R&S®SMBVB-K131
LoRa®
User Manual

1178971002
Version 07

ROHDE&SCHWARZ
Make ideas real

This document describes the following software option:

- R&S®SMBVB-K131 LoRa® (1423.8720.xx)

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

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1178.9710.02 | Version 07 | R&S®SMBVB-K131

The following abbreviations are used throughout this manual: R&S®SMBVB100B is abbreviated as R&S SMBVB, R&S®WinIQSIM2 is abbreviated as R&S WinIQSIM2; the license types 02/03/07/11/13/16/12 are abbreviated as xx.

Contents

1 Welcome to the LoRa option

The R&S SMBVB-K131 is a firmware application that adds functionality to generate signals in accordance with LoRa modulation.

The R&S SMBVB-K131 features

- Generation of LoRa up-/downlink signals
- Generation of waveforms for LoRa up-/downlink signals
- Frame configuration including modulation, coding and data configuration
- Impairing the output signal:
  - Adding symbol timing error and frequency offset
  - Applying a frequency drift to the carrier frequency of the output signal

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

All functions not discussed in this manual are the same as in the base unit and are described in the R&S SMBV100B user manual. The latest version is available at:

www.rohde-schwarz.com/manual/SMBV100B

Installation

You can find detailed installation instructions in the delivery of the option or in the R&S SMBV100B service manual.

1.1 Accessing the LoRa dialog

To open the dialog with LoRa settings

► In the block diagram of the R&S SMBV100B, select "Baseband > LoRa".

A dialog box opens that displays the provided general 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®SMBV100B.

Compared to the previous version, it provides the new features listed below:

- Time-based triggering, see "Time Based Trigger" on page 25 and "Trigger Time" on page 25.

- Editorial changes

1.3 Documentation overview

This section provides an overview of the R&S SMBV100B user documentation. Unless specified otherwise, you find the documents at:

www.rohde-schwarz.com/manual/smbv100b

1.3.1 Getting started manual

Introduces the R&S SMBV100B and describes how to set up and start working with the product. Includes basic operations, typical measurement examples, and general information, e.g. safety instructions, etc. A printed version is delivered with the instrument.

1.3.2 User manuals and help

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

- Base unit manual
  Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance, instrument interfaces and error messages. Includes the contents of the getting started manual.
- Software option manual
  Contains the description of the specific functions of an option. Basic information on operating the R&S SMBV100B is not included.

The contents of the user manuals are available as help in the R&S SMBV100B. 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 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

1.3.4 Instrument security procedures

Deals with security issues when working with the R&S SMBV100B in secure areas. It is available for download on the internet.

1.3.5 Printed safety instructions

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

1.3.6 Data sheets and brochures

The data sheet contains the technical specifications of the R&S SMBV100B. 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/smbv100b

1.3.7 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/smbv100b

1.3.8 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/smbv100b

1.3.9 Videos

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

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

Figure 1-1: Product search on YouTube

1.4 Scope

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

In particular, it includes:

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

For a description of such tasks, see the R&S SMBV100B user manual.

1.5 Notes on screenshots

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

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

2 About the LoRa option

2.1 Required options

The basic equipment layout for generating LoRa signals includes the options:

- Base unit
- Baseband real-time extension (R&S SMBVB-K520)
- Option LoRa (R&S SMBVB-K131)

You can generate signals via play-back of waveform files at the signal generator. To create the waveform file using R&S WinIQSIM2, you do not need a specific option.

To play back the waveform file at the signal generator, you have two options:

- Install the R&S WinIQSIM2 option of the digital standard, e.g. R&S SMBVB-K255 for playing LTE waveforms
- If supported, install the real-time option of the digital standard, e.g. R&S SMBVB-K55 for playing LTE waveforms

For more information, see data sheet.

2.2 About LoRa

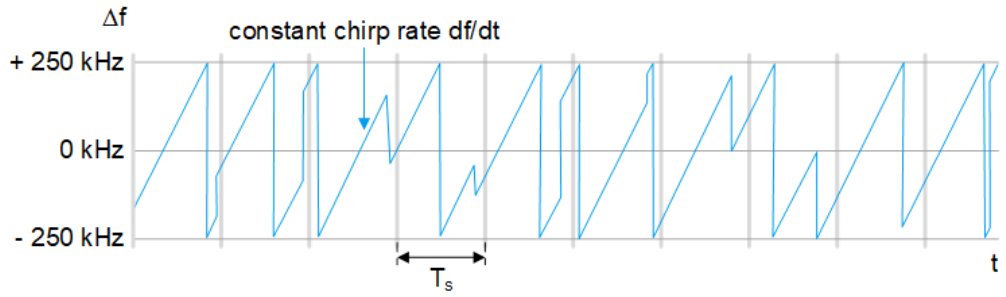
The term LoRa refers to a "Long Range" end-to-end communication technology based on a PHY with a proprietary modulation scheme. The standard is owned by Semtech Corporation, Camarillo California, USA.

Modulation

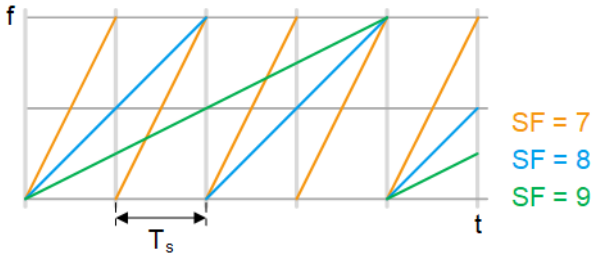
LoRa modulation is based on a proprietary CSS modulation scheme. The modulation scheme is used to encode data onto swept frequency chirps, i.e. rapid changes of the modulation frequency.

A chirp (compressed high intensity radar pulse) is a signal whose frequency changes at a fixed rate (chirp rate). Each modulation symbol is represented as a rapid change in the frequency of the chirp.

The spreading factor represents the number of encoded bits per symbol and thus the change in frequency per unit time.



The higher the spreading factor, the lower the change in frequency per unit time.



Chirp rate R_C, signal bandwidth Δf, spreading factor SF, sample rate R_S, symbol duration T_S, bit rate R_B and coding rate CR are linked as in the equations below. Furthermore, typical values are given for SF, Δf and CR.

Symbol rate: $R_S = 1 / T_S = \Delta f / 2^{SF}$ | 125 kHz ≤ Δf ≤ 500 kHz;

Chirp rate: $R_C = R_S * 2^{SF} = \Delta f$ | 7 ≤ SF ≤ 12;

Bit rate: $R_B = SF * \Delta f / 2^{SF} * 4 / (4 + CR)$ | 1 ≤ CR ≤ 4

A coding rate CR = 0 corresponds to no coding.

For related settings, see "Modulation and Coding Configuration" on page 18.

Channel allocation

LoRa communication channels can be freely attributed by the network following the spectrum allocation rules defined by the regional radio regulation authorities. In Europe, the allocation rules are defined by ETSI in the specifications ETSI Specification EN 300 220-1 and CEPT/ERC Recommendation 70-03. In North America, the allocation rules are defined by FCC in the FCC Specification 47 Part 15.247.

For detailed info about regional LoRa performance requirements, see LoRaWAN Regional Parameters Specification.

