R&S®SMBVB-K362, R&S®SMW-K362
Generic GNSS Test Suite
User Manual

1178912602
Version 05

ROHDE&SCHWARZ
Make ideas real

This manual describes the following R&S®CMWrun option for software version V1.9.12 or higher:

- R&S®SMBVB-K362 (generic GNSS test suite)
- R&S®SMW-K362 (generic GNSS test suite)

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

1178.9126.02 | Version 05 | R&S®SMBVB-K362, R&S®SMW-K362

The following abbreviations are used throughout this manual: Options R&S®SMBVB-K362 and R&S®SMW-K362 are abbreviated as R&S SMx-K362. R&S® is abbreviated as R&S.

Contents

1 Key features

The test suites R&S SMx-K362 provide generic GNSS tests with the sequencer tool R&S CMWrun. The tests are performed on a connected in-vehicle system (IVS).

The test equipment simulates a global navigation satellite system (GNSS). The R&S CMWrun controls the test equipment via SCPI commands and the IVS typically via vendor-specific commands. The test cases can be performed fully automatic, without user interaction.

Table 1-1: Supported test cases

Test case	Test purpose
1. Verify NMEA transmission from DUT	Checks that the GNSS receiver outputs the navigation parameter data to external devices in NMEA-0183 format
2. Location accuracy (static receiver)	Estimates the error in the evaluation of the plane view and altitude in the autonomous static mode. A static location is simulated and the error between actual and determined location is calculated
3. Location accuracy (moving receiver)	Estimates the error in the evaluation of the plane view, altitude and velocity in the dynamic mode with signal impairments. A certain trajectory is simulated, signal is faded and partly blocked. The velocity error and the error between actual and determined location as well as the velocity error is calculated
4. Time-to-first fix (TTFF) under cold start conditions	Determines the time to first navigation fix for a reset receiver. The ephemeris and almanac data from all satellites are cleared and thus, the receiver has to gain all data and the time to first fix is measured. One measurement step comprises signal acquisition at the TX level of -130 dBm and the cold start of the DUT, until it can acquire the signal again. The cold start is executed with specified repetitions. The averaged measurement time must not exceed configurable T_{PosFix} value. You can also change TX level configuring a power offset.
5. Reacquisition time	Evaluates the restore time for signal tracking for a certain GNSS constellation after tracking was lost due to signal blockage. To simulate blockage, the radio frequency signal is switched off for a specified time and the recovery time is measured after the signal was switched on. One measurement step comprises signal off, signal on, until the DUT can acquire the signal again. Each step is executed with specified repetitions.
6. Tracking and acquisition sensitivity	Verifies the sensitivity of the GNSS navigation module in signal acquisition mode and in tracking mode. The acquisition time is measured with the configurable start level and acquisition level (acquisition sensitivity). The tracking time is measured with the configurable signal level (tracking sensitivity). Acquisition and tracking step timeout is configurable.
7. Functional RAIM test	Checks the receiver autonomous integrity monitoring (RAIM) algorithm by degrading the pseudo range of several satellites over time in the simulated signal. The satellites are biased over time and detected satellites must be neglected after exceeding the specified threshold

2 Prerequisites

- R&S CMWrun base software, version 1.9.8 or higher.
  No smart card and no licenses are required for R&S CMWrun.

Required equipment for **R&S SMBVB-K362**:

- R&S SMBV100B for GNSS simulation must be equipped with the following options:

  Hardware:

  – HW option R&S SMBVB-B103

  Minimum required options:

  – R&S SMBVB-K520 real-time extension
  – R&S SMBVB-K44, GPS
  – R&S SMBVB-K106, SBAS

  Additional options for full test coverage:

  – R&S SMBVB-K66, Galileo
  – R&S SMBVB-K94, GLONASS
  – R&S SMBVB-K108, antenna pattern, spinning and attitude simulation for test location accuracy with moving receiver, blockage, and environment model (test case 4)

Required equipment for **R&S SMW-K362**:

- R&S SMW200A for GNSS simulation must be equipped with the following options:

  Hardware:

  – HW option R&S SMW-B10
  – HW option R&S SMW-B13
  – HW option R&S SMW-B103/-B203

  Minimum required options:

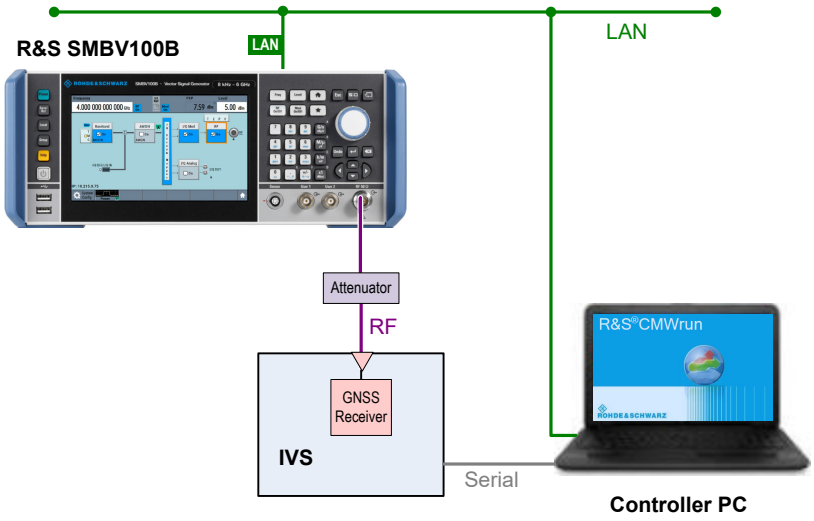
  – R&S SMW-K44, GPS
  – R&S SMW-K106, SBAS

  Additional options for full test coverage:

  – R&S SMW-K66, Galileo
  – R&S SMW-K94, GLONASS
  – R&S SMW-K108, antenna pattern, spinning and attitude simulation for test location accuracy with moving receiver, blockage, and environment model (test case 4)

3 Test setup

The following figure provides an overview of the test setup. In this example, the instrument R&S SMBV100B is used. The test setup with another supported instrument is similar.



The test setup comprises the following components:

- An instrument providing GNSS signals to the IVS for positioning.
  Connect the RF output port of the instrument to the RF port of the IVS (GNSS receiver).
- A computer executing the R&S CMWrun.
  The computer controls the instrument via SCPI connections (typically LAN). It controls the IVS typically via vendor-specific commands on a serial port interface.
- External attenuator is recommended for levels below -120 dBm, refer to "External Power Attenuation" on page 17.

4 System configuration

This chapter describes everything that you have to do before using the system for the first time. Skip this chapter if you already have an operable system.

4.1 Preparation of controller PC

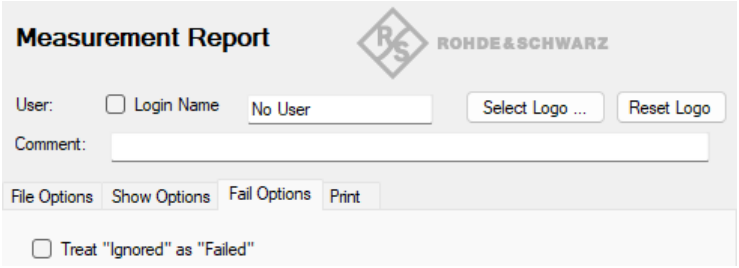
To set up the controller PC, install the base software of R&S CMWrun. No smart card and no licenses are required for the R&S CMWrun with the R&S SMx-K362 GNSS test suite.

