R&S®SMx-K109
Hardware in the Loop (HIL)
User Manual

1178839402
Version 10

ROHDE&SCHWARZ
Make ideas real

Described are the following software options:

- R&S®SMW-K109 Real-time interfaces (HIL) (1414.3013.xx)
- R&S®SMBVB-K109 Real-time interfaces (HIL) (1423.8014.xx)

This manual describes firmware version FW 5.30.047.xx and later of the R&S®SMW200A.
This manual describes firmware version FW 5.30.047.xx and later of the R&S®SMBV100B.

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1178.8394.02 | Version 10 | R&S®SMx-K109

The following abbreviations are used throughout this manual: R&S®SMW200A is indicated as R&S SMW, R&S®SMBV100B is abbreviated as R&S SMBVB; the license types 02/03/07/11/12/13/16 are abbreviated as xx.

Contents

1 Welcome to the Hardware in the Loop (HIL) Option

The term hardware in the loop (HIL) describes the mode in which the R&S SMW is remotely controlled by control application software (see Figure 1-1). The control application software sends remote commands over LAN in real time, possibly from a motion simulator. The R&S SMW processes the received position, motion and attitude information and generates the required signal.

The output GNSS signal is sent to system under test, that typically includes a GNSS receiver forwarding the calculated position to the application software. The application software can use the retrieved position for display purposes (such as infotainment platform in a vehicle) or to control the actual position of the vehicle (e.g. auto-pilot).

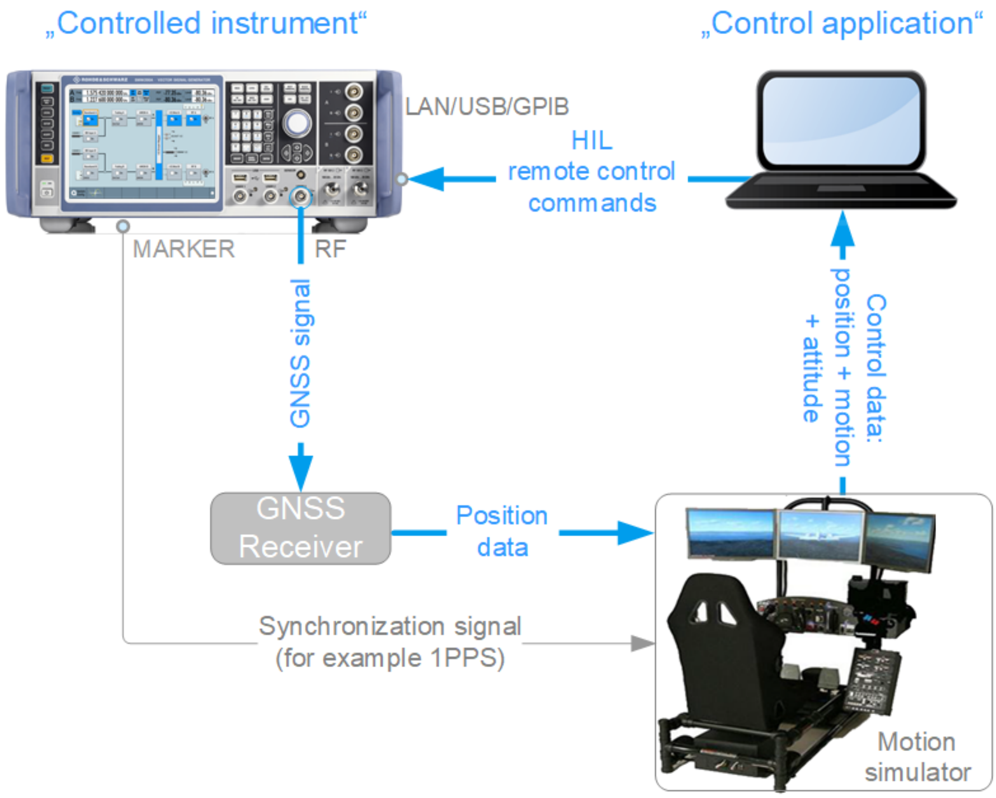


Figure 1-1: Example of HIL test setup

Refer to the following sections, for definition of the terms used in the context of HIL testing and settings. The description also gives recommendations on working with the R&S SMW in HIL setups.

1.1 Accessing the GNSS HIL Dialog

To open the dialog with HIL settings

1. In the block diagram of the R&S SMW, select "Baseband > GNSS".
2. Select "GNSS > Simulation Configuration > Receiver"
3. Select "Position" > "Remote Control (HIL)".
4. Select "Position Configuration".

   A dialog box opens that displays the provided HIL settings.

The signal generation is not started immediately. To start signal generation with the default settings, select "State > On".

1.2 What's new

This manual describes firmware version FW 5.30.047.xx and later of the R&S®SMW200A and R&S®SMBV100B.

Compared to the previous version, it provides editorial changes only.

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 com-

mands 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 1-2: 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 Tips for best results

We recommend that you consider the following measures.

Measures for proper operation

1. Synchronize the R&S SMW and the motion simulator.
(see Chapter 2.1, "Synchronization", on page 10).
2. Take measures for latency calibration.
(see Chapter 2.3, "Latency calibration", on page 11).
3. Add additional buffer time.
Chapter 2.4, "Adding a constant delay to compensate for command jitter", on page 13
4. If the first position fix and the latency calibration are successful but during the motion simulation the receiver loses its position fix, try out the following:
   a) Analyze the sent HIL data.
      - Evaluate the trajectory smoothness and search in particular for unwanted abrupt positions changes ("jumps").
      - Send HIL commands with lower update rate, for example each 100 ms. Reducing the update rate leads to interpolation and thus spreads the severity of the "jumps" over several 10 ms update intervals.
        See Chapter 2.5, "Interpolation", on page 15.
   b) Avoid abrupt positions changes.
      The motion simulator itself can cause position changes. Consult the specification of the used receiver for information on the high-order dynamic stress it is able to handle.

The measures for proper operation use the SCPI interface and the R&S SMW is in remote state. Switch to manual state after you finish the measures, if the R&S SMW retrieves HIL position data via UDP packets.

2.1 Synchronization

To process the HIL commands, the R&S SMW uses its internal 100 Hz clock signal, that corresponds to a time resolution of 10 ms.