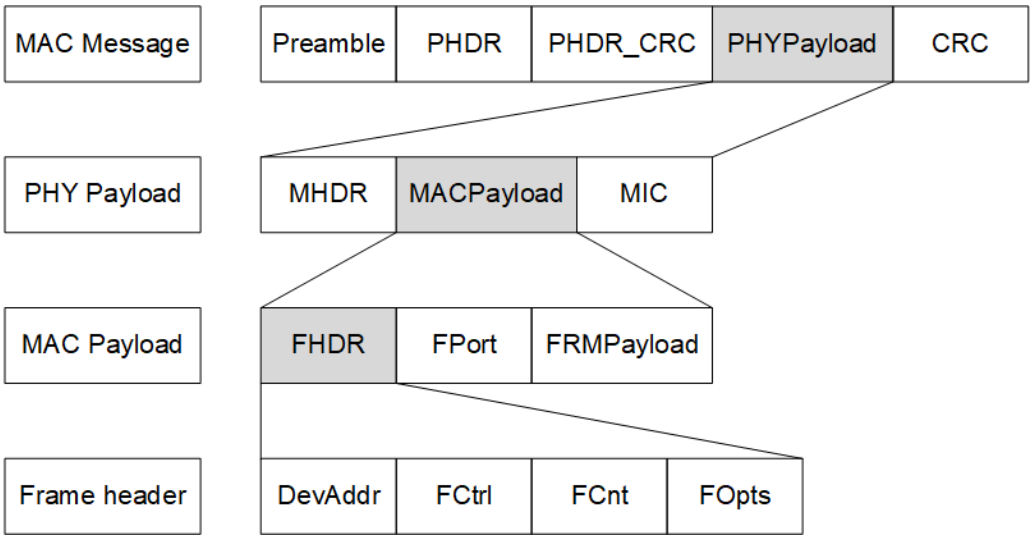
Table 2-1: Example: LoRaWAN regional parameters for Europe and North America

Parameter	Europe (ETSI)	North America (FCC)
Frequency band	863 MHz to 869 MHz	902 MHz to 928 MHz
Number of channels	Up- and downlink: 10	Uplink: 64 x 125 kHz and 8 x 500 kHz Downlink: 8 x 500 kHz

Parameter	Europe (ETSI)	North America (FCC)
Channel bandwidth	Uplink: 125 kHz and 250 kHz Downlink 125 kHz	Uplink: 125 kHz and 500 kHz Downlink: 500 kHz
TX power	Uplink: 14 dBm (20 dBm allowed) Downlink: 14 dBm	Uplink: 20 dBm (30 dBm allowed) Downlink: 27 dBm
Spreading factor	Uplink: 7 to 12	Uplink: 7 to 12
Data rate	250 bit/s to 50000 bit/s	980 bit/s to 21900 bit/s
Link budget	Uplink: 155 dB Downlink: 155 dB	Uplink: 154 dB Downlink: 157 dB

For related settings, see Chapter 3.1, "General settings", on page 14.

Message and frame structure



For related settings, see Chapter 3.2, "Frame configuration settings", on page 17.

2.3 About LoRaWAN

The LoRa Alliance, Inc. specifies a wide area network (WAN) stack for long range communication as shown in Figure 2-1 (1MA295). The LoRa modulation physical layer enables the long-range communication link. The LoRa MAC and application layers affect battery lifetime of the end-device, network capacity, quality of service and security.

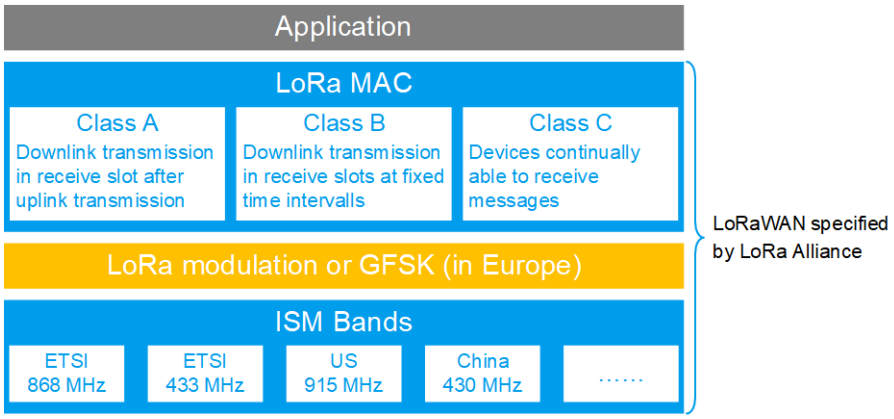


Figure 2-1: LoRaWAN stack

Network architecture

A LoRaWAN architecture has a star-shaped structure as shown in Figure 2-2 (1MA295). End-devices exchange data with the network server via gateways. Also, the network server is connected to application servers, on which typically IoT applications run.

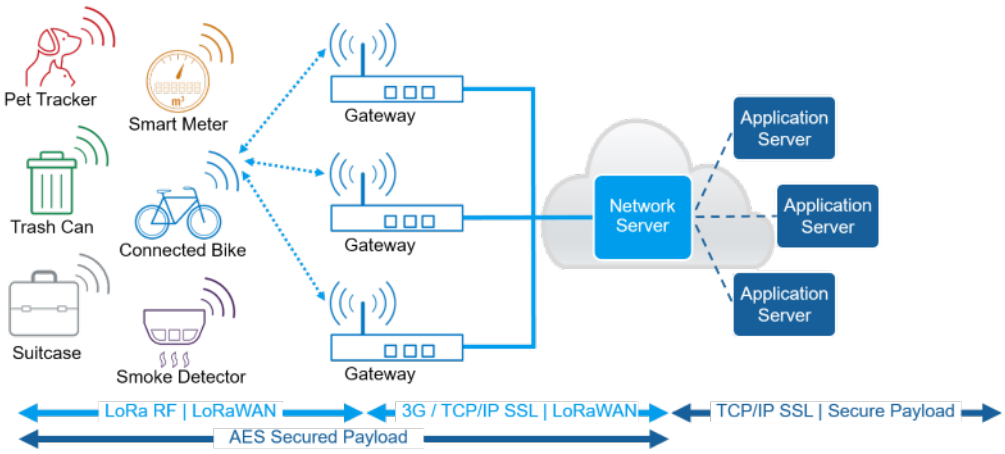


Figure 2-2: LoRaWAN network architecture

For more information, see the LoRaWAN Specification.

Device communication classes

There are three classes specified for LoRaWAN compliant devices:

- **Class A**: Bi-directional end-devices (mandatory support)
  Bi-directional communication between LoRa network server and receiver. A scheduled uplink transmission slot (Transmit) is followed by two downlink receive slots (Rx 1 and Rx 2).

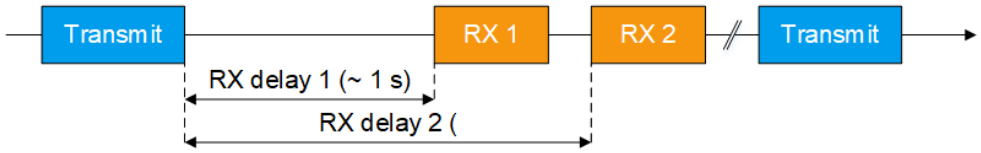


Figure 2-3: Class A communication

- **Class B**: Bi-directional end-devices with scheduled receive slots (optional support) Besides Class A communication, more downlink receive slots (Rx) are available due to a time synchronized periodic beacon signal (Beacon) from network gateway.

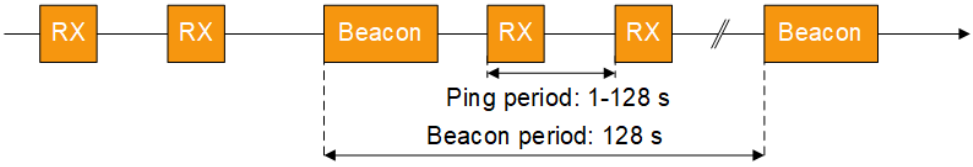


Figure 2-4: Class B communication

- **Class C**: Bi-directional end-devices with maximal receive slots (optional support) Besides Class A and B communication, there are continuously open receive slots except during transmission.