Refer to the sequencer user manual, section Installation.

Ignore the message indicating no license is found.

4.2 Preparation of instrument connection

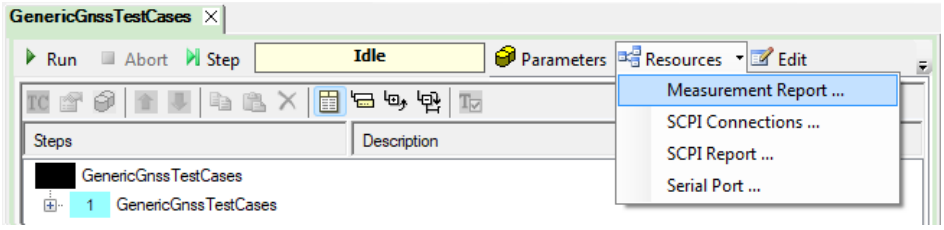
1. For remote control of the instrument, configure the resource settings "Resources" menu > "SCPI Connections". Configure the SCPI resource settings compatible to the instrument. For the control of R&S SMBV100B, use the entry with an alias "SMBV". For the control of R&S SMW200A, use the entry with an alias SMW. Refer to the sequencer user manual, section Resources > SCPI Connections.
2. Configure measurement report settings.
   For a standard view of the measurement report, deselect "Treat "Ignored" as "Failed"" in the configuration dialog of measurement report, tab "Fail Options".



   To access the measurement report configuration dialog, proceed as follows:

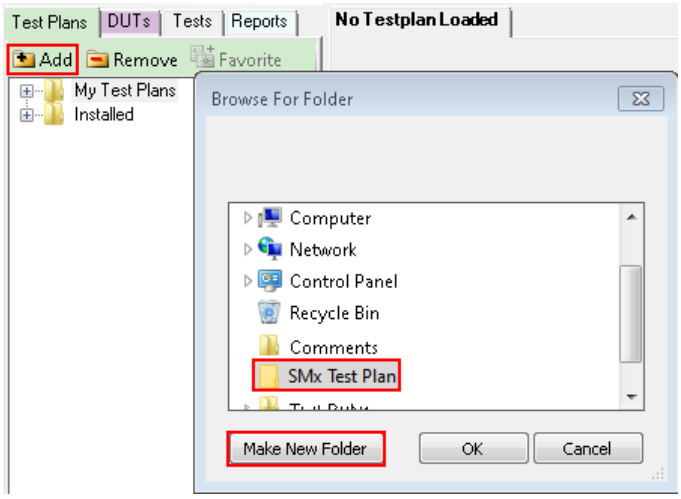
   a) To configure measurement report globally for all the tests, select "Resources" menu > "Measurement Report..."

b) For only test plan-specific measurement report settings, double-click your test plan in the "File Browsers" on the left, the tab "Test Plans". On the test plan toolbar, select "Resources" menu > "Measurement Report...", use the button "Create Specific Settings".
The settings of the test plan specific resources are saved within the test plan.



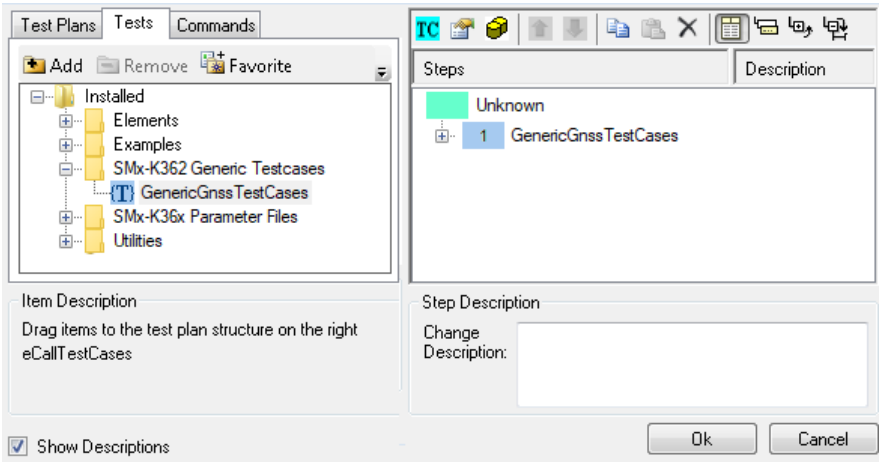
4.3 Preparation of IVS connection

1. For the remote control of an IVS, configure the resource settings in "Resources" menu > "Serial Port". Use settings compatible to your IVS.
   Refer to the sequencer user manual, section Resources > Serial Port.
2. The following steps configure DUT attributes and properties.
   Create your test plan:
   a) In the tab "Test Plans", specify a directory where you store your test plans.



   b) Open the configuration dialog via "File" > "New Testplan...".

c) In the tab "Tests", select the installed GNSS test plan.

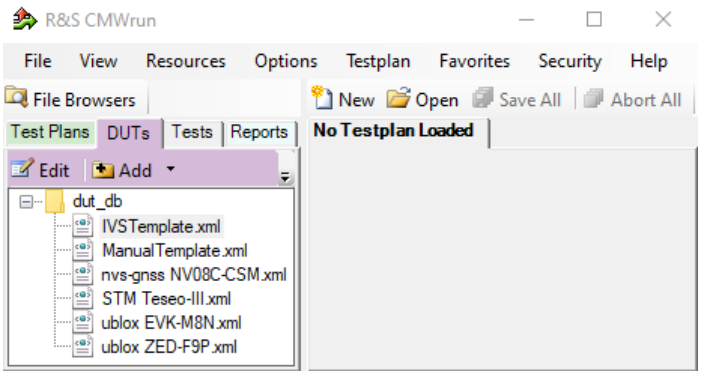


d) Press "OK".

3. **Save your test plan** in the directory created in step 2.

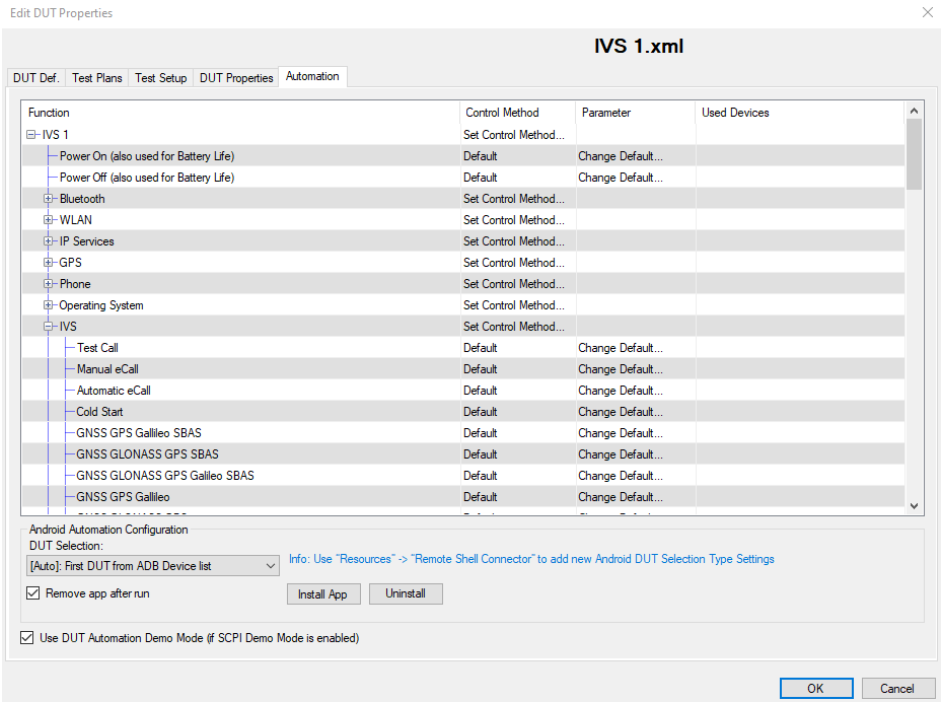
4. **Prepare your DUT's file**:

a) In the tab "DUTs", you find several predefined DUT's configurations. To create your own, double-click `IVSTemplate.xml` to open the configuration dialog "Edit DUT Properties".



b) Modify "Manufacturer" entry to assign DUTs name. Otherwise, you overwrite the predefined template.

c) In the tab "Automation", configure the DUT-related automation methods that are used for DUTs commands.
See also section DUT Files and Automation of the R&S CMWrun base manual.

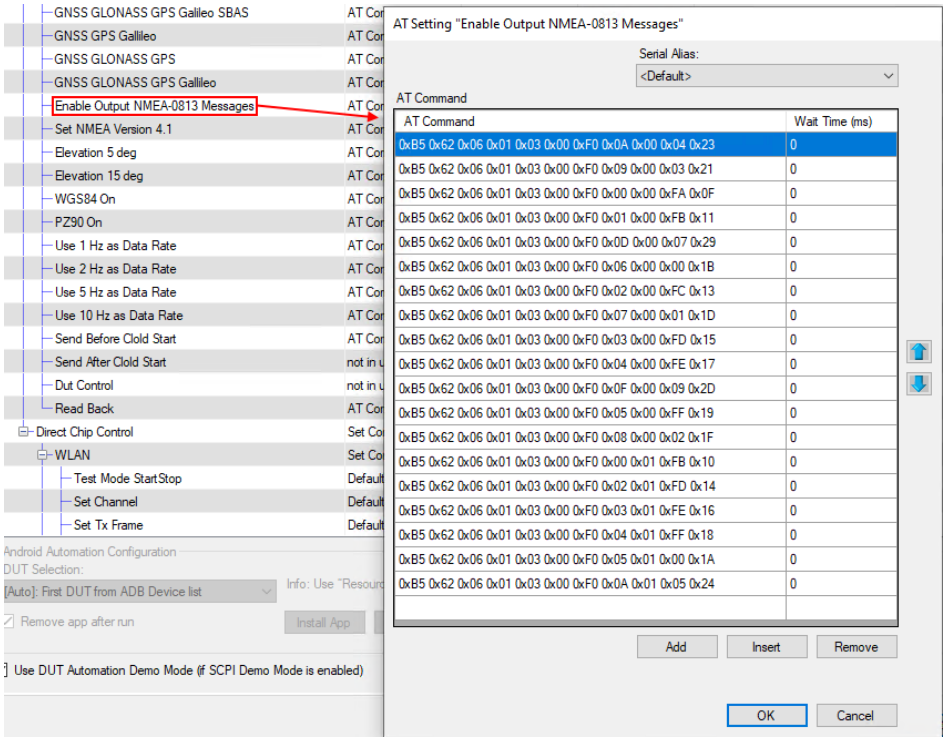


The test module supports the AT commands via COM ports and ADB commands. You can also mix control methods, e.g., ADB shell command sending with COM port NMEA reading. The default port is specified via "Resources" > "Serial Port".
Set all commands for which parameters are available. Furthermore, it is important to set the control method for the "IVS" -> "Read Back" function to read the NMEA stream properly.

For AT commands, map the serial ports accordingly to bi-directional or two-way usage.

- Bidirectional: uses a common serial port for IVS configuration and the transmission of NMEA messages.
- Two-way: configurates two serial ports to separate the control connection and the connection for NMEA data.

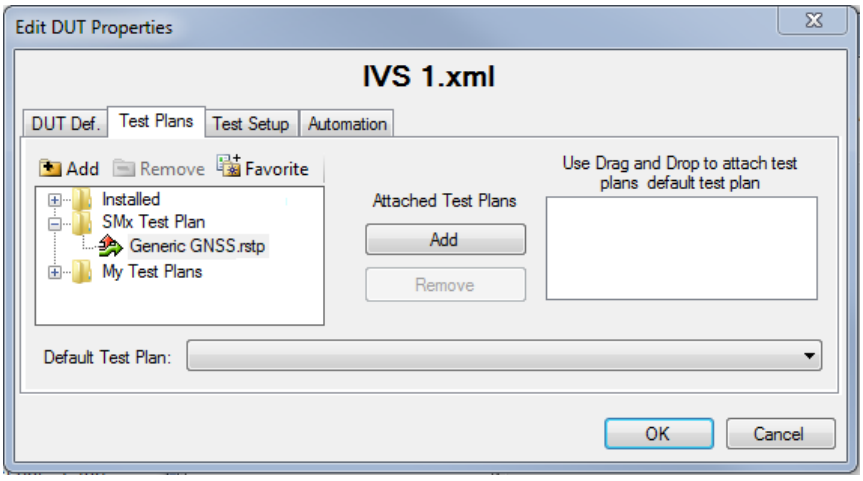
d) Each DUT command is connected to a new row in the corresponding dialog. A waiting time after the execution can be set for each single command. Set also not needed commands to "not in use" to avoid automated stops for manual input. ASCII or hexadecimal notations are supported.



e) Set all needed commands to control method "default"

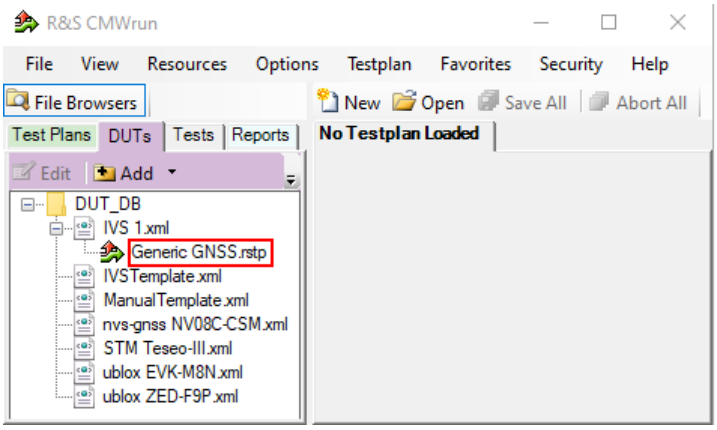
f) Set all not needed commands to control method "not in use"
During test case execution, only command requests for all "default" commands show up

5. **Assign a test plan to a DUT**:
In the tab "Test Plans", select your test plan created in step 2. Select "Add" and "OK".



Your test plan is now assigned to your DUT.

