Described are the following software options:

- R&S® SMW-K109

This manual describes firmware version FW 4.70.026.xx and later of the R&S® SMW200A.
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1 Preface

1.1 About This Manual

This user manual provides all the information specific to the hardware in the loop (HIL) option. All general instrument functions and settings common to all applications and operating modes are described in the main R&S SMW user manual. All GNSS specific settings are described in the R&S SMW GNSS user manual.

The main focus in this manual is on the provided settings and the tasks required to generate a signal when R&S SMW works in a hardware in the loop (HIL) setup. The following topics are included:

- **Welcome to the hardware in the loop (HIL) option R&S SMW-K109**
  Introduction to and getting familiar with the options

- **Tips for best results**
  Background information on basic terms and principles in the context of HIL operation
  The basic procedure to perform latency calibration tasks and step-by-step instructions for more complex tasks or alternative methods
  As well as detailed examples to guide you through typical signal generation scenarios and allow you to try out the application immediately

- **HIL configuration and settings**
  A concise description of all functions and settings available to configure signal generation with their corresponding remote control command

- **Remote control commands**
  Remote commands required to configure and perform signal generation in a remote environment
  (Commands required to set up the instrument or to perform common tasks on the instrument are provided in the main R&S SMW user manual)
  Programming examples demonstrate the use of many commands and can usually be executed directly for test purposes

- **List of remote commands**
  Alphabetical list of all remote commands described in the manual

- **Index**

**Contents and scope**

This description assumes R&S SMW equipped with all available options. Depending on your model and the installed options, some of the functions may not be available on your instrument.

**Notes on screenshots**

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

Hardware in the Loop (HIL)

6

User Manual 1178.8394.02 ─ 05

Documentation Overview

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.

1.2 Documentation Overview

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

www.rohde-schwarz.com/manual/smw200a

1.2.1 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.

1.2.2 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.

1.2.3 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.
1.2.4 Service Manual

Describes the performance test for checking the rated specifications, module replacement and repair, firmware update, troubleshooting and fault elimination, and contains mechanical drawings and spare part lists.

The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS, https://gloris.rohde-schwarz.com).

1.2.5 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.

1.2.6 Basic Safety Instructions

Contains safety instructions, operating conditions and further important information. The printed document is delivered with the instrument.

1.2.7 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

1.2.8 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 open source acknowledgment document provides verbatim license texts of the used open source software.

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

1.2.9 Application Notes, Application Cards, White Papers, etc.

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

2 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 acts as a slave and is remotely controlled by master application software (see Figure 2-1). The 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).

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.

![Figure 2-1: Example of HIL test setup](image-url)
3 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 3.1, "Synchronization", on page 9).

2. Take measures for latency calibration.
   (see Chapter 3.3, "Latency Calibration", on page 10).

3. Add additional buffer time.
   Chapter 3.4, "Adding a Constant Delay to Compensate for Command Jitter",
   on page 12

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.
   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.

3.1 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 9
- Always take the measures for latency calibration as described in Chapter 3.3, "Latency Calibration", on page 10.
- 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"

3.2 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 \( t_{\text{cal.latency}} \) 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 \( t_{\text{cal.latency}} \) 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 3.3, "Latency Calibration", on page 10. The system latency and the latency are related as follows:

\[
\text{System Latency} = t_{\text{cal.latency}} + 0.02
\]

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

See also:
- Chapter 3, "Tips for Best Results", on page 9

3.3 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 3.1, "Synchronization", on page 9).

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 position 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 \(t_0\):
   \[
   \Delta_{HW,0} = t_{MS,0} - t_{GNSS,0}
   \]
   **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 \(t_{ElapsedTime,1}\)
   \[
   t_{ElapsedTime,1} = t_{MS,1} \cdot \Delta_{HW,0}
   \]
   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:

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 \( t_{\text{cal.latency},i} = t_{\text{HW},i} - t_{\text{ElapsedTime},i} \). If UDP is used, send the \&GTL command after the query.