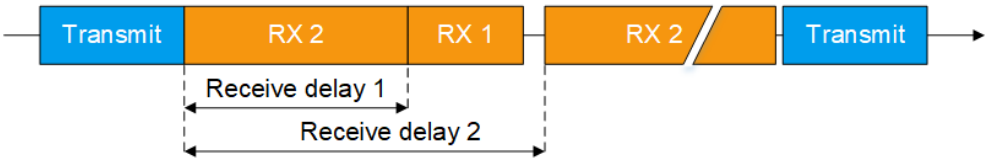


Figure 2-5: Class C communication

Typically, power consumption increases and latency decreases from Class A to Class C communication.

Key features and applications

Devices compliant with the LoRa technology and operating in a LoRaWAN offer the following key features:

- **Long range**: outdoor coverage of up to 30 miles/48.3 km (line of sight)
- **Low power consumption**: battery lifetime of up to 20 years
- **Low cost**: low-cost end-devices and open software

The key features meet the requirements for IoT applications in rural areas.

3 LoRa configuration and settings

Access:

► Select "Baseband > LoRa".

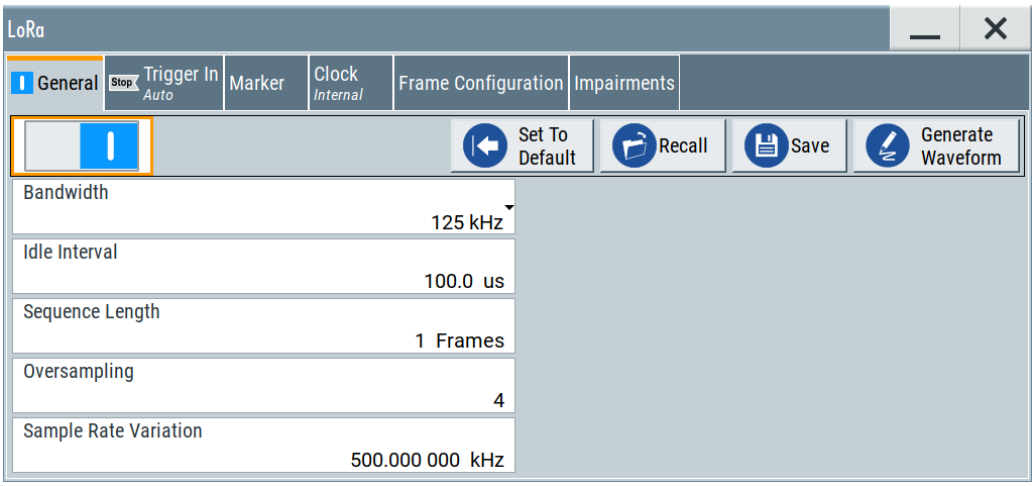
The remote commands required to define these settings are described in Chapter 6, "Remote-control commands", on page 36.

Settings:

3.1 General settings

Access:

► Select "Baseband > LoRa".



The tab comprises the standard general settings.

Settings:

State
Activates the standard and deactivates all the other digital standards and digital modulation modes in the same path.

Remote command:
`[:SOURce<hw>]:BB:LORA:STATe` on page 42

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

Parameter	Value
"State"	Not affected by the "Set to Default"
"Bandwidth"	125 kHz
"Idle Interval"	100.0 us
"Sequence Length"	1 frame
"Oversampling"	4
"Sample Rate Variation"	500.000 000 kHz

Remote command:
`[:SOURce<hw>]:BB:LORA:PRESet` on page 40

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

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

See also, chapter "File and Data Management" in the R&S SMBV100B user manual.

Remote command:
`[:SOURce<hw>]:BB:LORA:SETTing:CATalog` on page 40
`[:SOURce<hw>]:BB:LORA:SETTing:STORe` on page 41
`[:SOURce<hw>]:BB:LORA:SETTing:LOAD` on page 41
`[:SOURce<hw>]:BB:LORA:SETTing:DELete` on page 41

Generate Waveform File
With enabled signal generation, triggers the instrument to save the current settings of an arbitrary waveform signal in a waveform file with predefined extension `*.wv`. You can define the filename and the directory, in that you want to save the file.

Using the ARB modulation source, you can play back waveform files and/or process the file to generate multi-carrier or multi-segment signals.

Remote command:
[:SOURce<hw>]:BB:LORA:WAVeform:CREate on page 43

Bandwidth
Sets the channel bandwidth.

The sample rate and FFT size are calculated internally and updated automatically.

Remote command:
[:SOURce<hw>]:BB:LORA:BWIDth on page 40

Idle Interval
Sets the time of the interval separating two frames.

Remote command:
[:SOURce<hw>]:BB:LORA:IINTerval on page 40

Sequence Length
Sets the sequence length of the signal in number of frames. The signal is calculated in advance and output in the arbitrary waveform generator.

Remote command:
[:SOURce<hw>]:BB:LORA:SLENgth on page 41

Oversampling
Sets the oversampling factor of the generated waveform. The ARB generator of the R&S SMBV100B requires low oversampling factors and still provides excellent signal quality in terms of EVM and ACP.

A reduced sample rate saves significantly the amount of memory or allows an increased signal cycle time, and vice versa.

Remote command:
[:SOURce<hw>]:BB:LORA:OSAMpling on page 42

Sample Rate Variation
Sets the sample rate of the signal. A variation of this parameter affects the ARB clock rate; all other signal parameters remain unchanged.

When changing values of the affecting parameters, the sample rate is reset according to the equations below:

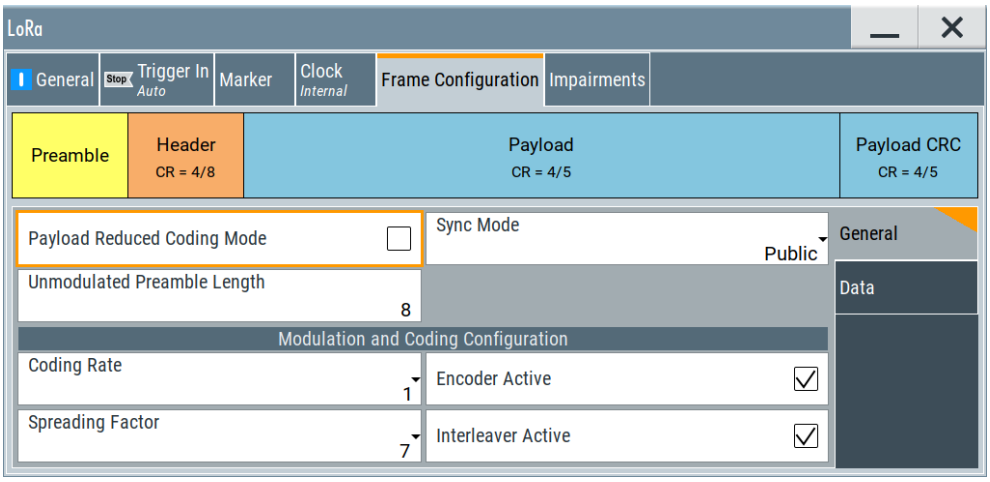
- Symbol Timing Error disabled:
  Sample rate = Bandwidth * Oversampling
- Impairments enabled:
  Sample rate = (abs(Freq. drift deviation) + abs(Freq. offset + (bandwidth * oversampling) / 2) * 2

Remote command:
[:SOURce<hw>]:BB:LORA:SRATe:VARiation on page 42

3.2 Frame configuration settings

Access:

► Select "Baseband > LoRa > Frame Configuration".



This tab comprises the general and data settings to configure the frame structure.

