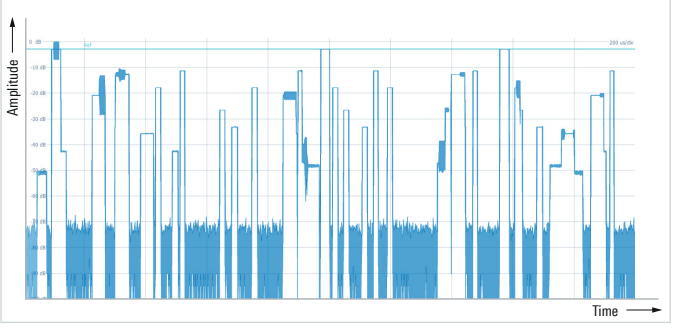
Innovative radar signal generation for scenarios with high pulse density

To simulate radar scenarios with frequency and level agility with high pulse density and long playtime, engineers can take advantage of the real-time sequencing capability of the R&S®SMW200A vector signal generator.

Radar scenario with high pulse density

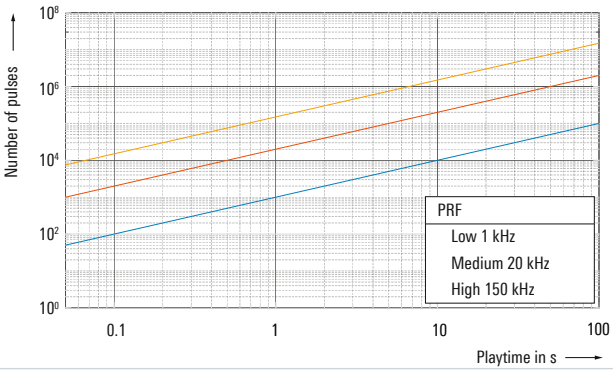


Your task

Before radar warning receivers can be deployed in a mission, they need to undergo intense operational testing. Radar warning receivers have to cope with dense pulse scenarios originating from many different, quite complex radars. The required radar signals have varying pulse repetition frequencies (PRF), which usually range from a few kHz to hundreds of kHz. A PRF of only 150 kHz with a scenario length of 1 s generates 150 000 pulses.

Scenarios with low PRFs can also produce many pulses since the required scenario length is often defined by the antenna scan duration, which can be quite slow. The major challenge is to reproduce such realistic scenarios with long scenario lengths in the lab with an appropriate simulator.

Resulting number of pulses vs. simulation duration



To produce a realistic scenario, the simulator also needs to support modulated and unmodulated pulses and agile switching of the frequency. Radars use this technique to avoid interception or jamming. Scenarios can also contain long silent times since the simulation needs to model the fact that the narrow Azimuth beam of the radar antenna only hits the DUT from time to time. Simulating these scenarios can quickly lead to very long calculation times and large signal file sizes on the order of Gbytes. Implementation using the traditional ARB approach is therefore very challenging or hardly realizable.

T&M solution

The R&S®SMW-K501 extended sequencing and R&S®SMW-K502 wideband extended sequencing options from Rohde&Schwarz provide a tailor-made solution for the above challenge. Based on the R&S®SMW200A vector signal generator's powerful digital baseband hardware and the R&S®Pulse Sequencer software, the solution enables engineers to quickly model complex pulse scenarios.

Example of a sequencing list calculated by the R&S®Pulse Sequencer software with four control words that define either a real-time (RT) signal or that make reference to a waveform (WV) segment

TOA	Mode	PW	Level	Frequency	Phase	MOP	Parameter
0.000 000 000 000 s	RT	20 µs	0.00 dB	–20 MHz	0.00°	LFM	2.001 MHz/µs
0.000 050 000 000 s	RT	11.535 µs	–2.00 dB	0 Hz	0.00°	BKR	R13
0.000 550 000 000 s	WV	–	0.00 dB	10 MHz	0.00°		Seg#0
0.001 050 000 000 s	WV	–	–1.00 dB	0 Hz	0.00°		Seg#1