The motion simulator uses its own clock. Depending on the capabilities of the processor (general purpose or real time) that the motion simulator uses, the processing time and the accuracy of the clock can vary. The R&S SMW internal clock signal is precise and stable. This clock is not only used to generate the GNSS signals but is also the time reference for the whole HIL setup.

We recommend that you synchronize the motion simulator to the R&S SMW. Consider the following:

- Follow the rules described in "Measures for proper operation" on page 10
- Always take the measures for latency calibration as described in Chapter 2.3, "Latency calibration", on page 11.
- If your motion simulator can receive and process the marker signal of the R&S SMW, generate a 1PPS (one pulse per second) or 10PPS (10 pulses per second) marker signal. Feed the marker signal to the motion simulator.
  If synchronized, the motion simulator sends the HIL commands right after each 1PPS marker signal.

  Related settings:
  – "GNSS > Marker > Marker Mode"

2.2 System latency

System latency is a term that describes the time it takes the R&S SMW to receive and process an incoming HIL command, calculate, output and transmit the signal to the GNSS receiver. The **default system latency is 20 ms**; this value corresponds to the R&S SMW hardware processing time.

In the context of this description, the term latency ($t_{cal.latency}$) describes the **additional latency (i.e. delay)** caused, for example, by the transmission and processing time of the HIL commands. If the system latency value is a constant parameter that cannot be reduced, the additional latency $t_{cal.latency}$ is a variable value, that can be partly or fully compensated. This description focuses on the measures to measure and compensate for additional latency.

You can query the additional latency value as described in Chapter 2.3, "Latency calibration", on page 11. The system latency and the latency are related as follows:

System Latency = $t_{cal.latency}$ + 0.02

The minimum system latency of the HIL setup is 2 ms and is achieved if the $t_{cal.latency}$ = 0 ms. The situation when $t_{cal.latency}$ = 0 ms is referred as a zero latency situation; it is also the best case scenario.

See also:

- Chapter 2, "Tips for best results", on page 10
- "Understanding the response of the query SOURce:BB:GNSS:RT:RECeiver1:HILPosition:LATency:STATistics?" on page 25

2.3 Latency calibration

Latency calibration is the process of compensating the latency time. Calibrate the latency at the beginning of the simulation and repeat the process periodically, every 5 or 10 seconds.

Initial latency calibration process

1. **Synchronize the R&S SMW and the motion simulator.**
   (see Chapter 2.1, "Synchronization", on page 10).
2. Set the same **initial position (P_0)** in both the motion simulator and the R&S SMW.
   The initial position is the position in the moment t_0.
   In R&S SMW, set the receiver postion with the parameters "Receiver Position > Location Coordinates".
   Tip: We recommend that you use the position that you are going to use as the first simulation position in the motion simulation.
3. Wait until the GNSS receiver performs its **first position fix**.
4. **Retrieve an initial time reference** information from the R&S SMW.
   Send the command `[:SOURce<hw>]:BB:GNSS:RT:HWTime?` to query the elapsed time from the simulation begin ($\Delta_{HW,0}$).
   The response is a value that reflects the difference between the current time in the R&S SMW ($t_{GNSS,0}$) and the motion simulator ($t_{MS,0}$) at the moment t_0:
   $\Delta_{HW,0} \approx t_{MS,0} - t_{GNSS,0}$
   Note: The retrieved value is a rough estimation. It does not consider the round-trip time of the HIL commands.
   Although not exact, the response of the command is suitable for the initial time alignment (first approximation).
   The precise calibration is performed with the next steps.
5. **Send the first HIL command as a function of the moment $t_{MS,1}$.**
   HIL commands define position P_i at a given moment of time $t_{ElapsedTime,i}$.
   To compensate for the time difference between the R&S SMW and the motion simulator, correct the $t_{ElapsedTime,i}$ value:
   a) Calculate the first elapsed time $t_{ElapsedTime,1}$
      $t_{ElapsedTime,1} = t_{MS,1} - \Delta_{HW,0}$
   b) Use the coordinates of the initial position P_0
   c) Send a remote command containing the timestamp with position and attitude information.
      If you use UDP packets, send the command `&GTL` first and then send the UDP packets.
      If you use SCPI commands, send the command depending on the position coordinates:
      `[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:A` for position data in ECEF coordinates.
      `[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:B` for position data in NED coordinates.
6. **Query the time difference ($t_{cal.latency,i}$)** between the elapsed time in the R&S SMW ($t_{HW,j}$) and the elapsed time in the last HIL command ($t_{ElapsedTime,i}$).

Send the command [:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:LATency:STATistics?.
The query returns several parameters and statistical information. For more information, see the description of the remote command.

Observe the value $t_{cal.latency,\mathbf{1}} = t_{HW,\mathbf{0}} - t_{ElapsedTime,\mathbf{1}}$.
If UDP is used, send the `&GTL` command after the query.

7. If $\mathbf{t_{cal.latency,i}} \geq$ **|System Latency - 20 ms|**, perform the following:
   a) Calculate $\Delta_{HW,\mathbf{j}} = \Delta_{HW,\mathbf{j-1}} + t_{cal.latency,\mathbf{i}}$

      Where:
      - i reflects the HIL update rate
      - j is the latency calibration iteration number
   b) Calculate the elapsed time $t_{ElapsedTime,\mathbf{i+1}} = t_{MS,\mathbf{i+1}} - \Delta_{HW,\mathbf{j}}$
   c) Send the subsequent HIL command as a function of $t_{MS,\mathbf{i+1}}$ and P_i

The latency is **successfully calibrated**, if *one of the following is true*:
- **-10 ms < <MinLatency> < <MaxLatency> < 10 ms**
- **<CmdReceived> = <CmdSync> + <CmdInterp>**
- **<MinUsed>$_{\mathbf{min}}$ ≥ 1**

Where <MaxLatency>, <MinLatency>, <MinUsed>, <CmdReceived>, <CmdSync> and <CmdInterp> are the value returned by the query [:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:LATency:STATistics?.
If UDP is used, send the `&GTL` command.
A latency of 0 ms corresponds to a system latency of 20 ms.