Settings

Payload Reduced Coding Mode
Activates the payload reduced coding mode.

Remote command:
`[:SOURce<hw>]:BB:LORA:FCONfiguration:PRCMode:STATe` on page 46

Unmodulated Preamble Length
Sets the unmodulated preamble length.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:UPLength on page 47

Sync Mode
Sets the synchronization mode of the preamble.

Public A preamble with a public sync word is generated.

Private A preamble with a private sync word is generated.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:SMODe on page 46

Modulation and Coding Configuration
Configures the modulation and coding information in the frame configuration.

Coding Rate ← Modulation and Coding Configuration
Sets the coding rate. The coding rate R_{Coding} is calculated as follows:

R_{Coding} = 4 / (4 + "Coding Rate")

"Coding Rate = 0" corresponds to no coding, i.e. R_{Coding} = 1.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:CRATe on page 43

Spreading Factor ← Modulation and Coding Configuration
Sets the spreading factor for the modulation.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:SFACtor on page 47

Encoder Active ← Modulation and Coding Configuration
Activates encoding of the modulation symbols.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:EACTive:STATe on page 45

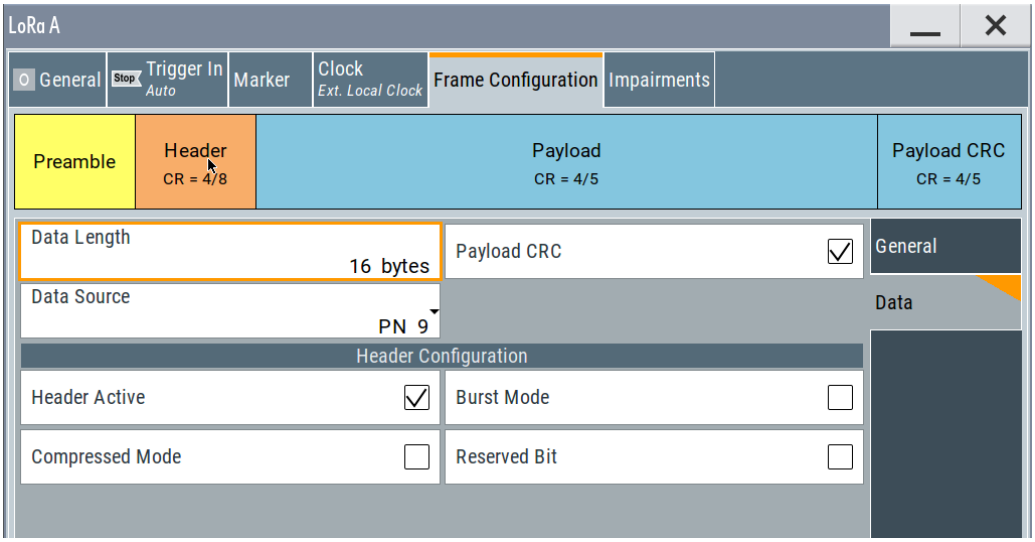
Interleaver Active ← Modulation and Coding Configuration
Activates the interleaver in the frame.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:IACTive:STATe on page 46

Data
Access:

Select "Baseband > LoRa> Frame Configuration > Data".

Configures header and payload data settings.



Data Length ← Data
Sets the data length of the payload in the frame.

Remote command:
`[:SOURce<hw>]:BB:LORA:FCONfiguration:DLENgth` on page 45

Data Source ← Data
Selects the data source for the payload.

The following standard data sources are available:

- "All 0, All 1"
  An internally generated sequence containing 0 data or 1 data.
- "PNxx"
  An internally generated pseudo-random noise sequence.
- "Pattern"
  An internally generated sequence according to a bit pattern.
  Use the "Pattern" box to define the bit pattern.
- "Data List/Select DList"
  A binary data from a data list, internally or externally generated.
  Select "Select DList" to access the standard "Select List" dialog.
  - Select the "Select Data List > navigate to the list file *.dm_iqd > Select" to select an existing data list.
  - Use the "New" and "Edit" functions to create internally new data list or to edit an existing one.
  - Use the standard "File Manager" function to transfer external data lists to the instrument.

See also:

- Section "Modulation Data" in the R&S SMBV100B user manual.
- Section "File and Data Management" in the R&S SMBV100B user manual.
- Section "Data List Editor" in the R&S SMBV100B user manual

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA on page 44
[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA:DPATtern on page 44
[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA:DSELection on page 45

Payload CRC ← Data
Activates a cyclic redundancy check (CRC) of the payload.

The "Payload CRC" bits are appended to the payload of the frame.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:PCRC:STATe on page 46

Header Configuration ← Data
Configures the header information in the payload.

Header Active ← Header Configuration ← Data
Activates the header data in the frame.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:HACTive:STATe on page 45

Compressed Mode ← Header Configuration ← Data
Activates the compressed mode of the header data in the frame.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:CMODe:STATe on page 43

Burst Mode ← Header Configuration ← Data
Activates the burst mode of header data in the frame.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:BMODe:STATe on page 43

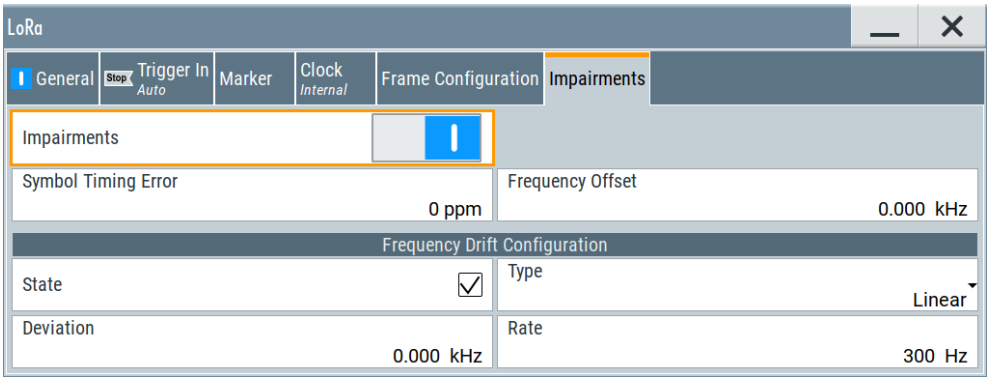
Reserved Bit ← Header Configuration ← Data
Enables the reserved bit in the frame header.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:RBIT:STATe on page 46

3.3 Impairments settings

Access:

► Select "Baseband > LoRa > Impairments".



This tab comprises the impairments settings for the signal.

Settings

Impairments
Activates the impairments settings.

Impairments change the signal to simulate a non-ideal transmitter.

Remote command:
`[:SOURce<hw>]:BB:LORA:IMPairments:STATe` on page 49

Symbol Timing Error
Sets the symbol timing error.

The set error corresponds to applying a deviation to the transmitter symbol clock.

Remote command:
`[:SOURce<hw>]:BB:LORA:IMPairments:STERror` on page 49

Frequency Offset
Sets the carrier frequency offset.

Remote command:
`[:SOURce<hw>]:BB:LORA:IMPairments:FOFFset` on page 48

Frequency Drift Configuration
Configures carrier frequency drift settings of the signal.

State ← Frequency Drift Configuration
Activates carrier frequency drift settings.

Remote command:
[:SOURce<hw>]:BB:LORA:IMPairments:FDRift:STATe on page 48

Deviation ← Frequency Drift Configuration
Sets the maximum deviation of the carrier signal from the center frequency during the frequency drift procedure.

Remote command:
[:SOURce<hw>]:BB:LORA:IMPairments:FDDeviation on page 47

Type ← Frequency Drift Configuration
Sets the type of frequency drift, i.e. how the carrier signal drifts around the center frequency.

