Cutting-edge radar simulation and testing

Introducing the R&S®Pulse Sequencer software

ROHDE&SCHWARZ

Product Brochure | Version 01.01

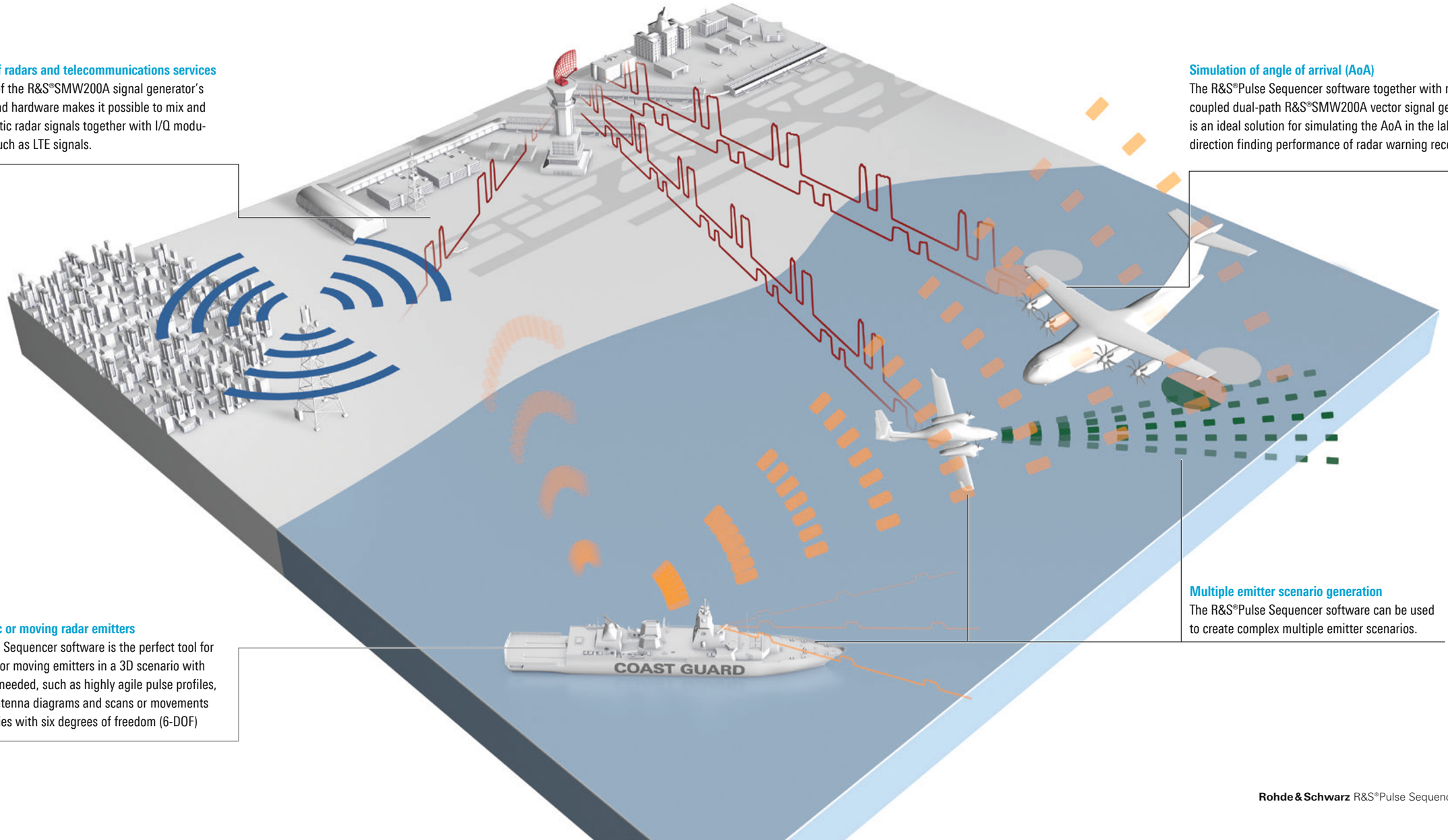
Our expertise in the modern radar world

Radar systems follow the same trend as radiocommunications systems and are becoming increasingly software defined. This enables the radars to be multifunctional with many complex waveforms, often together with frequency agility techniques. Depending on the radar task, radars can be operated in a wide variety of modes that can be quite complex. Together with different waveforms, advanced radars use electronically steered phased array antenna beams with a multitude of scanning methods. However, there are also systems in operation that use mechanically steered antennas instead of the phased array antenna technology. Scan duration can be in the range of seconds. Radar center frequencies range from UHF or VHF up to the millimeterwave region, depending on the type of radar.

Often many radars are operated in the same theater, leading to mutual interference and complex multi-emitter environments. It is vital to identify the nature of the signals, and important to also know where a radar signal is coming from. For that purpose, radar warning receivers are employed to intercept and classify the signals, often together with direction finding techniques to measure a signal's angle of arrival (AoA). Direction finding is typically achieved by evaluating the receive signal at the output of multiple antennas located at different positions.

Typical radar user groups are both civilian and governmental. Airport surveillance radars detect landing or departing planes, while navigation radars at sea help to identify other ships in the surroundings. Naval or airborne surveillance radars are used to get a situational overview in the theater of operation where a mission is conducted.