If the **latency calibration is unsuccessful**:
- **Add a buffer time**, see Chapter 2.4, "Adding a constant delay to compensate for command jitter", on page 13.
- Query HIL statistical information and **analyze** the values of the parameters **<CmdExtrap>** and **<CmdPredict>**.
  They indicate the number of times the prediction algorithm has been applied, see Chapter 2.6, "Trajectory prediction", on page 15.

2.4 Adding a constant delay to compensate for command jitter

If the motion simulator is not equipped with a real-time processor, it can happen that it sends the HIL commands with varying update rate. This effect is often referred as a command jitter.

The R&S SMW can compensate command jitter in the range of 1 ms to 30 ms. The mechanism is to add a buffer time t_{Buffer} so that the R&S SMW has enough time to process and realign the HIL commands. The drawback of this mechanism is the adding of an extra constant delay to the system.

Adding buffer time (t_{Buffer})

To compensate for the command jitter:

► Send the command `[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:SLATency`.

The command sets the system latency, i.e. a delay $\mathbf{t_{Delay}}$. The additional buffer time t_{Buffer} is calculated as follows:
$\mathbf{t_{Buffer} = t_{Delay} - 0.02}$
Where t_{Buffer} is the additional time available for processing.
The value 0.02 s is the hardware processing time of the R&S SMW.

If the value t_{Buffer} > 0 ms, the system latency equation changes as follows:
System Latency = $t_{cal.latency} + t_{Delay} = t_{cal.latency} + \mathbf{t_{Buffer}} + 0.02$

Finding out the best system latency value t_{Delay}

1. Select the **initial** $\mathbf{t_{Delay}}$ value depending on whether the motion simulator is equipped with real-time processor or not:
   - With real-time processor: `<Delay> = 0.02 s`
   - Without real-time processor: `<Delay> = 0.15 s`
2. Collect statistical information with the query `[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:LATency:STATistics?` for at least 30 min.
3. Evaluate the absolute minimum value returned for the parameter `<MinUsed>`.
4. **Reduce the** $\mathbf{t_{Delay}}$ value. Evaluate the statistics again.
   Repeat this step until **`<MinUsed>`$_{min}$ ≥ 1**.

Example:

If the R&S SMW and the motion simulator are connected in a HIL setup and:
- HIL update rate = 0.1 s
- t_{Delay} = 0.05 s
- t_{Buffer} = 0.03 s.
- In a *non-synchronized* setup with, for example, $t_{cal.latency}$ = 0.04 s, the current system latency is:
  System Latency = 0.04 + 0.05 = 0.09 s
- After the R&S SMW and the motion simulator are *synchronized* ($t_{cal.latency}$ = 0 s), the system latency becomes:
  System Latency = 0 + 0.05 = 0.05 s
  With the buffer time of 0.03 s, R&S SMW tolerates command jitter of up to 0.03 s.
  Because of the buffer time, prediction is not applied.

Adding of buffering time does not substitute the latency calibration. It is an add-on to it. **Always calibrate the latency** as described in Chapter 2.3, "Latency calibration", on page 11.

Related settings:

- Chapter 2.2, "System latency", on page 11

2.5 Interpolation

If the update rate of the HIL commands is less than 100 Hz, the instrument interpolates the two last received commands to achieve the required update rate. Interpolation can be applied if the system latency is higher than the update rate and if at least one HIL command was received and buffered. The former situation is present, if the query `[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:LATency:STATistics?` returns `<MinUsed>` = 1.

The interpolation mechanism can achieve a continuous signal and hence results in better result than the extrapolation and the prediction methods (see Chapter 2.6, "Trajectory prediction", on page 15).

2.6 Trajectory prediction

The R&S SMW tries to compensate for the latency ($t_{cal.latency}$) by applying a prediction algorithm. If the R&S SMW and the motion simulator are synchronized and the latency is less than 10 ms, prediction is not applied. If the latency exceeds 10 ms, prediction is applied. The R&S SMW uses the last received high-order dynamics (speed, acceleration and jerk) and predicts or extrapolates the position of the motion simulator at the subsequent update time.

Where:

- Extrapolation describes the process, where the position is calculated from a received command with an old timestamp and is based on the received speed, acceleration and jerk
- Prediction is applied if no command was received, for example if the update period is larger than 10 ms. When predicted, subsequent positions are calculated based on the last known speed, acceleration and jerk

Retrieving the number of automatically performed extrapolations and predictions

You can query statistical information on the number of times the R&S SMW applied predictions or extrapolation with the command `[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:LATency:STATistics?`.

Observe the values of the parameters `<CmdExterp>` and `<CmdPredict>`.

Example: How extrapolation can impair the results

Imagine that at the moment t_0 a vehicle is moving with a velocity *v = 1 m/s* and it stops (*v = 0 m/s*) after 0.1 s ($t_1 = t_0 + 0.1\ s$).

If the latency exceeds 10 ms, then the R&S SMW projects the movement assuming that the vehicle keeps its velocity *v = 1 m/s*. This result of position offset of 0.01 m.

At the next update period, for example 100 ms later, the R&S SMW receives the subsequent command and the correct velocity *v = 0 m/s*. The instrument corrects the position and removes the 0.01 m position offset.

This causes an abrupt change (a "jump") between the two consecutive positions.

As illustrated in the example, the prediction algorithm alone cannot assure that the trajectory is continuous. Without further measures, the predicted positions can cause abrupt changes between consecutive positions or lead to tracking loss of the GNSS signal. The severity of these abrupt changes depends on both the latency value and the current dynamics and therefore are tolerated or not by the GNSS receiver.

Prediction for instance is useful, if the application requires low latency and tolerates "jumps". Otherwise, we recommend that you use real-time PC with synchronized marker or add buffer to increase the system latency.

