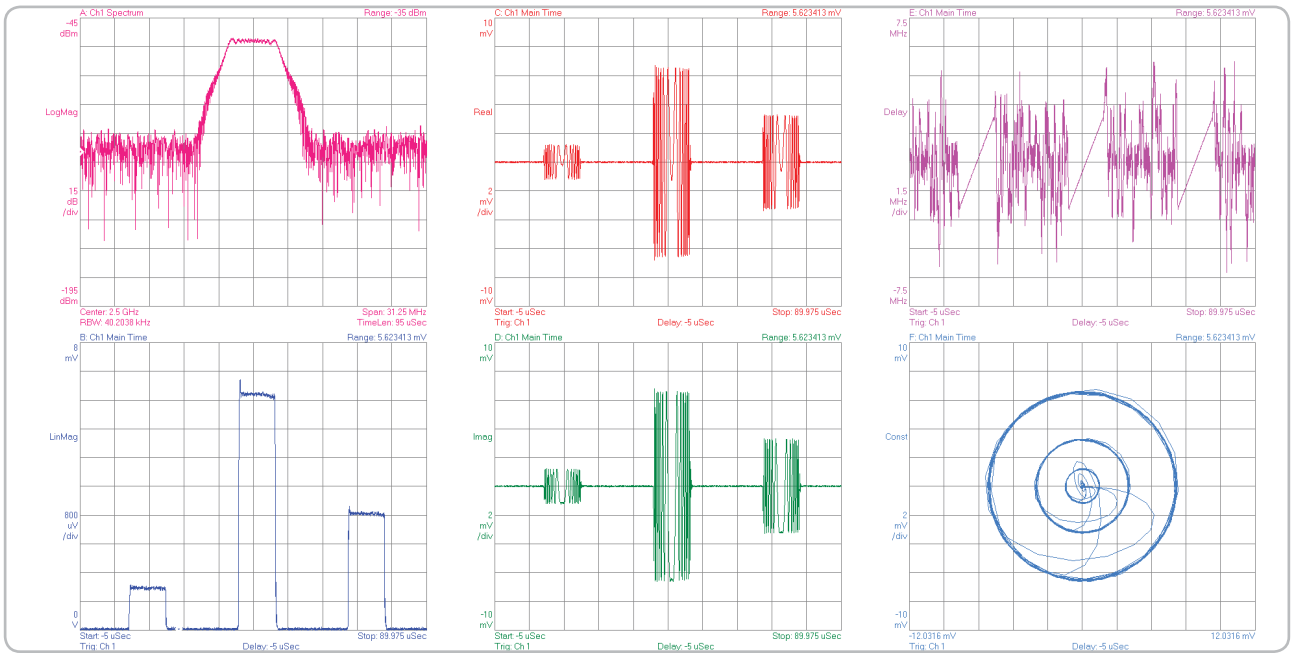

Figure 2. SystemVue was used to create a linear frequency modulation (LFM) chirp pulse, which is shown reflecting from one RCS target. Three echoes return, due to channel/propagation effects. Note the linearity of the delay parameter during the ON times of the reflected pulse (upper right). This waveform can be downloaded to an RF signal generator to provide realistic receiver testing, or remain in the simulation environment for purely algorithmic verification.