Because the electromagnetic spectrum is limited, telecom bands – such as those for cell phones that use the LTE standard – are often adjacent to noncommercial bands like those used for airport surveillance radars. To ensure quality of service, regulation authorities require all users of the electromagnetic spectrum to comply with the international standards in order to avoid mutual interference.



Coexistence of radars and telecommunications services
The flexibility of the R&S®SMW200A signal generator's digital baseband hardware makes it possible to mix and generate realistic radar signals together with I/Q modulated signals such as LTE signals.

Simulation of angle of arrival (AoA)
The R&S®Pulse Sequencer software together with multiple coupled dual-path R&S®SMW200A vector signal generators is an ideal solution for simulating the AoA in the lab to verify direction finding performance of radar warning receivers.

Realistic static or moving radar emitters
The R&S®Pulse Sequencer software is the perfect tool for defining static or moving emitters in a 3D scenario with all the realism needed, such as highly agile pulse profiles, effects from antenna diagrams and scans or movements along trajectories with six degrees of freedom (6-DOF)

Multiple emitter scenario generation
The R&S®Pulse Sequencer software can be used to create complex multiple emitter scenarios.

Your challenges

For engineers and technical staff responsible for testing radar receivers, the challenge of creating meaningful signals to stimulate the receiver is always a complex, time-consuming task. They always face the same challenges such as:

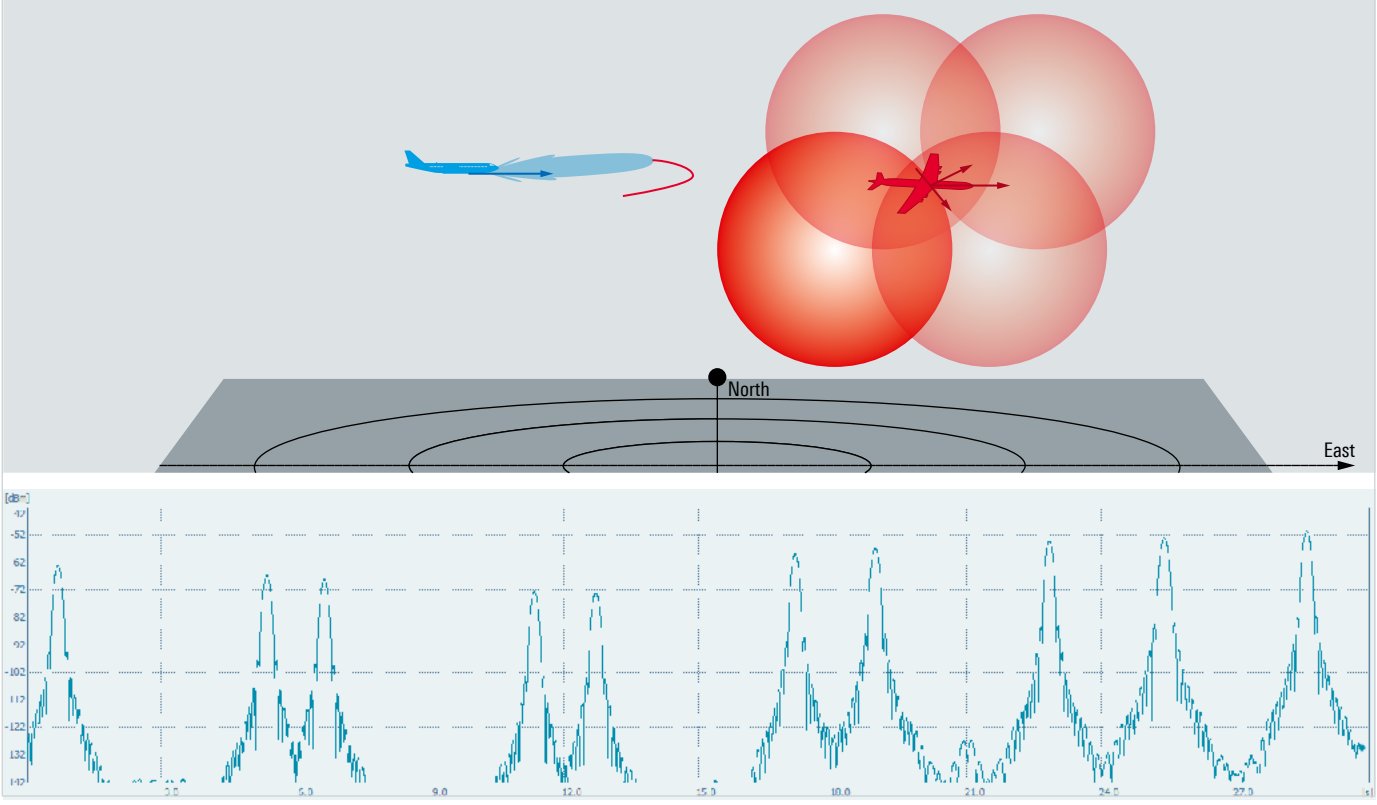
- Modeling agile pulses with interpulse modulation
- Generating signals with ultralong play time with millions of pulses
- Combining I/Q waveform files together with pulsed signals
- Re-using legacy scenario simulation files based on pulse descriptor words (PDW)
- Modeling effects coming from antenna diagrams and antenna scans
- Simulating static or moving emitters and receivers in 3D space
- Creating multi-emitter RF environments
- Simulating angle of arrival (AoA) for multichannel receivers

Our solution

The R&S®Pulse Sequencer software together with a vector signal generator from Rohde&Schwarz gives engineers a compelling radar signal generation solution. It provides an answer to the general trend to implement more test sessions in the lab than in expensive field tests. Co-engineered with the industry, this solution has been designed to support all relevant test cases of today's radar scenarios. It is based on the commercially available R&S®Pulse Sequencer PC software and off-the-shelf Rohde&Schwarz vector signal generators.