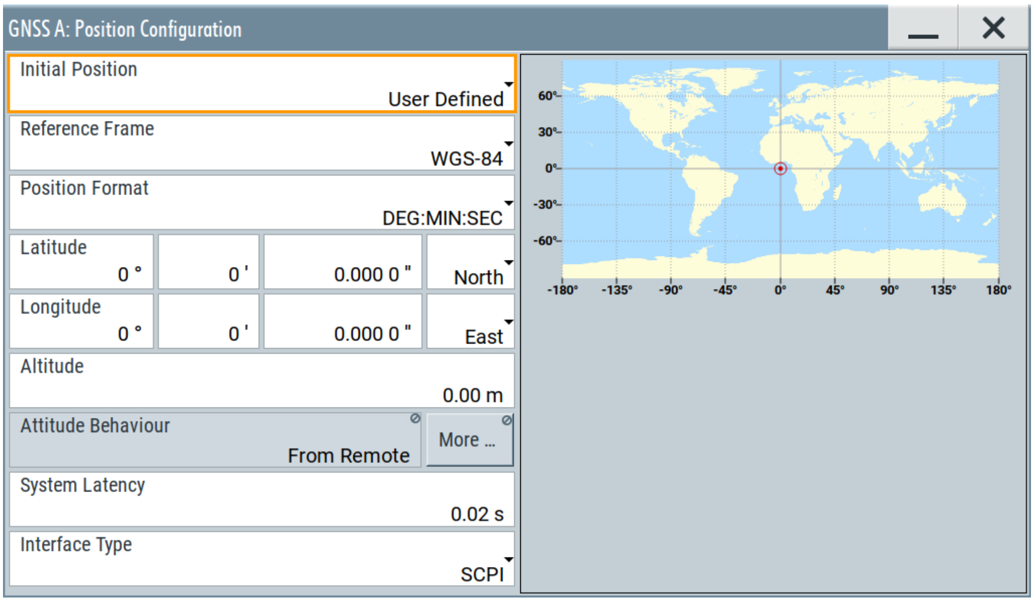
See Chapter 2, "Tips for best results", on page 10.

3 HIL settings

Option: R&S SMW-K109

Access:

1. Select "GNSS" > "Simulation Configuration" > "Receiver".
2. Select "Position" > "Remote Control (HIL)".
3. Select "Position Configuration".



Settings

Location, Initial Position

Selects the location or initial position depending on the simulated object:

- Static GNSS receiver ("Position > Static"):
  Selects the geographic location of the GNSS receiver.
- R&S SMW-K109: Hardware in the loop (HIL) GNSS receiver ("Position > From Remote"):
  Selects the initial position of the GNSS receiver.
- R&S SMW-K122: Real-time kinematics (RTK) base station:
  Selects the geographic location of the RTK base station.

The representation of the coordinates depends on the selected "Reference Frame" and "Position Format".

"User Defined" Sets the receiver position in terms of "Latitude", "Longitude" and "Altitude"

"City" Selects a predefined geographic location, see Table 3-1 for an overview.
The parameters "Latitude", "Longitude" and "Altitude" are set automatically.

Table 3-1: Coordinates of the simulated predefined positions

Continent	City	Latitude [deg]	Longitude [deg]	Altitude [m]
Europe	London	51.500625	-0.1246219	22
	Moscow	55.7522222	37.6155556	200
	Munich	48.15	11.5833333	508
	Paris	48.8584	2.2946278	66
America	New York	40.714667	-74.0063889	1
	San Francisco	37.8194389	-122.4784939	35
	Anchorage	61.2166667	-149.8833333	115
	Mexico City	19.4510539	-99.1255189	2310
	Bogota	4.7111111	-74.0722222	2640
	Sao Paulo	-23.5337731	-46.62529	760
	Santiago de Chile	-33.4474869	-70.6736758	522
Asia	Beijing	39.9055556	116.3913889	60
	New Delhi	28.6138889	77.2088889	77
	Seoul	37.5514997	126.9877939	265
	Singapore	1.3113108	103.8268528	110
	Taipei	25.0223439	121.5147581	10
	Tokyo	35.6838611	139.7450581	45
Africa	Cairo	30.0444419	31.2357117	23
	Dakar	14.7166769	-17.4676858	22
	Cape Town	-33.9188611	18.4233	6
Australia	Sydney	-33.8833333	151.2166667	3
	Perth	-31.9535119	115.8570481	2

Remote command:
`[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:CATalog`
on page 34
`[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation[:SELect]`
on page 33

Reference Frame

For GNSS receiver, selects the reference frame used to define the receiver coordinates. The transformation between the reference frames is performed automatically.

The following applies:

- $X_{WGS84} = (1 - 0.008*10^{-6})*X_{PZ\,90} - 0.2041*10^{-7}*Y_{PZ\,90} + 0.1716*10^{-7}*Z_{PZ\,90} - 0.013$
- $Y_{WGS84} = (1 - 0.008*10^{-6})*Y_{PZ\,90} - 0.2041*10^{-7}*X_{PZ\,90} + 0.1115*10^{-7}*Z_{PZ\,90} + 0.106$
- $Z_{WGS84} = (1 - 0.008*10^{-6})*Z_{PZ\,90} - 0.1716*10^{-7}*X_{PZ\,90} - 0.1115*10^{-7}*Y_{PZ\,90} + 0.022$

Both reference frames are ECEF frames with a set of associated parameters.

"WGS-84" The World Geodetic System WGS-84 is the reference frame used by GPS.

"PZ 90.11 (GLONASS)"
Parametry Zemli PZ (Parameters of the Earth) is the reference frame used by GLONASS.

Remote command:

`[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:RFRame` on page 34

Location Coordinates, Position Format

In the ECEF coordinate system, a geographic location is identified by three coordinates, the altitude, latitude and longitude. The last two can be displayed in decimal or DMS format. The display format is determined by the parameter "Position Format".

Parameter	Description
"Position Format"	Sets the format in which the Latitude and Longitude are displayed. • "DEG:MIN:SEC" The display format is Degree:Minute:Second and Direction, i.e. `XX°XX'XX.XX" Direction`, where direction can be North/South and East/West. • "Decimal Degrees" The display format is decimal degrees, i.e. `+/-XX.XXXXX°`, where "+" indicates North and East and "-" indicates South and West.
"Altitude"	Sets the altitude of the reference location. The altitude value is the height above the ellipsoid (HAE), that is the reference ellipsoid (WGS84 or PZ90).
"Latitude"	Sets the latitude of the reference location.
"Longitude"	Sets the longitude of the reference location.

Altitude, latitude and longitude are configurable, if "Location, Initial Position > User Defined".

Remote command:

`[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:FORMat` on page 34

To enter the coordinates in "Position Format > DEG:MIN:SEC"

`[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:DMS:PZ` on page 35

`[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:DMS[:WGS]` on page 35

To enter the coordinates in "Position Format > Decimal Degrees"

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:DECimal:PZ on page 34
[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:DECimal[:WGS] on page 34

Attitude Behaviour, More
Defines how the attitude information is defined.

