R&S®SMW-K78
Radar Echo Generation
User Manual

1177625202
Version 16

ROHDE&SCHWARZ
Make ideas real

This document describes the following software options:

- R&S®SMW-78 Radar Echo Generation (1414.1833.02)

This manual describes firmware version FW 5.20.043.xx and later of the R&S®SMW200A.

Muehldorfstr. 15, 81671 Muenchen, Germany
Phone: +49 89 41 29 - 0
Email: info@rohde-schwarz.com
Internet: www.rohde-schwarz.com

1177.6252.02 | Version 16 | R&S®SMW-K78

The following abbreviations are used throughout this manual: R&S®SMW200A is abbreviated as R&S SMW, R&S®FSW is abbreviated as R&S FSW, R&S®Pulse Sequencer is abbreviated as R&S Pulse Sequencer

Contents

1 Welcome to the Radar Echo Generation option

The R&S SMW-K78 is a firmware application that adds functionality to generate a single or multiple radar echo signals for radar tests.

The R&S SMW-K78 features include:

- Radar echo generation for any input in real time
- Simulation of up to 12 independent virtual static or moving objects
- 160 MHz RF bandwidth throughout the entire frequency range
- Excellent RF performance of signal generator and analyzer
- Possibility to add interferers and noise
- Internal generator solution, no need for external PC
- Intuitive and easy to use graphical user interface

This user manual contains a description of the functionality that the application provides, including remote control operation.

All functions not discussed in this manual are the same as in the base unit and are described in the R&S SMW user manual. The latest version is available at:

www.rohde-schwarz.com/manual/SMW200A

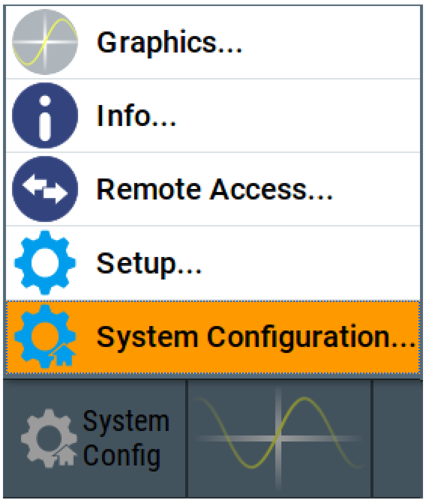
Installation

You can find detailed installation instructions in the delivery of the option or in the R&S SMW service manual.

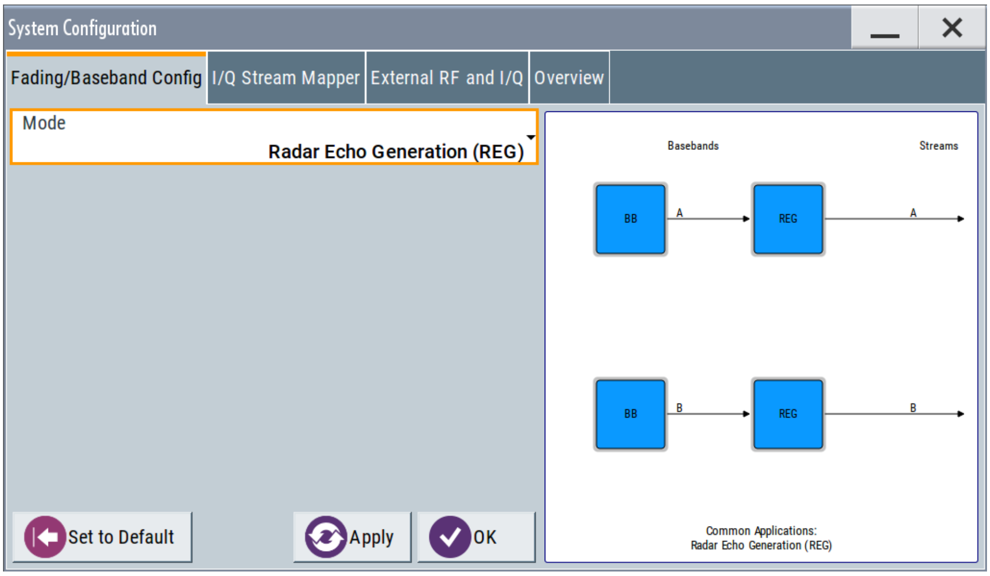
1.1 Accessing the Radar Echo Generation dialog

To open the dialog with Radar Echo Generation settings

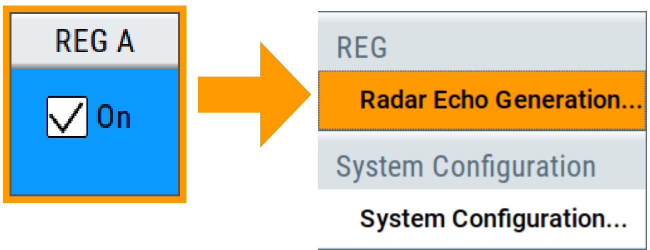
1. In the block diagram of the R&S SMW, select "System Config > System Configuration".



2. Select "Fading/Baseband Config > Mode > Radar Echo Generation (REG)".



3. Select "Apply".
4. Confirm with "OK"
5. In the block diagram, select "REG > Radar Echo Generation".



A dialog box opens that displays the provided general settings.

The signal echo generation is not started immediately.

For more information, see Chapter 4, "How to generate radar echo signals", on page 51.

1.2 What's new

This manual describes firmware version FW 5.20.043.xx and later of the R&S®SMW200A.

Compared to the previous version, the documentation provides corrected information on the delay for moving objects, see "Object Hold Off" on page 42.

1.3 Documentation overview

This section provides an overview of the R&S SMW user documentation. Unless specified otherwise, you find the documents at:

www.rohde-schwarz.com/manual/smw200a

1.3.1 Getting started manual

Introduces the R&S SMW and describes how to set up and start working with the product. Includes basic operations, typical measurement examples, and general information, e.g. safety instructions, etc. A printed version is delivered with the instrument.

1.3.2 User manuals and help

Separate manuals for the base unit and the software options are provided for download:

- Base unit manual
  Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance, instrument interfaces and error messages. Includes the contents of the getting started manual.
- Software option manual
  Contains the description of the specific functions of an option. Basic information on operating the R&S SMW is not included.

The contents of the user manuals are available as help in the R&S SMW. The help offers quick, context-sensitive access to the complete information for the base unit and the software options.

All user manuals are also available for download or for immediate display on the Internet.

1.3.3 Tutorials

The R&S SMW provides interactive examples and demonstrations on operating the instrument in form of tutorials. A set of tutorials is available directly on the instrument.

1.3.4 Service manual

Describes the performance test for checking compliance with rated specifications, firmware update, troubleshooting, adjustments, installing options and maintenance.

The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS):

https://gloris.rohde-schwarz.com

1.3.5 Instrument security procedures

Deals with security issues when working with the R&S SMW in secure areas. It is available for download on the internet.

1.3.6 Printed safety instructions

Provides safety information in many languages. The printed document is delivered with the product.

1.3.7 Data sheets and brochures

The data sheet contains the technical specifications of the R&S SMW. It also lists the options and their order numbers and optional accessories.

The brochure provides an overview of the instrument and deals with the specific characteristics.

See www.rohde-schwarz.com/brochure-datasheet/smw200a

1.3.8 Release notes and open source acknowledgment (OSA)

The release notes list new features, improvements and known issues of the current firmware version, and describe the firmware installation.

The software makes use of several valuable open source software packages. An open-source acknowledgment document provides verbatim license texts of the used open source software.

See www.rohde-schwarz.com/firmware/smw200a

1.3.9 Application notes, application cards, white papers, etc.

These documents deal with special applications or background information on particular topics.

See www.rohde-schwarz.com/application/smw200a and www.rohde-schwarz.com/manual/smw200a

1.3.10 Videos

Find various videos on Rohde & Schwarz products and test and measurement topics on YouTube: https://www.youtube.com/@RohdeundSchwarz

On the menu bar, search for your product to find related videos.

Figure 1-1: Product search on YouTube

1.4 Scope

Tasks (in manual or remote operation) that are also performed in the base unit in the same way are not described here.

In particular, it includes:

- Managing settings and data lists, like saving and loading settings, creating and accessing data lists, or accessing files in a particular directory.
- Information on regular trigger, marker and clock signals and filter settings, if appropriate.
- General instrument configuration, such as checking the system configuration, configuring networks and remote operation
- Using the common status registers

For a description of such tasks, see the R&S SMW user manual.

1.5 Notes on screenshots

When describing the functions of the product, we use sample screenshots. These screenshots are meant to illustrate as many as possible of the provided functions and possible interdependencies between parameters. The shown values may not represent realistic usage scenarios.

The screenshots usually show a fully equipped product, that is: with all options installed. Thus, some functions shown in the screenshots may not be available in your particular product configuration.

2 About the Radar Echo Generation option

Testing of radar system with real targets can be a complex task, including expensive and not reproducible field tests, or involving specially designed hardware. A novel approach is to use standard test and measurement equipment instead, for example the combination of the R&S SMW and the R&S FSW signal analyzer.

This description focuses on the functionality of the Radar Echo Generation (R&S SMW-K78) option. It explains how the radar echo generator receives, manipulates, and retransmits radar waveforms to the radar under test.

2.1 Required options and equipment

R&S SMW

R&S SMW base unit equipped with:

- Option baseband generator (R&S SMW-B10) and
  Option baseband main module, with one/two I/Q paths (R&S SMW-B13/-B13T)
- Frequency option (e.g. R&S SMW-B1003)
- Option fading simulator (R&S SMW-B14)
- Option Radar Echo Generation (R&S SMW-K78)

This configuration is sufficient for the generation of up to 6 echoes.

For more information, see data sheet.

R&S FSW

R&S®FSW signal and spectrum analyzer equipped with:

- R&S®FSW-B17 digital baseband Interface
- R&S®FSW-B160 160 MHz analysis bandwidth or any of the options R&S®FSW-B80/-B320/-B500

For more information, see data sheet.

Required additional equipment and cables

As a rule, always use short cable of good quality:

- One R&S®SMU-Z6 cable for connecting the digital I/Q interfaces of the R&S SMW and the R&S FSW
- 2 BNC cables: for feeding the external reference frequency and the trigger signal
- USB or LAN cable for connecting the R&S FSW and the R&S SMW
- Depending on the test setup, one of the following:
  – 2 RF cables (for conducted tests)
  – Rx and Tx antennas (for over-the-air OTA tests)

- Optional, an external attenuator to protect the input stage of the R&S FSW

2.2 The principle of echo generation with R&S SMW-K78

If equipped with the Radar Echo Generation (REG) option, the R&S SMW can work as an echo generator together with the R&S FSW signal analyzer. An example of this solution is the test setup shown on Figure 2-1. The figure illustrates the radar echo generation with **real radar signal** as a principle.

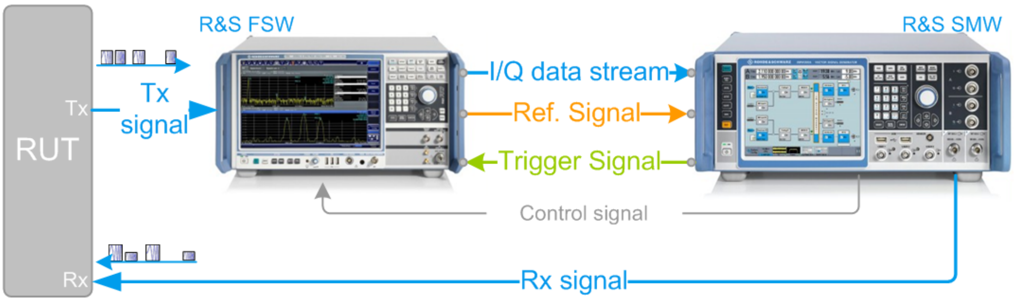


Figure 2-1: Radar echo generation with R&S FSW, R&S SMW, and real radar signal (conducted test)

RUT	= Radar under test
Tx signal	= Transmitted (original) radar signal
Rx signal	= Modified signal, fed back to the radar
I/Q data stream	= Digital baseband data stream
Ref. Signal	= 10 MHz common reference frequency signal to synchronize the R&S SMW to the R&S FSW
Trigger Signal	= Required to estimate the system latency of the system (blind zone (BZ))
Control signal	= USB (or LAN) connection for remote control of the analyzer from the R&S SMW

The R&S FSW acts as a downconverter. It captures the transmitted analog radar signal from the RUT (Tx signal) and converts it to a digital baseband signal. The R&S FSW provides the digital signal via the digital I/Q interface to the R&S SMW. The R&S SMW processes the received original signal (Tx signal), but changes the signal according to the individual objects. The R&S SMW simulates **range** by delaying the received radar signal. It simulates **velocity** by adding Doppler frequency shifts to the original signal and radar cross sections (**RCS**) by attenuating the signal. The modified signal (Rx signal) is up-converted and fed back to the radar receiver [3].

The combination of the R&S FSW and the R&S SMW equipped with the option R&S SMW-K78 is commonly referred as radar echo generator (**REG**).

In the test setup on Figure 2-1, there is a cable connection between the RUT and the measurement equipment. Throughout this description, this setup is referred as a **conducted test**. The RUT and the REG can also be located several meters away from each other. To transmit and receive the signal, both the RUT and the REG are equipped with transmit and receive antennas. An example of this setup is illustrated on Figure 2-2. This kind of setup is referred as an **over-the-air (OTA) test**, where the distance between the RUT and the REG is referred as OTA distance.

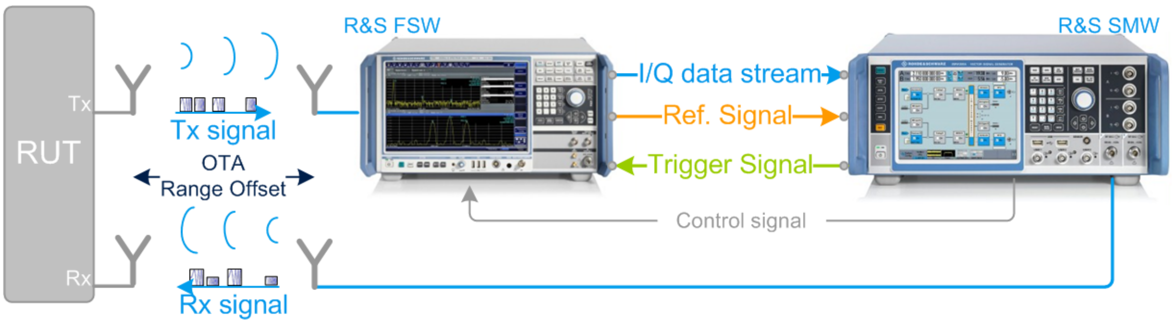


Figure 2-2: Radar echo generation with real radar signal (over-the-air tests)

OTA = Over-the-air
OTA Range Offset = Distance between the RUT and the REG antennas

Alternatively to the two previous examples, the radar signals can be created **internally** in the R&S SMW. The R&S SMW can play waveforms created with the R&S Pulse Sequencer software or custom waveforms, that are loaded in the ARB generator. In this case, a standalone R&S SMW is sufficient, for example for radar receiver tests (see Figure 2-3). The characteristics of the objects can be imposed on the original signal in the same way as in the tests with real radar signal.

Figure 2-3: Radar echo generation with R&S SMW and ARB-based radar signals created by R&S Pulse Sequencer

RUT = Radar under test
Rx signal = Modified test signal, transmitted to the radar

One of the advantages of this solution is the fact, that it is independent of the transmitter and the Tx signal of the radar system.

See:

- Chapter 4, "How to generate radar echo signals", on page 51 for step-by-step instructions.
- Chapter 3, "Radar echo generation configuration and settings", on page 25 for description of the related settings.

2.3 Analyzer and receiver overload protection

Follow the following general precautions:

- **NOTICE** Risk of overloading
  Signal strength outside the permissible input ranges may overload and damage the signal analyzer R&S FSW and the radar receiver.
  Always check the specifications for permissible input ranges.

Connect an external attenuator to protect the input stage of the analyzer.

- Observe the theoretical dynamic power range of the scenario before activating the REG.
  (see "Ext. Attenuator (Analyzer)" on page 30)
- To protect the radar inputs from overloading, limit the output power at the RF outputs of the R&S SMW.
  Set the parameter "RF A or RF B > RF Level > Level > Limit" to the maximum allowed receive power at the radar input.

For more information, see:

- The R&S SMW user manual
- The documentation of the radar under test (RUT)
- The R&S FSW user manual [4].

2.4 Important parameters and interdependencies

This section is an overview of most important parameters of the radar echo generator and the cross-reference between them. The section provides explanation of the used equations and the calculation principles, together with information on the related settings.

Radar parameter	Designation	R&S SMW simulates it as	Formula
Radar cross section (RCS)	σ	Level attenuation	"Radar equation" on page 16 Chapter 2.4.2, "Radar received power P_{Rx} calculation", on page 15
Range	R	Signal delay	Chapter 2.4.4, "Delay calculation", on page 21
Object velocity	v	Doppler frequency shift	Chapter 2.4.3, "Doppler frequency shift calculation", on page 20

Background knowledge on radar principles, radar testing, and common terms in the context of the radar systems is assumed.

For related information, see:

- White Paper 1MA239: "Radar Waveforms for A&D and Automotive Radar" for an overview of the radar waveforms
- Application note 1MA256: "Real-time Radar Target Generation" for information on radar testing
- Application note 1MA127: "Introduction to Radar System and Component Tests" for an overview of the radar measurements

2.4.1 Simulated objects types

The R&S SMW equipped with one Radar Echo Generation option can generate the echo signal of up to 12 independent static or moving objects. In context of this firmware, a **static object** is an object with a zero object velocity. Static objects are placed at a user-defined distance (range) from the radar.

A **moving object** is an object that approaches to or moves away from the radar with a constant user-defined velocity (i.e. the acceleration is zero). The Doppler frequency shift is a positive or negative value to indicate the direction of the movement. Different spectral components are applyed with different doppler shifts. The object can move back and forth between two user-defined positions (start range and end range). Its trajectory is a straight radial line leading out of the radar antennas.

A **static + moving object** is an artificial object, provided to simulate the combination of constant range and positive velocity.

The objects are placed on a plain area. Elevation (altitude) and angle information is not required. An isotropic antenna is assumed so that enabled objects are always visible.

2.4.2 Radar received power P_{Rx} calculation

In the radar theory, the power returned to the radar P_{Rx} is given by the radar equation. The illustration on Figure 2-4 shows the influence of the radar parameters on the radar received power P_{Rx}.

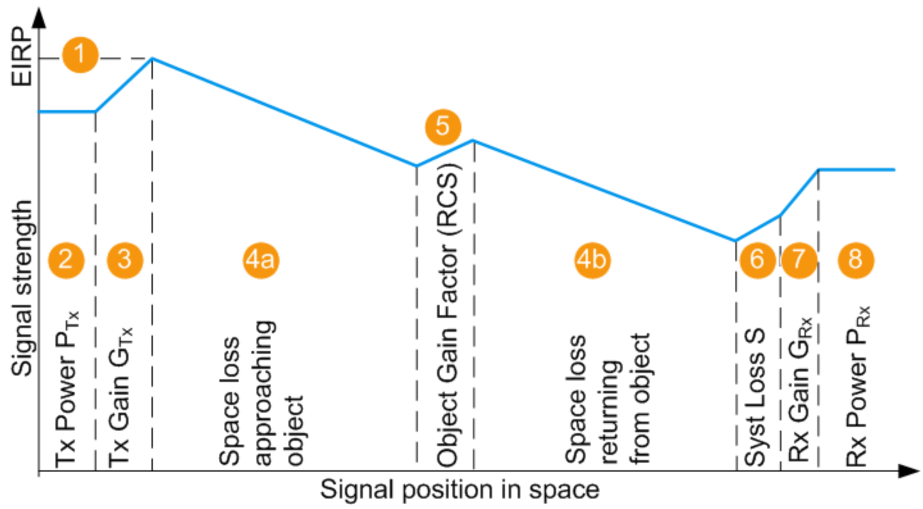


Figure 2-4: Variation of the signal strength

1 = Equivalent isotopically radiated power (EIRP) of the radar; if G_{Tx} = 0 dBi, EIRP = P_{Tx}
2,3,7 = Radar parameters, see Radar under test (RUT) settings
4a,4b = Signal attenuation, simulated by the selected (Start) Range and End Range
5 = Radar cross-section (RCS), see Radar cross-section RCS setup settings
6 = Gain to compensate for cable loss (see "System Loss" on page 29)
2 to 7 = Configurable values
8 = Power of the Rx signal returned to the radar antenna P_{Rx}, calculated according to Radar equation

Radar equation

The power of the signal Rx returned to the radar antenna P_{Rx} is calculated as follows:

P_{Rx} [dBm] =

$= P_{Tx} + G_{Tx} + G_{Rx} + S + \sigma_j + 20*\log_{10}(c_0) - 20*\log_{10}(f) - 40*\log_{10}(R_j) - 30*\log_{10}(4\pi)$

Where:

- P_{Rx} is the power of the whole scenario, calculated as the sum of the $P_{Rx,j}$ values; $P_{Rx,j}$ is the calculated Rx power per object j
- P_{Tx} is the radar transmitter power
  (see "Radar under test (RUT) settings" on page 29)
- G_{Tx} and G_{Rx} are the antenna gains of the transmitting and the receiving antennas of the RUT
  (see "Radar under test (RUT) settings" on page 29 and "OTA tests settings" on page 28)
- S is the system loss
  (see "OTA tests settings" on page 28)
- σ_j is the radar cross section (RCS), or scattering coefficient of the object
  (see Chapter 3.6, "Radar cross-section RCS setup settings", on page 45)
- R_j is the range
  (see "(Start) Range" on page 41 and "End Range" on page 41)
- f is the dedicated frequency
  (see "Dedicated Frequency" on page 37)
- $c_0 \approx 3*10^8$ m/s is the speed of light

The resulting $P_{Rx,j}$ [dB] for the start and end range of each object is displayed with the parameters:

- Radar Rx Power (Start)
- Radar Rx Power (End)

2.4.2.1 Calculating the REG input and output levels ($RefLevel_{Analyzer}$ and $Level_{R\&S\ SMW}$)

Figure 2-4 illustrates the theoretical P_{Rx} calculation. When you generate radar echo signal with the REG, the output level at the R&S SMW RF output is set so that the RUT receives the power P_{Rx}, as it is calculated with the radar equation.