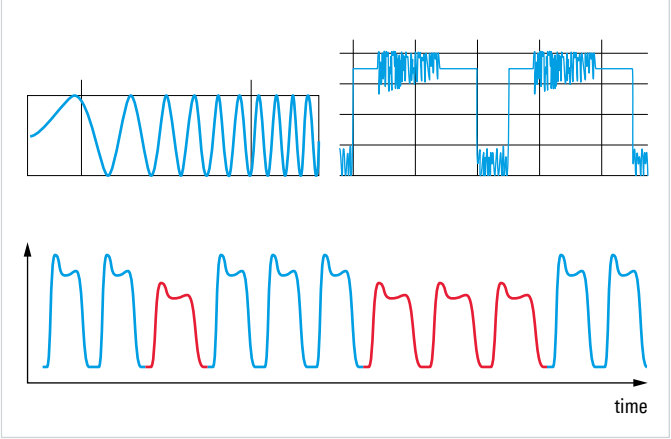
To relieve test engineers from manually programming time-consuming test cases, the R&S®Pulse Sequencer software provides many predefined items. Engineers can choose the complexity level they need – starting with simple pulsed signals to more complex sequences for simulating real-world environments. Built-in graphics and self-explanatory dialogs support the user throughout the signal definition chain. User friendliness has been made a top priority by providing 3D previews and graphical live visualization of configured signals. Operators can thus quickly familiarize themselves with the software and profit from its capabilities.

Live preview of 3D flight scenario with moving emitter and receiver



Pulsed signals and realtime sequencing

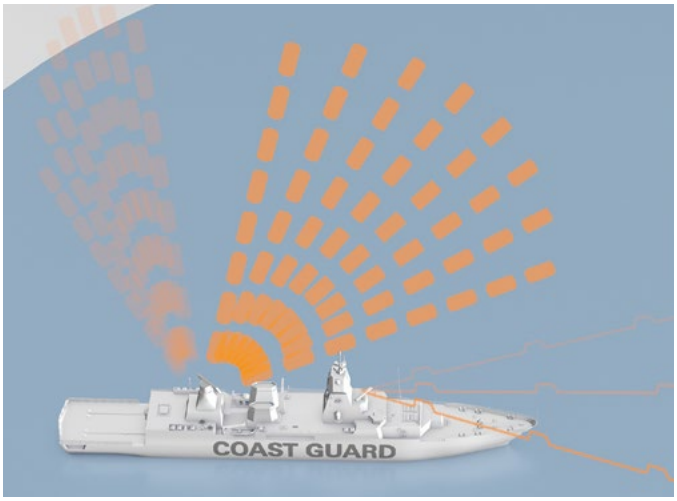
Pulsed signal generation and realtime sequencing



All required pulse parameters containing pulse slopes, pulse widths and all other envelope characteristics such as overshoot, pulse droop and ripple can be configured. Numerous modulation types such as linear frequency modulation (chirp), amplitude, frequency, phase and vector modulation are predefined and available. The single pulses can be embedded in a sequence together with interpulse modulation to define rule-based changes from pulse to pulse. Interpulse modulation can influence all agile parameters such as the pulse pause, frequency offsets, pulse levels, etc. Sequences can also include loops and nested loops.

In realtime sequencing mode, radar signals containing continuous wave signals, unmodulated rectangular CW pulses and pulses with linear frequency modulation or Barker codes are calculated in realtime in the R&S®SMW200A. Changes of amplitude, offset frequency, offset phase and off time are always applied in realtime as defined by the sequencing list.

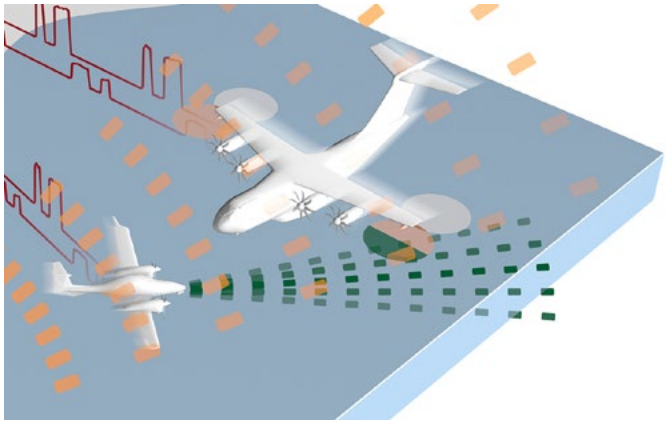
Realistic static or moving radar emitters and receiver



Emitters are transmitting stations that are characterized through items such as basic pulses with or without modulation on pulse (MOP), a sequence of the defined pulses, antenna diagram, antenna scan type and equivalent isotropically radiated power (EIRP). Emitters often have a variety of modes using a combination of the items mentioned above. The R&S®Pulse Sequencer software provides these simulation items for simulating complex 3D scenarios for receiver tests.