"From Remote"
Option: R&S SMW-K109
For "Receiver" > "Position" > "Remote Control (HIL)", the attitude parameters are set by the received HIL commands. The selection is suspended.

Remote command:
[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:ATTitude[:BEHaviour] on page 36

System Latency
Option: R&S SMW-K109

System latency is the time period, which the R&S SMW needs to receive and process incoming HIL commands.

The minimum value of 20 ms corresponds to the R&S SMW hardware processing time. Values higher than 20 ms constitute a delay or a buffer time to process incoming HIL position data.

The parameter is crucial for latency calibration between the R&S SMW and the control application program.

Remote command:
[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:SLATency on page 32

Interface Type
Option: R&S SMW-K109

Two interface types are provided for the HIL communication between the R&S SMW and the control application program, which remotely controls the R&S SMW:

"SCPI"
A SCPI connection is used for communication.
In some case, the Transfer Control Protocol (TCP) can suffer from the overhead caused by the acknowledgments and retransmission. In such cases, enable the socket option "TCP_NODELAY" on the sender side.

"UDP Raw Socket"
The R&S SMW listens to a unidirectional UDP stream, generated by the control application program.

Remote command:
[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:ITYPe on page 32

UDP Port
Option: R&S SMW-K109

Requires "Interface Type" > "UDP Raw Socket".

Sets the port for incoming UDP packets at the R&S SMW.

Remote command:
[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:PORT on page 32

4 UDP position data

Compared to the SCPI interface, the User Data Protocol (UDP) offers the following two advantages:

- UDP is known to have less communication overhead, and therefore recommended in time critical simulations.
- The user interface is not blocked (remote state) like when using the SCPI interface. Thus, using UDP you can change the satellite states, power offset and pseudorange bias on-the-fly.

Table 4-1 shows the structure of a UDP data packet containing position data. The position data is provided in a binary format as specified in the IEEE Standard 754 for Binary Floating-Point Arithmetic.

The measures for proper operation use the SCPI interface and require remote control. After calibration and for retrieving position data via UDP, you have to switch the R&S SMW from remote state to manual state.

On the control application, use the command `&GTL` for this purpose.

Table 4-1: UDP packet and parameter description for HIL position data

Data Type	Size	Parameter	Description	Default unit
`integer`	4 bytes	`reserve0`	-	-
`integer`	4 bytes	`reserve1`		
`integer`	4 bytes	`reserve2`		
`integer`	4 bytes	`reserve3`		
`double`	8 bytes	`ElapsedTime`	Elapsed time since the simulation start	s

`double`
`double`
`double`
	8 bytes
	8 bytes
	8 bytes
		`<X>`
		`<Y>`
		`<X>`
			Coordinate in the Earth Fixed Centered (ECEF) coordinate system	m

`double`
`double`
`double`
	8 bytes
	8 bytes
	8 bytes
		`<XDot>`
		`<YDot>`
		`<ZDot>`
			Velocity vector in ECEF
			(equivalently `<Vx>`, `<Vy>`, `<Vz>`)
				m/s

`double`
`double`
`double`
	8 bytes
	8 bytes
	8 bytes
		`<XDotDot>`
		`<YDotDot>`
		`<ZDotDot>`
			Acceleration vector in ECEF
			(equivalently `<Ax>`, `<Ay>`, `<Az>`)
				m/s^2

`double`
`double`
`double`
	8 bytes
	8 bytes
	8 bytes
		`<XDotDotDot>`
		`<YDotDotDot>`
		`<ZDotDotDot>`
			Jerk vector in ECEF
			(equivalently `<Jx>`, `<Jy>`, `<Jz>`)
				m/s^3

`double`
`double`
`double`
	8 bytes
	8 bytes
	8 bytes
		`<Yaw>`
		`<Pitch>`
		`<Roll>`
			Attitude angles
			(yaw/heading, pitch/elevation, roll/bank)
			Unlimited value range to simulate more than one cycle rotation between two updates
				rad

Data Type	Size	Parameter	Description	Default unit

`double`
`double`
`double`
	8 bytes
	8 bytes
	8 bytes
		`<YDot>`
		`<PDot>`
		`<RDot>`
			Attitude angular rate of change	rad/s

`double`
`double`
`double`
	8 bytes
	8 bytes
	8 bytes
		`<YDotDot>`
		`<PDotDot>`
		`<RDotDot>`
			Attitude angular second order derivative	rad/s^2

`double`
`double`
`double`
	8 bytes
	8 bytes
	8 bytes
		`<YDotDotDot>`
		`<PDotDotDot>`
		`<RDotDotDot>`
			Attitude angular third order derivative	rad/s^3

5 SCPI position data

During remote operation, the control application program sends real-time HIL (SCPI) commands to the R&S SMW. The HIL commands are sent with low and varying time resolution. This time resolution is also referred as a **HIL update rate**. It is typically a value from 10 Hz to 100 Hz (or 10 ms and 100 ms) and depends on the motion simulator, in particular on its real-time capabilities.

HIL position data is provided by two commands:

`[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:A`

`[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:B`

The command defines the HIL position, motion (velocity, acceleration, jerk) and attitude at a specific moment of time. The position is defined by earth centered earth fixed (ECEF) coordinates for mode A and by north east down (NED) coordinates for mode B. The moment of time is given as a time offset (`<ElapsedTime>`) from the simulation time start.

6 Remote-Control Commands

Option: R&S SMW-K109

The following commands are required for signal generation with the satellite navigation option HIL 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 remote commands:

Suffix	Value range	Description
SOURce<hw>	[1] to 4	available baseband signals
V<st> V<us>	1 to 2	number of simulated vechicles

Example: Setting the initial position of a receiver

```
// Select a user-defined position.
SOURce1:BB:GNSS:RECeiver:V1:LOCation:CATalog?
// Respone: "User Defined, Waypoints, New York, .."
SOURce1:BB:GNSS:RECeiver:V1:LOCation:SELect "User Defined"

SOURce1:BB:GNSS:RECeiver:V1:LOCation:COORdinates:RFRame WGS84
SOURce1:BB:GNSS:RECeiver:V1:LOCation:COORdinates:FORMat DMS
SOURce1:BB:GNSS:RECeiver:V1:LOCation:COORdinates:DMS:WGS?
// 11,35,0,EAST,48,9,0,NORT,508
SOURce1:BB:GNSS:RECeiver:V1:LOCation:COORdinates:FORMat DEC
SOURce1:BB:GNSS:RECeiver:V1:LOCation:COORdinates:DEC:WGS?
// 11.583333,48.150000,508
```

Understanding the response of the query SOURce:BB:GNSS:RT:RECeiver1:HIL-Position:LATency:STATistics?