Linear — Linear frequency drift.

Sine — Sine frequency drift.

Remote command:
[:SOURce<hw>]:BB:LORA:IMPairments:FDTYpe on page 48

Rate ← Frequency Drift Configuration
Sets the rate of the carrier frequency drift.

A rate of, e.g., 300 Hz implies, that the carrier signal drifts 300 times per second around the center frequency.

Remote command:
[:SOURce<hw>]:BB:LORA:IMPairments:FDRate on page 48

4 Signal generation control

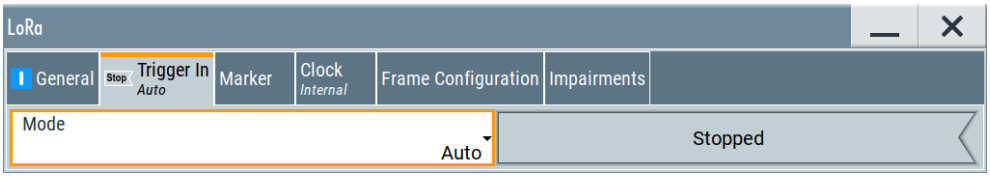
This section lists settings provided for configuring the baseband filter, for defining the signal generation start and for generating signals necessary for synchronization with other instruments.

Settings:

4.1 Trigger settings

Access:

► Select "Baseband" > "LoRa" > "Trigger In".



This tab provides settings to select and configure the trigger, like trigger source, trigger mode and trigger delays, and to arm or trigger an internal trigger manually. The header of the tab displays the status of the trigger signal and trigger mode. As in the tabs "Marker" and "Clock", this tab provides also access to the settings of the related connectors.

Routing and activating a trigger signal

1. Define the effect of a trigger event and the trigger signal source.
   a) Select "Trigger In" > "Mode".
   b) Select "Trigger In" > "Source".
2. For external trigger signals, define the connector for signal input. See Chapter 4.4, "Global connectors settings", on page 31.
   You can map trigger signals to one or more User x connectors.
   Global connectors settings allow you to configure the signal mapping, the polarity, the trigger threshold and the input impedance of the input connectors.
3. Activate baseband signal generation. In the block diagram, set "Baseband" > "On".
   The R&S SMBV100B starts baseband signal generation after the configured trigger event.

About baseband trigger signals

This section focuses on the available settings.

For information on how these settings affect the signal, refer to section "Basics on ..." in the R&S SMBV100B user manual.

Settings:

Mode
Selects trigger mode, i.e. determines the effect of a trigger event on the signal generation.

- "Auto"
  The signal is generated continuously.
- "Retrigger"
  The signal is generated continuously. A trigger event (internal or external) causes a restart.
- "Armed Auto"
  The signal is generated only when a trigger event occurs. Then the signal is generated continuously.
  An "Arm" stops the signal generation. A subsequent trigger event (internal or external) causes a restart.
- "Armed Retrigger"
  The signal is generated only when a trigger event occurs. Then the signal is generated continuously. Every subsequent trigger event causes a restart.
  An "Arm" stops signal generation. A subsequent trigger event (internal or external) causes a restart.
- "Single"
  The signal is generated only when a trigger event occurs. Then the signal is generated once to the length specified at "Signal Duration".
  Every subsequent trigger event (internal or external) causes a restart.

Remote command:
`[:SOURce<hw>]:BB:LORA[:TRIGger]:SEQuence` on page 50

Signal Duration Unit
Defines the unit for describing the length of the signal sequence to be output in the "Single" trigger mode.

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:SLUNit on page 52

Signal Duration
Requires trigger "Mode" > "Single".

Enters the length of the trigger signal sequence.

Use this parameter, for example, for the following applications:
- To output the trigger signal partly.
- To output a predefined sequence of the trigger signal.

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:SLENgth on page 52

Running/Stopped
With enabled modulation, displays the status of signal generation for all trigger modes.

- "Running"
  The signal is generated; a trigger was (internally or externally) initiated in triggered mode.
- "Stopped"
  The signal is not generated and the instrument waits for a trigger event.

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:RMODe on page 52

Time Based Trigger
Requires trigger "Mode" > "Armed Auto"/"Single".

Activates time-based triggering with a fixed time reference.

The R&S SMBV100B triggers signal generation when its operating system time ("Current Time") matches a specified time trigger ("Trigger Time"). As trigger source, you can use an internal trigger or an external global trigger.

How to: Chapter "Time-based triggering" in the R&S SMBV100B user manual.

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:TIME[:STATe] on page 54

Trigger Time
Requires trigger "Mode" > "Armed Auto"/"Single".

Sets date and time for a time-based trigger signal.

Set a trigger time that is later than the "Current Time". The current time is the operating system time of the R&S SMBV100B. If you set an earlier trigger time than the current time, time-based triggering is not possible.

How to: Chapter "Time-based triggering" in the R&S SMBV100B user manual.

"Date" Sets the date of the time-based trigger in format YYYY-MM-DD.

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:TIME:DATE on page 53

"Time" Sets the time of the time-based trigger in format hh:mm:ss.

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:TIME:TIME on page 53

Arm
Stops the signal generation until subsequent trigger event occurs.

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:ARM:EXECute on page 51

Execute Trigger
For internal trigger source, executes trigger manually.

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:EXECute on page 52

Source
The following sources of the trigger signal are available:

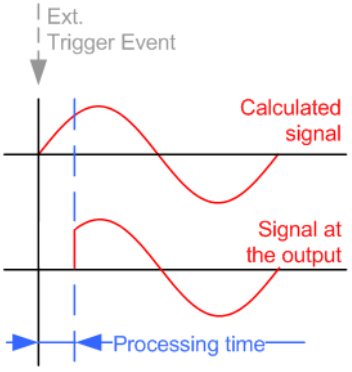
- "Internal"
  The trigger event is executed manually by the "Execute Trigger".
- "External Global Trigger"
  The trigger event is the active edge of an external trigger signal provided and configured at the User x connectors.
- "Baseband Sync In"
  In primary-secondary instrument mode, secondary instruments are triggered by the active edge of the synchronization signal.

How to: "Routing and activating a trigger signal" on page 23

Remote command:
[:SOURce<hw>]:BB:LORA:TRIGger:SOURce on page 50

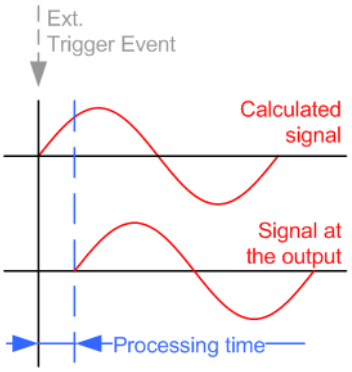
Sync. Output to External Trigger/Sync. Output to Trigger
Enables signal output synchronous to the trigger event.

- "On"
  Corresponds to the default state of this parameter.
  The signal calculation starts simultaneously with the trigger event. Because of the processing time of the instrument, the first samples are cut off and no signal is output. After elapsing of the internal processing time, the output signal is synchronous to the trigger event.



- "Off"

The signal output begins after elapsing of the processing time. Signal output starts with sample 0. The complete signal is output.
This mode is recommended for triggering of short signal sequences. Short sequences are sequences with signal duration comparable with the processing time of the instrument.



In primary-secondary instrument mode, this setting ensures that once achieved, synchronization is not lost if the baseband signal sampling rate changes.

Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal]:SYNChronize:OUTPut` on page 50

External Inhibit/Trigger Inhibit
Applies for external trigger signal.

Sets the duration with that any following trigger event is suppressed. In "Retrigger" mode, for example, a new trigger event does not cause a restart of the signal generation until the specified inhibit duration does not expire.