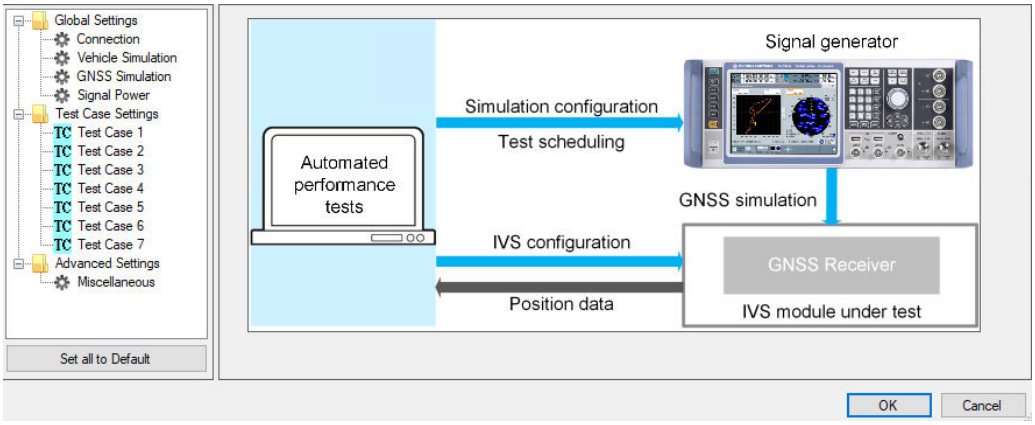
6. Always start your tests from the tab "DUTs" by double-clicking a test plan assigned to your DUT. It guarantees that the test plan executes the vendor-specific commands of your DUT. Otherwise, the test plan is aborted with the error "DUT type not found".



5 Test configuration

The property dialog box leads you to individual test configuration dialogs.

You can open the property dialog box from the "Testplan Details" subtab. Double-click the node, for example 1. Or select the node and click "Properties ...".



The property dialog box lists global settings, test case-specific settings for all supported GNSS test cases from test specifications, and advanced settings for non-conformance settings.

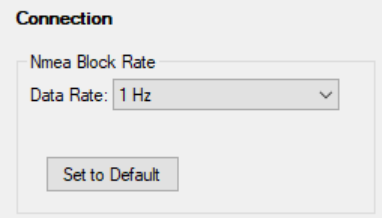
"Set all to Default" resets all settings: global settings, the settings of all test cases, and advanced settings.

Changing the default settings results in deviation from the recommendations of test specifications. Any such change is indicated in the measurement report. Test specification parameter values are always shown in the SCPI report.

Use the navigation tree on the left, to open the corresponding configuration dialog. For description, refer to the following sections.

5.1 Connection setting

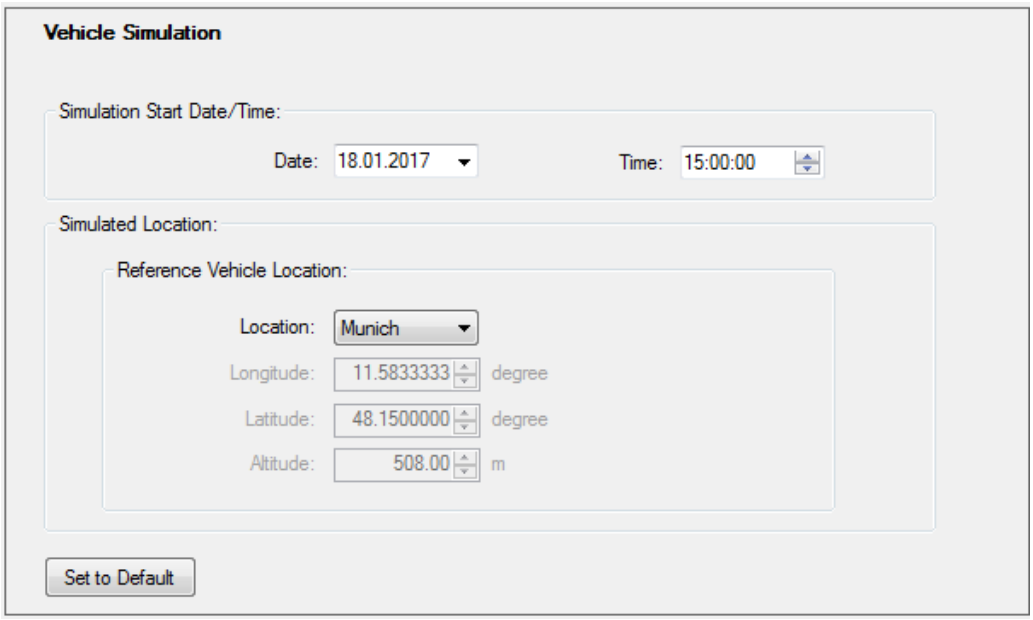
Specifies the data rate for NMEA stream transmitted by the GNSS generator.



Set to Default
Resets all settings in the dialog.

5.2 Vehicle simulation setting

The dialog specifies the geo-position of the IVS and simulates its movement.



Simulation Start Date/Time
Specifies the time signaled within the generated positioning data.

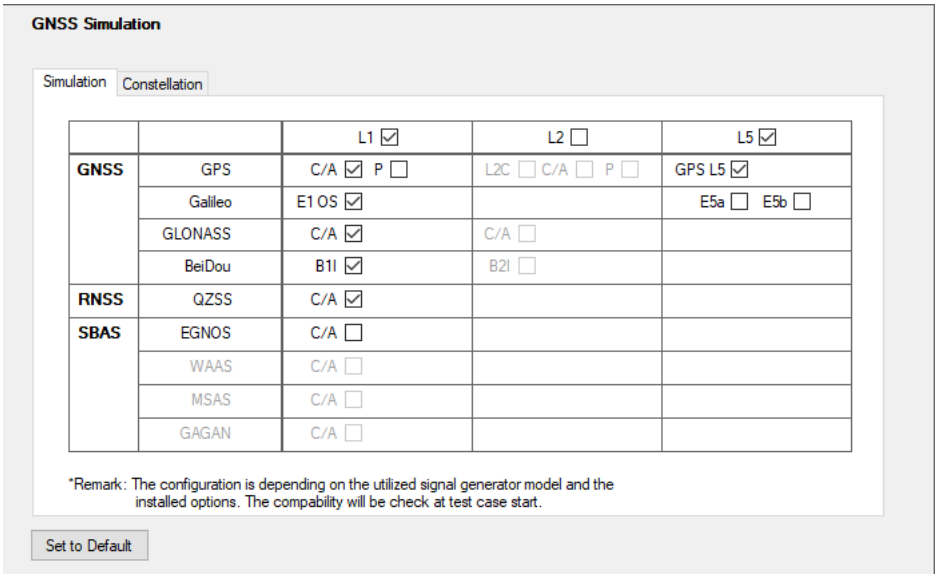
Reference Vehicle Location
Specifies the IVS location. Select a predefined location or specify a geographical position manually in coordinate system WGS84.

Set to Default
Resets all settings in the dialog.

5.3 GNSS simulation setting

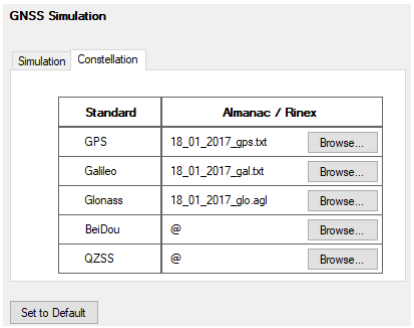
Defines the GNSS signal to be transmitted to the IVS during the measurements. The configuration uses three tabs: simulation and constellation.