The illustration on Figure 2-5 resembles the same information as Figure 2-4, but it also depicts the level at the REG input and output. The illustration assumes the case, where:

- The Tx output of the RUT is connected over cable to the input of the analyzer
- The RF output of the R&S SMW is connected over cable to the Rx input of the RUT

The following applies:

- The signal at the REG input is $RefLevel_{Analyzer} = P_{Tx}$
- The signal at the REG output is $Level_{R\&S\ SMW} = P_{Rx}$

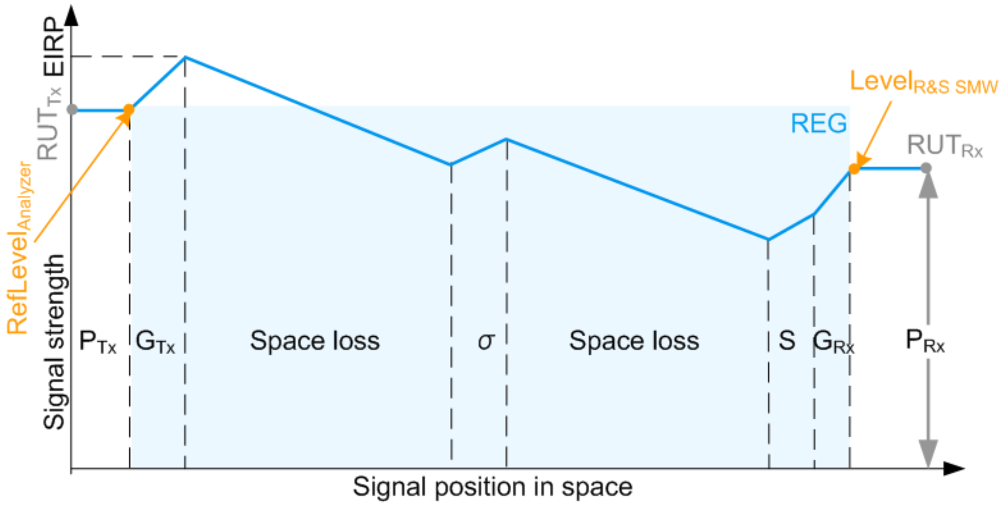


Figure 2-5: P_Rx calculation (simplified representation, "Ext. Attenuator A = 0 dB", "Test Setup = Conducted")

EIRP, P_{Tx}, G_{Tx}, G_{Rx}	=	Radar parameters
Space loss	=	Signal attenuation, simulated by the selected "Range"
σ	=	Radar cross-section (RCS)
S	=	Gain to compensate for cable loss
P_{Rx}	=	Power of the Rx signal returned to the radar antenna, calculated according to Radar equation
$RefLevel_{Analyzer}$	=	Signal input level at the analyzer; if "Ext. Attenuator A = 0 dB", $RefLevel_{Analyzer} = P_{Tx}$
$Level_{R\&S\ SMW}$	=	Signal level at the REG output; if "Test Setup = Conducted", $Level_{R\&S\ SMW} = P_{Rx}$
RUT_{Tx}	=	P_{Tx} is the signal level at the RUT output
RUT_{Rx}	=	P_{Rx} is the signal level at the RUT input; $P_{Rx} \leq P_{Rx\ max}$, where $P_{Rx\ max}$ is the set with the parameter "RF A or RF B > RF Level > Level > Limit" (see Chapter 2.3, "Analyzer and receiver overload protection", on page 13)

In practice, the RUT output is not directly connected to the REG input. The signal level at the R&S SMW RF outputs is configured in the way that the power level received by the RUT is **the calculated P_{Rx} of the whole scenario**. Connected external attenuator, antenna gains of the Rx and Tx antennas connected to the measurement equipment, distance between the antennas are considered automatically.

All these parameters are considered by the level settings in the signal analyzer and the output level of the R&S SMW. Figure 2-6 and Figure 2-7 illustrate this principle.

$RefLevel_{Analyzer}$ calculation

The reference level ($RefLevel_{Analyzer}$) depends on the external attenuation A and on the test setup. The $RefLevel_{Analyzer}$ is calculated as follows:

- **"Test Setup > Conducted Test"**
  $RefLevel_{Analyzer}$, [dBm] = P_{Tx} - A

  Where:
  - P_{Tx} is the radar transmitter power
    (see "Radar under test (RUT) settings" on page 29)
  - A is the attenuation of the external attenuator

(see "Ext. Attenuator (Analyzer)" on page 30)

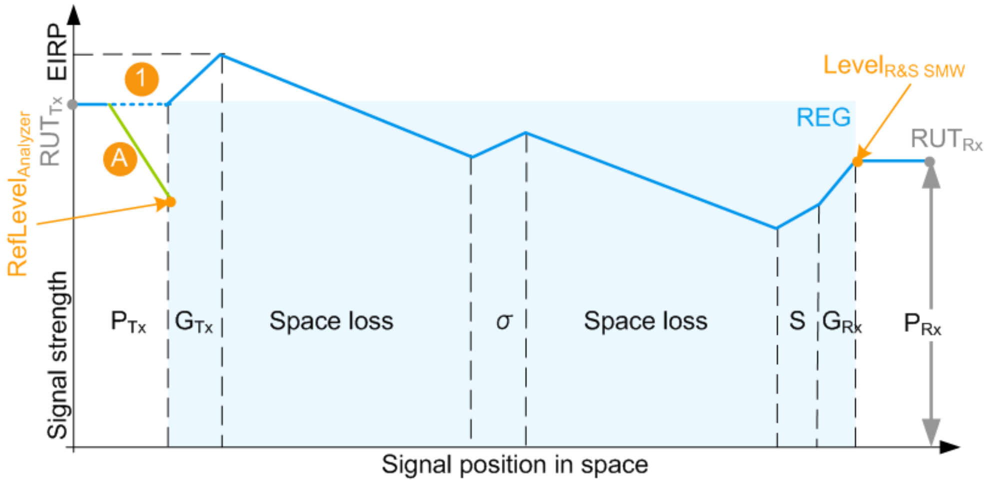


Figure 2-6: P_Rx calculation (simplified representation, "Ext. Attenuator A = A dB", "Test Setup = Conducted")

A = External attenuation
1 = External attenuation merely protects the input of the analyzer; in does not change the calculated P_{Rx} value

- **"Test Setup > OTA Test"**
  $RefLevel_{Analyzer}$, [dBm] = $P_{Tx} + G_{Tx} + G_{Rx\_REG} + 20\log_{10}(c_0) - 20\log_{10}(f) - 20\log_{10}(4\pi) - 20\log_{10}(R_{OTA}) - A$
  Where:
  – P_{Tx} is the radar transmitter power
  (see "Radar under test (RUT) settings" on page 29)
  – G_{Tx} and G_{Rx_REG} are the antenna gains of the transmitting at the radar and the receiving antennas at the REG
  (see "Radar under test (RUT) settings" on page 29 and "OTA tests settings" on page 28)
  – f is the dedicated frequency
  (see "Dedicated Frequency" on page 37)
  – $c_0 \approx 3*10^8$ m/s is the speed of light
  – A is the attenuation of the external attenuator
  (see "Ext. Attenuator (Analyzer)" on page 30)
  – R_{OTA} is the distance between the transmitting and receiving antennas of the RUT and the REG
  (see "OTA tests settings" on page 28)

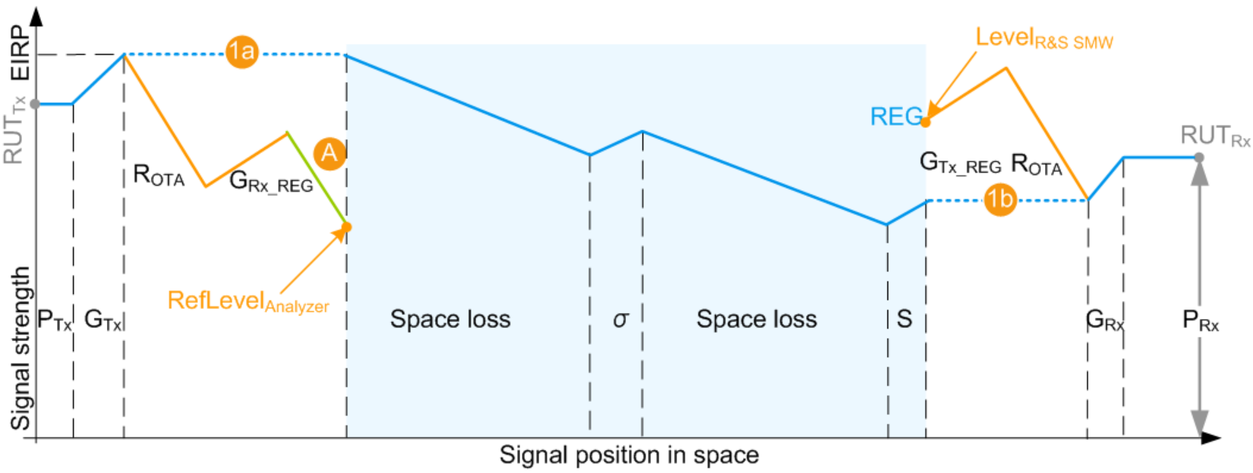


Figure 2-7: P_Rx calculation (simplified representation, "Ext. Attenuator A = A dB", "Test Setup = OTA")

A = External attenuation
1a, 1b = External attenuation A, R_{OTA}, G_{Rx_REG}, and G_{Tx_REG} do not change the calculated P_{Rx} value

Level$_{R\&S\ SMW}$ calculation

The signal power level at the RF outputs of the R&S SMW is configured in the way that **the power level received by the RUT is the calculated P_{Rx} of the whole scenario**. This is true irrespectively of the test setup and whether the $P_{Rx,j}$ values are calculated with the Radar equation or manually.

The calculated Level$_{R\&S\ SMW}$ is indicated with the parameter Level for Simulation. The displayed value considers also the following:

- Enabled level offset ("RF > RF Level > Offset")
- Current signal routing ("System Configuration > I/Q Stream Mapper > Stream A/B to RF A/B")

2.4.2.2 Setting the REG input and output levels (RefLevel$_{Analyzer}$ and Level$_{R\&S\ SMW}$)

The reference level of the analyzer RefLevel$_{Analyzer}$ is important value for the calculation of the required output level at the R&S SMW. The analyzer and the R&S SMW must be properly connected.

Correct calculation and leveling

We recommend that you connect the instruments via USB (or LAN) and configure their settings from the R&S SMW and the REG dialog.

Do not change the level settings of both, the generator and the analyzer manually. Use the following alternatives instead:

- Set the parameter "System Loss" to compensate for additional attenuation.
- Set the parameter "RF > RF Level > Offset" to add a level shift.

$RefLevel_{Analyzer}$ adjustment

To ensure correct leveling *at the beginning of the simulation*, the R&S SMW performs the following:

- Calculates the required reference level ($RefLevel_{Analyzer}$) depending on the Test Setup.
- Verifies whether the calculated reference level is within the permissible value range of the analyzer.
  (see the status indication in the parameter Set Ref. Level on Analyzer)
- Verifies whether the current reference level in the analyzer is equal to the calculated value.
  If an update is indicated, select "Set Ref. Level on Analyzer" to set the level to the calculated $RefLevel_{Analyzer}$ value.

The R&S SMW does not monitor the reference level in the analyzer during operation. Subsequent changes of the reference level value are not considered.

$Level_{R\&S\ SMW}$ adjustment

To ensure correct leveling, the R&S SMW performs the following:

- Calculates the required output level $Level_{R\&S\ SMW}$ and indicates it with the parameter Level for Simulation.
  (see "$Level_{R\&S\ SMW}$ calculation" on page 19)
- Verifies whether the calculated level is within the permissible value range.
  (see the status indication in the parameter Adjust Dedicated Level)
- Identifies the dedicated connectors, i.e. all connectors to that the signal of the REG block is routed.
  ("System Configuration > I/Q Stream Mapper > Stream A/B to RF A/B")
- Verifies whether the current output level at the dedicated connector is equal to the calculated value.
  If an update is indicated, select "Adjust Dedicated Level" to set the output level to the calculated value.

2.4.3 Doppler frequency shift calculation

The Doppler frequency shift f_D of the signal returning for an object is calculated as follows:

$f_D = m*2*v*f/c_0$

Where:

- m is a coefficient that indicates whether the object is approaching to or departing from the radar:
  - m = -1, if "End Range" ≥ "Start Range" (departing object)
  - m = 1 otherwise (approaching object)

- |v| is the velocity of the object in the direction of travel and is given by the absolute value of the radial velocity.
  (see "Object Velocity" on page 42)
- f is the dedicated frequency
  (see "Dedicated Frequency" on page 37)
- $c_0 \approx 3*10^8$ m/s is the speed of light

Because objects move with a constant velocity, the absolute values of the Doppler frequency shift f_D is a constant value and is calculated once for the carrier frequency. Different spectral components are applied with different doppler frequency shifts f_D. The Doppler frequency of a moving object that moves one way and then stops is f_D during the movement and $f_D = 0$ at the distance "End Range". The Doppler frequency of an object that moves fort and backwards alternates between the 2 values $\pm f_D$.

See the example on Figure 3-4.

2.4.4 Delay calculation

The delay τ of each returned pulse is calculated as follows:

$\tau_j = 2*(R_j - R_{OTA}) / c_0$

Where:

- R_j is the range per object j
  (see "(Start) Range" on page 41 and "End Range" on page 41)
- R_{OTA} is the distance between the transmitting and receiving antennas of the RUT and the REG
  (see "OTA tests settings" on page 28)
  $R_{OTA} = 0$, if "Test Setup" on page 27 > "Conducted Test" is used.
- $c_0 \approx 3*10^8$ m/s is the speed of light

The signal delay τ_j is a function of the range R_j.

For static objects and static + moving objects, the signal delay τ_j is a constant value and has to be calculated once. For moving objects, the delay is calculated along the whole trajectory, i.e. form the "Start Range" to the "End Range" values.

Eliminating the blind zone BZ effect for pulse sequences with a constant PRF

The minimum delay τ_j depends on the blind zone (BZ) of the REG (see "System Latency (Blind Zone/ BZ)" on page 35). The theoretical minimum range R_{min} is the distance at that the radar and the object are colocated and can be achieved only if the $t_{BZ} = 0$.

The blind zone (also referred as system latency) is the processing time of the REG for each incoming pulse, that is the time it takes the R&S SMW and the R&S FSW to process the radar signal. Per default, the $\tau_j \geq t_{BZ}$. The first retransmitted pulse is sent after the system latency time period has elapsed, see Figure 2-8.

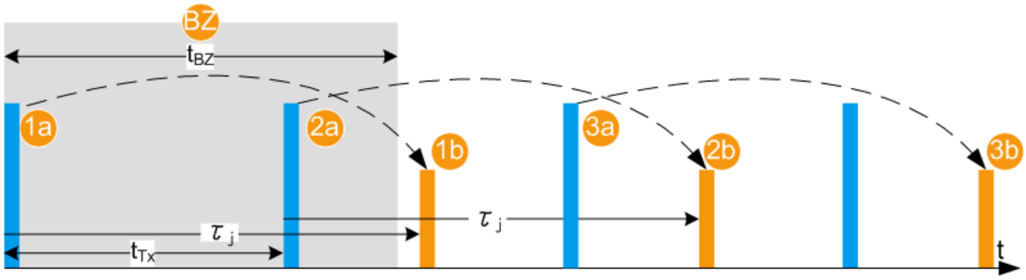


Figure 2-8: Effect of the blind zone (BZ)

BZ = Blind zone of the 1st pulse
t_{BZ} = Blind zone duration
1a, 1b = 1st Tx pulse and first Rx pulse (echo), retransmitted to the RUT
2a and 2b, 3a and 3b = Tx and Rx pulse pairs
τ_j = Delay
t_{Tx} = 1/PRF is the pulse repetition interval

If the radar signal is a pulse sequence with a constant known pulse repetition frequency (PRF), the bind zone limitation can be overcome. With enabled parameter Use Radar Range Ambiguity to reduce Min. Range, the REG retransmits the first echo so that once received in the RUT, this echo looks like it is the response of a subsequent (n^{th}) transmit pulse. The delay is, however, $\tau_j < t_{BZ}$. The n^{th} pulse is indicated with the parameter First Echo to Pulse#. The value depends on the PRF, t_{BZ} and the range R_j.

This process is illustrated on Figure 2-9. The example uses the same sequence as on Figure 2-8 but $\tau_j < t_{BZ}$. The software calculated the value $\Delta\tau_j = t_{BZ} - \tau_j$ and determines the earliest possible time point, after that an echo can be retransmitted. In this example, the first echo pulse is the response of the 2nd transmitted pulse.

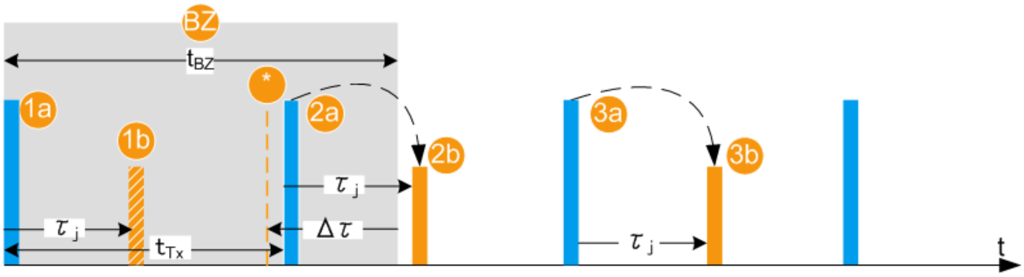


Figure 2-9: Effect of the parameter "Use Radar Range Ambiguity to Reduce min. Range = On"

BZ = Blind zone of the 1st pulse
t_{BZ} = Blind zone duration
PRF = Pulse repetition frequency; a known constant value
t_{Tx} = 1/PRF is the pulse repetition interval
τ_j = Delay
$\Delta\tau$ = $t_{BZ} - \tau_j$
1a, 2a, 1b = Pulses and echoes during the blind zone of the 1st pulse
1b = Theoretical echo of the 1st Tx pulse (not transmitted)
* = The earliest possible time point, after that an echo can be retransmitted

2a	= Tx pulse, as transmitted by the RUT; this pulse number is indicated with the parameter First Echo to Pulse#
2b	= Rx pulse (echo), retransmitted to the RUT
3a and 3b	= Tx and Rx pulse pairs

2.4.5 System latency calibration

The REG system latency can be estimated automatically or set manually.

Manual calibration

The REG blind zone is set manually with the parameter System Latency (Blind Zone/ BZ).

See Chapter 4.8, "Estimating the system latency time roughly", on page 61 for an example on how to estimate and correct the system latency manually.