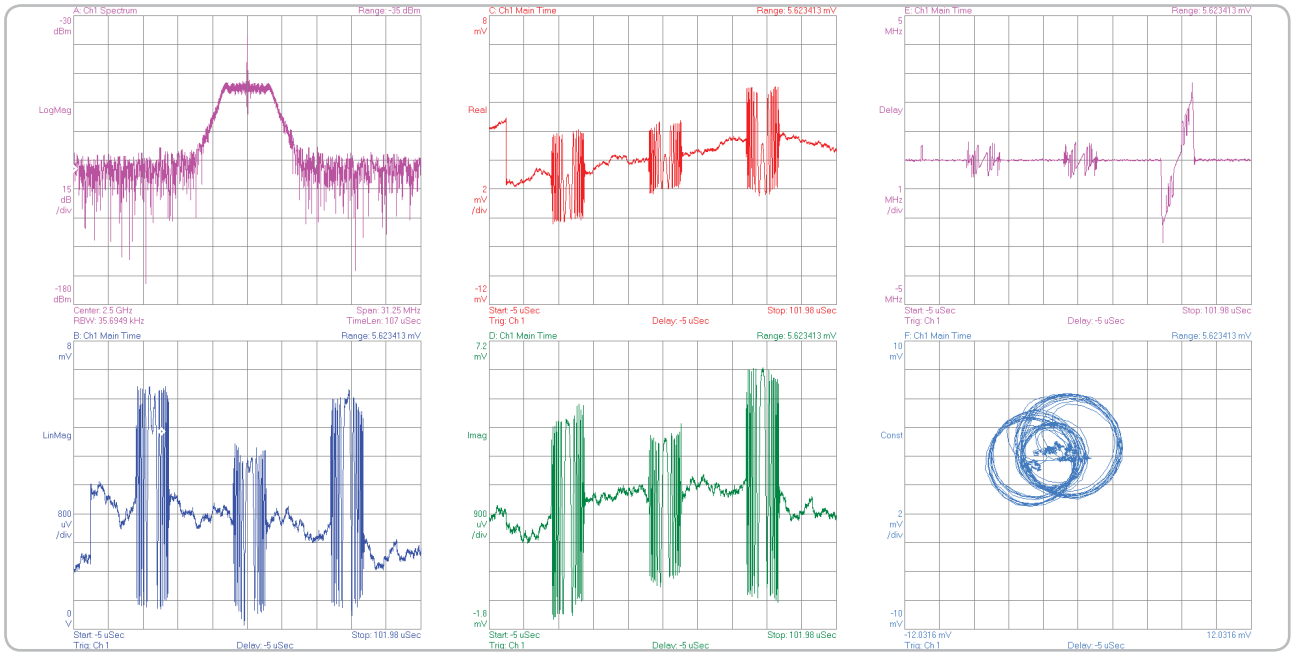

Figure 3. Shown here is an LFM pulse that is similar to Figure 2, but with additional clutter and degradation, as measured by Agilent's 89601 Vector Signal Analysis (VSA) measurement software (not included with SystemVue). With simulated impairments, the waveforms are repeatable and highly parameterized.

Who should buy the W1905 radar model library?

It is suitable for radar system designers in military, regulatory, commercial, avionics, medical, automotive, research, academic, and consulting applications.

Applications

Accurate radar system architecture and scenario analysis

- Include realistic radio frequency (RF) effects, clutter, fading, and directly-measured waveforms
- Leverage your existing math, HDL and C++ algorithms
- Continue into hardware test using the same SystemVue environment and intellectual property (IP)
- Ideal for proposals, hardware design or verification

Algorithmic reference and test vector generation

- For baseband DSP hardware design

Precisely-degraded baseband/RF signal generation for receiver testing

- Save time by verifying algorithms, prior to targeted hardware implementation
- Reduce NRE and scripting with regression suites of simulated scenarios
- Re-use Agilent equipment assets with SystemVue for functional verification
- Reduce the need for expensive chambers, hardware emulators, faders, and field testing in the early phases of design

For more information

Please contact your local Agilent EEsof EDA sales representative directly to inquire about this library and its associated training and consulting services.

W1905 radar model library block list

Table 1. The W1905 radar model library block list.

Signal sources	
LFM	Linear FM wave generator
NLFM	Nonlinear FM wave generator
BarkerCode	Poly-phase code wave generator
FrankCode	Frank code wave generator
ZCCode	Zadoff–Chu code wave generator
MatchedSrc	Generates the matched source signal for pulse compression
Signal processing	
Detector	Video signal detector
FFT	Complex fast Fourier transform
PC	Pulse compression processing
PD	Pulse Doppler processing
MTI	Moving target indication
MTD	Moving target detection
CFAR	Constant false-alarm rate process
Window	Windowing for sidelobe control
Transmitter	
CICInterp	Interpolation with cascaded CIC filters
DUC	Digital up-converter, baseband to intermediate frequency
UpSample	Up sampler with poly-phase filter
Tx	Transmitter front end
Receiver	
CICDecimate	Decimation with cascaded CIC filters
DDC	Digital down-converter, intermediate frequency to baseband
DownSample	Down sampler with poly-phase filter
Rx	Receiver front end
Environment	
RCS	Radar cross-section modeling
Target	Target modeling, including RCS, Doppler effect, delay, attenuation
Clutter	Clutter modeling
Antenna	
Tx Ant	Transmitter antenna
Rx Ant	Receiver antenna
Measurement	
Pd Measurement	Detection probability estimation
Pf Measurement	False-alarm rate estimation

Radar Examples and Test Benches

The radar library provides various test benches that can be used to verify the radar transmitter, receiver and system performance.