The following are three examples that illustrate how the HIL update rate and the buffer time influence the way the received HIL commands are processed.

The query is sent each 5 s as indicated by the difference between two subsequently `<CmdHwTime>` values.

The response of each individual query is a string. The set of strings per example have been converted to a `*.csv` file and formatted for better understanding.

Example: Non-real-time (RT) processor, HIL update rate = 100 Hz, t_{Delay} = 0.02 s

<CmdHwTime>	<LastLatency>	<MaxLatency>	<MinLatency>	<NoZeroValues>	<CmdReceived>	<CmdUsed>	<CmdSync>	<CmdExterp>	<Interp>	<Predictions>	<MaxUsed>	<MinUsed>
254.07	0	0.04	0	26	500	492	474	18	0	8	2	0
259.07	0	0.05	0	15	500	491	485	6	0	9	2	0
264.07	0	0.04	0	23	500	491	477	14	0	9	2	0
269.07	0	0.04	0	14	500	492	486	6	0	8	3	0
274.07	0	0.04	0	38	500	488	462	26	0	12	2	0
279.07	0	0.04	0	18	500	493	482	11	0	7	2	0
284.07	0	0.04	0	47	500	484	453	31	0	16	2	0

Figure 6-1: Example of latency statistics

1 = Varying latency of up to 50 ms
2 = Number of non-zero latency values varies
3 = Number of commands received during each period = 500
4 = Not all received commands are used (<CmdUsed> < <CmdReceived>)
5 = Not all commands are applied at their specified time (<CmdSync> < <CmdUsed>)
6 = Interpolation not applied; commands do not arrive in advance
7 = Number of times the prediction algorithm was applied

Example: Non-real-time (RT) processor, HIL update rate = 100 Hz, t_{Delay} = 0.15 s

This example illustrates that the increased t_{Delay} improves the number of processed HIL commands. The system latency however also increases.

<CmdHwTime>	<LastLatency>	<MaxLatency>	<MinLatency>	<NoZeroValues>	<CmdReceived>	<CmdUsed>	<CmdSync>	<CmdExterp>	<Interp>	<Predictions>	<MaxUsed>	<MinUsed>
253.94	0	0.04	0	45	500	500	500	0	0	0	14	9
258.94	0	0.05	0	45	500	500	500	0	0	0	14	8
263.94	0	0.04	0	46	500	500	500	0	0	0	14	9
268.94	0	0.05	0	50	500	500	500	0	0	0	14	8
273.94	0	0.04	0	76	500	500	500	0	0	0	14	9
278.94	0	0.05	0	30	500	500	500	0	0	0	14	8

Figure 6-2: Impact of the increased t_Delay

1 = All commands are used synchronous
2 = Interpolation or prediction is not necessary and not applied
3 = Increased number of buffered commands; the values indicate that there is a room to decrease (optimize) the t_{Delay} (see Chapter 2.4, "Adding a constant delay to compensate for command jitter", on page 13)

Example: Non-real-time (RT) processor, HIL update rate = 10 Hz, t_{Delay} = 0.15 s

This example illustrates that varying the HIL update rate while keeping the same t_{Delay} also improves the HIL command processing. The generated signal is continuous. The system latency however also increases.

<CmdHwTime>	<LastLatency>	<MaxLatency>	<MinLatency>	<NoZeroValues>	<CmdReceived>	<CmdUsed>	<CmdSync>	<CmdExterp>	<Interp>	<Predictions>	<MaxUsed>	<MinUsed>
98.85	0	0.03	0	2	50	50	50	0	450	0	2	1
103.85	0	0.02	0	2	50	50	50	0	450	0	2	1
108.85	0	0.03	0	2	50	50	50	0	450	0	2	1
113.85	0	0.03	0	1	50	50	50	0	450	0	2	1
118.85	0	0.04	0	2	50	50	50	0	450	0	2	0
123.85	0	0.02	0	3	50	50	50	0	450	0	2	1

Figure 6-3: Impact of the reduced HIL update rate

1 = All commands are used synchronous
2 = Interpolation is required and applied (ideal situation where each HIL command is executed synchronous and there are enough HIL commands to interpolate the values from)

The last two examples show approaches that are suitable if your system tolerates system delays.

Related commands

[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:A <ElapsedTime>, <X>, <Y>, <Z>, <XDot>, <YDot>, <ZDot>, <XDotDot>, <YDotDot>, <ZDotDot>, <XDotDotDot>, <YDotDotDot>, <ZDotDotDot>, <Yaw>, <Pitch>, <Roll>, <YawDot>, <PitchDot>, <RollDot>, <YawDotDot>, <PitchDotDot>, <RollDotDot>, <YawDotDotDot>, <PitchDotDotDot>, <RollDotDotDot>

Sets hardware in loop (HIL) position, motion (velocity, acceleration, jerk) and attitude in Earth Fixed Earth Centered ECEF coordinates.

The yaw/heading, pitch/elevation, roll/bank rotation angles and their derivatives are obtained by rotating the body (XYZ) frame. The frame is rotated starting from an aligned state with the local NED frame. Three consecutive Euler rotations are: around the z axis, the y axis and the x axis.