Automatic calibration

If the trigger signal of the R&S SMW is fed to the analyzer, the system latency can be estimated automatically. The trigger output connector depends on the test setup up and the signal routing ("System Configuration > I/Q Stream Mapper"). Observe the Show Trigger Connector information and connect the indicated output.

The system latency is measured once, after the automatic calibration is selected. The estimated value corresponds to the processing time of the REG, i.e. the processing time of the R&S SMW and the analyzer. The value is measured for the current REG configuration, in particular the selected signal routing. Do not change the signal routing afterwards.

The estimated value can deviate form the real system latency. Errors in the system latency result in a constant offset applied to all objects. System latency errors can be compensated by adding a correction value (Correction Values).

See:

- Data sheet for information on the system latency calibration error
- Figure 4-1 and Figure 4-2 for an overview of the default connectors and connections
- Chapter 4.8, "Estimating the system latency time roughly", on page 61 for general example on how to compensate for system latency errors

2.5 General recommendations

Consider the following general recommendations for best results:

1. Use short connection cables
2. Connect all required cables between the REG and the RUT: reference frequency, data, control, trigger, RF signals

3. Follow the rules for overload protection
4. Configure the "System Configuration" settings, in particular the signal routing form the BB IN block to the REG blocks and to the RF outputs.
5. Set the RF frequency and if necessary a level limit and a level offset.
6. Do not change the parameter "I/Q Modulator > Digital Impairments > I/Q Delay". A value different than 0 adds an extra delay. When observed on the RUT, all objects are shifted with a constant delay
7. Set the reference frequency source
8. Configure the Radar Setup settings. Configure one ore more object.
9. Adjust the REG input level
10. Adjust the REG output level
11. Adjust the RF at the analyzer
12. If necessary, estimate the system latency automatically

For step-by-step instructions, see Chapter 4, "How to generate radar echo signals", on page 51.

3 Radar echo generation configuration and settings

This section describes the related settings.

The remote commands required to define these settings are described in Chapter 5, "Remote-control commands", on page 63.

For step-by-step instructions, see Chapter 4, "How to generate radar echo signals", on page 51.

The Radar Echo Generation settings are grouped into several tabs. The "Radar Setup" tab comprises the settings of your test setup, like the setup type, RUT Tx power, antenna gains at the transmitter and the receiver side, or attenuations. The "Simulation Setup" tab is where you calibrate the REG. In the "Object Configuration" tab, you can describe the objects for that the echoes are generated. If at least one object is configured and the REG is activated, the graph in the "Object Preview" tab visualizes the variation of the received power.

3.1 Radar setup settings

This dialog provides access to the default and the "Save/Recall" settings, and to the power and antenna gain parameters of the radar and the radar echo generator (REG). The power and gain parameters are required to calculate the received power Rx.

Access:

1. In the block diagram of the R&S SMW, select "System Config > System Configuration > Fading/Baseband Config > Mode > Radar Echo Generation".
2. Select "Apply". Confirm with "OK".
3. Close the "System Configuration" dialog.
4. In the block diagram, select "REG > Radar Echo Generation"

   The Radar Echo Generation dialog box opens and displays the "Radar Setup" settings.

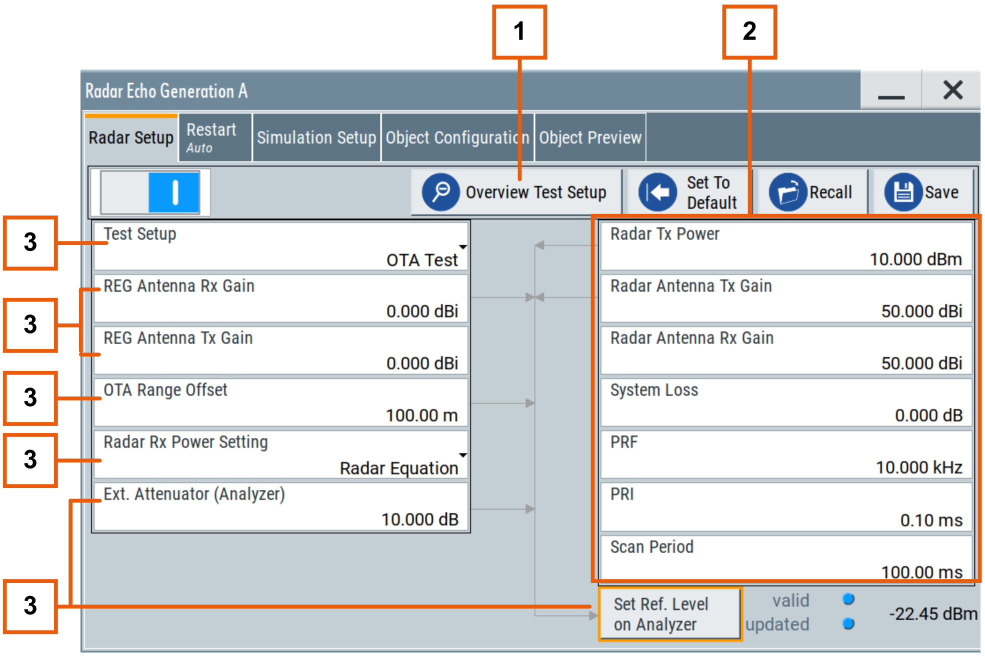


Figure 3-1: Radar Setup: Understanding the displayed information

1 = Test setup overview, see Figure 3-2
2 = Radar under test (RUT) settings
3 = External attenuator and analyzer-related settings
4 = General decision on the radar Rx power settings calculation, see Chapter 2.4.2, "Radar received power P_{Rx} calculation", on page 15
6 = Radar echo generator (REG) settings
7, 5 = Test setup type; in this example: test setup with real radar signal, incl. R&S SMW, and signal analyzer; the radar signal is transmitted over the air (OTA)

Settings:

State

Enables/disables the Radar Echo Generation.

Remote command:
`[:SOURce<hw>]:REGenerator[:STATe]` on page 66

Overview Test Setup

Opens a dialog that illustrates the required (and connected) equipment and cables for the configuration selected with the parameter "Test Setup", see Figure 3-2.

The displayed information resumes the settings selected in the "Radar Setup" dialog.

Set to Default

Calls the default settings. The values of the main parameters are listed in the following table.

Parameter	Value
State	Off
Test setup	Conducted
Tx power of radar	0 dBm
Radar Rx power settings	Radar equation
Radar antenna Tx and Rx gain	50 dBi
System loss	0 dB

Remote command:
`[:SOURce<hw>]:REGenerator:PRESet` on page 67

Save/Recall

Accesses the "Save/Recall" dialog, that is the standard instrument function for saving and recalling the complete dialog-related settings in a file. The provided navigation possibilities in the dialog are self-explanatory.

The settings are saved in a file with predefined extension. You can define the filename and the directory, in that you want to save the file.

See also, chapter "File and Data Management" in the R&S SMW user manual.

Remote command:
`[:SOURce<hw>]:REGenerator:CATalog?` on page 67
`[:SOURce<hw>]:REGenerator:STORe` on page 67
`[:SOURce<hw>]:REGenerator:LOAD` on page 67

Test Setup

Selects how the radar signal is fed from the RUT to the signal analyzer and fed back from the R&S SMW to the RUT.

Tip: Use the "Overview Test Setup" function to retrieve more information on the current setup.

See for example Figure 3-2.

Tip: Use the parameter "System Loss" to compensate for system or cable loss.

"Conducted Test"
The radar signal is transmitted over cables; there is a cable connection between the RUT and the radar echo generator (REG).

"OTA Test" The transmission is performed over-the-air (OTA); there is no cable connection but Tx and Rx antennas are used in both the RUT and the REG.

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:TSETup` on page 71

OTA tests settings
If a "Test Setup > OTA Test" is used, the following parameters are required for the calculation of the Rx signal power, the ranges and the reference level of the analyzer.

The calculation is performed according to the Radar equation.

REG Antenna Rx Gain ← OTA tests settings
Sets the gain of receiving antenna that is connected to the REG (G_{Rx_REG}).

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:ANTenna:REG:GAIN:RX` on page 73

REG Antenna Tx Gain ← OTA tests settings
Sets the gain of transmitting antenna that is connected to the REG (G_{Tx_REG}).

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:ANTenna:REG:GAIN:TX` on page 73

OTA Range Offset ← OTA tests settings
Sets the distance between the transmitting and receiving antennas of the RUT and the REG (R_{OTA}).

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:OTA:OFFSet` on page 74

Radar Rx Power Setting
Determines how the radar receive power is calculated.

"Radar Equation"
The radar Rx power is calculated according to the radar equation, see Chapter 2.4.2, "Radar received power P_{Rx} calculation", on page 15.
Each object is described by its radar cross-section (RCS).
To select the applied model and its settings, select "Object Configuration > RCS...".
See Chapter 3.6, "Radar cross-section RCS setup settings", on page 45.

"Manual" The radar equation is not used; you set the $P_{Rx, j}$ value of each object instead.
See Radar Rx Power.
This parameter is useful if your test situation requires a specific Rx power.

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:POWer:MODE` on page 73

Radar under test (RUT) settings
Refer to the product documentation of the RUT for information on its characteristics.

The following input parameters are required for the calculation of the Rx signal power P_{Rx} of the signal returning to the radar antenna.

The calculation is performed for each object and according to the Radar equation.

Radar Tx Power ← Radar under test (RUT) settings
Sets the radar transmit power P_{Tx}.

If the "Radar Antenna Tx Gain = 0 dBi", the P_{Tx} value corresponds to the EIRP of the radar (see Figure 2-4).

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:POWer:TX` on page 72

Radar Antenna Tx Gain ← Radar under test (RUT) settings
Sets the antenna gain of transmitting antenna G_{Tx}

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:ANTenna:GAIN:TX` on page 73

Radar Antenna Rx Gain ← Radar under test (RUT) settings
Sets the antenna gain of receiving antenna G_{Rx}

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:ANTenna:GAIN:RX` on page 73

System Loss ← Radar under test (RUT) settings
Gain to compensate for system or cable loss.

Remote command:
`[:SOURce<hw>]:REGenerator:RADar:POWer:LOSS` on page 72

PRF ← Radar under test (RUT) settings
Sets the pulse repetition frequency (PRF).

The value is used for the function "Simulation Setup" > Use Radar Range Ambiguity to reduce Min. Range.

PRI and PRF are interdependent, setting on of the value changes the other.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:PRF` on page 72

PRI ← Radar under test (RUT) settings
Sets the pulse repetition interval (PRI), where PRI = 1 / PRF.

PRI and PRF are interdependent, setting on of the value changes the other.

For RCS swerling models II and IV, a new random RCS value is generated according to the duration of the "PRI" (pulse-to-pulse).

Remote command:
[:SOURce<hw>]:REGenerator:SIMulation:PRI on page 72

Scan Period ← Radar under test (RUT) settings
Set the time which the radar needs for one scan.

For RCS swerling models I and III, a new random RCS value is generated according to the duration of the "Scan Period" (scan-to-scan).

Remote command:
[:SOURce<hw>]:REGenerator:SIMulation:SPERiod on page 73

Ext. Attenuator (Analyzer)
The parameter is enabled only if FSW is connected to the R&S SMW.

Connect an external attenuator to reduce the radar Tx power and to protect the input stage of the analyzer, see Chapter 2.3, "Analyzer and receiver overload protection", on page 13.

Set the parameter to the attenuation (A) of your external attenuator.

Remote command:
[:SOURce<hw>]:REGenerator:RADar:ANALyzer:POWer:ATTenuator on page 74

Set Ref. Level on Analyzer
Indicates the calculated reference level and sets this level in the R&S FSW; see Chapter 2.4.2.1, "Calculating the REG input and output levels ($RefLevel_{Analyzer}$ and $Level_{R\&S\ SMW}$)", on page 16.

The operation "Set Ref. Level on Analyzer" is enabled and a value is displayed only if FSW is connected to the R&S SMW.

Status LED and status information indicate the following:
- **Valid + blue LED**: the calculated reference level is within the permissible value range of the R&S FSW.
- **Valid + orange LED**: indicates that the reference level is outside the permissible value range; the operation "Set Ref. Level on Analyzer" is disabled.
- **Update + orange LED**: the reference level of the R&S FSW deviates from the calculated value; execute the operation "Set Ref. Level on Analyzer".
- **Update + blue LED**: the reference level of the R&S FSW is equal to the calculated value.

Remote command:
[:SOURce<hw>]:REGenerator:RADar:ANALyzer:POWer:REFerence? on page 74
[:SOURce<hw>]:REGenerator:RADar:ANALyzer:POWer:APPLy on page 75
[:SOURce<hw>]:REGenerator:RADar:ANALyzer:STATus? on page 75

3.2 Overview test setup

Access:

1. Select "REG > Radar Echo Generation > Overview Test Setup"

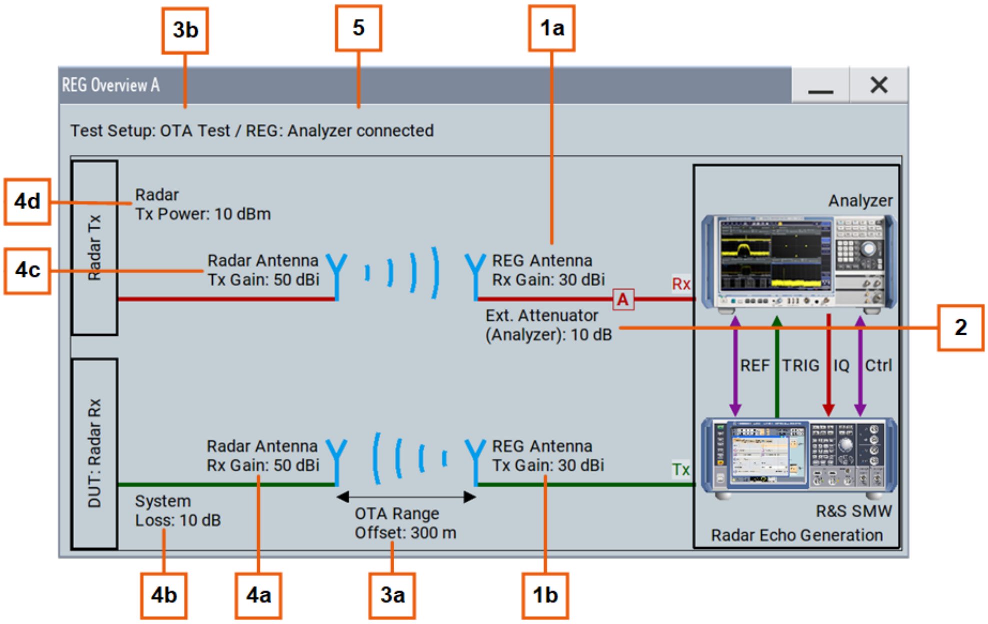


Figure 3-2: Overview Test Setup: Understanding the displayed information

1a, 1b	= REG settings
2	= External attenuator
3a	= Distance between the antennas
3b	= Test setup type, incl. information on the detected connected analyzer
4a, 4b, 4c, 4d	= RUT settings
5	= Status of the physical connection to the analyzer

The displayed information depends on the setup and resumes the settings selected in the "Radar Setup" dialog, see Figure 3-1.

2. In the diagram, select the R&S SMW or the R&S FSW.
   Use the context menu to show the physical location of the connectors.

   For example, the test setup shown on Figure 3-2 requires the following connections:
   - **REF:** R&S FSW "Ref Out" to R&S SMW "REF IN"
   - **IQ:** R&S FSW "Dig Baseband Output" to R&S SMW "DIG I/Q" on the "CODER" board
   - **TRIG:** R&S SMW "USER 4" to R&S FSW "Trigger 3"
   - **Ctrl:** R&S SMW "USB" (type A) to R&S FSW "USB Device", alternative connect the instruments via LAN
   - R&S SMW "RF A" to REG Tx antenna

   See also:
   - Figure 2-1

- Chapter 4.2, "Connecting the R&S FSW to the R&S SMW", on page 52

Show DIG I/Q IN/OUT, reference frequency, trigger, RF connector
Opens the "Show Connector" dialog and displays the physical location of the connectors on the front/rear panel of the R&S SMW and R&S FSW.

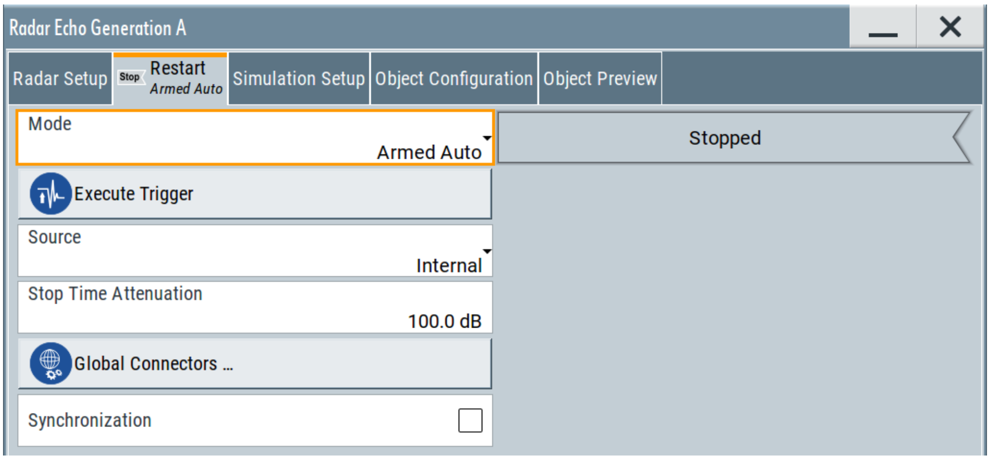
A blinking LED on the front/rear panel indicates the selected connector, too.

The required connections depend on the test setup.

3.3 Restart settings

Access:

► Select "REG > Radar Echo Generation > Restart".



Settings:

Mode
Selects the event which leads to a restart of the REG simulation.

"Auto" The signal generation starts after the REG is enabled ("REG > State = On"). The signal is generated continuously; all configured objects are simulated.

"Armed Auto" The signal is generated only when a trigger event occurs.
Simulation starts upon trigger event. Then the signal is generated continuously; all configured objects are simulated.
Internal or external trigger event is used, as set with the parameter Source.

Remote command:
[:SOURce<hw>]:REGenerator:RESTart:MODE on page 69

Running/Stopped

With enabled REG ("REG > State = On"), displays the status of signal generation for all trigger modes.

- "Running"
  The signal is generated and all configured objects are simulated; a trigger was (internally or externally) initiated.
- "Stopped"
  The signal is not generated and the instrument waits for a trigger event.

Remote command:
[:SOURce<hw>]:REGenerator:RESTart:RMODe? on page 70

Execute Trigger

In "Restart > Mode > Armed Auto", triggers a restart of the REG simulation.

Remote command:
[:SOURce<hw>]:REGenerator:RESTart:EXECute on page 70

Arm

Stops the signal generation until subsequent trigger event occurs.

Remote command:
[:SOURce<hw>]:REGenerator:RESTart:ARM:EXECute on page 70

Source

Determines the signal used as source for the trigger event.

"Internal" The trigger event is executed manually, by the "Execute Trigger" on page 33 function.

"External Restart REG Trigger A/B"
Option: "External Restart REG Trigger A" with R&S SMW-B14; "External Restart REG Trigger B" - 2xR&S SMW-B14
The trigger event is the active edge of an external trigger signal provided and configured at the global [USER x] connectors.
Open the Global Connectors dialog and configure the input signals.

Remote command:
[:SOURce<hw>]:REGenerator:RESTart:SOURce on page 69

Stop Time Attenuation

If "Trigger Mode = Armed Auto" is used, this parameter defines how the signal is processed during the time the signal generation is stopped:

- "Stop Time Attenuation = 60 dB" suppresses the signal output

- "Stop Time Attenuation = 0 dB" forwards the signal to the output without additional attenuation.

Remote command:
`[:SOURce<hw>]:REGenerator:RESTart:STATtenuation` on page 71

Global Connectors
Provides a quick access to the related global connector settings.

For information, refer to the description R&S SMW user manual, section "Local and Global Connectors".

Synchronization
Couples the REG blocks so that if both blocks are active, a subsequent restart event in any of them causes a simultaneous restart of the other.