For more information, see chapter "Basics" in the R&S SMBV100B user manual.

Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal]:INHibit` on page 51

External Delay/Trigger Delay
Delays the trigger event of the signal from:
- The external trigger source

Use this setting to:
- Synchronize the instrument with the device under test (DUT) or other external devices
- Compensate delays and align the signal generation start in multi-instrument setup

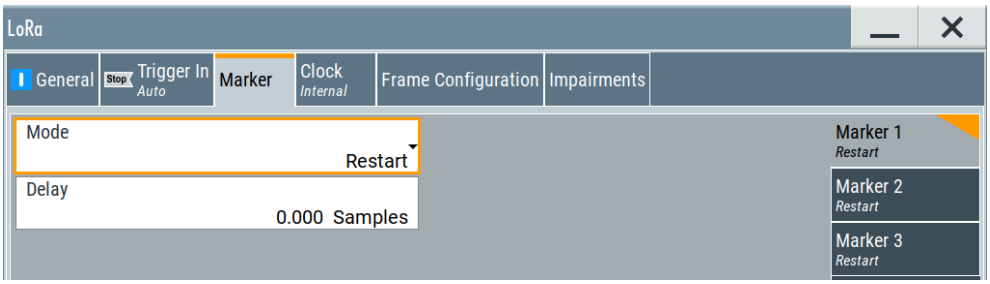
For more information, see chapter "Basics on ..." in the R&S SMBV100B user manual.

Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal]:DELay` on page 50

4.2 Marker settings

Access:

► Select "Baseband" > "LoRa" > "Marker".



This tab provides settings to select and configure the marker output signal including marker mode and marker delay.

Routing and activating a marker signal

1. To define the signal shape of an individual marker signal "x", select "Marker" > "Marker x" > "Mode".
2. Optionally, define the connector for signal output. See Chapter 4.4, "Global connectors settings", on page 31.
   You can map marker signals to one or more User x connectors.
3. Activate baseband signal generation. In the block diagram, set "Baseband" > "On".

   The R&S SMBV100B adds the marker signal to the baseband signal. Also, R&S SMBV100B outputs this signal at the configured User x connector.

About marker output signals

This section focuses on the available settings.

For information on how these settings affect the signal, refer to section "Basics on ..." in the R&S SMBV100B user manual.

Settings:

Mode
Marker configuration for up to 3 markers. The settings are used to select the marker mode defining the shape and periodicity of the markers. The contents of the dialog change with the selected marker mode.

How to: "Routing and activating a marker signal" on page 28

"Restart" A marker signal is generated at the start of each ARB sequence.

"Frame" A frame clock with the frame period specified under "Period" is generated on the output connector. The marker signal is generated after every specified number of frames.

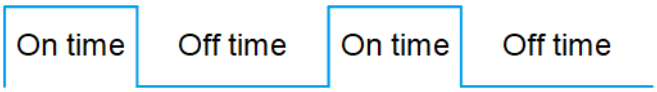
"Pulse" A regular marker signal is generated. The pulse frequency is defined by entering a divider. The frequency is derived by dividing the sample rate by the divider. The input box for the divider opens when "Pulse" is selected, and the resulting pulse frequency is displayed below it. The maximum pulse frequency is half the symbol rate.

Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:PULSe:DIVider` on page 55
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:PULSe:FREQuency?` on page 56

"Pattern" A marker signal that is defined by a bit pattern is generated. The pattern has a maximum length of 64 bits and is defined in an input field which opens when pattern is selected.

Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:PATTern` on page 55

"On/Off Ratio" A regular marker signal that is defined by an On/Off ratio is generated. A period lasts one On and Off cycle.



Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:ONTime` on page 55
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:OFFTime` on page 55

Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:MODE` on page 54

Delay
Delays the marker signal at the marker output relative to the signal generation start.

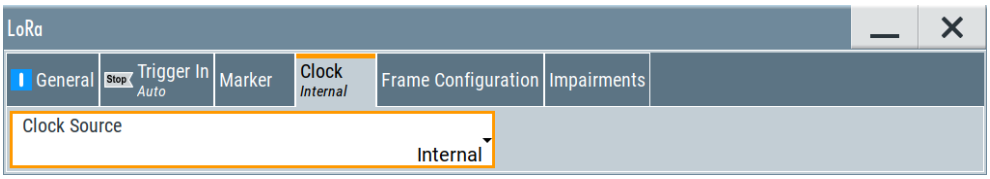
Variation of the parameter "Marker x" > "Delay" causes signal recalculation.

Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:DELay` on page 54

4.3 Clock settings

Access:

► Select "Baseband" > "LoRa" > "Clock".



This tab provides settings to select and configure the clock signal, like the clock source and clock mode.

Defining the clock

1. Select "Clock" > "Source" to define the source of clock signal.
2. For external clock signals, define the connector for signal input. See Chapter 4.4, "Global connectors settings", on page 31.
   You can map clock signals to one or more User x connectors.

   Global connectors settings allow you to configure the signal mapping, the polarity, the trigger threshold and the input impedance of the input connectors.
3. Activate baseband signal generation. In the block diagram, set "Baseband" > "On".

   The R&S SMBV100B starts baseband signal generation with a symbol rate that equals the clock rate.

About clock signals

This section focuses on the available settings.

For information on how these settings affect the signal, refer to section "Basics on ..." in the R&S SMBV100B user manual.

Settings:

Clock Source
Selects the clock source.

- "Internal"
  The instrument uses its internal clock reference.

How to: "Defining the clock" on page 30

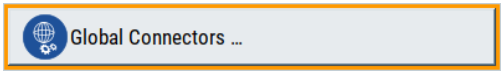
Remote command:
`[:SOURce<hw>]:BB:LORA:CLOCk:SOURce` on page 56

4.4 Global connectors settings

Accesses a dialog to configure global connectors.

The button is available in the following dialogs or tabs:

- "Trigger / Marker / Clock" dialog that is accessible via the "TMC" block in the block diagram.
- "Trigger In", "Marker" and "Clock" tabs that are accessible via the "Baseband" block in the block diagram.



See also chapter "Global connectors settings" in the user manual.

5 Generating LoRa test signals

The section describes how to set up and configure the R&S SMBV100B for LoRa signal generation for simple receiver tests.

See also:

- Application note 1MA295, for a comprehensive overview on LoRa device characterization, including Tx measurements.
- Chapter 6.1, "Programming examples", on page 36, for remote command configuration examples.

5.1 Generating RX sensitivity test signals

Rx sensitivity test setup

The R&S SMBV100B generates a LoRa test signal. The LoRa DUT receives and demodulates the test signal. The LoRa Test Tool, installed on an external PC, analyzes the demodulation data in terms of PER analysis.