7. If \( t_{\text{cal.latency},i} \geq |\text{System Latency - 20 ms}| \), perform the following:
   a) Calculate \( \Delta_{\text{HW},j} = \Delta_{\text{HW},j-1} + t_{\text{cal.latency},i} \)
      Where:
      - \( i \) reflects the HIL update rate
      - \( j \) is the latency calibration iteration number
   b) Calculate the elapsed time \( t_{\text{ElapsedTime},i+1} = t_{\text{MS},i+1} - \Delta_{\text{HW},j} \)
   c) Send the subsequent HIL command as a function of \( t_{\text{MS},i+1} \) and \( P_i \)

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

Where \(<\text{MaxLatency}> , <\text{MinLatency}> , <\text{MinUsed}> , <\text{CmdReceived}> , <\text{CmdSync}> \) and \(<\text{CmdInterp}>\) 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 3.4, "Adding a Constant Delay to Compensate for Command Jitter", on page 12.
   - Query HIL statistical information and analyze the values of the parameters \(<\text{CmdExtrap}>\) and \(<\text{CmdPredict}>\).
      They indicate the number of times the prediction algorithm has been applied, see Chapter 3.6, "Trajectory Prediction", on page 14.

### 3.4 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 \( t_{\text{buffer}} \) 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\text{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 t\text{Delay}. The additional buffer time t\text{Buffer} is calculated as follows:

\[ t_{\text{Buffer}} = t_{\text{Delay}} - 0.02 \]

Where t\text{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\text{Buffer} > 0 ms, the system latency equation changes as follows:

\[ \text{System Latency} = t_{\text{cal.latency}} + t_{\text{Delay}} = t_{\text{cal.latency}} + t_{\text{Buffer}} + 0.02 \]

Finding out the best system latency value t\text{Delay}

1. Select the initial t\text{Delay} value depending on whether the motion simulator is equipped with real-time processor or not:
   - With real-time processor: \( <\text{Delay}> = 0.02 \text{ s} \)
   - Without real-time processor: \( <\text{Delay}> = 0.15 \text{ s} \)


3. Evaluate the absolute minimum value returned for the parameter \( <\text{MinUsed}> \).

4. Reduce the t\text{Delay} value. Evaluate the statistics again.

Repeat this step until \( <\text{MinUsed}>_{\min} \geq 1 \).

Example:

If the R&S SMW and the motion simulator are connected in a HIL setup and:

- HIL update rate = 0.1 s
- t\text{Delay} = 0.05 s
- t\text{Buffer} = 0.03 s.

- In a non-synchronized setup with, for example, \( t_{\text{cal.latency}} = 0.04 \text{ s} \), the current system latency is:
  \[ \text{System Latency} = 0.04 + 0.05 = 0.09 \text{ s} \]

- After the R&S SMW and the motion simulator are synchronized \( (t_{\text{cal.latency}} = 0 \text{ s}) \), the system latency becomes:
  \[ \text{System Latency} = 0 + 0.05 = 0.05 \text{ s} \]

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 3.3, "Latency Calibration", on page 10.

**Related settings:**
- Chapter 3.2, "System Latency", on page 10

### 3.5 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 3.6, "Trajectory Prediction", on page 14).

### 3.6 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 $v = 1 \text{ m/s}$ and it stops ($v = 0 \text{ m/s}$) after 0.1 s ($t_1 = t_0 + 0.1 \text{ s}$).

If the latency exceeds 10 ms, then the R&S SMW projects the movement assuming that the vehicle keeps its velocity $v = 1 \text{ m/s}$. 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 $v = 0 \text{ m/s}$. 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 3, "Tips for Best Results", on page 9.
4 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 geographic location of a static GNSS receiver ("Position > Static").
Selects the initial position of the hardware in the loop GNSS receiver ("Position > From Remote").
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 fixed geographic location (see Table 4-1). The parameters "Latitude", "Longitude" and "Altitude" are set automatically.

Table 4-1: Coordinates of the simulated predefined positions

<table>
<thead>
<tr>
<th>Continent</th>
<th>City</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>America</td>
<td>New York</td>
<td>40.7142</td>
<td>-74.0064</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>San Francisco</td>
<td>37.8194388888</td>
<td>-122.4784944</td>
<td>35</td>
</tr>
<tr>
<td>Asia</td>
<td>Beijing</td>
<td>39.90555555555</td>
<td>116.3913888888</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>New Delhi</td>
<td>28.61388889</td>
<td>77.2088889</td>
<td>216</td>
</tr>
<tr>
<td></td>
<td>Seoul</td>
<td>37.5515</td>
<td>126.987794444444</td>
<td>265</td>
</tr>
<tr>
<td></td>
<td>Singapore</td>
<td>1.31131111111111</td>
<td>103.826852777777</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Taipei</td>
<td>25.022344444444</td>
<td>121.514758333333</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Tokyo</td>
<td>35.683861111111</td>
<td>139.745058333333</td>
<td>45</td>
</tr>
<tr>
<td>Australia</td>
<td>Sydney</td>
<td>-33.8833</td>
<td>151.2167</td>
<td>3</td>
</tr>
<tr>
<td>Europe</td>
<td>London</td>
<td>51.500625</td>
<td>-0.1246222</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Moscow</td>
<td>55.752222</td>
<td>37.615556</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Munich</td>
<td>48.150</td>
<td>11.5833</td>
<td>508</td>
</tr>
<tr>
<td></td>
<td>Paris</td>
<td>48.8584</td>
<td>2.29462777777777</td>
<td>66</td>
</tr>
</tbody>
</table>