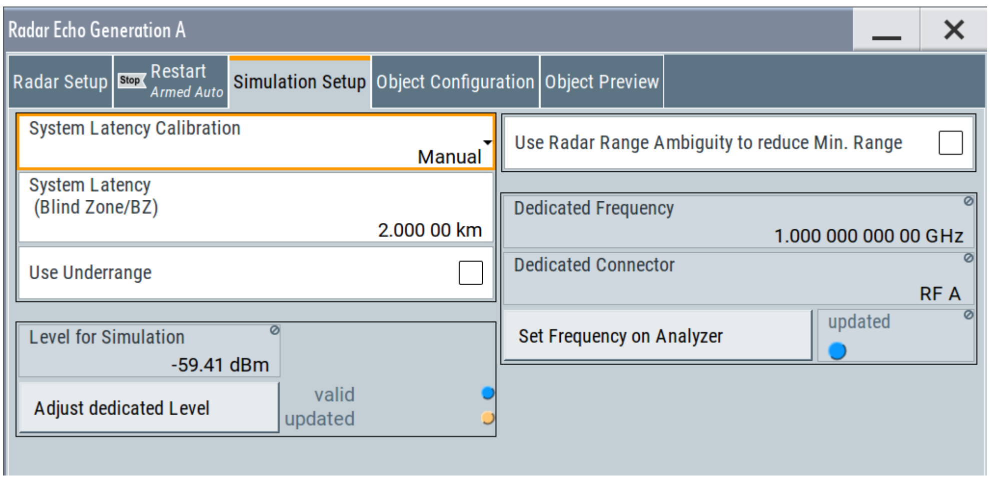
Restart event can be caused by a start/stop alternation or a parameter change that results in a signal recalculation and therefore a process restart.

Remote command:
`[:SOURce<hw>]:REGenerator:RESTart:SYNChronize[:STATe]` on page 70

3.4 Simulation setup settings

Access:

► Select "REG > Radar Echo Generation > Simulation Setup".



Settings:

System Latency Calibration

Determines how the system latency is estimated.

"Automatic" This value is enabled only if FSW is connected to the R&S SMW.
If an analyzer is connected to the R&S SMW, the system latency can be estimated automatically. The value corresponds to the processing time of the REG that is the processing time of the R&S SMW and the analyzer.
If necessary, you can enter a correction value (see Correction Values).
For more information, see Chapter 2.4.5, "System latency calibration", on page 23.

"Manual" Sets the blind zone value manually, see System Latency (Blind Zone/ BZ).
See also Chapter 4.8, "Estimating the system latency time roughly", on page 61.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:CALibration:MODE` on page 76

System Latency (Blind Zone/ BZ)

("System Latency Calibration > Manual")

The system latency (also referred as blind zone) is the processing time of the REG *for each incoming Tx pulse* transmitted by the RUT. Per default, the first retransmitted pulse is sent after the system latency time period has elapsed.

To simulate objects that are closer to the radar than the BZ of the REG, enable the parameter Use Radar Range Ambiguity to reduce Min. Range.

See also:

- "Eliminating the blind zone BZ effect for pulse sequences with a constant PRF" on page 21
- Chapter 4.8, "Estimating the system latency time roughly", on page 61.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:LATency[:BZ]` on page 76

Use Underrange

Enable this parameter to simulate objects at a range closer than 2.1 km.

This minimum range value corresponds to the "Blind Zone/BZ" (see data sheet).

"Off" $Range_{min}$ = 2.1 km
This value is also the min value of the parameter (Start) Range/End Range.

"On" Range$_{min}$ = System Latency (Blind Zone/ BZ) + Correction Values
Where "Correction Value" is required in System Latency Calibration > "Automatic" mode.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:CALibration:URANge`
on page 76

Calibration Successful
The parameter is enabled only if FSW is connected to the R&S SMW.

If the system latency is estimated automatically, the color LED indicates the calibration status:
- **Blue LED:** successful calibration
- **Orange LED:** calibration failure

Note: Unsuccessful calibration.
If the calibration fails, check the cabling between the R&S SMW and the R&S FSW.

Check in particular the connection between the [DIG I/Q] interfaces and the cable supplying the trigger signal, see Figure 2-1.

See also Chapter 2.4.5, "System latency calibration", on page 23.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:CALibration[:STATe]?`
on page 77

Correction Values
Adds a correction to the automatically estimated system latency value.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:CALibration:CORRection`
on page 77

Use Radar Range Ambiguity to reduce Min. Range
Enable this parameter to simulate objects closer to the radar than the minimal range (BZ) for a constant PRF.

For more information, see Figure 2-9.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:MINRange[:STATe]` on page 78

Level for Simulation
Show the calculated level value for the signal at the RF output (Level$_{R\&S\ SMW}$).

The level is calculated for the current scenario settings, incl. test setup, objects settings, enabled level offset ("RF > RF Level > Offset") etc. The level is calculated so that the RUT receives the power P_{Rx}, as it is calculated with the radar equation.

See:
- "Level$_{R\&S\ SMW}$ adjustment" on page 20
- Chapter 2.4.2, "Radar received power P_{Rx} calculation", on page 15

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:LEVel?` on page 79

Adjust Dedicated Level

Sets the output level ("Status bar > Level") to the value displayed with the parameter Level for Simulation. The affected output connector depends on the signal routing ("System Configuration > I/Q Stream Mapper").

If the test setup requires a level offset, always set the value "RF > RF Level > Offset" before selecting "Adjust Dedicated Level".

Status LED and status information indicate the following:

- **Valid + blue LED**: the calculated output level is within the permissible value range of the R&S SMW.
- **Valid + orange LED**: indicates that the reference level is outside the permissible value range; the operation "Adjust Dedicated Level" is disabled.
- **Update + orange LED**: the output level ("Status bar > Level") deviates from the calculated value; execute the operation "Adjust Dedicated Level".
- **Update + blue LED**: the output level of the R&S SMW is equal to the calculated value.

See:

- "$Level_{R\&S\ SMW}$ adjustment" on page 20
- Chapter 2.4.2, "Radar received power P_{Rx} calculation", on page 15

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:LEVel:APPLy` on page 79
`[:SOURce<hw>]:REGenerator:SIMulation:LEVel:UPDated[:STATus]?` on page 80
`[:SOURce<hw>]:REGenerator:SIMulation:LEVel:VALid[:STATus]?` on page 80

Dedicated Frequency

Displays the dedicated RF frequency that is used for the calculation of the P_{Rx} and of the Doppler shift for the carrier frequency. Different spectral components with different Doppler frequency shifts f_D are applied for moving objects.

The value also includes enabled "Frequency Offset" in the "I/Q Stream Mapper".

See "Radar equation" on page 16.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:FREQuency` on page 78

Dedicated Connector

Displays the connector used to determine the Dedicated Frequency.

Remote command:
`[:SOURce<hw>]:REGenerator:SIMulation:CONNector` on page 78

Set Frequency on Analyzer

The parameter is enabled only if FSW is connected to the R&S SMW.

Sets the frequency indicated with the parameter Dedicated Frequency in the connected analyzer.

The color LED indicates the update status:

- **Blue LED:** Analyzer frequency is updated; it matches the "Dedicated frequency" value

- **Orange LED:** Analyzer frequency differs from "Dedicated frequency" value.

Remote command:
[:SOURce<hw>]:REGenerator:SIMulation:ANALyzer:FREQuency:APPLy on page 79
[:SOURce<hw>]:REGenerator:SIMulation:ANALyzer:STATus on page 79

3.5 Object configuration settings

Access:

► Select "REG" > "Radar Echo Generation" > "Object Configuration".

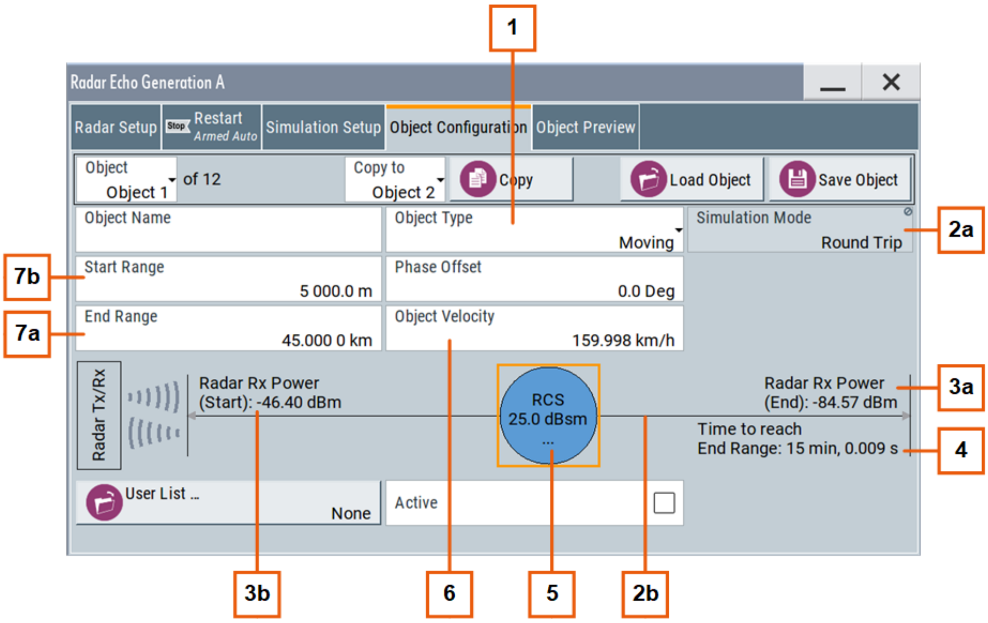


Figure 3-3: Object Configuration: Understanding the displayed information

1	= Moving object
2a, 2b	= Movement mode selection and indication of the trajectory
3a, 3b and 7a, 7b	= Start and end range and the calculated radar Rx power.
4, 6	= Object velocity and the duration of a single movement form the start to the end range
5	= Access to the "RCS Setup" dialog, see Chapter 3.6, "Radar cross-section RCS setup settings", on page 45

The visualization depends on the selected "Object Type".
You can configure up to 12 objects individually, store their configuration into files, and load these files for quick setup later.

Settings:

Object # of 12

Selects the number of the current object.

If the "Copy" function is used, this object is also the object whose settings are applied to the other objects.

Remote command:

`[:SOURce<hw>]:REGenerator:OBJect:COPY:SOURce` on page 82

Copy to

Selects the objects whose settings are to be overwritten.

Remote command:

`[:SOURce<hw>]:REGenerator:OBJect:COPY:DESTination` on page 82

Copy

Triggers the copy function.

Remote command:

`[:SOURce<hw>]:REGenerator:OBJect:COPY:EXECute` on page 82

Load/Save Object

Accesses the "File Select" dialog for storing and loading the object settings from a file.

You can configure several objects and store their configuration in files, for example to build an object library. Use the "Save/Recall" on page 27 function to store the common scenario settings in a file.

Remote command:

`[:SOURce<hw>]:REGenerator:OBJect:CATalog?` on page 81

`[:SOURce<hw>]:REGenerator:OBJect<ch>:STORe` on page 81

`[:SOURce<hw>]:REGenerator:OBJect<ch>:LOAD` on page 81

Object Name

Enter a name to indicate the object.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:NAME on page 82

Object Type

Sets the object type or disables it.

Further settings depend on the object type.

See also Chapter 2.4.1, "Simulated objects types", on page 15.

"Off" Disables the object, for example to exclude the object temporarily from the simulation.

"Static" Static objects are described with a fixed range and no velocity.

"Static + Moving"
These artificial objects are described with a fixed range and a velocity.

"Moving" Moving object are described with different start and end range and a velocity.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:TYPE on page 83

Simulation Mode

Describes how the object moves.

Observe the graphical indication on the display.

"One Way" The object moves from the start to the end range once.
Once the end range is reached, the object is simulated as a "Static + Moving" object.

"Cyclic" The object moves cyclically from the start to the end range.
Once the end range is reached, the movement restarts; the object jumps from the end to the start range.

"Round Trip" The object moves back and forth between the start and end range.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:SIMMode on page 83

Radar Rx Power (Start)

Indicates the radar Rx power P_{Rx} at the beginning of the simulation. The value is calculated according to the Radar equation for the Start Range R.

If the Radar Rx Power Setting > "Manual" is used, the $P_{Rx,j}$ is a user-defined value (see "Radar Rx Power" on page 42).

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX on page 83
[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX:STARt? on page 84

Radar Rx Power (End)

Indicates the radar Rx power P_{Rx} at the farthest distance that a moving object reaches. The value is calculated according to the Radar equation for the End Range.

If the Radar Rx Power Setting > "Manual" is used, the $P_{Rx,j}$ is a user-defined value (see "Radar Rx Power" on page 42).

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX:END? on page 84

Time to Reach End Range
Indicates how long it takes that the object moves from the Start Range to the End Range position.

The value is calculated as follows:

"Time to Reach End Range" = ("End Range" - "Start Range") / "Object velocity"

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:TIME:TOENd? on page 87

(Start) Range
Sets the distance between the object and the radar (range, R) at the beginning of the simulation.

Static objects are simulated at a constant "Range".

Moving objects slide with the selected Object Velocity from the Start Range towards the End Range. Further movement depends on the selected Simulation Mode.

The value is required for the calculation of the radar start Rx power P_{Rx} according to the Radar equation.

Ranges are simulated by adding a delay to the signal.

The minimum start range R_{min} has to fulfill the following:

$R_{min} \geq$ BZ + OTA Range Offset + Correction Values

Where "Correction Value" is required in System Latency Calibration > "Automatic" mode.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:RANGe:STARt on page 85

End Range
Sets the farthest distance to the radar that a moving object reaches.

Moving objects slide with the selected Object Velocity from the Start Range towards the End Range. Further movement depends on the selected Simulation Mode.

The value is required for the calculation of the radar end Rx power P_{Rx} according to the Radar equation.

Ranges are simulated by adding a delay to the signal.

The minimum end range R_{min} has to fulfill the following:

$R_{min} \geq$ BZ + OTA Range Offset + Correction Values

Where "Correction Value" is required in System Latency Calibration > "Automatic" mode.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:RANGe:END on page 85

Phase Offset

Enables a phase offset between the transmitted pulse and the echo signal.

Use this parameter to simulate a phase shift introduced by reflection at an object.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:PHASe[:OFFSet] on page 88

Object Velocity

Sets the speed of a moving object in the direction of travel.

Velocity is simulated by applying a Doppler frequency shift to the signal.

See also "Direction" on page 42.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:OVELocity on page 85

Direction

Sets the direction of travel of a static + moving object. Direction defines whether a moving object is approaching to or departing from the radar.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:DIRection on page 85

Object Hold Off

Requires "Object Type" > "Moving" and "Simulation Mode" > "One Way"/"Cyclic".

Sets a time delay between the simulation start and appearance of the selected object. The simulation start means when setting "REG" > "State" > "On".

Example:

Two objects with the following object hold off:

- Object 1 "Object Hold Off" = "0 s"
- Object 2 "Object Hold Off" = "1 s"

Object 2 appears 1 s after the object 1.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:HOLD:OFF on page 87

First Echo to Pulse#

Indicates the number of the first pulse for that an echo signal is generated.

The value is calculated as a function of the BZ, the delay τ and the PRF, see Figure 2-9.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:FEPNumber? on page 88

Radar Rx Power

If Radar Rx Power Setting > "Manual" is used, this parameter sets the Rx power of each object.

The radar equation is not used; you set the $P_{Rx,\ j}$ value instead.

If a moving object is simulated, set also the parameter Radar Rx Power Dedicated to.

See also Figure 2-4.

Remote command:
`[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX` on page 83

Radar Rx Power Dedicated to
If Radar Rx Power Setting > "Manual" is used, defines how the Rx power of a moving object is calculated at its start and end positions.

"All Range" The Rx power of the moving object is constant value, set as follows:
$P_{Rx, jStartRange} = P_{Rx, jEndRange}$ = Radar Rx Power

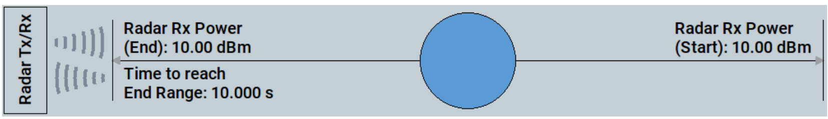
"Start Range" The value set with the parameter "Radar Rx Power" corresponds to the Rx power at the start range:
$P_{Rx, jStartRange}$ = Radar Rx Power
The Rx power at the end range is calculated depending on the distance between both positions.

"End Range" The calculation is analog to the calculation in the "Radar Rx Power Dedicated to > Start Range" case.

Example:

- "Radar Setup > Radar Rx Power Settings = Manual"
- "Object Configuration > Object Type = Moving"
- "Start Range = 5 km"
- "End Range = 4 km"
- "Radar Rx Power = 10 dBm"
- "Radar Rx Power Dedicated to > End Range"

Observe the visualization and the displayed value.



- The displayed information confirms that the object is arriving toward the RUT.
  Its "End Range" < "Start Range".
- Radar Rx power $P_{Rx, jEndRange}$ = 10 dBm
- Radar Rx power $P_{Rx, jStartRange}$ = 6.12 dBm

Remote command:
`[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX:DEDication`
on page 84

RCS
Accesses the "RCS Setup" dialog for selecting the applied model, see Chapter 3.6, "Radar cross-section RCS setup settings", on page 45.

User List
Access: select "Object = Object 1, 2, 3, 7, 8 or 9".

Accesses the "Load File" dialog, which is a standard instrument function for loading settings form a file. The provided navigation possibilities in the dialog are self-explanatory.

User lists are ASCII files with file extension `*.reg_list` and predefined file format. User lists define phase and amplitude offsets over time and thus allow you to modify the phase and amplitude of the simulated echo of an object.

A user list file contains of a header row and up to 1000 lines. Each line contains two or three columns, separated by semicolons. The header and all further lines in the file must have the same number of columns.

The first row in the file is the header; it is mandatory and contains the column names in the format: `Timestamp;Phase;Amplitude`. The `Phase` and `Amplitude` values can be used simultaneously or exclusively.

- `Timestamp` (mandatory)
  Value in ms.
  Gives the time in ascending order and defines when the `Phase` and `Amplitude` values should be applied. Repetitions in the `Timestamp` values are not allowed.
- `Phase`
  Value range 0 degrees to 359.9 degrees.
  Defines a phase offset to be applied at the echo of an object. A value of 0 means no phase modification.
- `Amplitude`
  Value in dB. Allowed are negative values and 0.
  Defines an amplitude offset to be applied at the echo of an object. A value of 0 means no modification.

Example: User list example

With the following example, each 1000 ms the phase offset is configured to be increased by 20 degrees and the amplitude offset to be changed by -1 dB.

```
Timestamp;Phase;Amplitude
0;20;0
1000;40;-1
2000;60;-2
3000;80;-3
4000;100;-4
5000;120;-6
```

The following **timing constraints** apply:

- Sometimes, changes of phase and amplitude offsets do not take effect immediately at the points in time specified by the timestamp. Depending, among other, on velocity and RCS model, there are certain points in time at which changes of phase and amplitude offsets can be applied. Changes are applied at the next possible point in time after the one specified by the timestamp.
- The phase offset within the first 40 µs of the simulation are random, regardless the phase offset specified in the user list for that time period.
- For "Object Type = Moving" and "Simulation Mode = One Way/Cyclic":
  – Lines with `Timestamp` greater than the value of Time to Reach End Range are ignored.
  – If Time to Reach End Range is greater than the last timestamp in the user list, the offsets given in the last line are applied until "Time to Reach End Range".
  – In "Simulation Mode = Cyclic", the timestamps are evaluated relative to the beginning of each cycle.

- For "Object Type = Moving" and "Simulation Mode = Round Trip":
  – Lines with `Timestamp` greater than twice the value of Time to Reach End Range are ignored.
  – If twice the value of Time to Reach End Range is greater than the last time-stamp in the user list, the offsets given in the last line are applied until twice the value of "Time to Reach End Range".
  – The timestamps are evaluated relative to the beginning of each round trip.

To apply the simulation parameters in the files, select Active > "On".

See also, chapter "File and Data Management" in the R&S SMW user manual.