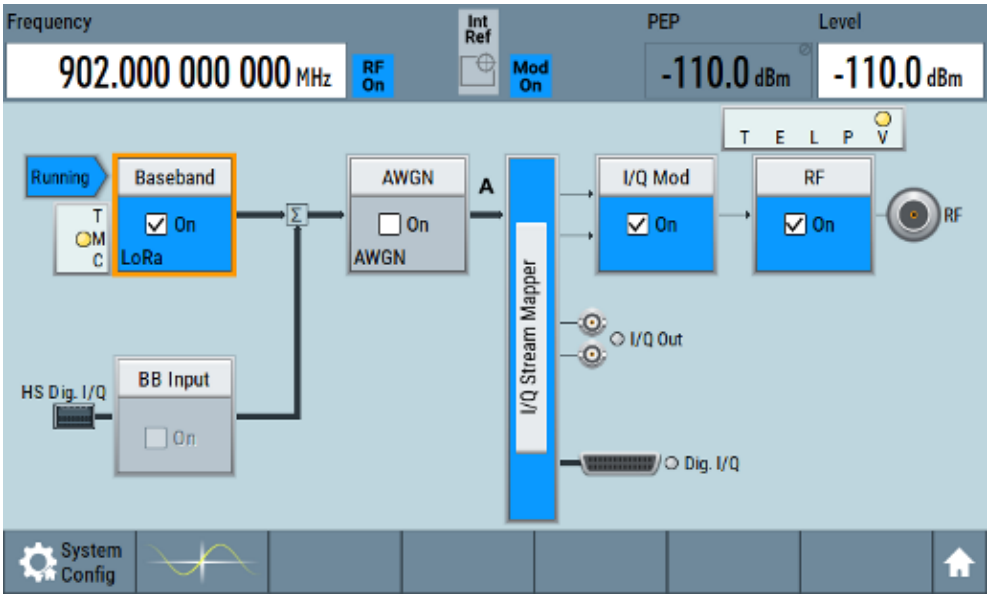
Figure 5-1: Test setup for Rx sensitivity test

1 = R&S SMBV100B generating the RF signal
2 = LoRa DUT receiving the RF signal
3 = External PC with LoRa Test Tool for PER analysis
Blue arrow = LoRa test RF signal path
Orange arrow = Connection for LoRa DUT control and analysis via LoRa Test Tool at the external PC

To perform an Rx sensitivity test

1. Preset the R&S SMBV100B.
2. Select "Baseband > LoRa".
3. Configure "General" settings of the LoRa test signal, e.g. the "Bandwidth" compatible with the DUT.

4. Select "Frame Configuration > General" to configure modulation and coding parameters, e.g. "Coding Rate" and "Spreading Factor".
5. Select "Frame Configuration > Data" to configure payload, e.g. "Data Length" and "Data Source".
6. Set "General > State > On" to activate LoRa baseband modulation.
7. In the block diagram, set "I/Q Mod > On" and "RF > On" to activate I/Q modulation and signal generation.
8. On the "Status Bar", set "Frequency" and "Level".



9. Configure the DUT for reception of the LoRa test signal generated at the R&S SMBV100B.
10. Gradually reduce the level of the LoRa test signal.
11. Monitor the PER at the DUT, e.g. at an external PC with an analysis software (LoRa Test Tool).

    The Rx sensitivity level corresponds to a specified PER value, e.g. "Level > -137 dBm" with PER = 1 %. The level depends on the spreading factor.

5.2 Generating blocking test signals

Blocking test setup

The R&S SMBV100B generates a LoRa test signal, the wanted signal. A second signal generator, e.g. an R&S SGS, generates an interfering CW signal, the unwanted signal. Both signals are combined via an RF power combiner. The LoRa DUT receives and

demodulates the combined signal. The LoRa Test Tool, installed on external PC, analyzes the demodulation data in terms of PER analysis.

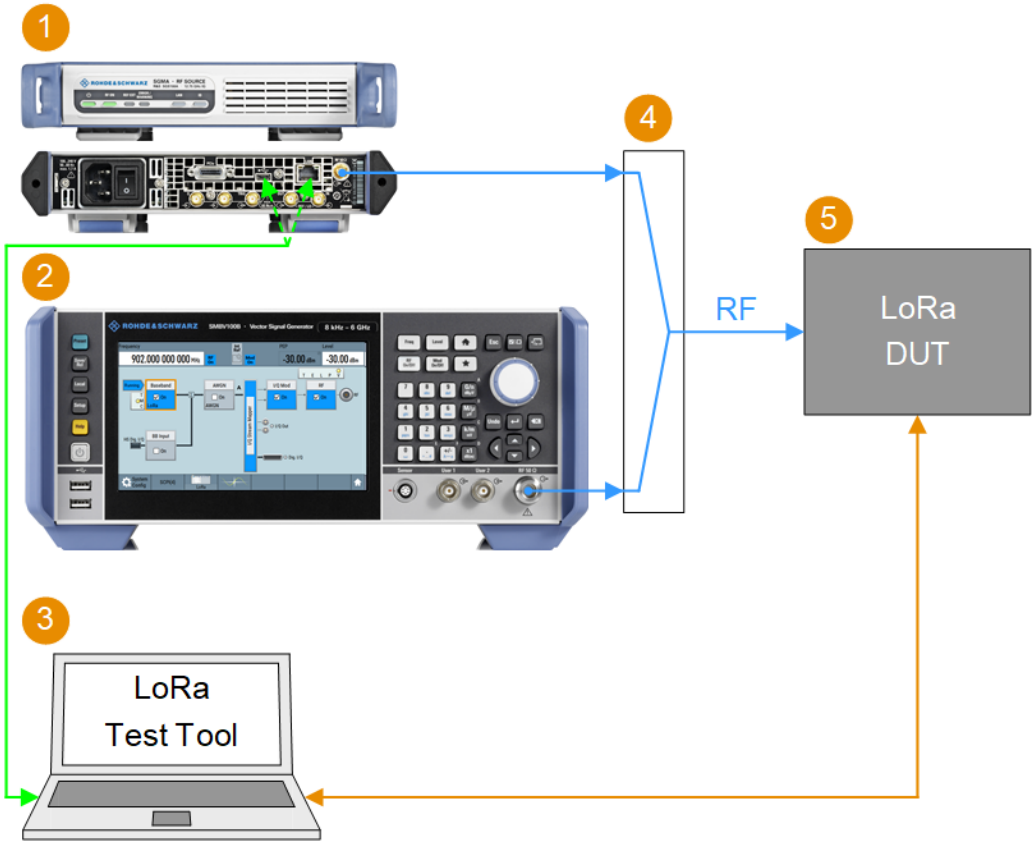


Figure 5-2: Test setup for blocking test

1 = R&S SGS generating an interfering RF signal, the unwanted signal
2 = R&S SMBV100B generating a LoRa test signal, the wanted signal
3 = External PC with R&S SGS control software and with LoRa Test Tool for PER analysis
4 = RF power combiner combining the interfering RF signal and the LoRa test signal
5 = LoRa DUT receiving the combined RF signal
Blue arrow = LoRa test signal path
Green arrow = Connection for R&S SGS control via R&S SGMA-GUI control software at the external PC
Orange arrow = Connection for LoRa DUT control and analysis via LoRa Test Tool at the external PC

To perform an adjacent channel blocking test

1. To generate the wanted signal, configure the R&S SMBV100B as in "To perform an Rx sensitivity test" on page 32.
2. To generate the adjacent channel blocking signal at the second signal generator, e.g. the R&S SGS, proceed as follows:
   a) Preset the R&S SGS.
   b) Set the frequency as specified.
   The frequency value is typically a few hundred kilohertz higher/lower than the frequency of the wanted signal.

c) Set the level as specified.
The level values for uplink and downlink can differ.

3. At the R&S SMBV100B, increase the level of the wanted signal.
4. Monitor the PER at the DUT, e.g. with an analysis software (LoRa Test Tool).

The adjacent channel blocking level is the wanted signal level, that corresponds to a specified PER value, typically PER < 1 %.

To perform an on-channel blocking test

1. To generate the wanted signal, configure the R&S SMBV100B as in "To perform an Rx sensitivity test" on page 32.
2. To generate the on-channel blocking signal at the second signal generator, e.g. the R&S SGS, proceed as follows:
   a) Preset the R&S SGS.
   b) Set the frequency, that is the same frequency as the wanted signal (step 8).
   c) Set the level as specified.
   The level values for uplink and downlink can differ.
3. At the R&S SMBV100B, increase the level of the wanted signal.
4. Monitor the PER at the DUT, e.g. with an analysis software (LoRa Test Tool).