Remote command:

[:SOURce<hw>:BB:GNSS:RECeiver[:V<st>]:LOCation:CATalog on page 30
[:SOURce<hw>:BB:GNSS:RECeiver[:V<st>]:LOCation[:SELect] on page 30

Reference Frame
Select the reference frame used to define the receiver coordinates. The transformation between the reference frames is performed automatically.

The following applies:

- \[ X_{WGS84} = (1 - 0.008*10^{-6})X_{PZ90} - 0.2041*10^{-7}Y_{PZ90} + 0.1716*10^{-7}Z_{PZ90} - 0.013 \]
- \[ Y_{WGS84} = (1 - 0.008*10^{-6})Y_{PZ90} - 0.2041*10^{-7}X_{PZ90} + 0.1115*10^{-7}Z_{PZ90} + 0.106 \]
- \[ Z_{WGS84} = (1 - 0.008*10^{-6})Z_{PZ90} - 0.1716*10^{-7}X_{PZ90} - 0.1115*10^{-7}Y_{PZ90} + 0.022 \]

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 31
**Attitude Behaviour**
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. This setting is a read-only value.

Remote command:
```
[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:ATTitude[:BEHaviour]
```
on page 31

**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 default 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 master application program.

Remote command:
```
[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:SLATency
```
on page 29

**Interface Type**
Option: R&S SMW-K109
Two interface types are provided for the HIL communication between the R&S SMW and the master application program, which remotely controls the R&S SMW:

"SCPI"
An 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 master application program.

Remote command:
```
[:SOURce<hw>]:BB:GNSS:RECeiver[:V<st>]:HIL:ITYPe
```
on page 29

**UDP Port**
Option: R&S SMW-K109
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 29
5 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 5-1 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 master application, use the command &GTL for this purpose.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Size</th>
<th>Parameter</th>
<th>Description</th>
<th>Default unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>integer</td>
<td>4 bytes</td>
<td>reserve0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>integer</td>
<td>4 bytes</td>
<td>reserve1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>integer</td>
<td>4 bytes</td>
<td>reserve2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>integer</td>
<td>4 bytes</td>
<td>reserve3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>ElapsedTime</td>
<td>Elapsed time since the simulation start</td>
<td>s</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;X&gt;</td>
<td>Coordinate in the Earth Fixed Earth Centered (ECEF) coordinate system</td>
<td>m</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;Y&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;Z&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;XDot&gt;</td>
<td>Velocity vector in ECEF (equivalently &lt;Vx&gt;,&lt;Vy&gt;,&lt;Vz&gt;)</td>
<td>m/s</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;YDot&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;ZDot&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;XDotDot&gt;</td>
<td>Acceleration vector in ECEF (equivalently &lt;Ax&gt;,&lt;Ay&gt;,&lt;Az&gt;)</td>
<td>m/s^2</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;YDotDot&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;ZDotDot&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;XDotDotDot&gt;</td>
<td>Jerk vector in ECEF (equivalently &lt;Jx&gt;,&lt;Jy&gt;,&lt;Jz&gt;)</td>
<td>m/s^3</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;YDotDotDot&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;ZDotDotDot&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;Roll&gt;</td>
<td>Attitude angles (yaw/heading, pitch/elevation, roll/bank)</td>
<td>rad</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;Pitch&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>&lt;Yaw&gt;</td>
<td>Unlimited value range to simulate more than one cycle rotation between two updates</td>
<td></td>
</tr>
<tr>
<td>Data Type</td>
<td>Size</td>
<td>Parameter</td>
<td>Description</td>
<td>Default unit</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>-----------</td>
<td>----------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>RDot</td>
<td>Attitude angular rate of change</td>
<td>rad/s</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>PDot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>YDot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>RDotDot</td>
<td>Attitude second order derivative</td>
<td>rad/s²</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>PDotDot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>YDotDot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>RDotDotDot</td>
<td>Attitude third order derivative</td>
<td>rad/s³</td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>PDotDotDot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>double</td>
<td>8 bytes</td>
<td>YDotDotDot</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6 SCPI Position Data