Transmitter measurement

PDRADAR_Tx_Waveform

This example measures the radar transmitter RF signal and intermediate frequency (IF) signal waveforms and spectrums.

1. The radar signal is an LFM pulse in this example.
2. The simulation is carried out with digital IF and analog RF front-end, where both DUC/DDC and front-end circuit effects are considered.

Receiver measurement

PDRADAR_Rx_Waveform

This example measures the waveform of a PD radar receiver with clutter and noise.

1. The waveform includes the components from target echo, clutter and noise.
2. Both the RF waveform and the RF spectrum of the received signal are measured.

PDRADAR_Clutter

This example measures the clutter signal of the radar environment. The clutter refers to RF echoes returned from targets which are uninteresting to the radar operators.

1. A statistical model is set up to simulate the real-world clutter.
2. The clutter has certain magnitude probability density functions and power spectrum densities.

PDRADAR_DynamicRange

This example measures the dynamic range of the radar receiver. Dynamic range is defined as the input signal power range to be amplified without distortion.

1. Measured the 1-dB gain compression power of the low noise amplifier in RF.
2. Measured the output IF signal power.
3. Measured the baseband signal power after the analog-to-digital converter (ADC) and digital down converter.
4. Results are shown in associated graphs

PDRADAR_Selectivity

This example measures the adjacent band selectivity of the radar receiver. Radar frequency sensitivity is a very important characteristic as it determines radar's interference immunity.

1. A filtered noise is constructed to simulate the interference in the adjacent band of the radar signal.
2. The simulation is carried out with digital IF and analog RF front-end, where both DUC/DDC and front-end circuit effects are considered.

PDRADAR_Sensitivity

This example measures sensitivity of the radar receiver. Radar sensitivity is determined by the ability to reliably detect weak signals in the presence of noise.

1. A noise model is the simulated thermal noise. Note that the noise spectrum density is -173.975 dBm/Hz.
2. The simulation is carried out with digital IF and analog RF front-end, where both DUC/DDC and front-end circuit effects are considered.

Performance measurement

PDRADAR_DetectionProbability_AWGN

This example measures a PD radar's detection probability under additive white Gaussian noise (AWGN).

1. The PD radar detects a target at a distance of 60 km and a velocity of 60 m/s.
2. The received signal-to-noise ratio (SNR) is swept from -18 to -10 dB.
3. The PD radar uses a pulse compressor based on a Hamming window with a BT product of 50.
4. The PD processing utilizes a MTD with a coherent processing interval (CPI) of 32 pulses.
5. The constant false-alarm rate (CFAR) algorithm is cell average (CA).

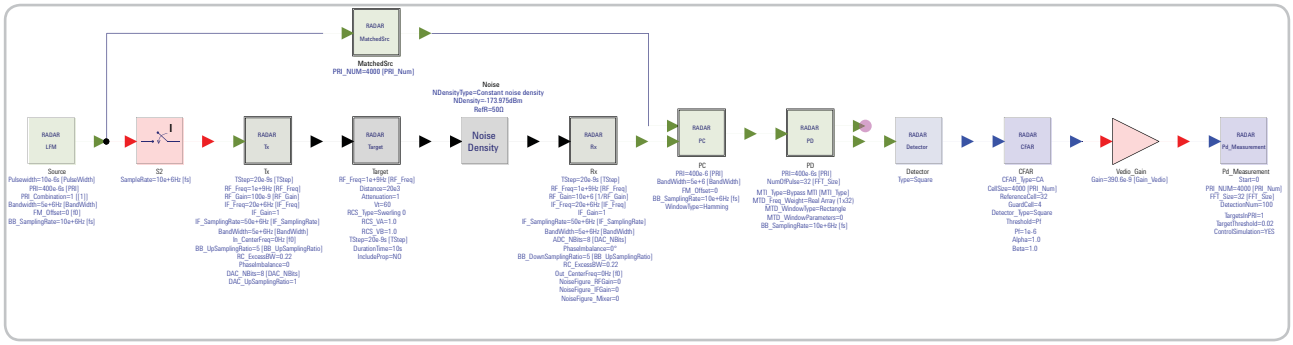

Figure 5. In this example, a PD radar's detection probability under AWGN is measured.