Remote command:
`[:SOURce<hw>]:REGenerator:OBJect:ULISt:CATalog?` on page 88
`[:SOURce<hw>]:REGenerator:OBJect<ch>:ULISt:SELect` on page 89

Active

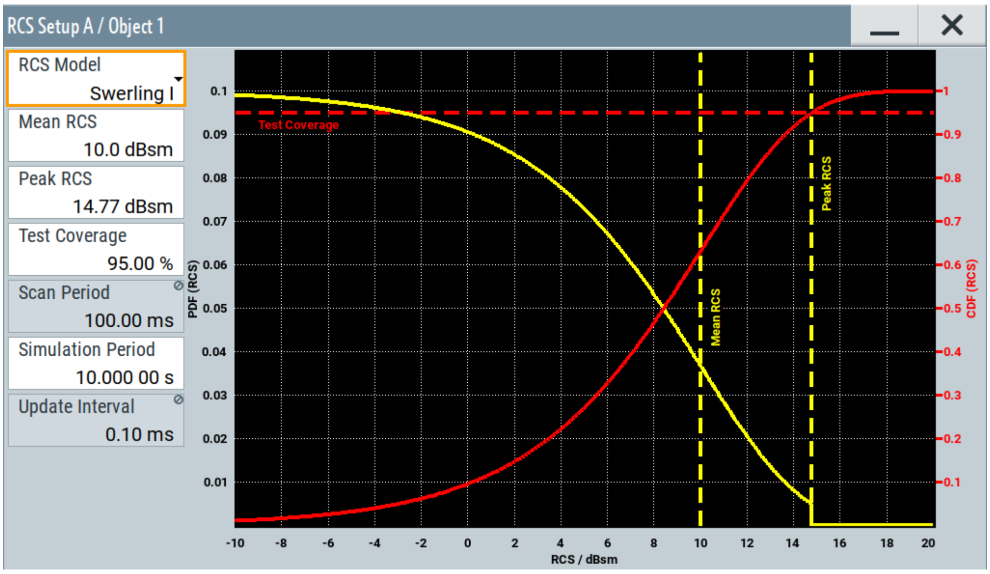
Enables the selected user list. Thus, the level and phase values defined in the list are added to the level and phase values, resulting form the other settings in the dialog.

Remote command:
`[:SOURce<hw>]:REGenerator:OBJect<ch>:ULISt:STATe` on page 89

3.6 Radar cross-section RCS setup settings

Access:

1. Select "REG > Radar Echo Generation > Object Configuration"
2. Select the number of the particular object, for example "Object = 1".
3. In the diagram, click the "RCS" circle.



4. In the "RCS Setup" dialog, select the applied model and its settings.

   The dialog displays a graph of the RCS probability distribution function. For the "Swerling 0" model, this RCS probability is 1 at the "Mean RCS" value and zero elsewhere.

Settings:

RCS Model

Selects the model used to describe the radar cross-section (RCS) of the selected object.

"Swerling 0" Standard model used to describe the statistical properties of the RCS as a function of the Mean RCS value. Represents a constant RCS.

"Swerling I, II, III, IV"

Models used to describe the statistical properties of the RCS as a function of the further parameters in the dialog.

Swerling models represent the target as several individual radiators. Swerling random sequence is calculated in advance and considered in internal power calculation. There is no real-time pulse/scan detection. The calculated random sequence is processed depending on the object type as follows:

- "Object Type = Moving", the whole random sequence is repeated as the "Range", "Object Velocity" and "Power" values.
- "Object Type = Static/Static + Moving", the whole random sequence is repeated as the "Simulation Period".
- Swerling I and II
  These models use random sequence with 2 degrees of freedom. They model the result from many independent scatterers of roughly equal areas, whereas for swerling II, RCS values change from pulse-to-pulse, instead of scan-to-scan as it is with swerling I.
  The probability density function ρ(σ) is calculated as follows:
  $\rho(\sigma) = (1/\text{"Mean RCS"})e^{-(\text{"RCS"}/\text{"Mean RCS"})}$
- Swerling III and IV
  These models use random sequence with 4 degrees of freedom. They represent objects with one large scattering surface with several other small scattering surfaces. For swerling IV, RCS values change from pulse-to-pulse, instead of scan-to-scan as it is with swerling III.
  The probability density function ρ(σ) is calculated as follows:
  $\rho(\sigma) = 4(\text{"RCS"}/\text{"Mean RCS"}^{2})e^{-2\text{"RCS"}/\text{"Mean RCS"}}$

Remote command:
`[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:MODel` on page 86

Mean RCS

Sets the mean RCS value required for the RCS calculation.

Remote command:
`[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:MEAN` on page 86

Peak RCS

Sets the peak RCS value required for the RCS calculation.

The peak RCS is the highest random RCS values which the R&S SMW can generate. If "Peak RCS" is too close to "Mean RCS", the distribution and the actual mean value of the distribution is adversely affected.

The "Peak RCS" and "Test Coverage" values are interdepending. Setting one of them, changes the other value automatically.

Remote command:
`[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:PEAK` on page 86

Test Coverage

For swerling I and II, sets the test coverage. Test coverage indicates the intersection between CDF curve and "Peak RCS" line and thus gives information on how much of the CDF is covered.

The "Peak RCS" and "Test Coverage" values are interdepending. Setting one of them, changes the other value automatically.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:TCOVerage on page 86

PRI

Sets the pulse repetition interval (PRI), where PRI = 1 / PRF.

PRI and PRF are interdependent, setting on of the value changes the other.

For RCS swerling models II and IV, a new random RCS value is generated according to the duration of the "PRI" (pulse-to-pulse).

Remote command:
[:SOURce<hw>]:REGenerator:SIMulation:PRI on page 72

Scan Period

Set the time which the radar needs for one scan.

For RCS swerling models I and III, a new random RCS value is generated according to the duration of the "Scan Period" (scan-to-scan).

Remote command:
[:SOURce<hw>]:REGenerator:SIMulation:SPERiod on page 73

Simulation Period

For "Object Type = Static/Static + Moving", defines the interval in that the swerling random sequence is repeated.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:SPER on page 87

Update Interval

Indicates how often a new swerling random value is created:

- For "Object Type = Moving", the update interval is determined by the "Start/End Range" and "Object Velocity".
  Desired update interval of swerling sequence is approximated to the internal update interval.
- For "Object Type = Static/Static + Moving", the update interval is determined by the "Scan Period" or "PRI".
  Desired update interval of swerling sequence is equal to internal update interval.

Remote command:
[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:UPINterval? on page 87

3.7 Object preview settings

Access:

1. In the block diagram, select "REG > Radar Echo Generation > Object Preview".
2. Select "Diagram Type > Range/Velocity View".

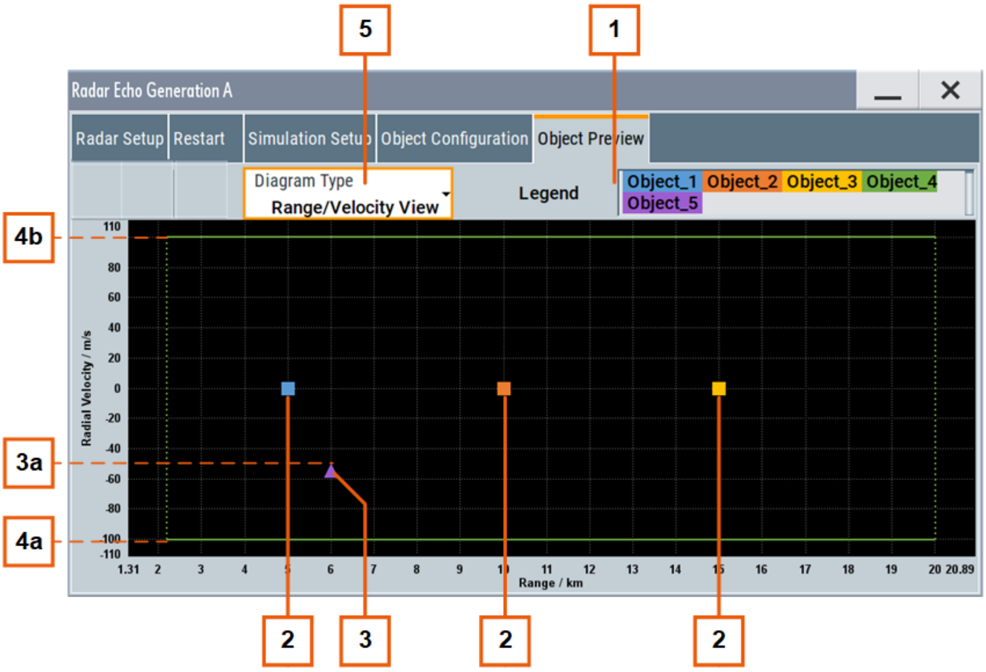


Figure 3-4: Object Preview > Range/Velocity View: Understanding the displayed information

1	= Legend that indicates the object and the assigned colors
2	= Static objects; static objects have different "Ranges" and "Velocity = 0 km/h".
3, 3a	= Moving + static object; moving + static objects have "Range" and "Velocity≠0 km/h"; the negative velocity value indicates an approaching object (see Direction).
5	= Range variation of moving objects with fixed "Velocity"; object that moves fort and backwards ("Round Trip").
Colored arrows	= Indicate the direction of travel of the moving objects.
4a, 4b	= The Doppler frequency alternates between the two values $\pm f_D$ and so does the "Velocity" (see Chapter 2.4.3, "Doppler frequency shift calculation", on page 20).

3. Select "Diagram Type > Radar Rx Power View".

   The diagram shows the variation of the radar Rx power (P_{Rx}) as a function of the range. It gives information on the min and max value the P_{Rx}, which is the theoretical dynamic power range of the scenario.

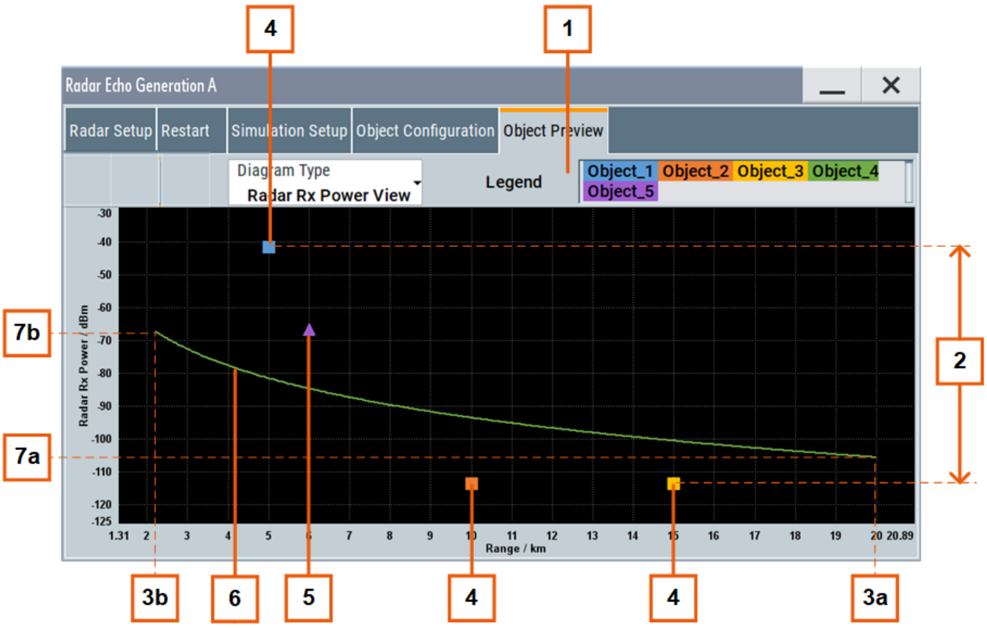


Figure 3-5: Object Preview > Radar Rx Power View: Understanding the displayed information

1 = Legend that indicates the object and the assigned colors
2 = Theoretical dynamic power range of the scenario, where the max value is the $P_{Rx, 3}$ (static object) and the min value is the $P_{Rx, 6}$ (static object).
3a, 3b = Start and end range of one object.
4 = Static objects
5 = Moving + static object
6 = P_{Rx} variation over the range
7a, 76b = Max and min value of P_{Rx} (per object)

Both diagrams visualize *all active* objects, where different colors are assigned to each object. Moving + static objects are indicated with triangles; the static objects with squares.
Static objects are displayed at their "Range". Moving objects slide between the "Start Range" and "End Range", where the speed is relative to the object velocity.

Settings:

Diagram Type

Switches between the "Radar Rx Power View" and "Range/Velocity View".

See Chapter 3.7, "Object preview settings", on page 49.

Remote command:
`[:SOURce<hw>]:REGenerator:DIAGram:TYPE` on page 89

4 How to generate radar echo signals

This section shows you how to use the R&S SMW to generate radar echo signals. If there are several possibilities to connect the instruments or to configure the settings, the most common one of them is shown.

In the following, we assume that:

- The R&S SMW is equipped all options required to generate 24 echoes.
  (see Chapter 2.1, "Required options and equipment", on page 11)
- All required cables are available.
  (see "Required additional equipment and cables" on page 11)
- A **conducted test setup** is used
  (see Figure 4-1)

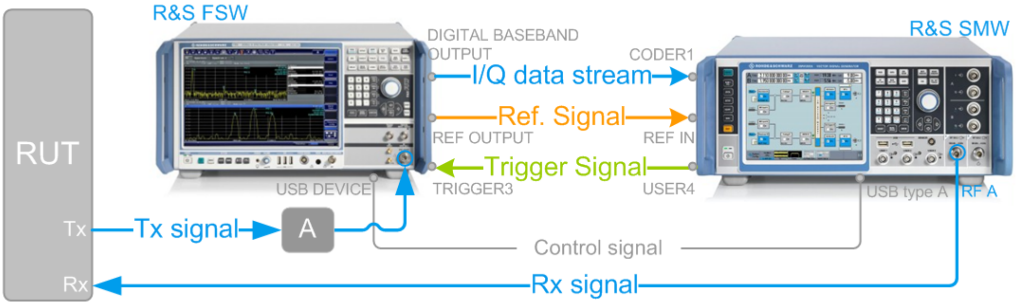


Figure 4-1: Example of conducted test setup (front panel view)

RUT	= Radar under test
Tx signal	= Transmitted (original) radar signal
Rx signal	= Modified signal, fed back to the radar
I/Q data stream	= Digital baseband data stream
Ref. signal	= 10 MHz common reference frequency signal to synchronize the R&S SMW to the R&S FSW
Trigger signal	= Required to estimate the system latency of the system (blind zone (BZ))
Control signal	= USB (or LAN) connection for remote control of the analyzer from the R&S SMW
A	= External attenuator to protect the R&S FSW input stage
Dig Baseband Output, CODER1	= Digital IQ connectors (rear panel)
REF IN, Ref Output	= Reference frequency signal connectors (rear panel)
Trigger3, USER4	= Connectors for trigger signal (rear panel)
USB (type A), USB Device	= USB connectors (rear panel)

Try out the following:

4.1 Connecting the RUT and the REG (conducted test)

Required connectors are on the front panels, see Figure 4-1.

Connect the following:

1. RUT Tx output to the external attenuator.
2. **NOTICE!** Risk of overloading. Signal strength outside the permissible input ranges can overload and damage the signal analyzer R&S FSW and the radar receiver. Always check the specifications for permissible input ranges.

   Connect the external attenuator to R&S FSW "RF Input".
3. R&S SMW "RF A" to the RUT Rx input.

4.2 Connecting the R&S FSW to the R&S SMW

Required connectors are on the rear panels.

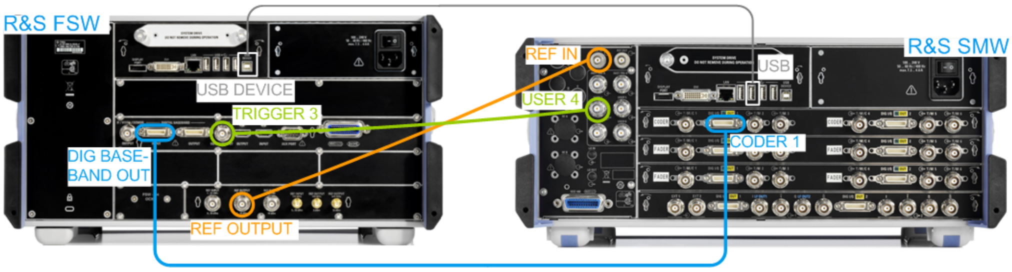


Figure 4-2: Example of test setup (rear panel view)

Connect the following:

1. R&S FSW "Ref Output" to R&S SMW "REF IN"
2. R&S FSW "Dig IQ Out" to R&S SMW "CODER1"
3. R&S SMW "USER4" to R&S FSW "Trigger 3"
4. R&S SMW "USB" (type A) to R&S FSW "USB Device" (type B)

4.3 Using the reference frequency of the R&S FSW

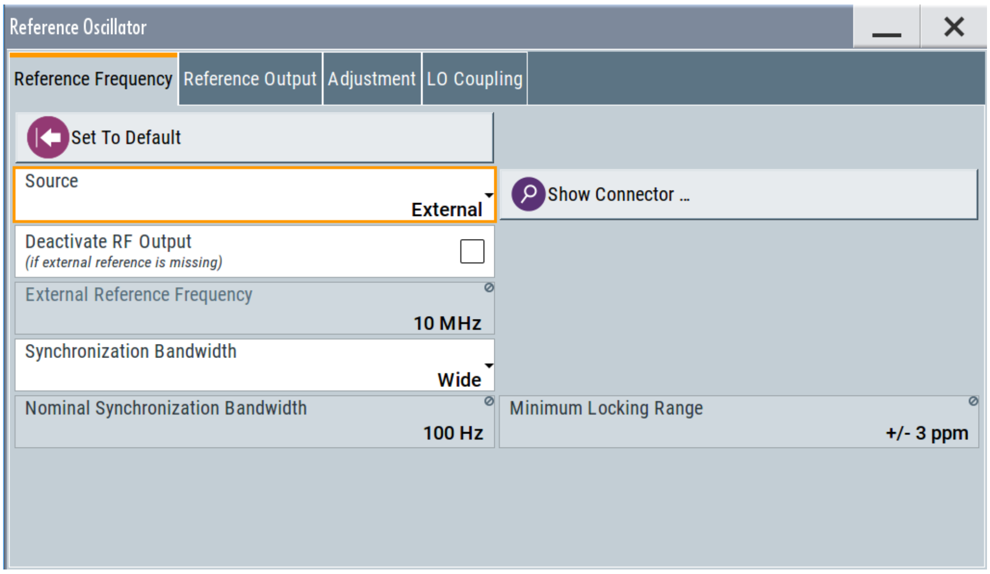
In the R&S SMW, perform the following:

1. On the front panel, press [Preset].

2. In the status bar, tap on the "Int Ref".

   The "Ref. Frequency /LO Coupling" dialog opens.

3. Set "Reference Frequency > Source > External".



   The R&S SMW is synchronized to the reference frequency of the R&S FSW.

4. Use the default settings. Close the dialog.

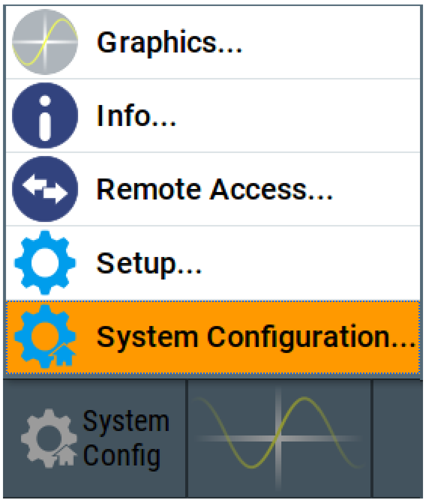
Always configure the R&S FSW from the R&S SMW and the REG dialog.

Do not change the level settings of both, the generator and the analyzer manually. Use the parameter "System Loss" to compensate for system or cable loss.