In typical remote operation, the master 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.
7 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:

<table>
<thead>
<tr>
<th>Suffix</th>
<th>Value range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOURce&lt;hw&gt;</td>
<td>[1] to 4</td>
<td>available baseband signals</td>
</tr>
<tr>
<td>V&lt;st&gt;</td>
<td>1 to 2</td>
<td>number of simulated vechicles</td>
</tr>
<tr>
<td>V&lt;us&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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


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, $t_{\text{Delay}} = 0.02$ s

Figure 7-1: 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 ($<\text{CmdUsed}> < <\text{CmdReceived}>$)
5 = Not all commands are applied at their specified time ($<\text{CmdSync}> < <\text{CmdUsed}>$)
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, $t_{\text{Delay}} = 0.15$ s

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

Figure 7-2: Impact of the increased $t_{\text{Delay}}$

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 $t_{\text{Delay}}$ (see Chapter 3.4, "Adding a Constant Delay to Compensate for Command Jitter", on page 12)

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

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

Figure 7-3: 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:LATeny?]..................................26
[:SOURce<hw>:BB:GNSS:RECeiver[V<st>]:HIL:SLATency.................................................29
[:SOURce<hw>:BB:GNSS:RECeiver[V<st>]:HIL:ITYPe......................................................29
[:SOURce<hw>:BB:GNSS:RECeiver[V<st>]:HIL:PORT ..........................................................29
[:SOURce<hw>:BB:GNSS:RECeiver[V<st>]:HIL:SLATency.................................................29
[:SOURce<hw>:BB:GNSS:RECeiver[V<st>]:LOCation[SELect].............................30
[:SOURce<hw>:BB:GNSS:RECeiver[V<st>]:LOCation:CATalog..............................30
[:SOURce<hw>:BB:GNSS:RECeiver[V<st>]:LOCation:COORdinates:RFFrame...............31
[:SOURce<hw>:BB:GNSS:RECeiver[V<st>]:ATTitude[BEHaviour].............................31
```

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 7-1: SCPI parameter description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Default unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;X&gt;,&lt;Y&gt;,&lt;Z&gt;</td>
<td>Mandatory Coordinate in the Earth Fixed Earth Centered (ECEF) coordinate system</td>
<td>m</td>
</tr>
<tr>
<td>&lt;XDot&gt;,&lt;YDot&gt;,&lt;ZDot&gt;</td>
<td>Mandatory Velocity vector in ECEF (equivalently Vx, Vy, Vz)</td>
<td>meter/sec</td>
</tr>
<tr>
<td>&lt;XDotDot&gt;,&lt;YDotDot&gt;,&lt;ZDotDot&gt;</td>
<td>Mandatory Acceleration vector in ECEF (equivalently Ax, Ay, Az )</td>
<td>meter/sec</td>
</tr>
<tr>
<td>&lt;XDotDotDot&gt;,&lt;YDotDotDot&gt;,&lt;ZDotDotDot&gt;</td>
<td>Mandatory Jerk vector in ECEF (equivalently Jx, Jy, Jz )</td>
<td>meter/sec</td>
</tr>
<tr>
<td>[&lt;Roll&gt;,&lt;Pitch&gt;,&lt;Yaw&gt;]</td>
<td>Optional Attitude angles (yaw/heading, pitch/elevation, roll/bank)</td>
<td>Radians</td>
</tr>
</tbody>
</table>

Unlimited value range to simulate more that one cycle rotation between two updates
Parameter | Description | Default unit
--- | --- | ---
[<RDot>,<PDot>,<YDot>] | Optional | Attitude angular rate of change | rad/sec
[<RDotDot>,<PDotDot>,<YDotDot>] | Optional | Attitude angular second order derivative | rad/sec^2
[<RDotDotDot>,<PDotDotDot>,<YDotDotDot>] | Optional | Attitude angular third order derivative | rad/sec^3

See also Chapter 3.3, "Latency Calibration", on page 10.

For HIL mode A, position data can also be retrieved via UDP packets, see Chapter 5, "UDP Position Data", on page 19.

**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 7-1.

**Usage:**

- *Setting only*