Tab Simulation



Selects the satellite standard and signals to be transmitted. For choosing a signal, first select one or several bands (L1, L2, L5) and then the corresponding signals.

Tab Constellation



Selects navigation files simulating satellite positions.

Current GNSS almanac data can be downloaded from the Internet via:

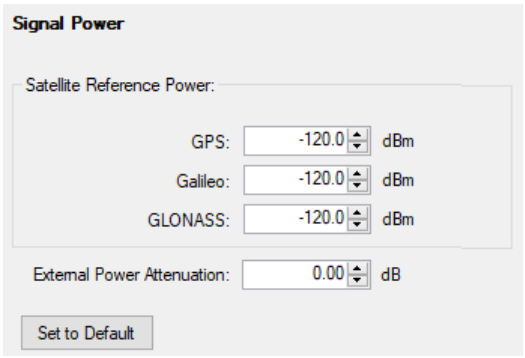
- https://www.navcen.uscg.gov/?Do=gpsArchives&exten=txt
- ftp://ftp.glonass-iac.ru/MCC/ALMANAC/
- RINEX files can be downloaded from http://cddis.gsfc.nasa.gov/gnss_data-sum.html#brdc
- Beidou files can be downloaded from http://www.csno-tarc.cn/support/downloads
- QZSS files can be downloaded from https://sys.qzss.go.jp/dod/en/archives/pnt.html
- SBAS (WAAS) files can be downloaded from ftp://ftp.nstb.tc.faa.gov/pub/NSTB_data/

- SBAS (EGNOS) files can be downloaded from http://www.egnos-pro.esa.int/ems/index.html

Set to Default
Resets all settings in the dialog.

5.4 Signal power setting

Configures RF power.



Received Satellite Power
Specifies the power of one GPS, Galileo, GLONASS, BeiDou, and QZSS satellite.

The power can be changed for every system individually if selected in a GNSS simulation.

External Power Attenuation
Specifies external power attenuation.

External attenuator is recommended for levels below -120 dBm for the following reasons:

- The level uncertainty increases for lower levels
- The maximum attenuation of the internal step attenuator is -150 dBW. Lower levels are achieved by reducing the internal amplification. The signal level goes down, but the noise floor remains at a constant level. Applying an external attenuator instead decreases the signal level and the noise floor to the same degree, thus maintaining the dynamic range.
- The minimum of the level setting range is -200 dBW. Attenuators are the only way to reach even lower levels

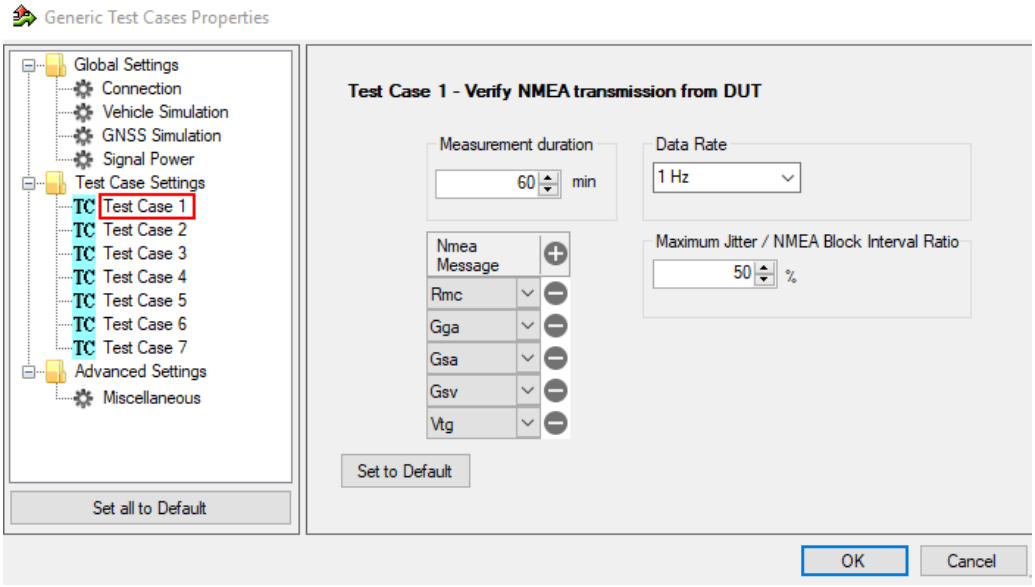
Refer to Chapter 3, "Test setup", on page 7.

Set to Default
Resets all settings in the dialog.

5.5 Test case setting

The dialog box lists all supported GNSS test cases from the selected test specification.

Click an individual test case to the left, to open the corresponding configuration dialog. Most of the signal settings are by default according to the test specification.



Several test cases contain self-explanatory settings as "Measurement Duration", "Total Test Duration...", or "Set to Default".

The total test duration per system specifies the total time for each subtest enabled in this test module per GNNS standard including waiting time (e.g. for acquisition).

The following description covers only the remaining settings.

Test Case 1
Verify NMEA transmission from DUT.

- **Data rate** for NMEA messages transmission
- **Maximum jitter /NMEA block interval ratio**: maximal jitter allowed for the transmission of NMEA block related to the NMEA data rate
- **NMEA message**: allowed types of NMEA messages received from the DUT. For other message types, the test fails.
  To add a message type into the list, use "+" sign. To remove it, use "-" sign. The drop-down list in each line allows you to replace a message type by another supported one.

Test Case 2
Location accuracy (static receiver)

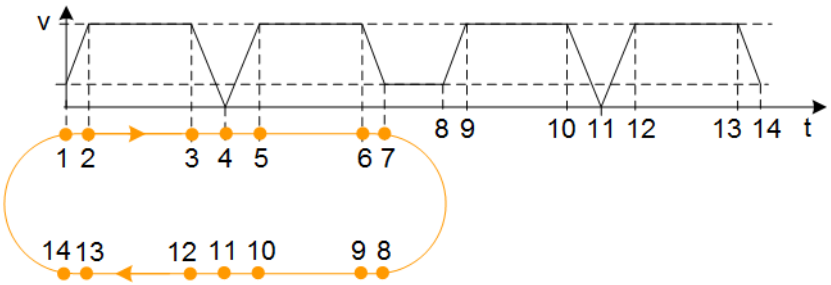
Specifies the test and measurement durations, and test limit values for the static receiver.