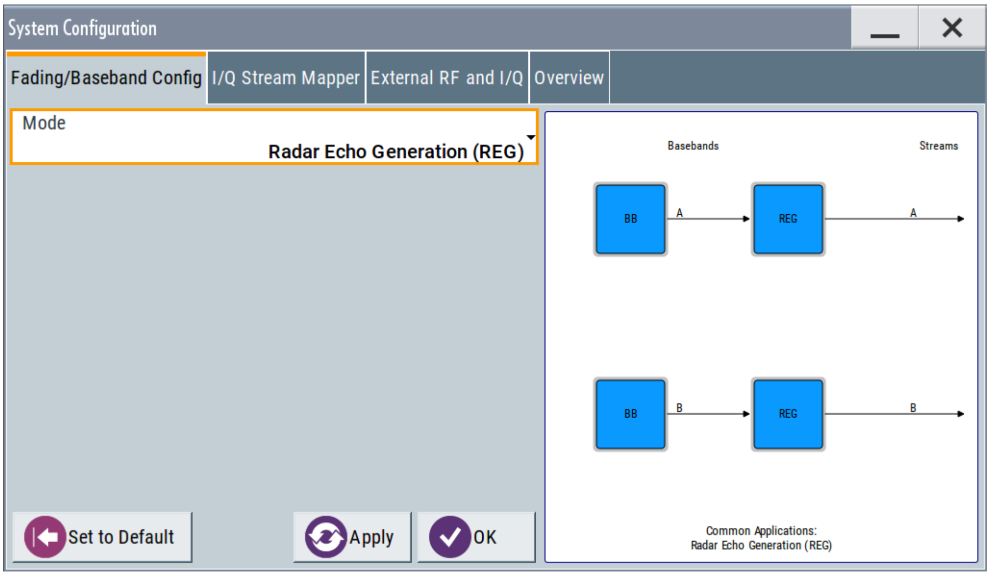
4.4 Configure the connection to the R&S FSW

In the R&S SMW, perform the following:

1. In the block diagram, select "System Config > System Configuration".

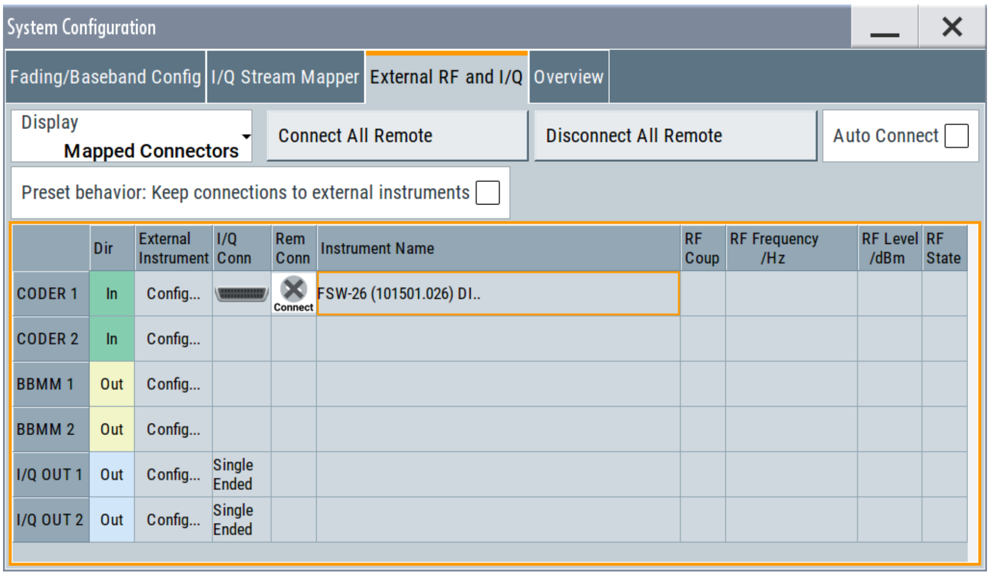


2. Select "Fading/Baseband Config > Mode > Radar Echo Generation (REG)".



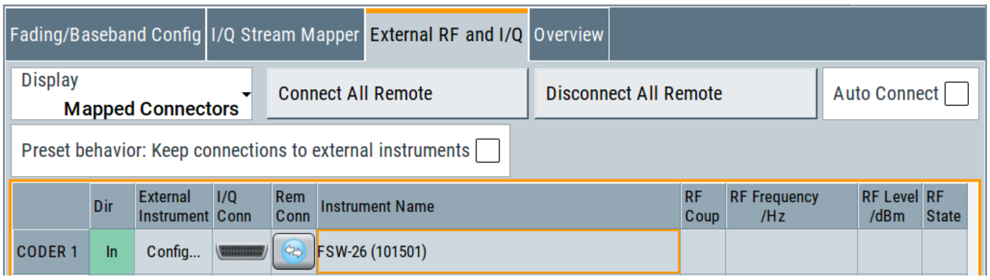
3. Select "Apply".
4. Select "External RF and I/Q".

   If the R&S FSW is connected to the R&S SMW as shown on Figure 4-1, the R&S SMW automatically detects it.



The "External RF and I/Q" indicates that the analyzer is connected to the "CODER1" connector of the R&S SMW. The remote connection is, however, not active.

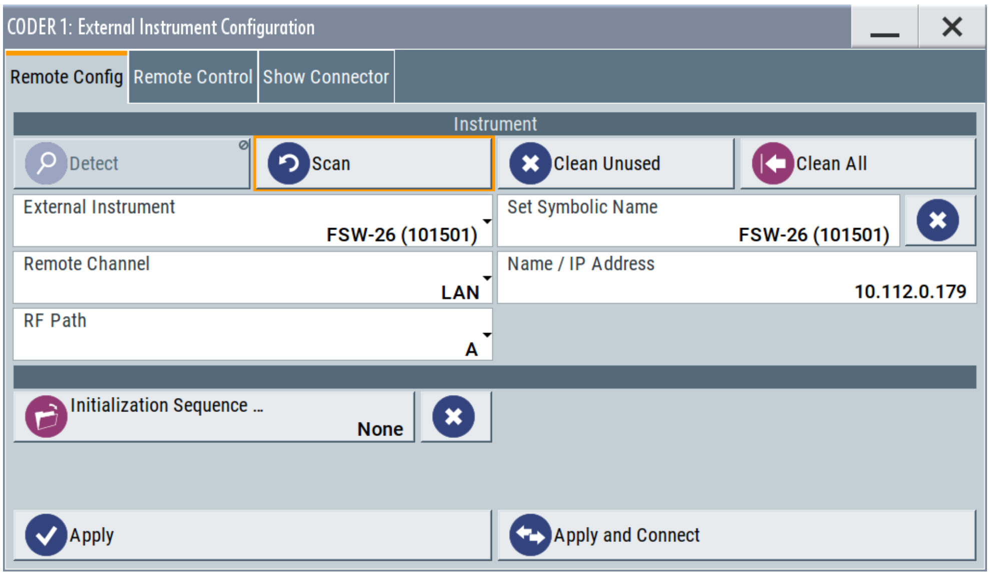
5. Select "Auto Connect > On".
Tip: If the "Auto Connect" fails, select "CODER1 > External Instrument > Config > Remote Config > Detect" and confirm with "Apply and Connect".



The R&S SMW performs the following:
- Activates the remote connection to the R&S FSW.
- Sends the command `DEVice:PRESet`.
- Sends an SCPI sequence to the R&S FSW and sets its settings as required for the test setup.
- Activates the "BB Input" block where the R&S FSW is connected (in this example, " BB Input A > On").
- In the "BB Input" block, sets the "Sampling Rate".

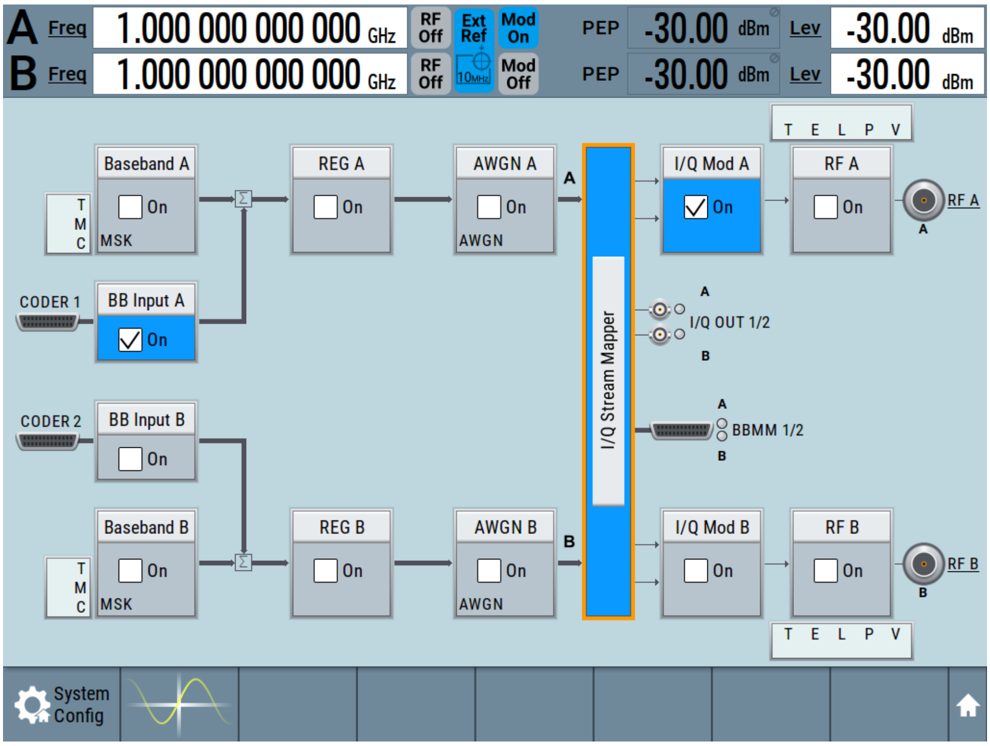
Note: We recommend that you do not change the analyzer settings.

6. Perform the following, only if you connect the R&S SMW and the R&S FSW over **LAN**, with dedicated connection or over a network:
   a) Select "Coder 1" > "External Instrument > Config > Remote Config > Scan".
   b) Select the R&S FSW in the "External Instrument" list.
   c) Confirm with "Apply and Connect".



7. Close the dialogs.

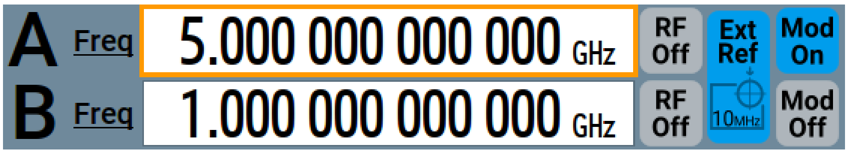
   The "I/Q Modulator" is activated automatically.
   The block diagram resembles the following.



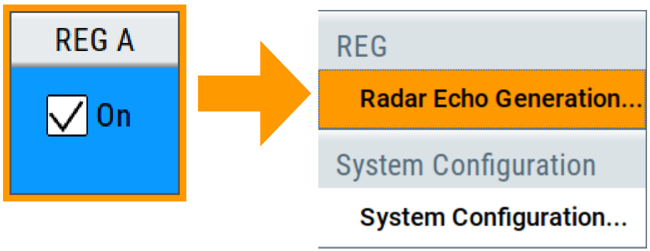
4.5 Simulating six echoes

In the R&S SMW, perform the following:

1. On the status bar, select the "A Freq." field and enter the radar frequency.

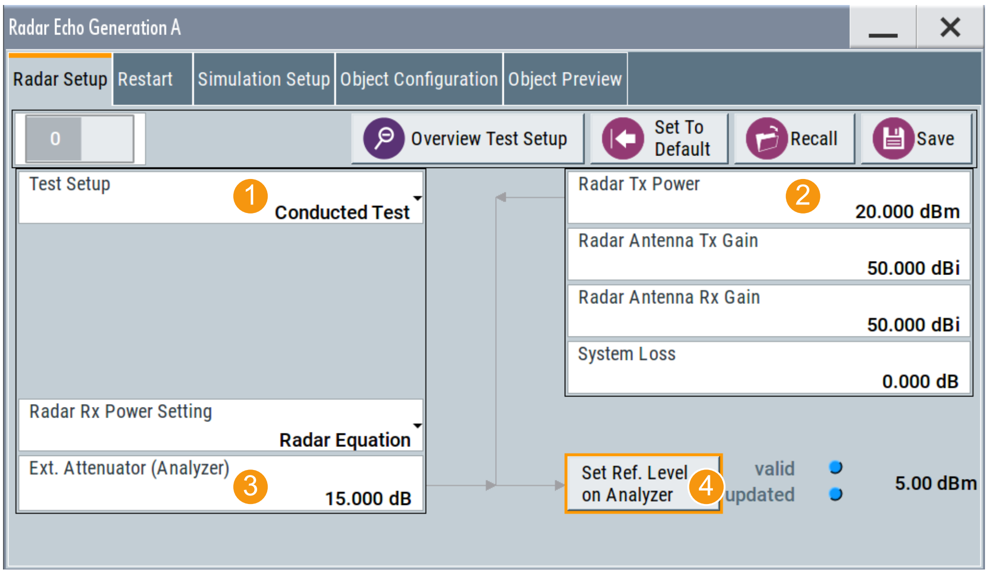


2. In the block diagram, select "REG A > Radar Echo Generation".



   The Radar Echo Generation dialog box opens and displays the "Radar Setup" settings.

3. In the "Radar Setup" dialog:
   a) Use the default "Test Setup > Conducted Test".
   b) Set the settings influencing the reference level of the analyzer:
      - "Radar Tx Power"
      - "Ext. Attenuator (Analyzer)"
   c) Execute "Set Ref. Level on Analzer".



4. Set the parameter "RF A > RF Level > Level > Limit" to protect the RUT input.

5. Select "Simulation Setup".

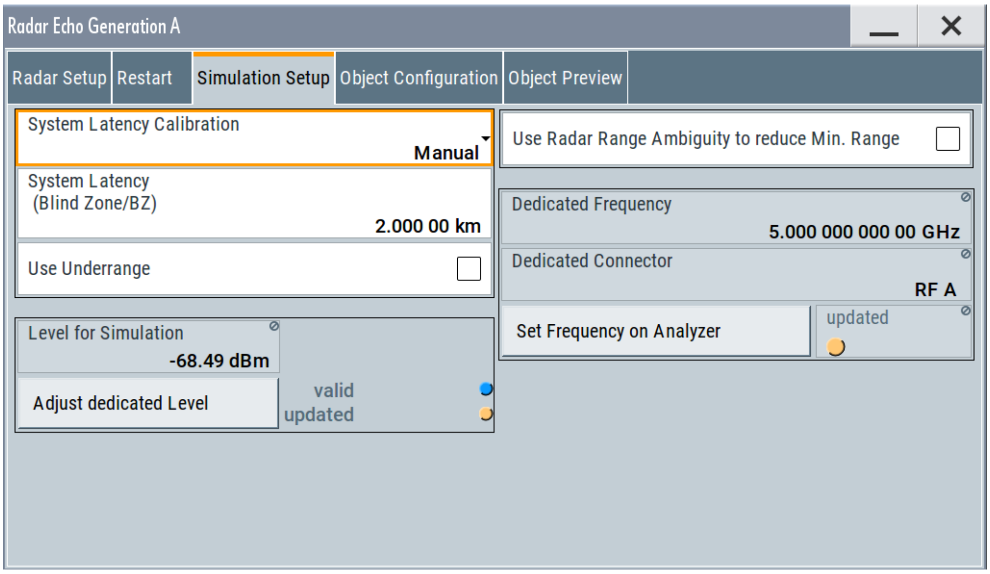
   The dialog confirms that he used frequency ("Dedicated Frequency = 5 GHz") is as set with the parameter "Freq".
   The analyzer frequency, however, deviates from this value.

6. Execute "Set Frequency on Analyzer".

7. Select "Object Configuration" and configure the objects as required.
   See for example the example on Figure 3-3.
   For detailed explanation of all functions, see Chapter 3, "Radar echo generation configuration and settings", on page 25.

8. In the "Simulation Setup" dialog, observe the value of the parameter "Level for Simulation".
   The output signal level at the "RF A" connector ("Status Bar > RF A > Level") deviates from this value.

9. Execute "Adjust dedicated Level".



10. Close the dialog.

11. In the block diagram, select "REG > State > On".

12. Select "RF A > On".

    The signal output starts when the RF output is activated. The start moment cannot be synchronized.
    To add a start delay to the objects, use the parameter Object Hold Off.

4.6 Generating up to 24 echoes

This example extends the configurations described in Chapter 4.5, "Simulating six echoes", on page 57. It shows how to route the real radar signal to both R&S SMW paths, so that you can generate up to 24 echoes from the same input signal.

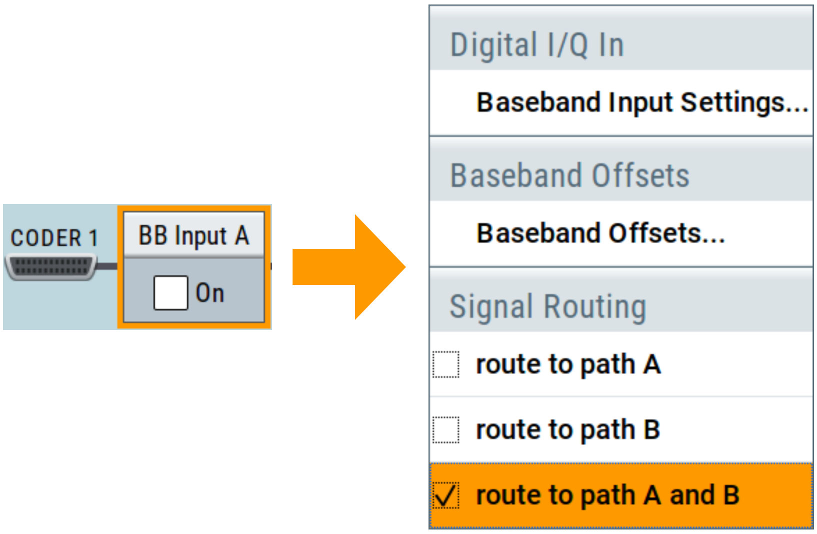
The instruments are connected as illustrated on Figure 4-1. The digital signal is fed at the CODER1 connector of the R&S SMW.

For an overview of the required options, see the data sheet. See also Chapter 2.1, "Required options and equipment", on page 11.

We assume, that the REG is configured and that there is at least one active object, with settings different than the default settings.

In the R&S SMW, perform the following:

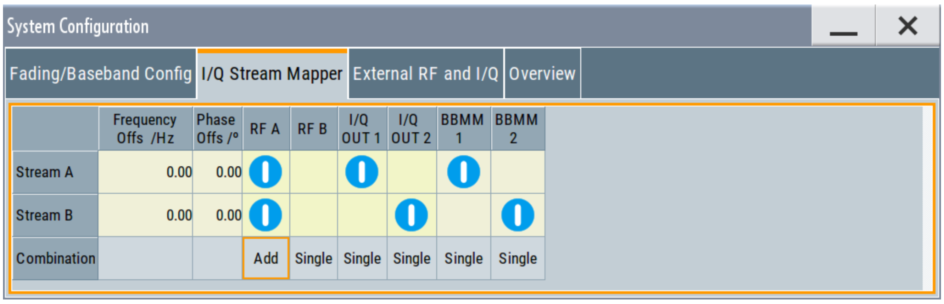
1. In the block diagram, select "Baseband Input A > Signal Routing > route to path A and B".



   The input radar signal is routed to both paths. That is, you can configure up to 12 objects per REG block.

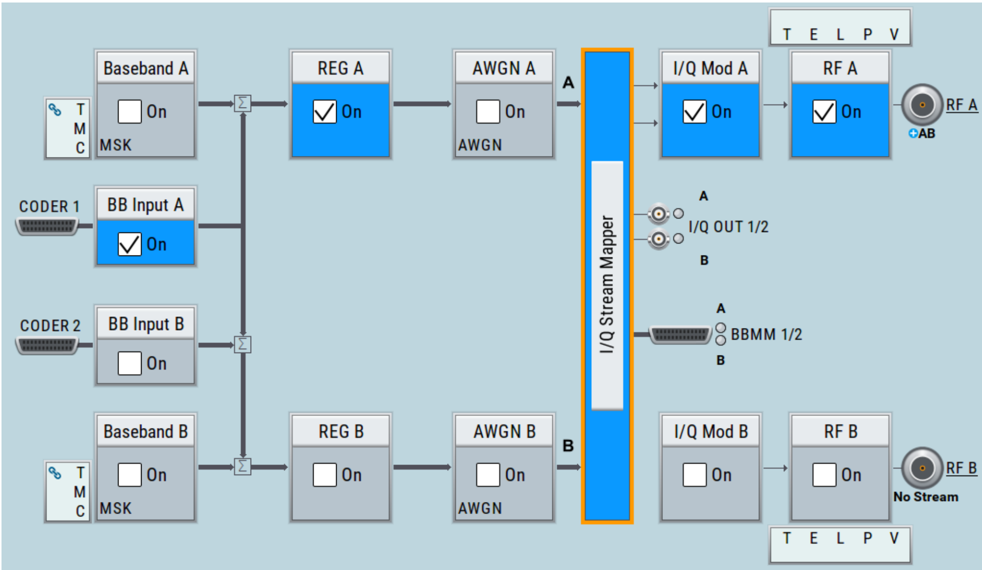
2. In the block diagram, select "IQ Stream Mapper" and perform the following:
   a) In the stream mapping table, for "RF A" select "Combination > Add".

b) Route "Stream B to RF A" and disable it for "RF B".



c) Close the dialog.

The signal streams of both paths are output at the RF A connector.