Emitters can be static or moving along trajectories with six degrees of freedom (6-DOF). Contributions from receiver antenna diagram and scan type can also be considered. Combined with the signal generator hardware, this is a compact, space-saving solution for simulating emitter stations. It brings reality into the lab, significantly simplifying the testing of radar receiver hardware with real-world radar signal profiles.

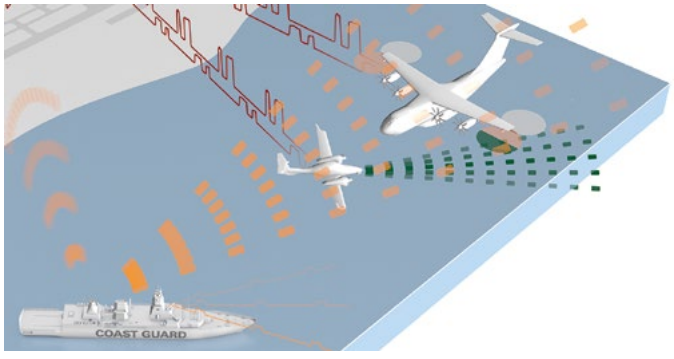
Simulation of moving emitters and receiver



From slowly moving vessels to rapidly maneuvering airplanes, simulating moving radar emitters in the lab is relevant for many test cases in order to perform conclusive electronic warfare (EW) receiver tests. The R&S®Pulse Sequencer software lets engineers quickly model scenarios with any kind of movement type for emitters and receiver. Predefined trajectories such as straight lines and circular arc segments allow quick and simple scenario configuration. Users can also individualize scenarios thanks to a powerful import mechanism for waypoint files with six degrees of freedom (6-DOF) and time tags.

Simulation of acceleration and Doppler offsets make the simulation as realistic as possible. The software calculates the resulting signals at the receiver input port and considers all configured emitter and receiver characteristics such as antenna diagrams and antenna scans. A powerful 3D preview of the simulation helps to visualize the configured scenario so that the user can quickly verify that the configured scenario is correct.

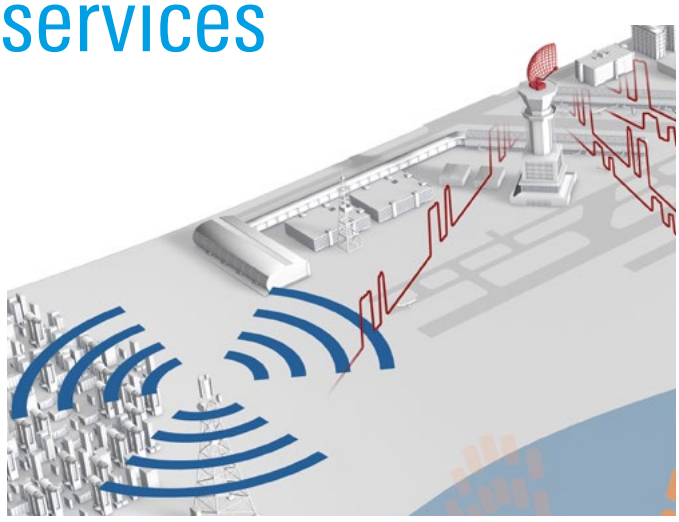
Simulation of multi-emitter scenarios



Engineers want to minimize the number of RF sources and maximize the number of produced radar signals. A good approach is to interleave the individual radar signals and produce a single combined signal. Due to the high density of radars present, it is likely that pulses overlap and create pulse-on-pulse situations. The R&S®Pulse Sequencer software uses a smart algorithm to interleave signals and drop pulses in case they collide – based on an optimized, user-defined priority scheme. This ensures lowest drop rates and makes it possible to simulate and interleave classic pulsed radar signals together with any I/Q modulated pulsed signals.