Table 6-1: SCPI parameter description

Parameter		Description	Default unit
`<X>,<Y>,<Z>`	Mandatory	Coordinate in the Earth Fixed Earth Centered (ECEF) coordinate system	m
`<XDot>,<YDot>, <ZDot>`	Mandatory	Velocity vector in ECEF (equivalently `Vx, Vy, Vz`)	m/s
`<XDotDot>, <YDotDot>, <ZDotDot>`	Mandatory	Acceleration vector in ECEF (equivalently `Ax, Ay, Az`)	m/s^2
`<XDotDotDot>, <YDotDotDot>, <ZDotDotDot>`	Mandatory	Jerk vector in ECEF (equivalently `Jx, Jy, Jz`)	m/s^3

Parameter		Description	Default unit
[<Yaw>,<Pitch>, <Roll>]	Optional	Attitude angles (yaw/heading, pitch/elevation, roll/bank) Unlimited value range to simulate more that one cycle rotation between two updates	rad
[<YDot>,<PDot>, <RDot>]	Optional	Attitude angular rate of change	rad/s
[<YDotDot>, <PDotDot>, <RDotDot>]	Optional	Attitude angular second order derivative	rad/s^2
[<YDotDotDot>, <PDotDotDot>, <RDotDotDot>]	Optional	Attitude angular third order derivative	rad/s^3

See also Chapter 2.3, "Latency calibration", on page 11.

For HIL mode A, position data can also be retrieved via UDP packets, see Chapter 4, "UDP position data", on page 22.

Parameters:

<ElapsedTime> float

Elapsed time from the simulation start, as queried with the command [:SOURce<hw>]:BB:GNSS:RT:HWTime?.
For description of the other parameters, see Table 6-1.

Range: 0 to 99999999

Usage: Setting only

[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:B <ElapsedTime>, <Latitude>, <Longitude>, <Altitude>, <NDot>, <EDot>, <DDot>, <NDotDot>, <EDotDot>, <DDotDot>, <NDotDotDot>, <EDotDotDot>, <DDotDotDot>, <Yaw>, <Pitch>, <Roll>, <YawDot>, <PitchDot>, <RollDot>, <YawDotDot>, <PitchDotDot>, <RollDotDot>, <YawDotDotDot>, <PitchDotDotDot>, <RollDotDotDot>

Sets hardware in loop (HIL) position, motion (velocity, acceleration, jerk) and attitude in North East Down (NED) coordinates.

The yaw/heading, pitch/elevation, roll/bank rotation angles and their derivatives are obtained by rotating the body (XYZ) frame. The frame is rotated starting from an aligned state with the local NED frame. Three consecutive Euler rotations are: around the z axis, the y axis and the x axis.

Table 6-2: Parameter description

Parameter		Description	Default unit
<Latitude>, <Longitude>, <Altitude>	Mandatory	Geodetic location	°
<NDot>,<EDot>, <DDot>	Mandatory	Velocity vector in the North East Down (NED) coordinate system (equivalently Vn, Ve, Vd)	m/s

Parameter		Description	Default unit
<NDotDot>, <EDotDot>, <DDotDot>	Mandatory	Acceleration vector in NED (equivalently An, Ae, Ad)	m/s^2
<NDotDotDot>, <EDotDotDot>, <DDotDotDot>	Mandatory	Jerk vector in NED (equivalently Jn, Je, Jd)	m/s^3
[<Yaw>,<Pitch>, <Roll>]	Optional	Attitude angles (yaw/heading, pitch/elevation, roll/bank) Unlimited value range to simulate more that one cycle rotation between two updates	rad
[<YDot>,<PDot>, <RDot>]	Optional	Attitude angular rate of change	rad/s
[<YDotDot>, <PDotDot>, <RDotDot>]	Optional	Attitude angular second order derivative	rad/s^2
[<YDotDotDot>, <PDotDotDot>, <RDotDotDot>]	Optional	Attitude angular third order derivative	rad/s^3

See also Chapter 2.3, "Latency calibration", on page 11.

This mode is currently supported for position data retrieved via SCPI commands only. For HIL mode A, position data can also be retrieved via UDP packets, see Chapter 4, "UDP position data", on page 22.

Parameters:

<ElapsedTime> float

Elapsed time from the simulation start, as queried with the command [:SOURce<hw>]:BB:GNSS:RT:HWTime?.
For description of the other parameters, see Table 6-2.

Range: 0 to 99999999

Usage: Setting only

[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:LATency?

Queries the predicted latency that is the time delay between the elapsed time of HIL mode command and the time to execute this command in the R&S SMW. HIL command refers to HiL mode A or HiL mode B commands:

[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:A

[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:B

How to: Chapter 2.3, "Latency calibration", on page 11

Return values:

<Latency> float

Range: min to max
Increment: 0.001
*RST: 0
Default unit: s

Usage: Query only

[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:LATency:STATistics?

Queries the current latency $t_{cal.latency,i}$ and statistics on the latency values.

This command returns also the minimum deviation and the maximum deviation from zero latency. Also, it returns the measured number of non-zero latency values since the last query with this command.

The following terms are used:

- HIL command refers to HiL mode A or HiL mode B commands:
  `[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:A`
  `[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:B`
- Dropped commands are commands that are evaluated, buffered but not applied because they become outdated as more up-to-date information is received
- Return values apply for the period since the last query with this command.

How to: Chapter 2.3, "Latency calibration", on page 11

Return values:

<CmdHwTime> float

The hardware time at the moment the last HIL command is received.

Increment: 0.001
*RST: 0

<LastLatency> float

Time delay between the time specified with the parameter `<ElapsedTime>` in a HIL command and the time this command is executed in the R&S SMW.

Increment: 0.001
*RST: 0
Default unit: s

<MaxLatency> float

The largest latency value since the last time this query was sent.

Increment: 0.001
*RST: 0
Default unit: s

<MinLatency>	float The smallest latency value since the last time this query was sent. Increment: 0.001 *RST: 0 Default unit: s
<NoZeroValues>	integer Number of non-zero latency values since the last time this query was sent. *RST: 0
<CmdReceived>	integer Accumulated <LastLatency> values since the last time this query was sent. *RST: 0
<CmdUsed>	integer The number of used HIL commands, excluding the dropped HIL commands, since the last time this query was sent. *RST: 0
<CmdSync>	integer The number of HIL commands applied at their specified time *RST: 0
<CmdExterp>	integer The number of extrapolated HIL commands. The commands are applied later than their specified time. *RST: 0
<CmdInterp>	integer The number of internal position updates. The value includes commands describing both situations, moment of time in past and moment of time in the future. *RST: 0
<CmdPredict>	integer The number of internal position updates performed by the prediction algorithm, see Chapter 2.6, "Trajectory prediction", on page 15. *RST: 0
<MaxUsed>	integer The maximum number buffered commands *RST: 0

<MinUsed> integer

The minimum number buffered commands

*RST: 0

Example: See "Understanding the response of the query SOURce:BB:GNSS:RT:RECeiver1:HILPosition:LATency:STATistics?" on page 25.