```plaintext
[:SOURce<hw>]:BB:GNSS:RT:RECeiver[:V<st>]:HILPosition:MODE:B
<ElapsedTime>, <Latitude>, <Longitude>, <Altitude>, <NDot>, <EDot>, <DDot>,
<NDotDot>, <EDotDot>, <DDotDot>

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 7-2: Parameter description**

| Parameter | Description | Default unit
--- | --- | ---
<Latitude>, <Longitude>, <Altitude> | Mandatory | Geodetic location | degrees
<NDot>,<EDot>,<DDot> | Mandatory | Velocity vector in the North East Down (NED) coordinate system (equivalently Vn, Ve, Vd) | meters/second
### Hardware in the Loop (HIL)

#### Remote-Control Commands

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Default unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt;\text{NDotDot}),\n(&lt;\text{EDotDot}),\n(&lt;\text{DDotDot}&gt;))</td>
<td>Mandatory Acceleration vector in NED (equivalently An, Ae, Ad)</td>
<td>meters/second^2</td>
</tr>
<tr>
<td>(&lt;\text{NDotDotDot}),\n(&lt;\text{EDotDotDot}),\n(&lt;\text{DDotDotDot}&gt;))</td>
<td>Mandatory Jerk vector in NED (equivalently Jn, Je, Jd)</td>
<td>meters/second^3</td>
</tr>
<tr>
<td>[(&lt;\text{Roll}),\n(&lt;\text{Pitch}&gt;,\n(&lt;\text{Yaw})&gt;])</td>
<td>Optional Attitude angles (yaw/heading, pitch/elevation, roll/bank) Unlimited value range to simulate more that one cycle rotation between two updates</td>
<td>Radians</td>
</tr>
<tr>
<td>[(&lt;\text{RDot}&gt;,\n(&lt;\text{PDot}),\n(&lt;\text{YDot}&gt;])</td>
<td>Optional Attitude angular rate of change</td>
<td>rad/sec</td>
</tr>
<tr>
<td>[(&lt;\text{RDotDot}),\n(&lt;\text{PDotDot}),\n(&lt;\text{YDotDot}&gt;])</td>
<td>Optional Attitude angular second order derivative</td>
<td>rad/sec^2</td>
</tr>
<tr>
<td>[(&lt;\text{RDotDotDot}),\n(&lt;\text{PDotDotDot}),\n(&lt;\text{YDotDotDot}&gt;])</td>
<td>Optional Attitude angular third order derivative</td>
<td>rad/sec^3</td>
</tr>
</tbody>
</table>

See also Chapter 3.3, "Latency Calibration", on page 10.

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 5, "UDP Position Data", on page 19.

**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 7-2. | Range: 0 to 99999999 |

**Usage:** Setting only

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

Queries the time delay (or prediction latency) 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.

You can use the retrieved value for latency calibration, see Chapter 3.3, "Latency Calibration", on page 10.

**Return values:**

<table>
<thead>
<tr>
<th>Latency</th>
<th>float</th>
<th>Range: min to max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Increment: 0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*RST: 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default unit: s</td>
</tr>
</tbody>
</table>
Usage: Query only

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

Queries the current latency $t_{\text{cal.latency}}$ and statistics on the latency values. This command returns also information on the minimum and maximal deviation from zero latency and the number of non-zero latency values measured since the last time this query was sent.

The following terms are used:
- **HIL command** refers to the command $[:\text{SOURce<hw>}]:\text{BB}:\text{GNSS}:\text{RT}:\text{RECeiver}[:\text{V<st>}]:\text{HILPosition}:\text{MODE}:A$
- **Dropped commands** are commands that are evaluated, buffered but not applied because they become outdated as more up-to-date information is received
- **Returned values** apply for the period from the last time the query was sent.

See also Chapter 3.3, "Latency Calibration", on page 10.