This is a major benefit for testing the performance of EW receivers against the most advanced and agile signals. Now, with the R&S®Pulse Sequencer software together with the R&S®SMW200A vector signal generator, engineers have a perfect alternative to large simulators based on commercial-off-the-shelf (COTS) T&M equipment. To make operation simple and intuitive, previews, online help and result dialogs together with drop rate statistics allow engineers to quickly define and verify the scenarios, enabling them to quickly configure test cases.

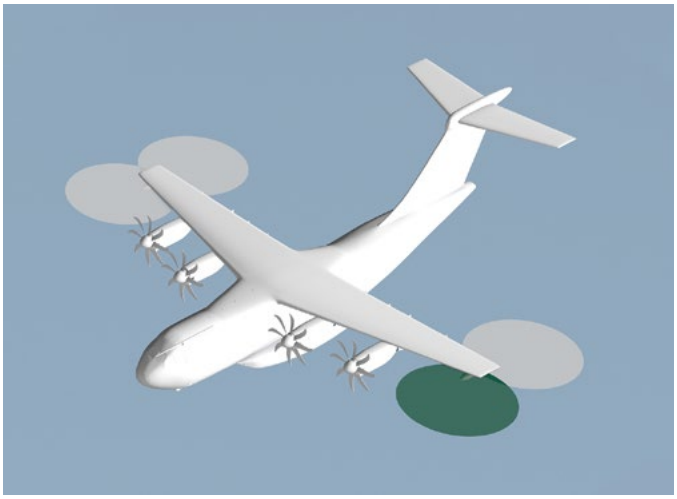
Coexistence of radars and telecommunications services



Coexistence testing of radars in the spectral vicinity of base stations or mobile phones requires a mix of communications signals and radar signals. S-band navigation radars operating in the spectral vicinity of LTE base stations or a mobile phone are a typical example. The performance of the radar receiver must be tested against this interference scenario.

The R&S®Pulse Sequencer software supports test cases that combine both scenarios with radar emitters and interferer stations that can be configured with any customer waveform. Scenario parameters such as frequency spacing, individual signal power, distance between radar and interferer, etc., can be set. As a result, the user gets one realistic signal containing both the wanted radar waveform together with the interfering LTE signals and can inject it into the radar receiver to test its robustness against interferers in the adjacent band.

Reference solution for simulation of angle of arrival (AoA)



Multichannel radar receivers are used to determine the AoA of a signal by evaluating the relative amplitude, relative phase or relative time between the individual receive signals. Typically, direction finding test cases require stimulating all RF inputs of the multichannel receiver simultaneously in order to simulate the angle of arrival (AoA) of a radar transmitter. Rohde&Schwarz offers a compact solution for simulating the angle of arrival in the lab. It consists of multiple coupled R&S®SMW200A vector signal generators and the R&S®Pulse Sequencer software.

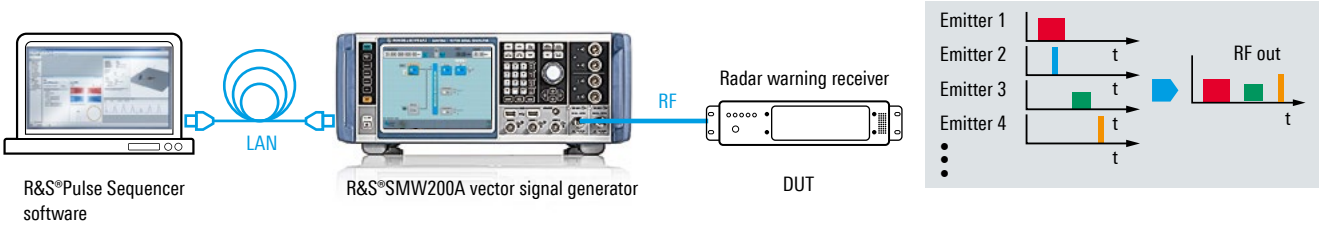
Rack space can be minimized if dual-path instruments are used. The software defines the test case and is used to monitor and control the RF hardware of the test setup. Signals are defined based on the receiver and emitter location, taking into account the receiver's multi-antenna configuration, the emitter antenna and all other effects such as antenna pointing, scan types, etc., together with the required radar signal.