- **Planimetric error**: error threshold for the position estimation
- **Linear error confidence interval**: error threshold for the position estimation as a percentage value

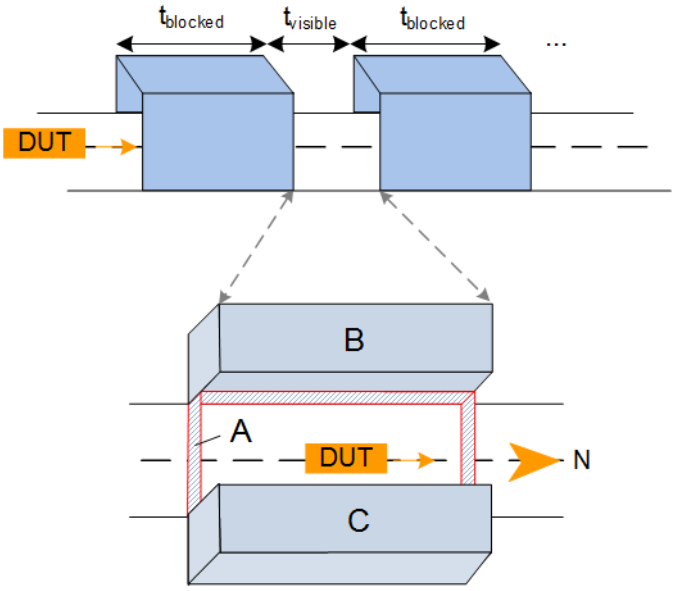
The map displays the simulated geographical location as configured in Vehicle simulation setting.

Test Case 3
Location accuracy (moving receiver)

- **Movement model**:
  The predefined movement file `eCallT3_T4.txt` for eCall is provided in the installation package. It specifies the starting position of the DUT in Munich, Germany, an elliptical trajectory with changing velocity.



  A user-defined movement model can also be selected.
- **Error thresholds** define the test limit values for a moving receiver, see also "Test Case 2" on page 19.
- **Blockage** model simulates a vehicle passing through two tunnels one after another.
  To use the blockage model, enable the "Blockage" and specify the time duration when the satellite is invisible ("$t_{blocked}$") and visible ("$t_{visible}$").
- **Environment** model simulates a partial blocking of the GNSS signal in a low elevation angle, e.g., due to a building.
  To use the environment model, enable the "Environment" checkbox. Then the satellite signal is visible, but partly blocked as specified via the antenna pattern file `eCallUrbanCanyon.ant_pat` for partial blocking, e.g., between two buildings. This predefined file for `eCall` is provided in the installation package. It specifies the following antenna pattern:



A user-defined environment model can also be used.

Table 5-1: Predefined urban canyon

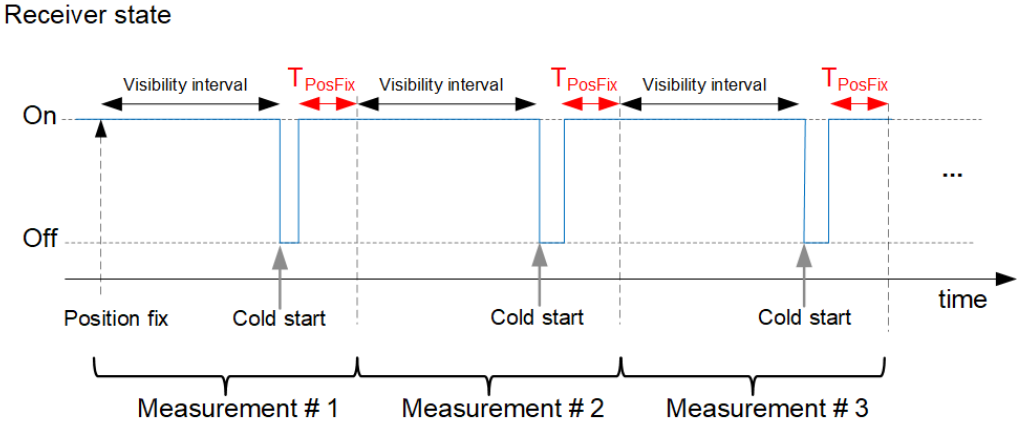
Zone	Elevation	Azimuth	Attenuation	Description
A	0° to 5°	0° to 360°	≦ -100 dB	No signal
B	5° to 30°	210° to 330°	-40 dB	Shield to the west
C	5° to 30°	30° to 150°	-40 dB	Shield to the east
	remaining	remaining	0 dB	Open sky

Test Case 4

Time-to-first fix under cold start conditions

Configures the number of measurements and the power offset to the reference satellite system power.

One measurement comprises a configurable visibility interval, cold start of the DUT while satellites are continuously available and the configurable recovery time T_{PosFix}, refer to the following figure.

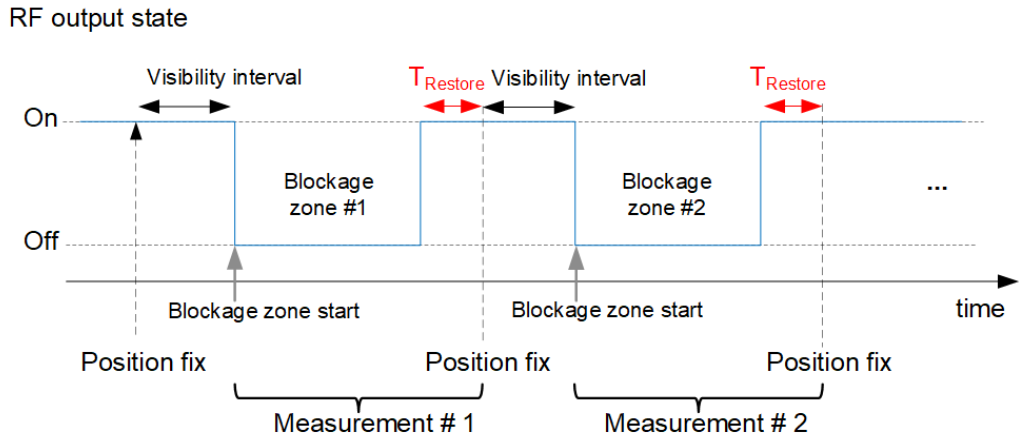


The DUT is required to acquire the signal again within the specified T_{PosFix}.

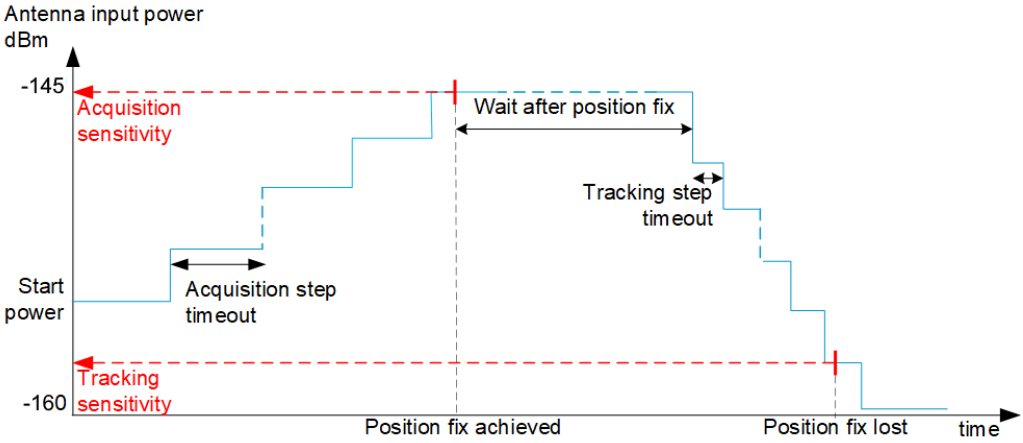
Test Case 5
Reacquisition time

Configures the number of measurements. One measurement comprises a visibility interval, cold start of the DUT and the specified recovery time T_{PosFix}.

The DUT is required to acquire the signal again within the specified T_{PosFix}.