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
### Remote-Control Commands

#### Hardware in the Loop (HIL)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;NoZeroValues&gt;</code></td>
<td>Integer&lt;br&gt;Number of non-zero latency values since the last time this query was sent. *RST: 0</td>
</tr>
<tr>
<td><code>&lt;CmdReceived&gt;</code></td>
<td>Integer&lt;br&gt;The number of received HIL commands since the last time this query was sent. *RST: 0</td>
</tr>
<tr>
<td><code>&lt;CmdUsed&gt;</code></td>
<td>Integer&lt;br&gt;The number of used HIL commands, excluding the dropped HIL commands, since the last time this query was sent. *RST: 0</td>
</tr>
<tr>
<td><code>&lt;CmdSync&gt;</code></td>
<td>Integer&lt;br&gt;The number of HIL commands applied at their specified time. *RST: 0</td>
</tr>
<tr>
<td><code>&lt;CmdExterp&gt;</code></td>
<td>Integer&lt;br&gt;The number of extrapolated HIL commands. The commands are applied later than their specified time. *RST: 0</td>
</tr>
<tr>
<td><code>&lt;CmdInterp&gt;</code></td>
<td>Integer&lt;br&gt;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</td>
</tr>
<tr>
<td><code>&lt;CmdPredict&gt;</code></td>
<td>Integer&lt;br&gt;The number of internal position updates performed by the prediction algorithm, see Chapter 3.6, &quot;Trajectory Prediction&quot;, on page 14. *RST: 0</td>
</tr>
<tr>
<td><code>&lt;MaxUsed&gt;</code></td>
<td>Integer&lt;br&gt;The maximum number buffered commands *RST: 0</td>
</tr>
<tr>
<td><code>&lt;MinUsed&gt;</code></td>
<td>Integer&lt;br&gt;The minimum number buffered commands *RST: 0</td>
</tr>
</tbody>
</table>


**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 3.2, "System Latency", on page 10.

You can use the retrieved value for latency calibration, see Chapter 3.3, "Latency Calibration", on page 10.

Parameters:

<table>
<thead>
<tr>
<th>&lt;SystemLatency&gt;</th>
<th>float</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range:</td>
<td>0.002 to 0.15</td>
</tr>
<tr>
<td>Increment:</td>
<td>0.001</td>
</tr>
<tr>
<td>*RST:</td>
<td>0.02</td>
</tr>
<tr>
<td>Default unit:</td>
<td>s</td>
</tr>
</tbody>
</table>


Manual operation: See "System Latency" on page 18

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

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

Parameters:

<table>
<thead>
<tr>
<th>&lt;InterfaceType&gt;</th>
<th>SCPI</th>
<th>UDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>*RST:</td>
<td>SCPI</td>
<td></td>
</tr>
</tbody>
</table>

Example: SOURcel:BB:GNSS:RECeiver1:HIL:ITYPe UDP

Manual operation: See "Interface Type" on page 18

[: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:

<table>
<thead>
<tr>
<th>&lt;UdpPort&gt;</th>
<th>integer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range:</td>
<td>0 to 65535</td>
</tr>
<tr>
<td>*RST:</td>
<td>7755</td>
</tr>
</tbody>
</table>

Example: SOURcel:BB:GNSS:RECeiver1:HIL:PORT 7756

Manual operation: See "UDP Port" on page 18

[: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:**  

**Usage:**  
Query only

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

Selects the geographic location of the GNSS receiver.

**Parameters:**

<Location>  
"User Defined" | "New York" | "San Francisco" | "Beijing" |  
"New Delhi" | "Seoul" | "Singapore" | "Taipei" | "Tokyo" |  
"Sydney" | "London" | "Moscow" | "Munich" | "Paris"  
*User Defined*  
Enables the definition of the "Latitude", "Longitude" and "Altitude" of the GNSS receiver with fixed position in the ECEF WGS84 coordinate system.

"New York" | "San Francisco" | "Beijing" | "New Delhi" |  
"Seoul" | "Singapore" | "Taipei" | "Tokyo" | "Sydney" | "London" | "Moscow" | "Munich" | "Paris"  
*Selects one of the predefined fixed geographic locations. 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 22.

**Manual operation:**  
See "Location, Initial Position" on page 16

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

Queries the names of the predefined geographic locations.

**Example:**  
See Example "Setting the initial position of a receiver" on page 22.

**Manual operation:**  
See "Location, Initial Position" on page 16
[:SOURce<hw>]:BB:GNSS:RECiever[:V<st>]:LOCation:COORdinates:RFrame
<ReferenceFrame>

Select the reference frame used to define the receiver coordinates.

**Parameters:**
<ReferenceFrame>  PZ90 | WGS84
*RST:  WSG84

**Manual operation:**  See "Reference Frame" on page 17

[:SOURce<hw>]:BB:GNSS:RECiever[:V<st>]:ATTitude:[BEHaviour]
<AttitudeBehaviou>

Defines how the attitude information is defined.

**Parameters:**
<AttitudeBehaviou>  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" on page 18
List of Commands

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