This solution supports simulation of scenarios with static or moving emitters. Also multiple moving emitters are supported.

Radar receiver test applications

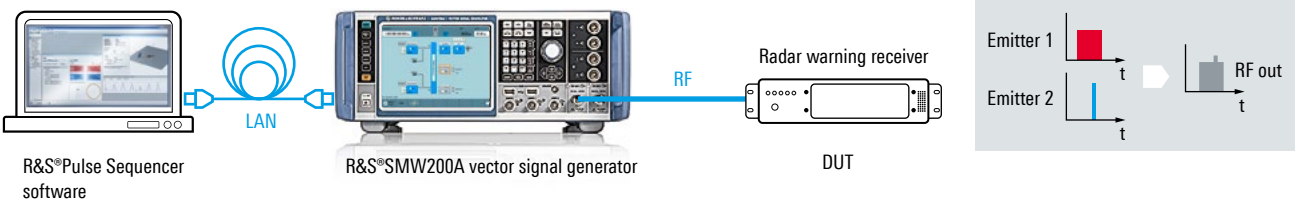
The R&S®Pulse Sequencer software and the highly scalable R&S®SMW200A vector signal generator combine perfectly to become a flexible radar scenario simulator. This makes it possible to test single-channel receivers as well as radar receivers with multiple RF channels in the lab. Typical setups in simplified form are shown below.

Simulation of single or multi emitter signals with the R&S®SMW200A vector signal generator



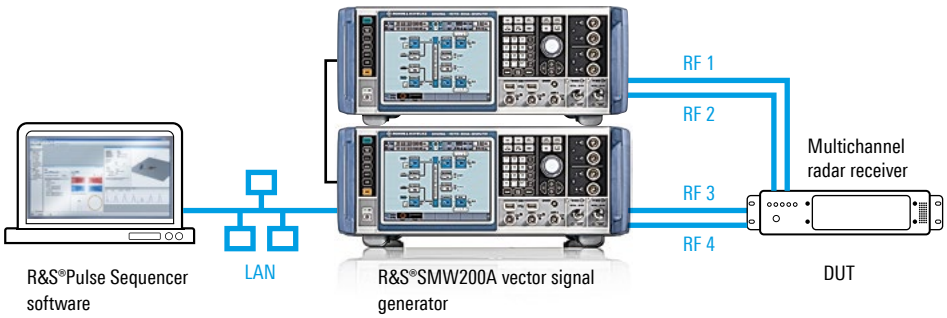
This setup is good for testing a single-channel radar receiver (DUT) in the frequency range up to 40 GHz with 2 GHz signal bandwidth. The R&S®Pulse Sequencer software simulates the radar scenarios and takes advantage of the R&S®SMW200A vector signal generator's powerful hardware. The R&S®Pulse Sequencer software uses a smart algorithm to interleave signals and drop pulses in case they collide. It ensures lowest drop rates thanks to an optimized, userdefined priority scheme. In the example above, the pulse from emitter 2 (blue pulse) is dropped as it overlapps with the pulse from emitter 1 (red pulse).

Simulation of pulse-on-pulse signals with the R&S®SMW200A vector signal generator



This setup is good for testing a single-channel radar receiver (DUT) in the frequency range up to 40 GHz with 2 GHz signal bandwidth and overlapping pulses (pulse-on-pulse signals). For this application, the R&S®SMW200A vector signal generator has two integrated baseband generators to generate the pulse-on-pulse signal through internal addition of the baseband signals.