3. Use the "Save/Recall" function to store the settings of the first REG and load it in the second one:
   a) In the block diagram, select "REG A > Radar Echo Generation".
   b) Select "Save", enter a filename, and confirm with "Save".
      The settings of the entire dialog are stored in a file.
   c) In the block diagram, select "REG B > Radar Echo Generation".
   d) Select "Recall", navigate to the file with settings, select it and confirm with "Select".

   The configuration of REG B is the same as in the REG A, also concerning the object configuration. REG B is, however, not activated ("REG B > State > Off").

4. In the RUT, observe the received signal.

   The RUT detects the objects as configured in the first REG.
   The RUT also receives its own signal; this signal is unmodified but delayed because of the REG "System Latency" time, see Chapter 4.8, "Estimating the system latency time roughly", on page 61.

5. In the R&S SMW, open "REG B > Radar Echo Generation" dialog, adjust the objects settings and set "Radar Setup > State > On".

   The RUT detects the up to 24 objects, as activated in "REG A" and "REG B" blocks.

4.7 Deactivating subset of objects configured in one REG blocks

To deactivate the objects in e.g. REG A, use one of the following alternatives:

1. Disable the REG and the stream at the RF output:
   a) Select "REG A > Off"
   b) Select "IQ Stream Mapper > Stream A > RF A > Off".
2. Route the digital input signal only to the other REG.
   That is, select "BB Input A > Signal Routing > route to path B".
3. To deactivate a single object, disable it.
   That is, select "REG > Radar Echo Generation > Objects Configuration > Object# > Obect Type > Off".

4.8 Estimating the system latency time roughly

This example shows you how to estimate the system latency time of the REG and set the value manually. It also provides hints on how to verify and correct the value.

The exact calibration procedure is, however, beyond the scope of this description.

1. Follow the instructions described in:
   - Chapter 4.1, "Connecting the RUT and the REG (conducted test)", on page 52
   - Chapter 4.2, "Connecting the R&S FSW to the R&S SMW", on page 52
   - Chapter 4.3, "Using the reference frequency of the R&S FSW", on page 52
   - Chapter 4.4, "Configure the connection to the R&S FSW", on page 53
2. In the block diagram of R&S SMW, select "RF A > On".

   The R&S SMW receives the digital baseband signal ("BB Input A > On") and outputs it unmodified at the "RF A" output.
3. In the RUT, observe the received signal.

   The RUT receives its own signal. The signal is unmodified but delayed because of the REG "System Latency" time.

4. Measure the signal delay for example with an oscilloscope.
5. In the block diagram R&S SMW, select "REG A > Radar Echo Generation > Simulation Setup".
6. Select "System Latency Calibration > Manual".
7. Set the parameter "System Latency" to the measured value, for example "System Latency = 13.342 µs".
   This value corresponds to a "Blind Zone = 2 km".
8. To verify the value, configure one static object at a define range and measure the range in the RUT.
   For example:
   a) Select "Object Configuration > Object#1 > Object Type > Static " and set "Range = 3 km".
   b) In the RUT, observe the measured range value.

   The RUT measures, for example, a range of 3.1 km.
   There is a difference $\Delta BZ = Range_{RUT} - Range_{REG} = 0.1$ km
9. Correct the "System Latency (Blinz Zone)" value with the ΔBZ.
   Set "Blind Zone = 2 km + 0.1 km = 2.1 km".

   The measured range value in the RUT should match the expected range.

5 Remote-control commands

The following commands are required to perform signal generation with the option R&S SMW-K78 in a remote environment. We assume that the R&S SMW has already been set up for remote operation in a network as described in the R&S SMW documentation. A knowledge about the remote control operation and the SCPI command syntax are assumed.

Conventions used in SCPI command descriptions

For a description of the conventions used in the remote command descriptions, see section "Remote Control Commands" in the R&S SMW user manual.

Common Suffixes

The following common suffixes are used in the remote commands:

Suffix	Value range	Description
SOURce<hw>	[1] to 4	Available baseband signals
OBJect<ch>	1 to 12	Objects Max. value depends on the installed options

Sending commands to the connected R&S FSW analyzer

Commands that contain the keyword ANALyzer can be used only if a R&S FSW is connected to the R&S SMW.

The following commands specific to the R&S SMW-K78 option are described here:

5.1 Programming example

This example shows you how to configure the Radar Echo Generation in a remote environment.

We assume that a R&S FSW is connected to the R&S SMW as described in Chapter 4, "How to generate radar echo signals", on page 51.

```
SOURce1:ROSCillator:SOURce EXT

SCONfiguration:MODE REG
```

```
SCONfiguration:APPLy
SCONfiguration:EXTernal:REMote:SCAN
SCONfiguration:EXTernal:CODer1:REMote:ISELect "FSW (102030)","A","FSW (102030)","A"
SCONfiguration:EXTernal:CODer1:REMote:INITialization:PREDefined:FILE "REG_init_analyzer"
SCONfiguration:EXTernal:CODer1:REMote:CONNect

SOURce1:BBIN:STATe?
// 1

SOURce1:REGenerator:PRESet
SOURce1:REGenerator:UNIT:LENGth KM
SOURce1:REGenerator:RADar:TSETup OTA
SOURce1:REGenerator:RADar:POWer:TX 10
SOURce1:REGenerator:RADar:ANTenna:GAIN:TX 50
// SOURce1:REGenerator:RADar:ANTenna:GAIN:RX 50
SOURce1:POWer:LIMit:AMPLitude 5
SOURce1:REGenerator:RADar:POWer:LOSS 10
SOURce1:REGenerator:SIMulation:PRF 10000
SOURce1:REGenerator:SIMulation:PRI?
// 0.0001
SOURce1:REGenerator:SIMulation:SPERiod 0.1
SOURce1:REGenerator:RADar:POWer:MODE REQuation
SOURce1:REGenerator:RADar:ANALyzer:POWer:ATTenuator 10
SOURce1:REGenerator:RADar:ANTenna:REG:GAIN:RX 30
SOURce1:REGenerator:RADar:ANTenna:REG:GAIN:TX 30
SOURce1:REGenerator:RADar:OTA:OFFSet 300
SOURce1:REGenerator:RADar:ANALyzer:POWer:REFerence?
// -1.99020831627664
SOURce1:REGenerator:RADar:ANALyzer:POWer:APPLy
SOURce1:REGenerator:RADar:ANALyzer:STATus?
// UPT

SOURce1:REGenerator:SIMulation:CALibration:MODE MAN
SOURce1:REGenerator:SIMulation:LATency:BZ 2000
SOURce1:FREQuency:CW 5000000000
SOURce1:REGenerator:SIMulation:CONNector?
// RFA
SOURce1:REGenerator:SIMulation:FREQuency?
// 5000000000
SOURce1:REGenerator:SIMulation:ANALyzer:FREQuency:APPLy
SOURce1:REGenerator:SIMulation:ANALyzer:STATus?
// UPD
SOURce1:REGenerator:SIMulation:MINRange:STATe 1
SOURce1:REGenerator:SIMulation:LEVel?
// 10.85
SOURce1:REGenerator:SIMulation:LEVel:VALid:STATus?
// 1
SOURce1:REGenerator:SIMulation:LEVel:UPDated:STATus?
// 0
SOURce1:REGenerator:SIMulation:LEVel:APPLy
```

```
SOURce1:POWer:LEVel:IMMediate:AMPLitude?
// 10.85

SOURce1:REGenerator:OBJect2:NAME "MovObj_2_20_100"
SOURce1:REGenerator:OBJect2:TYPE MOV
SOURce1:REGenerator:OBJect2:SIMMode ROUN
SOURce1:REGenerator:OBJect2:HOLD:OFF 2
SOURce1:REGenerator:OBJect2:RCS:MODel SWE0
SOURce1:REGenerator:OBJect2:RCS:MEAN 3
SOURce1:REGenerator:OBJect2:RANGe:STARt 2000
SOURce1:REGenerator:OBJect2:RANGe:END 20000
SOURce1:REGenerator:OBJect2:OVELocity 27.778
// value in m/s; 27.778 m/s = 100 km/h
SOURce1:REGenerator:OBJect2:PHASe:OFFSet 0
// value in deg

// the following commands change the units in the dialogs
// but not in the remote control commands
SOURce1:REGenerator:UNIT:TIME S
SOURce1:REGenerator:UNIT:ANGLe DEG
SOURce1:REGenerator:UNIT:VELocity KMH

SOURce1:REGenerator:OBJect2:TIME:TOENd?
// 647.995
// value in seconds; 647.995 s = 10 min 47,995s
SOURce1:REGenerator:OBJect2:POWer:RX:STARt?
// -66.46
SOURce1:REGenerator:OBJect2:POWer:RX:END?
// -106.46
SOURce1:REGenerator:OBJect2:FEPNumber?
// 3

SOURce1:REGenerator:OBJect3:TYPE STAT
SOURce1:REGenerator:OBJect3:RANGe:STARt 5000
SOURce1:REGenerator:OBJect3:RCS:MEAN 80

SOURce1:REGenerator:OBJect4:TYPE SMOV
SOURce1:REGenerator:OBJect4:RANGe:STARt 10000
SOURce1:REGenerator:OBJect4:RCS:MEAN 80
SOURce1:REGenerator:OBJect4:OVELocity 5.556
SOURce1:REGenerator:OBJect4:DIRection APPRoaching

SOURce1:REGenerator:DIAGram:STATe 1
SOURce1:REGenerator:DIAGram:TYPE POW

// appling level and phase values from custom lists
SOURce1:REGenerator:OBJect3:TYPE STAT
SOURce1:REGenerator:OBJect3:RANGe:STARt 2000

SOURce1:REGenerator:OBJect:ULISt:CATalog?
// list1, list2
```

```
SOURce1:REGenerator:OBJect3:ULISt:SELect "/var/user/list1"
SOURce1:REGenerator:OBJect3:ULISt:STATe 1

SOURce1:REGenerator:STATe 1
OUTPut1:STATe 1

SOURce1:REGenerator:STORe "/var/user/reg"
SOURce1:REGenerator:CATalog?
// reg

// starting the simulation at a defined moment of time
SOURce1:REGenerator:STATe 1
OUTPut1:STATe 1

SOURce1:REGenerator:RESTart:SOURce INT
SOURce1:REGenerator:RESTart:MODE AAUT
SOURce1:REGenerator:RESTart:STATtenuation 60
// the signal at the output is suppressed during the time
// in that the signal generation is stopped
SOURce1:REGenerator:RESTart:EXECute
// triggers the instrument
SOURce1:REGenerator:RESTart:RMODe?
// 1
// signal is generated and output at the output connector
// all configured objects are simulated
```

Example: Configuring RCS swerling model

```
SOURce1:REGenerator:OBJect10:RCS:MODel SWE1
SOURce1:REGenerator:OBJect10:RCS:MEAN 10
SOURce1:REGenerator:OBJect10:RCS:PEAK 14.77
SOURce1:REGenerator:OBJect10:RCS:TCOVerage 95
SOURce1:REGenerator:SIMulation:SPERiod?
// 0.1
SOURce1:REGenerator:OBJect10:RCS:SPER?
// 0.00001
SOURce1:REGenerator:OBJect10:RCS:UINTerval?
// 0.00001
```

5.2 General commands

[:SOURce<hw>]:REGenerator[:STATe] <State>

Enables/disables the Radar Echo Generation.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "State" on page 27

[:SOURce<hw>]:REGenerator:PRESet

Calls the default settings.

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Event

Manual operation: See "Set to Default" on page 27

[:SOURce<hw>]:REGenerator:CATalog?

Queries the files with settings in the default directory. Listed are files with the file extension `*.reg`.

Return values:

<FileNames> <filename1>,<filename2>,...
Returns a string of file names separated by commas.

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Save/Recall" on page 27

[:SOURce<hw>]:REGenerator:STORe <Filename>

Stores the current settings into the selected file; the file extension (`*.reg`) is assigned automatically.

Setting parameters:

<Filename> string

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Setting only

Manual operation: See "Save/Recall" on page 27

[:SOURce<hw>]:REGenerator:LOAD <Filename>

Loads the selected file from the default or the specified directory. Loaded are files with extension `*.reg`.

Setting parameters:

<Filename> string
file name or complete file path; file extension can be omitted

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Setting only

Manual operation: See "Save/Recall" on page 27

[:SOURce<hw>]:REGenerator:UNIT:ANGLe <Unit>

Sets the default unit for the parameter as displayed in the dialog.

Note: This command changes only the units displayed in the graphical user interface. While configuring the angle via remote control, the angle units must be specified.

Parameters:

<Unit>	DEGree | DEGRee | RADian	
	*RST:	DEGree

Example: See Chapter 5.1, "Programming example", on page 63.

[:SOURce<hw>]:REGenerator:UNIT:LENGth <Unit>

Sets the default unit for the parameter as displayed in the dialog.

Note: This command changes only the units displayed in the graphical user interface. While configuring the range or the distance via remote control, the units must be specified.

Parameters:

<Unit>	MI | NM | KM | M	
	*RST:	M

Example: See Chapter 5.1, "Programming example", on page 63.

[:SOURce<hw>]:REGenerator:UNIT:TIME <Unit>

Sets the default unit for the parameter as displayed in the dialog.

Note: This command changes only the units displayed in the graphical user interface. While configuring the time releted parameters via remote control, the time units must be specified.

Parameters:

<Unit>	S | MS	
	*RST:	S

Example: See Chapter 5.1, "Programming example", on page 63.

[:SOURce<hw>]:REGenerator:UNIT:VELocity <Unit>

Sets the default unit for the parameter as displayed in the dialog.

Note: This command changes only the units displayed in the graphical user interface. While configuring the velocity via remote control, the velocity units must be specified.

Parameters:

<Unit>	MPS | KMH | MPH | NMPH	
	*RST:	MPS

Example: See Chapter 5.1, "Programming example", on page 63.

5.3 Restart commands

[:SOURce<hw>]:REGenerator:RESTart:MODE <Mode>

Selects the event which leads to a restart of the REG simulation.

Parameters:

<Mode> AUTO | AAUTo

AUTO
The signal generation starts after the REG is enabled. The signal is generated continuously; all configured objects are simulated.

AAUT
Simulation starts upon trigger event (`[:SOURce<hw>]:REGenerator:RESTart:EXECute`). Then the signal is generated continuously; all configured objects are simulated.

*RST: AUTO

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Mode" on page 32

[:SOURce<hw>]:REGenerator:RESTart:SOURce <Source>

Selects the trigger signal source and determines the way the triggering is executed.

Parameters:

<Source> INTernal | ERRTA | ERRTB

INTernal
Internal triggering by the command `[:SOURce<hw>]:REGenerator:RESTart:EXECute`.

ERRTA|ERRTB
External trigger signal via one of the external global trigger connectors.

*RST: INTernal

Example: See Chapter 5.1, "Programming example", on page 63.

Options: ERRTA requires R&S SMW-B14
ERRTB requires 2xR&S SMW-B14

Manual operation: See "Source" on page 33

[:SOURce<hw>]:REGenerator:RESTart:EXECute

If `[:SOURce<hw>]:REGenerator:RESTart:MODE` `AAUT`, restarts the REG simulation.

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Event

Manual operation: See "Execute Trigger" on page 33

[:SOURce<hw>]:REGenerator:RESTart:ARM:EXECute

Stops signal generation; a subsequent trigger event restarts signal generation.

Example:

```
SOURce1:REGenerator:TRIGger:SOURce INT
SOURce1:REGenerator:RESTart:MODE AAUT
SOURce1:REGenerator:RESTart:EXECute
// executes a trigger, signal generation starts
SOURce1:REGenerator:RESTart:ARM:EXECute
// signal generation stops
SOURce1:REGenerator:RESTart:EXECute
// executes a trigger, signal generation starts again
```

Usage: Event

Manual operation: See "Arm" on page 33

[:SOURce<hw>]:REGenerator:RESTart:RMODe?

Queries the status of signal generation for all trigger modes.

Return values:

<RMode> STOP | RUN

*RST: STOP

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Running/Stopped" on page 33

[:SOURce<hw>]:REGenerator:RESTart:SYNChronize[:STATe] <RegSyncState>

Couples the REG blocks so that if both blocks are active, a subsequent restart event in any of them causes a simultaneous restart of the other.

Restart event can be caused by a start/stop alternation or a parameter change that results in a signal recalculation and therefore a process restart.

Parameters:

<RegSyncState> 1 | ON | 0 | OFF

*RST: 0

Example:

```
SOURce1:REGenerator:STATe 1
SOURce2:REGenerator:STATe 1
SOURce:REGenerator:RESTart:SYNChronize:STATe 1
SOURce1:REGenerator:STATe 0
SOURce1:REGenerator:STATe 1
// the REG blocks restart simultaneously
```

Manual operation: See "Synchronization" on page 34

[:SOURce<hw>]:REGenerator:RESTart:STATtenuation <StopTimeAtt>

If [:SOURce<hw>]:REGenerator:RESTart:MODE AAUT, sets the attenuation applied on the output signal during the time the signal generation is stopped.

Parameters:

<StopTimeAtt> float

Range: 0 to 60
Increment: 0.1
*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Stop Time Attenuation" on page 33

5.4 Radar setup commands

[:SOURce<hw>]:REGenerator:RADar:TSETup <TestSetup>

Sets the test setup type.

Parameters:

<TestSetup> CONDucted | OTA

*RST: CONDucted

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Test Setup" on page 27

[:SOURce<hw>]:REGenerator:RADar:POWer:TX <Power>

Sets the radar transmit power P_{Tx}.

Parameters:

<Power> float

Range: -50 to 100
Increment: 0.001
*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Radar Tx Power" on page 29

[:SOURce<hw>]:REGenerator:RADar:POWer:LOSS <PowerLoss>

Additional loss to compensate for system or cable loss.

Parameters:

<PowerLoss> float

Range: 0 to 100
Increment: 0.001
*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "System Loss" on page 29

[:SOURce<hw>]:REGenerator:SIMulation:PRF <PRF>

Sets the pulse repetition frequency (PRF).

Parameters:

<PRF> integer

Range: 1 to 1E6
*RST: 10E3

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "PRF" on page 29

[:SOURce<hw>]:REGenerator:SIMulation:PRI <SimPri>

Sets the pulse repetition frequency (PRI).

Parameters:

<SimPri> float

Range: 3.74742e-5 to 1
Increment: 1E-5
*RST: 1E-4

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "PRI" on page 29

[:SOURce<hw>]:REGenerator:SIMulation:SPERiod <SimScanPeriod>

Set the time which the radar needs for one scan.

Parameters:

<SimScanPeriod> float

Range: 3.74742e-5 to 10
Increment: 1E-5
*RST: 0.1

Example: See Example"Configuring RCS swerling model" on page 66.

Manual operation: See "Scan Period" on page 30

[:SOURce<hw>]:REGenerator:RADar:POWer:MODE <Mode>

Sets how the radar receive power is calculated.

Parameters:

<Mode> REQuation | MANual

*RST: REQuation

Example: See Chapter 5.1, "Programming example", on page 63.

Example:

```
SOURce1:REGenerator:RADar:POWer:MODE MANual
SOURce1:REGenerator:OBJect2:POWer:RX -114.4
```

Manual operation: See "Radar Rx Power Setting" on page 28

[:SOURce<hw>]:REGenerator:RADar:ANTenna:GAIN:RX <GainRx>
[:SOURce<hw>]:REGenerator:RADar:ANTenna:GAIN:TX <GainTx>
[:SOURce<hw>]:REGenerator:RADar:ANTenna:REG:GAIN:RX <GainRx>
[:SOURce<hw>]:REGenerator:RADar:ANTenna:REG:GAIN:TX <GainTx>

Sets the antenna gain.

Parameters:

<GainTx> float

Range: 0 to 100
Increment: 0.001
*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "REG Antenna Tx Gain" on page 28

[:SOURce<hw>]:REGenerator:RADar:OTA:OFFSet <OtaOffset>

Sets the OTA (over-the-air) distance.

Parameters:

<OtaOffset> float

Range: 0.01 to 50E3
Increment: 0.01
*RST: 100

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "OTA Range Offset" on page 28

[:SOURce<hw>]:REGenerator:RADar:ANALyzer:POWer:ATTenuator <PowerAttenuator>

Sets the attenuation of the external attenuator.

The command can be used only if a R&S FSW is connected to the R&S SMW.

Parameters:

<PowerAttenuator> float

Range: -600 to 500
Increment: 0.001
*RST: 10

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Ext. Attenuator (Analyzer)" on page 30

[:SOURce<hw>]:REGenerator:RADar:ANALyzer:POWer:REFerence?