PDRADAR_DetectionProbability

This example measures a PD radar's detection probability with clutter.

1. The PD radar detects a target at a distance of 60 km and a velocity of 60 m/s.
2. The received SNR is swept from -14 to -6 dB.
3. The clutter has a Rayleigh distribution in amplitude and a Gaussian distribution in spectrum. To speed up simulation it is stored in data files.
4. The clutter-to-noise Ratio (CNR) is set to 10 dB.
5. The PD radar uses a pulse compressor based on a Hamming window with a BT product of 50.
6. The PD processing utilizes MTD with a CPI of 32 pulses.
7. The CFAR algorithm is CA.

PDRADAR_FalseAlarmRate_AWGN

This example measures a PD radar's false alarm rate under AWGN.

1. The input to the PD radar receiver is noise only.
2. The PD radar uses a pulse compressor based on a Hamming window with a BT product of 50.
3. The PD processing utilizes MTD with a CPI of 32 pulses.
4. The CFAR algorithm is CA.

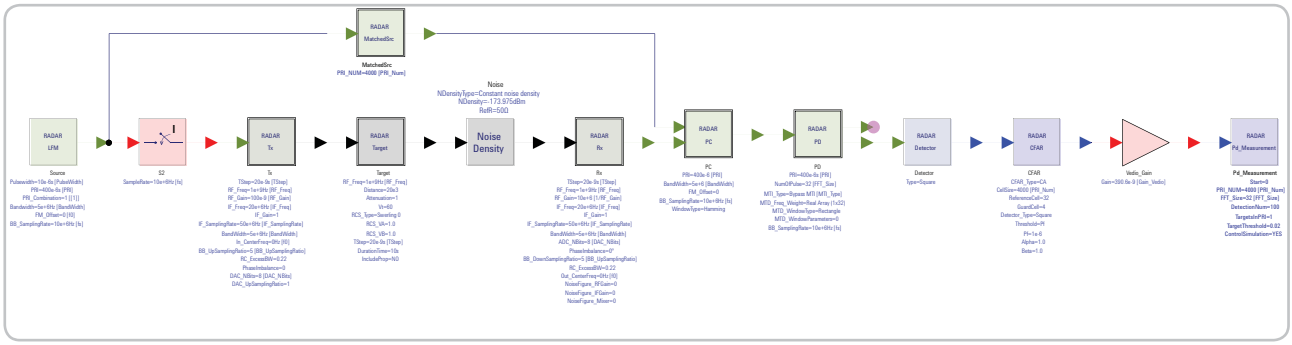

Figure 6. In this example, a PD radar's false alarm rate under AWGN is measured.