Usage: Query only

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:SLATency <SystemLatency>

Sets the time delay between the time specified with the parameter `<ElapsedTime>` in the HIL `mode A` position data command and the time this command is executed in the R&S SMW.

See also Chapter 2.2, "System latency", on page 11.

You can use the retrieved value for latency calibration, see Chapter 2.3, "Latency calibration", on page 11.

Parameters:

<SystemLatency> float

Range: 0.02 to 0.15
Increment: 0.001
*RST: 0.02
Default unit: s

Example: See "Understanding the response of the query SOURce:BB:GNSS:RT:RECeiver1:HILPosition:LATency:STATistics?" on page 25.

Manual operation: See "System Latency" on page 20

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:ITYPe <InterfaceType>

Set the interface type for the remote communication between R&S SMW and the control application.

Parameters:

<InterfaceType> SCPI | UDP

*RST: SCPI

Example: `SOURce1:BB:GNSS:RECeiver:V1:HIL:ITYPe UDP`

Manual operation: See "Interface Type" on page 20

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:PORT <UdpPort>

Set the UDP port number at the R&S SMW for the HIL interface.

Parameters:

<UdpPort> integer

Range: 0 to 65535
*RST: 7755

Example: `SOURce1:BB:GNSS:RECeiver:V1:HIL:PORT 7756`

Manual operation: See "UDP Port" on page 20

[:SOURce<hw>]:BB:GNSS:RT:HWTime?

Queries the time elapsed since the simulation start.

To query the simulation start time, use the command:

`[:SOURce<hw>]:BB:GNSS:TIME:STARt:TIME`

Return values:

<ElapsedTime> float

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

Example: See `[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:A` on page 27.

Usage: Query only

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation[:SELect] <Location>

Selects the geographic location of the GNSS receiver.

Parameters:

<Location> string

User Defined
Enables the definition of the "Latitude", "Longitude" and "Altitude" of the GNSS receiver with fixed position in the ECEF WGS84 coordinate system.

"<City>"
Selects one of the predefined geographic locations, see Table 3-1. The parameters latitude, longitude and altitude are set according to the selected position.

Example: See Example"Setting the initial position of a receiver" on page 25.

Manual operation: See "Location, Initial Position" on page 17

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:CATalog

Queries the names of predefined geographic locations of the GNSS receiver. The query returns a comma-separated list of available locations.

For predefined geographic locations, see Table 3-1.

Example: See Example"Setting the initial position of a receiver" on page 25.

Manual operation: See "Location, Initial Position" on page 17

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:RFRame <ReferenceFrame>

Selects the reference frame used to define the receiver coordinates.

Parameters:

<ReferenceFrame> PZ90 | WGS84

*RST: WGS84

Manual operation: See "Reference Frame" on page 19

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:FORMat <PositionFormat>

Sets the format in which the latitude and longitude are set.

Parameters:

<PositionFormat> DMS | DECimal

*RST: DMS

Example: See Example"Setting the initial position of a receiver" on page 25.

Manual operation: See "Location Coordinates, Position Format" on page 19

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:DECimal:PZ <Longitude>, <Latitude>, <Altitude>

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:DECimal[:WGS] <Longitude>, <Latitude>, <Altitude>

Defines the coordinates of the geographic location of the GNSS receiver in decimal format.

Parameters:

<Longitude> float

Defines the longitude.

Range: -180 to 180
Increment: 1E-7
*RST: 0

<Latitude> float

Defines the latitude.

Range: -90 to 90
Increment: 1E-7
*RST: 0

<Altitude> float

Defines the altitude. The altitude value is in meters and is the height above the reference ellipsoid.

Range: -10E3 to 50E6
Increment: 0.01
*RST: 0

Manual operation: See "Location Coordinates, Position Format" on page 19

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:DMS:PZ <LongitudeDeg>, <LongitudeMin>, <LongitudeSec>, <LongitudeDir>, <LatitudeDeg>, <LatitudeMin>, <LatitudeSec>, <LatitudeDir>, <Altitude>

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:LOCation:COORdinates:DMS[:WGS] <LongitudeDeg>, <LongitudeMin>, <LongitudeSec>, <LongitudeDir>, <LatitudeDeg>, <LatitudeMin>, <LatitudeSec>, <LatitudeDir>, <Altitude>

Defines the coordinates of the geographic location of the GNSS receiver in degrees, minutes and seconds.

Parameters:

<LongitudeDeg> integer

Defines the longitude degrees.

Range: 0 to 180
*RST: 0

<LongitudeMin> integer

Defines the longitude minutes.

Range: 0 to 59
*RST: 0

<LongitudeSec> float

Defines the longitude seconds.

Range: 0 to 59.999
Increment: 1E-4
*RST: 0

<LongitudeDir> EAST | WEST

Defines the longitude direction.

*RST: EAST

<LatitudeDeg> integer

Defines the latitude degrees.

Range: 0 to 90
*RST: 0

<LatitudeMin>	integer Defines the latitude minutes. Range: 0 to 59 *RST: 0
<LatitudeSec>	float Defines the latitude seconds. Range: 0 to 59.999 Increment: 1E-4 *RST: 0
<LatitudeDir>	NORTh | SOUTh Defines the latitude direction. *RST: NORT
<Altitude>	float Defines the altitude. The altitude value is in meters and is the height above the reference ellipsoid. Range: -10E3 to 50E6 Increment: 0.01 *RST: 0

Manual operation: See "Location Coordinates, Position Format" on page 19

[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:ATTitude[:BEHaviour] <AtitudeBehaviou>

Defines how the attitude information is defined.

Parameters:

<AtitudeBehaviou> CONStant | FILE | MOTion | SPINning | REMote

`FILE` enabled if smoothing is not used.

Options: CONStant | FILE | MOTion | SPINning require R&S SMW-K108
REMote requires R&S SMW-K109

Manual operation: See "Attitude Behaviour, More" on page 20

List of commands

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