Queries the reference level of the analyzer.

The command can be used only if a R&S FSW is connected to the R&S SMW.

Return values:

<PowerReference> float

Range: -400 to 500
Increment: 0.01
*RST: -10

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Set Ref. Level on Analyzer" on page 30

[:SOURce<hw>]:REGenerator:RADar:ANALyzer:POWer:APPLy

Sets the referenece level of the analyzer.

The command can be used only if a R&S FSW is connected to the R&S SMW.

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Event

Manual operation: See "Set Ref. Level on Analyzer" on page 30

[:SOURce<hw>]:REGenerator:RADar:ANALyzer:STATus?

Queries the reference level status.

The command can be used only if a R&S FSW is connected to the R&S SMW.

Return values:

<AnalyzerStatus> NCONected | INValid | VALid | UPDated

NCONected
Analyzer is not connected

INValid
Reference level outside the permissible level range of the analyzer

VALid
Reference level within the permissible level range of the analyzer; value not set

UPDated
Refence level is updated

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Set Ref. Level on Analyzer" on page 30

5.5 Simulation setup commands

[:SOURce<hw>]:REGenerator:SIMulation:CALibration:MODE <CalMode>

Sets how the system latency is estimated.

Parameters:

<CalMode> MANual | AUTomatic

`AUTomatic` mode can be used only if a R&S FSW is connected to the R&S SMW.

*RST: AUTomatic

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "System Latency Calibration" on page 35

[:SOURce<hw>]:REGenerator:SIMulation:LATency[:BZ] <BlindZone>

Sets the system latency value manually.

Parameters:

<BlindZone> float

Range: 0 to 3000
Increment: 0.01
*RST: 2000

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "System Latency (Blind Zone/ BZ)" on page 35

[:SOURce<hw>]:REGenerator:SIMulation:CALibration:URANge <UseUnderRange>

Allows you to simulate objects at a range closer than 2.1 km.

Parameters:

<UseUnderRange> 1 | ON | 0 | OFF

*RST: 0

Example:

```
SOURce1:REGenerator:SIMulation:CALibration:MODE MAN
SOURce1:REGenerator:SIMulation:CALibration:URANge 0
SOURce1:REGenerator:OBJect12:TYPE STAT
SOURce1:REGenerator:OBJect12:RANGe:STARt 1300
SOURce1:REGenerator:OBJect12:RANGe:STARt?
// 2400
// Range min [m] = 2400 = BZ + 300

SOURce1:REGenerator:SIMulation:CALibration:URANge 1
SOURce1:REGenerator:SIMulation:LATency:BZ 1000
SOURce1:REGenerator:OBJect12:RANGe:STARt 1300
SOURce1:REGenerator:OBJect12:RANGe:STARt?
// 1300
// Range min [m] = 1300 = 1000 + 300

SOURce1:REGenerator:SIMulation:CALibration:MODE AUT
SOURce1:REGenerator:SIMulation:LATency:BZ?
// 1900
SOURce1:REGenerator:SIMulation:CALibration:CORRection -100
SOURce1:REGenerator:SIMulation:CALibration:URANge 0
SOURce1:REGenerator:OBJect12:RANGe:STARt 1300
SOURce1:REGenerator:OBJect12:RANGe:STARt?
// 2100
// Range min [m] = 2100 = BZ + 300 + CORRection
SOURce1:REGenerator:SIMulation:CALibration:URANge 1
SOURce1:REGenerator:OBJect12:RANGe:STARt 1000
SOURce1:REGenerator:OBJect12:RANGe:STARt?
// 2100
// no effect on the min Range value
```

Manual operation: See "Use Underrange" on page 35

[:SOURce<hw>]:REGenerator:SIMulation:CALibration[:STATe]?

Queries the status of the automatic system calibration process.

Return values:

<CalibrationStat> FAILed | SUCCess

Example: See [:SOURce<hw>]:REGenerator:SIMulation:CALibration:CORRection on page 77

Usage: Query only

Manual operation: See "Calibration Successful" on page 36

[:SOURce<hw>]:REGenerator:SIMulation:CALibration:CORRection <CorrValue>

Adds a correction to the automatically estimated system latency value.

Parameters:

<CorrValue> float

Range: -100 to 100
Increment: 0.01
*RST: 0

Example:

```
SOURce1:REGenerator:SIMulation:CALibration:MODE AUTomatic
SOURce1:REGenerator:SIMulation:CALibration:STATe?
// SUCC
SOURce1:REGenerator:SIMulation:CALibration:CORRection 1
```

Manual operation: See "Correction Values" on page 36

[:SOURce<hw>]:REGenerator:SIMulation:MINRange[:STATe] <State>

Enables the simulation of delays that are shorter than the system latency ($\tau < t_{BZ}$).

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Use Radar Range Ambiguity to reduce Min. Range" on page 36

[:SOURce<hw>]:REGenerator:SIMulation:CONNector <Connector>

Queries the instrument connector used to set the frequency `[:SOURce<hw>]:REGenerator:SIMulation:FREQuency`.

Parameters:

<Connector> RFA | RFB | BBMM1 | BBMM2 | IQOUT1 | IQOUT2 | FAD1 | FAD2 | FAD3 | FAD4 | DEF

*RST: RFA

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Dedicated Connector" on page 37

[:SOURce<hw>]:REGenerator:SIMulation:FREQuency <Frequency>

Queries the RF frequency that is used for the calculation of the Doppler shift and the P_{Rx}.

Parameters:

<Frequency> float

Range: 100E3 to 100E9
Increment: 0.01
*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Dedicated Frequency" on page 37

[:SOURce<hw>]:REGenerator:SIMulation:ANALyzer:FREQuency:APPLy

Sets the analyzer frequency.

The command can be used only if a R&S FSW is connected to the R&S SMW.

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Event

Manual operation: See "Set Frequency on Analyzer" on page 37

[:SOURce<hw>]:REGenerator:SIMulation:ANALyzer:STATus

Queries the frequency status.

The command can be used only if a R&S FSW is connected to the R&S SMW.

Parameters:
<Status> VALid | UPDated

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Set Frequency on Analyzer" on page 37

[:SOURce<hw>]:REGenerator:SIMulation:LEVel? <Level>

Queries the calculated level value.

Parameters:
<Level> float

Range: -541 to 591
Increment: 0.01
*RST: n.a. (no preset. default: -30)

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Level for Simulation" on page 36

[:SOURce<hw>]:REGenerator:SIMulation:LEVel:APPLy

Sets the output level at the dedicated connector to the calculated level. To query the calculated level, use the command `[:SOURce<hw>]:REGenerator:SIMulation:LEVel?`.

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Event

Manual operation: See "Adjust Dedicated Level" on page 37

[:SOURce<hw>]:REGenerator:SIMulation:LEVel:UPDated[:STATus]? <Status>

Queries whether the current output level at the dedicated connector is equal to the calculated level.

To query the calculated level, use the command `[:SOURce<hw>]:REGenerator:SIMulation:LEVel?`.

Parameters:
<Status> 1 | ON | 0 | OFF

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Adjust Dedicated Level" on page 37

[:SOURce<hw>]:REGenerator:SIMulation:LEVel:VALid[:STATus]? <Status>

Queries whether the calculated output level is within the permissible value range for the dedicated connector.

Parameters:
<Status> 1 | ON | 0 | OFF

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Adjust Dedicated Level" on page 37

5.6 Object configuration commands

[:SOURce<hw>]:REGenerator:OBJect:CATalog?

Queries files with object setting in the default directory. Listed are files with the file extension `*.reg_obj`.

Return values:

<FileNames> <filename1>,<filename2>,...

Returns a string of file names separated by commas.

Example:

```
SOURce1:REGenerator:OBJect:CATalog?
// Obj2
SOURce1:REGenerator:OBJect2:STORe "/var/user/MovObj_5_10_100"
SOURce1:REGenerator:OBJect:CATalog?
// MovObj_5_10_100, Obj2
SOURce1:REGenerator:OBJect3:LOAD "/var/user/MovObj_5_10_100"
```

Usage: Query only

Manual operation: See "Load/Save Object" on page 39

[:SOURce<hw>]:REGenerator:OBJect<ch>:STORe <Filename>

Stores the current settings into the selected file; the file extension (`*.reg_obj`) is assigned automatically.

Setting parameters:

<Filename> string

Example: See `[:SOURce<hw>]:REGenerator:OBJect:CATalog?` on page 81

Usage: Setting only

Manual operation: See "Load/Save Object" on page 39

[:SOURce<hw>]:REGenerator:OBJect<ch>:LOAD <Filename>

Loads the selected file from the default or the specified directory. Loaded are files with extension `*.reg_obj`.

Setting parameters:

<Filename> string

Example: See [:SOURce<hw>]:REGenerator:OBJect:CATalog? on page 81

Usage: Setting only

Manual operation: See "Load/Save Object" on page 39

[:SOURce<hw>]:REGenerator:OBJect:COPY:SOURce <Source>

Selects the object whose settings are copied.

Parameters:

<Source> 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 11 | 12 | 10

*RST: 1

Example: See [:SOURce<hw>]:REGenerator:OBJect:COPY:EXECute on page 82

Manual operation: See "Object # of 12" on page 39

[:SOURce<hw>]:REGenerator:OBJect:COPY:DESTination <Destination>

Sets the object whose settings are overwritten.

Parameters:

<Destination> ALL | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 12 | 11 | 10

*RST: 2

Example: See [:SOURce<hw>]:REGenerator:OBJect:COPY:EXECute on page 82.

Manual operation: See "Copy to" on page 39

[:SOURce<hw>]:REGenerator:OBJect:COPY:EXECute

Copies the settings of one selected object to the other one.

Example:

```
SOURce1:REGenerator:OBJect:COPY:SOURce 2
SOURce1:REGenerator:OBJect:COPY:DESTination 3
SOURce1:REGenerator:OBJect:COPY:EXECute
```

Usage: Event

Manual operation: See "Copy" on page 39

[:SOURce<hw>]:REGenerator:OBJect<ch>:NAME <Name>

Enter a symbolic name.

Parameters:

<Name> string

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Object Name" on page 40

[:SOURce<hw>]:REGenerator:OBJect<ch>:TYPE <Type>

Sets the object type or disables it.

Parameters:

<Type> OFF | STATic | MOVing | SMOVing

*RST: STAT for 1st object, else OFF

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Object Type" on page 40

[:SOURce<hw>]:REGenerator:OBJect<ch>:SIMMode <Mode>

Describes how the object moves.

Parameters:

<Mode> ROUNdtrip | ONEWay | CYCLic

*RST: ROUNdtrip

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Simulation Mode" on page 40

[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX <RadarPowerRx>

In `[:SOURce<hw>]:REGenerator:RADar:POWer:MODE` `MANual` mode, sets the Rx power of each object.

Parameters:

<RadarPowerRx> float

Range: -145 to 30
Increment: 0.01
*RST: 0

Example: See `[:SOURce<hw>]:REGenerator:RADar:POWer:MODE` on page 73

Manual operation: See "Radar Rx Power (Start)" on page 40
See "Radar Rx Power" on page 42

[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX:DEDication <Dedication>

In `[:SOURce<hw>]:REGenerator:RADar:POWer:MODE` `MANual` mode and for moving objects, defines how to interpret the value P_{RX} set with the command `[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX`.

Parameters:

<Dedication> STARt | END | ALL

STARt
$P_{Rx, jStartRange} = P_{RX}$

END
$P_{Rx, jEndRange} = P_{RX}$

ALL
$P_{Rx, jStartRange} = P_{Rx, jEndRange} = P_{RX}$

*RST: ALL

Example:

```
SOURce1:REGenerator:RADar:POWer:MODE MAN
SOURce1:REGenerator:OBJect1:TYPE MOV
SOURce1:REGenerator:OBJect1:RANGe:STARt 5000
SOURce1:REGenerator:OBJect1:RANGe:END 4000
SOURce1:REGenerator:OBJect1:POWer:RX 10

SOURce1:REGenerator:OBJect1:POWer:RX:DEDication END
SOURce1:REGenerator:OBJect1:POWer:RX:STARt?
// 6.12359947967774
SOURce1:REGenerator:OBJect1:POWer:RX:END?
// 10

SOURce1:REGenerator:OBJect1:POWer:RX:DEDication ALL
SOURce1:REGenerator:OBJect1:POWer:RX:STARt?
// 10
SOURce1:REGenerator:OBJect1:POWer:RX:END?
// 10
```

Manual operation: See "Radar Rx Power Dedicated to" on page 43

[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX:STARt?
[:SOURce<hw>]:REGenerator:OBJect<ch>:POWer:RX:END?

Queries the radar Rx power P_{Rx}.

Return values:

<RadarPowRxStart> float

Range: -465 to 578
Increment: 0.01
*RST: -81.4

<RadarPowerRxEnd> float

Range: -465 to 578
Increment: 0.01
*RST: -77.52

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Radar Rx Power (End)" on page 40

[:SOURce<hw>]:REGenerator:OBJect<ch>:RANGe:STARt <RangeStart>
[:SOURce<hw>]:REGenerator:OBJect<ch>:RANGe:END <RangeEnd>

Sets the distance between the object and the radar.

Parameters:

<RangeEnd> float

Range: 2100 to 10000000
Increment: 0.1
*RST: 5000 (RANGe:STARt) / 4000 (RANGe:END)
Default unit: km

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "End Range" on page 41

[:SOURce<hw>]:REGenerator:OBJect<ch>:OVELocity <ObjectVelocity>

Sets the speed of a moving object.

Parameters:

<ObjectVelocity> float

Range: 0.001 to 2E11
Increment: 0.001
*RST: 100
Default unit: m/s

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Object Velocity" on page 42

[:SOURce<hw>]:REGenerator:OBJect<ch>:DIRection <Direction>

Sets the object direction of a static+moving object.

Parameters:

<Direction> APPRoaching | DEParting

*RST: APPRoaching

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Direction" on page 42

[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:MODel <Model>

Set the model that describes the radar cross-section (PCS) of the object.

Parameters:

<Model> SWE0 | SWE1 | SWE2 | SWE3 | SWE4

*RST: SWE0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "RCS Model" on page 46

[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:MEAN <Mean>

Sets the mean RCS value required for the RCS calculation.

Parameters:

<Mean> float

Range: -60 to 100
Increment: 0.1
*RST: 10

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Mean RCS" on page 47

[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:PEAK <RcsPeak>

Sets the peak RCS value required for the RCS calculation.

Parameters:

<RcsPeak> float

Range: -60 to 100
Increment: 0.01
*RST: 14.77

Example: See Example"Configuring RCS swerling model" on page 66.

Manual operation: See "Peak RCS" on page 47

[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:TCOVerage <TestCoverage>

Sets the test coverage.

Parameters:

<TestCoverage> float

Range: 0.01 to 99.99
Increment: 0.01
*RST: 95

Example: See Example"Configuring RCS swerling model" on page 66.

Manual operation: See "Test Coverage" on page 48

[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:SPER <RcsSimPeriod>

Sets the interval in that the swerling random sequence is repeated.

Parameters:

<RcsSimPeriod> float

Range: 3.74742E-5 to 3600
Increment: 1E-5
*RST: 10

Example: See Example"Configuring RCS swerling model" on page 66.

Manual operation: See "Simulation Period" on page 48

[:SOURce<hw>]:REGenerator:OBJect<ch>:RCS:UPINterval?

Queries how often a new swerling random value is created.

Return values:

<RcsUpdateInterv> float

Range: 3.74742E-5 to 3600
Increment: 1E-5
*RST: 1E-4

Example: See Example"Configuring RCS swerling model" on page 66.

Usage: Query only

Manual operation: See "Update Interval" on page 48

[:SOURce<hw>]:REGenerator:OBJect<ch>:HOLD:OFF <HoldOff>

Enters a time delay form the simulation start time to the moment at that an object appears for the first time.

Parameters:

<HoldOff> float

Range: 0 to 35999.999
Increment: 0.001
*RST: 0
Default unit: s

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Object Hold Off" on page 42

[:SOURce<hw>]:REGenerator:OBJect<ch>:TIME:TOENd?

Queries the time it takes that the object moves from its start to its end range position.

Return values:

<TimeToEnd> float

Range: 0 to 1E15
Increment: 0.001
*RST: 0
Default unit: s

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "Time to Reach End Range" on page 41

[:SOURce<hw>]:REGenerator:OBJect<ch>:PHASe[:OFFSet] <Offset>

Sets a phase offset between the transmitted pulse and the echo signal.

Parameters:

<Offset> float

Range: 0 to 359.9
Increment: 0.1
*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Phase Offset" on page 42

[:SOURce<hw>]:REGenerator:OBJect<ch>:FEPNumber?

Queries the number of the first pulse for that an echo signal is generated.

Return values:

<FirstEchoToPuls> integer

Range: 0 to 100E6
*RST: 0

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "First Echo to Pulse#" on page 42

[:SOURce<hw>]:REGenerator:OBJect:ULISt:CATalog?

Queries files with user setting in the default directory. Listed are files with the file extension `*.reg_list`.

Return values:

<FileNames> <filename1>,<filename2>,...

Returns a string of file names separated by commas.

Example: See Chapter 5.1, "Programming example", on page 63.

Usage: Query only

Manual operation: See "User List" on page 43

[:SOURce<hw>]:REGenerator:OBJect<ch>:ULISt:SELect <UserListSelect>

Loads the selected list from the default or the specified directory. Loaded are files with extension `*.reg_list`.

- Query the existing list with `[:SOURce<hw>]:REGenerator:OBJect:ULISt:CATalog?`
- Apply the list with `[:SOURce<hw>]:REGenerator:OBJect<ch>:ULISt:STATe`

Suffix:
<ch> 1, 2, 3, 7, 8, 9
Object number

Parameters:
<UserListSelect> "<filename>"
Filename or complete file path; file extension can be omitted.

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "User List" on page 43

[:SOURce<hw>]:REGenerator:OBJect<ch>:ULISt:STATe <UserListState>

Enables the selected list.

- Query the existing list with `[:SOURce<hw>]:REGenerator:OBJect:ULISt:CATalog?`
- Load the list with `[:SOURce<hw>]:REGenerator:OBJect<ch>:ULISt:SELect`

Suffix:
<ch> 1, 2, 3, 7, 8, 9
Object number

Parameters:
<UserListState> OFF | ON | 1 | 0
*RST: OFF

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Active" on page 45

5.7 Preview diagram commands

[:SOURce<hw>]:REGenerator:DIAGram:TYPE <Type>

Sets the diagram type.

Parameters:

<Type> VELocity | POWer

*RST: VELocity

Example: See Chapter 5.1, "Programming example", on page 63.

Manual operation: See "Diagram Type" on page 50

Glossary: Terms and abbreviations

A

ARB: Arbitrary Waveform Generator
An I/Q modulation source forming an integral part of the supported signal generators. The ARB allows the playback and output of any externally calculated modulation signal in the form of waveform file as well as the generation of multi carrier or multi segment signals from waveform files.

AWGN: Additive white gaussian noise

B

BW: Bandwidth

BZ: Blind zone
The minimum required distance to the object so that it can be detected.

D

DUT: Device under test

E

EIRP: Equivalent isotopically radiated power

F

FFT: Fast Fourier transform

FM: Frequency modulation

G

Gain: Antenna gain is a measure of the antenna's ability to concentrate electromagnetic energy in a narrow beam.

GUI: Graphical User Interface

P

PRF: Pulse repetition frequency

PRI: Pulse repetition interval
Defines the overall time of a pulse cycle.

PRT: Pulse repetition time

PW: Pulse width

R

RADAR: Radio Detecting and Ranging

RCS: Radar cross section, RCS or σ
The RCS is a measure of the energy that an object intercepts and scatters back towards the radar.

RUT: Radar under test

V

VSG: Vector Signal Generator

Glossary: Specifications, references, documents with further information

Symbols

[1]: Rohde & Schwarz
Application note 1MA127: "Introduction to Radar System and Component Tests"

[2]: Rohde & Schwarz
White Paper 1MA239: "Radar Waveforms for A&D and Automotive Radar"

[3]: Rohde & Schwarz
Application note 1MA256: "Real-time Radar Target Generation"

[4]: Rohde & Schwarz
R&S FSW user manual available for download from the Rohde & Schwarz website, on the R&S FSW product page at http://www.rohde-schwarz.com/product/FSW.html

[5]: Rohde & Schwarz
R&S SMW user manual available for download from the Rohde & Schwarz website, on the R&S SMW product page at http://www.rohde-schwarz.com/product/SMW200A.html

List of commands

Index

P

R

S

T

U

V

W