Simulation of angle of arrival (AoA) with a four-channel test setup



This setup is good for simulating angle of arrival (AoA) of emitters with two coupled dual-path R&S®SMW200A vector signal generators.

The R&S®Pulse Sequencer software automatically calculates the relative delay, relative phase or relative amplitude values between the individual RF ports.

Features and benefits

Pulsed radar signals

The basic pulse is often the core item for each radar signal. The complexity level of signals that can be generated ranges from simple pulses for component tests to complex and framed pulse sequences including modulation on pulse (MOP). The R&S®Pulse Sequencer software is especially designed for that purpose and can generate waveform files for all Rohde&Schwarz vector signal generators. The classical waveform playback concept of Rohde&Schwarz vector signal generators is the perfect solution for signals containing basic pulses or short sequences.

For radar test cases that require ultralong playtime producing millions of pulses combined with frequency and level agility, engineers can take advantage of the realtime sequencing capability to the R&S®SMW200A.

Powerful radar signal simulator

Scenarios consisting of complex radar emitters including antenna diagrams and scans or interferers together with the antenna configuration of receivers can be simulated. The simulator can provide all required signals for simulating the AoA of radar transmitters. Taking into account a propagation loss model, it provides the RF power levels as they occur in real-world scenarios. Rohde&Schwarz vector signal generators equipped with R&S®Pulse Sequencer software options are ready for validating state-of-the-art receiver equipment and next generation single-channel or multichannel digital receivers in the lab. The simulator supports static or moving emitters together with a single static or moving receiver.

Unprecedented flexibility

The R&S®Pulse Sequencer software is not limited to pulsed radar scenarios. It also makes it possible to define radar signals mixed with mobile communications interferers or telecom signals. This is a perfect solution for testing coexistence of radar systems and telecommunications infrastructure. A wide variety of typical digital modulation formats for radar signals is supported. Users can also import their own telecom or radar waveform files and simulate scenarios mixed with signals based on predefined modulation formats. Furthermore, the software capabilities can be expanded by using its open plug-in interface.

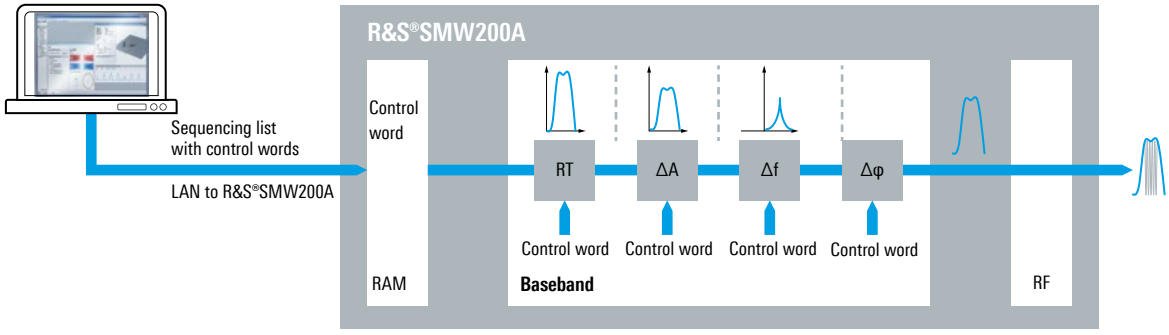
Powerful hardware platform

The R&S®Pulse Sequencer software is designed to take full advantage of the R&S®SMW200A vector signal generator. It offers a maximum RF frequency of 40 GHz and 2 GHz agile bandwidth. For direction finding test setups, an upgrade path from single channel to multichannel phase coherent test setups is available.

For more information:

https://www.rohde-schwarz.com/pulse-sequencer

Realtime sequencing with R&S®SMW200A and R&S®Pulse Sequencer software



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Rohde&Schwarz

The Rohde&Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

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