The R&S®Pulse Sequencer software models the signal based on a sequencing list with control words. Together, all control words in the list define the final signal. The control words contain all pulse parameters that define the pulsed signal. The format of the control words used by the R&S®Pulse Sequencer software contains the pulse width, the modulation format (MOP), a relative power level (e.g. to model antenna scans), a frequency or phase offset (e.g. to model frequency hopping). A relative time stamp with time of arrival (ToA) information is assigned to each control word to define the time of playback of every pulse (e.g. to model PRI stagger or long off times). Instead of holding the pulse description, the format can reference precalculated waveform segments in the ARB. Frequency offset, phase offset and relative power level are always applied in real time for each control word.

Real-time sequencing and real-time signal generation using a sequencing list

Thanks to the real-time signal generation capability of the R&S®SMW200A, the digital baseband hardware interprets the uploaded list of control words and generates the signals at the point of time defined by the ToAs relative to a trigger event. Unmodulated rectangular pulses and pulses with linear frequency modulation or Barker codes are generated in real time together with any level, frequency, or phase offset as well as changes in pulse width. Long off times between two pulses are modelled by different ToA values. No I/Q samples need to be precalculated to fill the void between the pulses. This real-time sequencing and signal generation concept enormously reduces memory needs and calculation times compared to the traditional ARB approach.

In the following example, the resulting file size for a scenario using a sequencing list with control words is compared to the classical ARB approach. The scenario example creates different pulse top power levels for each pulse. This level variation is implemented using the interpulse modulation mechanism of the R&S®Pulse Sequencer software.

Scenario parameters

Scenario parameter	Value	Unit
Pulse width	20	µs
Chirp bandwidth	20	MHz
Pulse repetition interval	1	ms
Scenario duration	1	s

As can be seen in the following table, the scenario file size resulting from using the sequencing approach is much lower than that of the ARB approach. Calculation time is also greatly reduced.

Resulting file size

Concept	File size
ARB approach	305 Mbyte
Sequencing approach using a sequencing list with control words	22 kbyte

Real-time sequencing of precalculated waveform segments

The sequencing list can also address precalculated waveform segments and play them in real time. This is needed if non-rectangular pulse envelopes are used or for any modulation format other than Barker codes or linear frequency modulation. Only a single waveform segment, including the modulation format, is calculated together with the sequencing list. This waveform segment is manipulated and played as defined by the offset values and ToAs in the sequencing list.

All segments are precalculated for scenarios that use non-rectangular pulses with random effects on pulse parameters, e.g. pulse rise time jitter between the pulses. A lot of memory is still saved since off times between two segments, level variations, frequency offsets, etc. are defined by the sequencing list. Waveform segments imported by the customer can also be used with this sequencing approach. It is also possible to mix control words that define a real-time signal and control words that reference a predefined waveform segment in the ARB. The R&S®Pulse Sequencer software automatically takes care of this.

With this solution, it has never been easier to test radar equipment such as radar warning receivers or hopping transponders with realistic scenarios that produce hundreds of thousands of pulses. Minimum file size and minimum calculation time make this solution convenient to use. The user can utilize the full modulation bandwidth of the R&S®SMW200A signal generator of up to 2 GHz and benefit from its excellent RF performance.

Key benefits

- Ultra-long signal playtime with minimum memory needs and calculation times
- Real-time sequencing of waveform segments
- Real-time sequencing and signal generation of unmodulated rectangular pulses, linear frequency modulation and Barker codes
- Model dense pulse scenarios
- Supports modulation bandwidths up to 2 GHz

See also

www.rohde-schwarz.com/product/pulse-sequencer

Rohde&Schwarz GmbH&Co. KG
Europe, Africa, Middle East | +49 89 4129 12345
North America | 1 888 TEST RSA (1 888 837 87 72)
Latin America | +1 410 910 79 88
Asia Pacific | +65 65 13 04 88
China | +86 800 810 82 28 | +86 400 650 58 96
www.rohde-schwarz.com
customersupport@rohde-schwarz.com

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