Test Case 6
Tracking and acquisition sensitivity

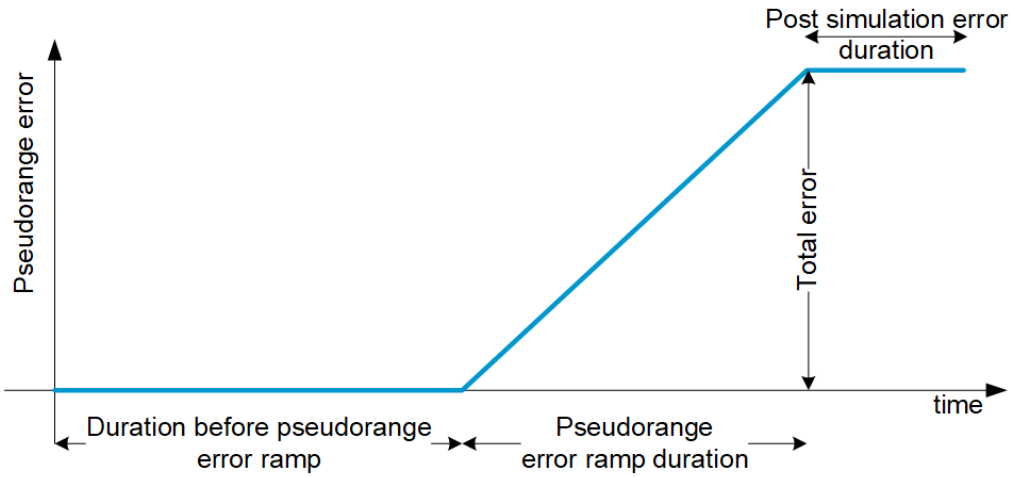


- **Start power**: The initial power in the acquisition phase.
- **Acquisition step timeout**: Wait the duration for the position fix at a certain power level before increasing the level again. The acquisition sensitivity is measured at increasing power steps and is stopped if IVS reports signal acquisition or the maximum output power of the instrument is reached.
- **Acquisition sensitivity**: Test threshold utilized for the verdict
- **Wait after position fix**: Time duration with fixed position to wait before decreasing the level of satellite signals

- **Tracking step timeout**: Wait the duration for the position fix lost at a certain power level before decreasing the level again. The tracking sensitivity is measured at decreasing power steps and is stopped when IVS reports position loss.
- **Tracking sensitivity**: Test threshold utilized for the verdict

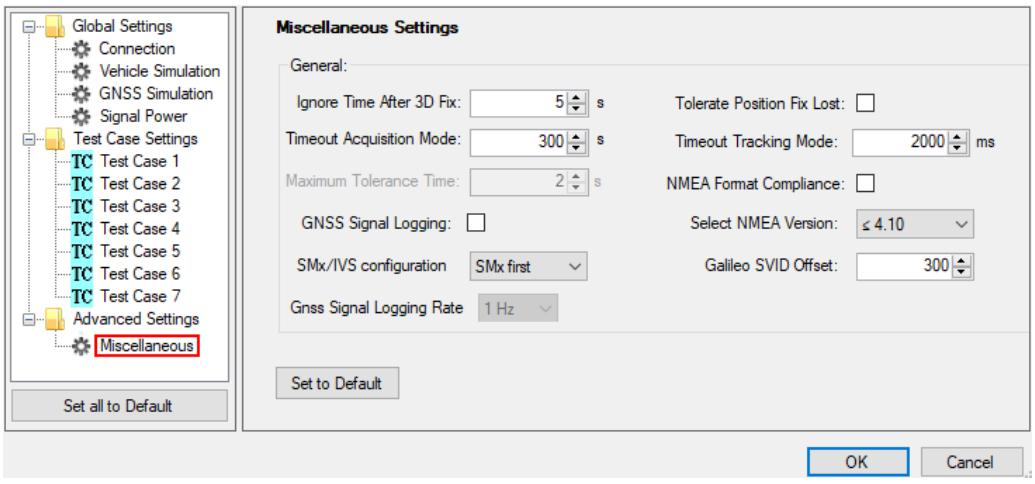
Test Case 7
Functional RAIM test

- **Error SV type**: The supported satellite systems depend on the selection in the GNSS simulation (GPS, Galileo, GLONASS, Beidou)
- **Number of SV**: Number of satellites with erroneous pseudorange
- **Durations**: Duration before, during and after pseudorange error ramp
- **Total error**: Simulated position error in m



5.6 Advanced settings

The following section specifies the settings to speed up the tests or to loosen the strict limits and conditions.



The following parameters are configurable.

Miscellaneous
Specifies the general signal and measurement settings.

- **Ignore time after 3D fix**: the time when the coordinates calculated by receivers are ignored in the test case for some time after the first 3D fix is attained. Some receivers make a fix far away from the true location and converge to that point after a couple of seconds. This setting can bias the error statistics and can be increased for more stability of the results.
- **Timeout acquisition mode**: maximum time duration after that the IVS has to acquire satellite signals
- **GNSS signal logging**: If enabled, the results with NMEA sentence are stored in a log file in the instrument directory `/hdd/Gnss_Gen/Log`.
- **SMx/IVS configuration**:
  – "Parallel": the configurations of the instrument and IVS are started in parallel
  – "SMx first": the instrument is configured first, afterwards the IVS is configured
- **GNSS signal logging rate**: sets the rate for GNSS signal logging at R&S CMWrun.
- **Tolerate position fix lost, maximum tolerance time**: allows the 3D fix to be lost and sets its maximum time duration
- **Timeout tracking mode**: maximum total time duration for the tracking sensitivity search iterations
- **NMEA format compliance**: if enabled, the strict format compliance of the DUTs messages with NMEA standard is required to pass the test
- **Select NMEA version**:
  – NMEA version 4.10 uses system ID to distinguish between GPS and Galileo satellites
  – NMEA 4.00 and older: No specified Galileo support by NMEA specification. Galileo ID offset is necessary to distinguish GPS and Galileo.
- **Galileo SVID offset**: offset useful to distinguish between GPS and Galileo satellites in NMEA versions < 4.10

Set to Default
Resets all settings in the dialog to the values required by the test specification.

6 Test results

The measurement report contains results, one table for each executed test case. The tables list the test items and conditions, the performed test steps, their results and pass/fail verdicts.