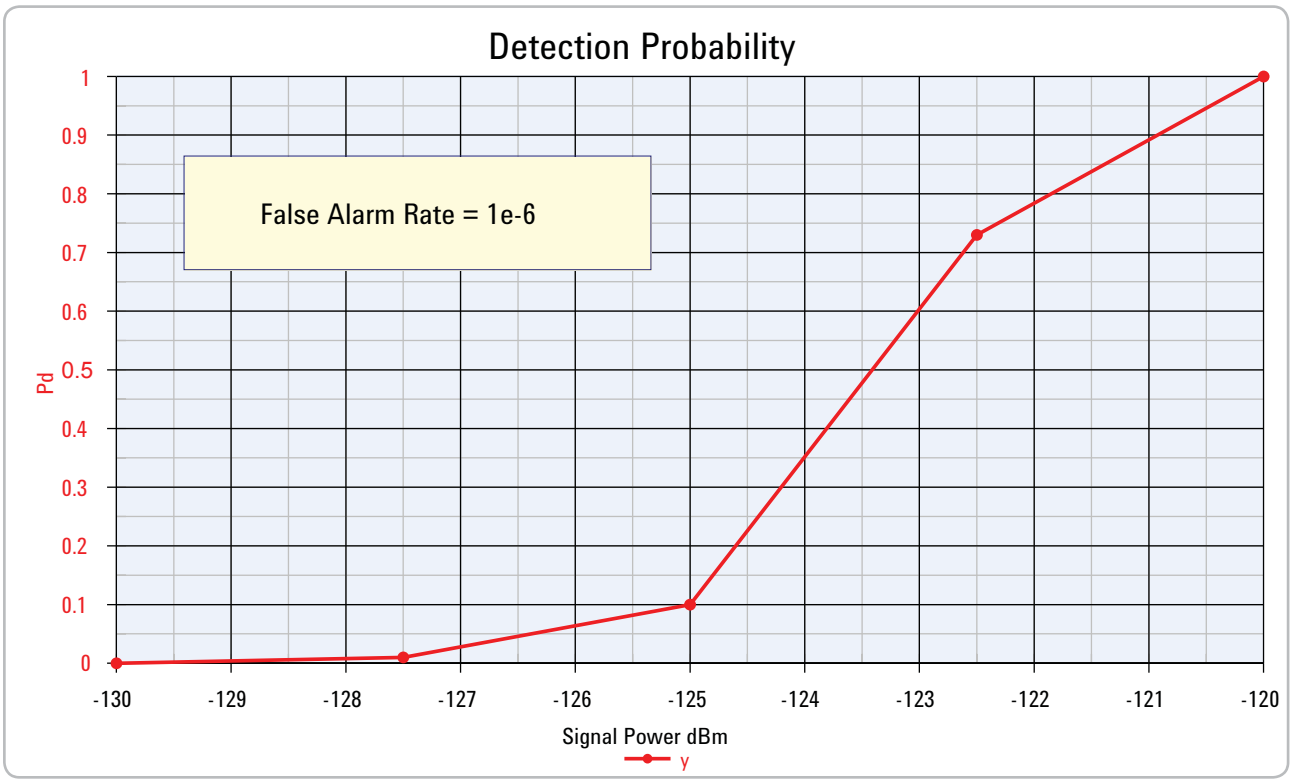

Figure 7. The detection probability of the example in Figure 6 is shown here.

PDRADAR_FalseAlarmRate

This example measures a PD radar's false alarm rate with clutter.

1. The inputs to the PD radar receiver are clutter and noise.
2. The clutter has a Rayleigh distribution in amplitude and a Gaussian distribution in spectrum. To speed up simulation it is stored in data files.
3. The CNR is set to 10 dB.
4. The PD radar uses a pulse compressor based on a Hamming window with a BT product of 50.
5. The PD processing utilizes MTD with a CPI of 32 pulses.
6. The CFAR algorithm is CA.

PDRADAR_Measurement

This example measures a target's range and velocity in clutter and noise.

1. The PD radar detects a target at a distance of 100 km and a velocity of 60 m/s.
2. The received SNR is -10 dB.
3. The clutter has a Rayleigh distribution in amplitude and a Gaussian distribution in spectrum. To speed up simulation it is stored in data files.
4. The CNR is set to 10 dB.
5. The PD radar uses a pulse compressor based on a Hamming window with a BT product of 50.
6. The PD processing utilizes MTD with a CPI of 32 pulses.
7. The CFAR algorithm is CA.

Name	Description
RADAR_CFAR	Constant False Alarm Rate
RADAR_CICDecimate	RADAR CIC Decimation
RADAR_CICInterp	RADAR CIC Interpolation
RADAR_Clutter_H	Radar clutter simulation
RADAR_DDC	RADAR Digital Down Converter
RADAR_Detector	RADAR Detector
RADAR_DownSample	Down sampler with Poly Phase Filter
RADAR_DUC	RADAR Digital Up Converter
RADAR_FFT	Complex fast Fourier transform
RADAR_LFM	Linear Frequency Modulation wave generator
RADAR_MatchedSrc	generate the matched source signal for pulse compression
RADAR_MTD	Moving Target Detection
RADAR_MTI	Moving Target Indication
RADAR_PC	Pulse Compression
RADAR_PD	Pulse Doppler
RADAR_Pd_Measurement	Detection Probability Estimation
RADAR_Pf_Measurement	False Alarm Rate Estimation
RADAR_RCS	Radar target RSC simulation
RADAR_Rx	RADAR Receiver Front End
RADAR_Target	Radar target simulation, including RCS, Doppler effect, Delay
RADAR_Tx	RADAR Transmitter Front End
RADAR_UpSample	Up sampler with Poly Phase Filter

Figure 4. Screen shot of the W1905 radar model library block list.

Additional Radar Resources

Recordings
"Uncovering Hidden Impairments in Radar Systems" (live webinar, 14 April 2010)
http://seminar2.techonline.com/s/agilent_apr1410

Application notes
5990-5392EN "Simulation & Verification of Pulsed Doppler Radar Systems"

5990-5393EN "Radar System Design and Interference Analysis Using SystemVue"

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