GNSS Generic Test Cases: Test Case 1 - Verify NMEA transmission from DUT

Test Items and Conditions	Threshold	Result	Unit	Status
DUT: ublox EVK-M8N				
NMEA-0183 Sentence rate 1 Hz *Gps/Beidou*	500	44,01	ms	
NMEA-0183 Format: RMC *Gps/Beidou*		OK		
NMEA-0183 Format: GGA *Gps/Beidou*		OK		
NMEA-0183 Format: GSA *Gps/Beidou*		OK		
NMEA-0183 Format: GSV *Gps/Beidou*		OK		
NMEA-0183 Format: VTG *Gps/Beidou*		OK		
NMEA-0183 Format: DTM *Gps/Beidou*		OK		
Test result				Passed

GNSS Generic Test Cases: Test Case 2 - Location accuracy (static receiver)

Test Items and Conditions	Threshold	Result	Unit	Status
DUT: ublox EVK-M8N				
Planimetric error *Gps/Beidou*	15	2.87	m	
Linear error *Gps/Beidou*	95	100	%	
Test result				Passed

GNSS Generic Test Cases: Test Case 3 - Location accuracy (moving receiver)

Test Items and Conditions	Threshold	Result	Unit	Status
DUT: ublox EVK-M8N				
Planimetric error *Gps/Beidou*	40	3.98	m	
Linear error *Gps/Beidou*	95	100	%	
Test result				Passed

GNSS Generic Test Cases: Test Case 4 - Time-to-first fix (TTFF) under cold start conditions

Test Items and Conditions	Threshold	Result	Unit	Status
DUT: ublox EVK-M8N				
Average position fix time in cold start mode *Gps/Beidou*	60	25.8	sec	
Test result				Passed

GNSS Generic Test Cases: Test Case 5 - Reacquisition time

Test Items and Conditions	Threshold	Result	Unit	Status
DUT: ublox EVK-M8N				
-120 dBm: Average reacquisition time *Gps/Beidou*	20	1.89	sec	
Test result				Passed

GNSS Generic Test Cases: Test Case 6 - Tracking and acquisition sensitivity

Test Items and Conditions	Threshold	Result	Unit	Status
DUT: ublox EVK-M8N				
Acquisition mode sensitivity *Gps/Beidou*	-145	-147	dBm	
Tracking mode sensitivity *Gps/Beidou*	-160	-168	dBm	
Test result				Passed

GNSS Generic Test Cases: Test Case 7 - Functional RAIM test

Test Items and Conditions	Threshold	Result	Unit	Status
DUT: ublox EVK-M8N				
Gps satellite 16 removed from solution *Gps/Beidou/Sbas*		NOK		
Beidou satellite 6 removed from solution *Gps/Beidou/Sbas*		OK		
Test result				Failed

The last table lists all errors and warnings collected during the test execution.

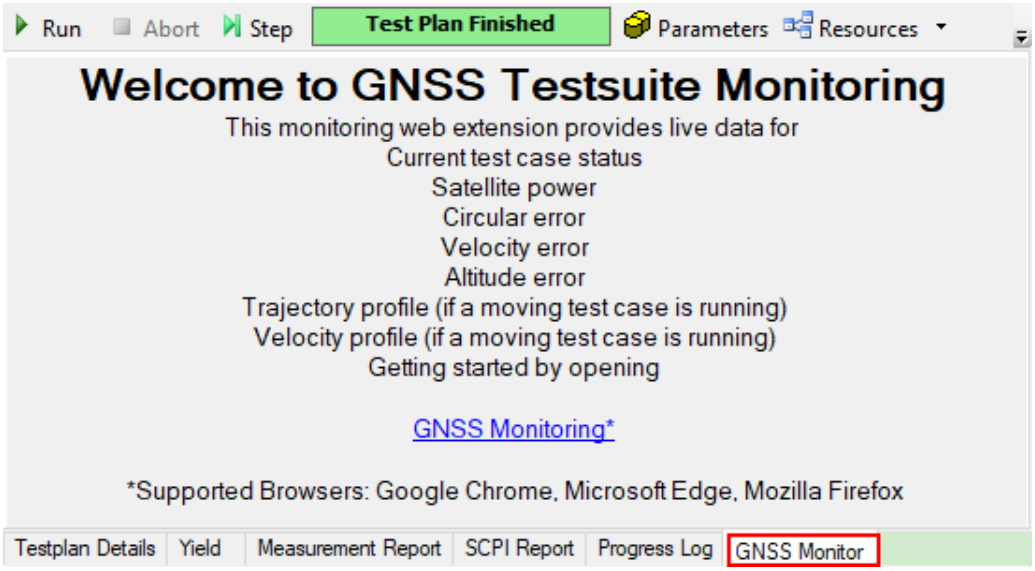
Annex: Errors and Warnings

Message	Test	Testcase			
Errors and Warnings					
[TC::TESTCASE] Gps satellite 16 not removed from solution	GenericGnssTestCases	Testcase7			Error

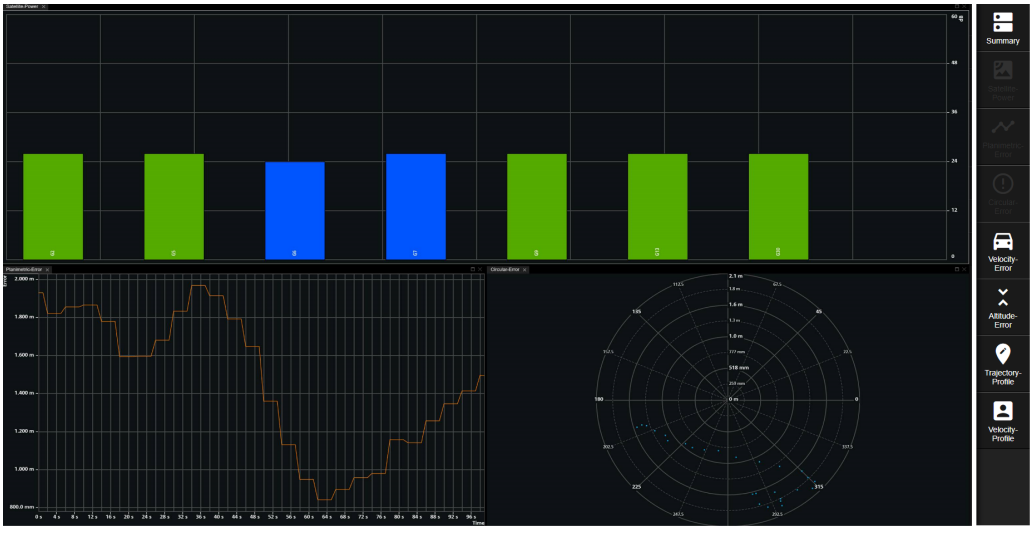
7 Monitoring

This option provides a "GNSS Monitor" subtab of a test plans pane.

After the execution of the test module, you can open a monitoring view via "GNSS Monitoring" link in a web browser.



In the monitoring view, you find a graphical representation of measured signal characteristics. The monitoring view consists of a main view ("Welcome to GNSS Testsuit Monitoring") and several views that can be dragged and dropped to the main pane via buttons to the right.



The views can be opened using the buttons to the right via drag and drop to the main view. A button of an opened view changes to gray. You can resize or close particular active view.

The following monitoring views are supported:

- **"Summary"** : lists the testcase name, overall elapsed time, position fix and position fix mode
- **"Sattelite Power"** : displays the satellite signal level (in dB) vs time
  Blue satellites are only tracked. The IVS does not use their positioning data.
- **"Planimetric Error"** : displays the position estimation error (in meters) vs time
- **"Circular Error"** : displays the position estimation error (in meters) vs angle
- **"Velocity Error"** : displays the measured velocity error (in meters per second) vs time
- **"Altitude Error"** : displays the altitude estimation error (in meters) vs time
- **"Trajectory Profile"** : displays the trajectory length (in km) vs position (distance in km)
- **"Velocity Profile"** : displays the velocity (in meters per second) vs position (distance in 100 m)

8 Test module details

The tests configure and control the simulated GNSS.

For each test case, the test automatically configures and controls the IVS, as required for the test case.

The test executes all test cases listed with an enabled checkbox.