The on-channel blocking level is the wanted signal level, that corresponds to a specified PER value, typically PER < 1 %.

See also:

- R&S SGS100A user manual
- R&S SGMA-GUI Software software for control of the R&S SGS

6 Remote-control commands

The following commands are required to generate signals with the LoRa option in a remote environment. We assume that the R&S SMBV100B has already been set up for remote operation in a network as described in the R&S SMBV100B 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 SMBV100B user manual.

Common suffixes

The following common suffixes are used in the remote commands:

Suffix	Value range	Description
`ENTity<ch>`	1	Optional keyword, provided for compatibility with R&S®SMW200A `ENTity1:SOURce1` = `SOURce1`
`SOURce<hw>`	1	Available baseband signals
`OUTPut<ch>`	1 to 3	Available markers

The following commands specific to the R&S SMBV100B-K131 option are described here:

6.1 Programming examples

The corresponding sections of the same title provide simple programming examples for the R&S SMBV100B. The purpose of the examples is to present **all** commands for a given task. In real applications, one would rather reduce the examples to an appropriate subset of commands.

The programming examples have been tested with a software tool which provides an environment for the development and execution of remote tests. To keep the examples as simple as possible, only the "clean" SCPI syntax elements are reported. Non-executable command lines (for example comments) start with two // characters.

At the beginning of the most remote control program, an instrument (p)reset is recommended to set the R&S SMBV100B to a definite state. The commands `*RST` and `SYSTem:PRESet` are equivalent for this purpose. `*CLS` also resets the status registers and clears the output buffer.

Example: Storing current configuration

```
SOURce1:BB:LORA:SETTing:STORe "/var/user/my_settings"
*RST
SOURce1:BB:LORA:SETTing:CATalog?
// my_lora, lora
SOURce1:BB:LORA:SETTing:LOAD "/var/user/lora"
SOURce1:BB:LORA:STATe 1
SOURce1:BB:LORA:SETTing:DEL "my_lora"
SOURce1:BB:LORA:WAVeform:CREate "/var/user/my_lora_wv"
```

Example: Generating a LoRa signal

```
SOURce1:BB:LORA:PRESet
// Configure LoRa general settings: Bandwidth, idle interval time, sequence
// length and sampling parameters
SOURce1:BB:LORA:BWIDth BW125
SOURce1:BB:LORA:IINTerval 0.0001
SOURce1:BB:LORA:SLENgth 1
SOURce1:BB:LORA:OSAMpling 4
SOURce1:BB:LORA:SRATe:VARiation 500000
SOURce1:BB:LORA:STATe 1
// Configure the carrier signal, e.g. for ETSI compliant devices.
SOURce1:FREQuency:CW 868500000
SOURce1:POWer:POWer 14
OUTPut1:STATe 1
```

Example: Configuring LoRa frame parameters

```
SOURce1:BB:LORA:PRESet
// Configure preamble and synchronization parameters.
SOURce1:BB:LORA:FCONfiguration:PRCMode:STATe 0
SOURce1:BB:LORA:FCONfiguration:SMODe PUBL
SOURce1:BB:LORA:FCONfiguration:UPLength 8

// Configure modulation and coding parameters.
SOURce1:BB:LORA:FCONfiguration:CRATe CR1
SOURce1:BB:LORA:FCONfiguration:EACTive:STATe 1
SOURce1:BB:LORA:FCONfiguration:SFACtor SF7
SOURce1:BB:LORA:FCONfiguration:IACTive:STATe 1

// Configure data, header and payload parameters.
SOURce1:BB:LORA:FCONfiguration:DLENgth 16
SOURce1:BB:LORA:FCONfiguration:PCRC:STATe 1
SOURce1:BB:LORA:FCONfiguration:DATA PN9
SOURce1:BB:LORA:FCONfiguration:HACTive:STATe 1
SOURce1:BB:LORA:FCONfiguration:BMODe:STATe 0
SOURce1:BB:LORA:FCONfiguration:CMODe:STATe 0
SOURce1:BB:LORA:FCONfiguration:RBIT:STATe 0
```

Example: Configuring impairments to LoRa modulation

```
SOURce1:BB:LORA:PRESet
// Configure symbol timing error and frequency offset.
SOURce1:BB:LORA:IMPairments:STERror 0
SOURce1:BB:LORA:IMPairments:FOFFset 0
// Configure frequency drift parameters.
SOURce1:BB:LORA:IMPairments:FDTYpe LIN
SOURce1:BB:LORA:IMPairments:FDDeviation 0
SOURce1:BB:LORA:IMPairments:FDRate 300
SOURce1:BB:LORA:IMPairments:FDRift:STATe 1
// Activate the impairment settings.
SOURce1:BB:LORA:IMPairments:STATe 1
```

Example: Trigger configuration

```
SOURce1:BB:LORA:TRIGger:SOURce INTernal
SOURce1:BB:LORA:TRIGger:SEQuence ARETrigger
SOURce1:BB:LORA:STAT ON
SOURce1:BB:LORA:TRIGger:EXECute
SOURce1:BB:LORA:TRIGger:ARM:EXECute
SOURce1:BB:LORA:TRIGger:RMODe?
// stopped
SOURce1:BB:LORA:TRIGger:EXECute
SOURce1:BB:LORA:TRIGger:RMODe?

// run
SOURce1:BB:LORA:TRIGger:SEQuence SING
SOURce1:BB:LORA:TRIGger:SLUNit SAMP
SOURce1:BB:LORA:TRIGger:SLENgth 25777
SOURce1:BB:LORA:TRIGger:SEQuence ARET
SOURce1:BB:LORA:TRIGger:SOURce EGT1
SOURce1:BB:LORA:TRIGger:EXTernal:SYNChronize:OUTPut 1
SOURce1:BB:LORA:TRIGger:EXTernal:INHibit 100
SOURce1:BB:LORA:TRIGger:EXTernal:DELay 10
```

Example: Configure and enable standard marker signals

```
// Configure marker 1 settings.
SOURce:BB:LORA:TRIGger:OUTPut1:MODE RAT
SOURce:BB:LORA:TRIGger:OUTPut1:ONTime 10
SOURce:BB:LORA:TRIGger:OUTPut1:OFFTime 20
// Configure marker 2 settings.
SOURce:BB:LORA:TRIGger:OUTPut2:MODE?
// RESTart
SOURce:BB:LORA:TRIGger:OUTPut2:DELay 16384
// Configure marker 3 settings.
SOURce:BB:LORA:TRIGger:OUTPut3:MODE PATT
SOURce:BB:LORA:TRIGger:OUTPut3:PATTern #H2,2
```

Example: Clock settings

```
SOURce1:BB:LORA:CLOCk:SOURce? INT
```

6.2 General commands

[:SOURce<hw>]:BB:LORA:BWIDth <Bw>

Sets the channel bandwidth.

Parameters:

<Bw> BW7 | BW10 | BW15 | BW20 | BW31 | BW41 | BW62 | BW125 | BW250 | BW500

*RST: BW125

Example: See Example"Generating a LoRa signal" on page 37.

Manual operation: See "Bandwidth" on page 16

[:SOURce<hw>]:BB:LORA:IINTerval <IInterval>

Sets the time of the interval separating two frames.

Parameters:

<IInterval> float

Range: 0 to 1
Increment: 0.1E-6
*RST: 100E-6
Default unit: s

Example: See Example"Generating a LoRa signal" on page 37.

Manual operation: See "Idle Interval" on page 16

[:SOURce<hw>]:BB:LORA:PRESet

Sets the parameters of the digital standard to their default values (`*RST` values specified for the commands).

Not affected is the state set with the command `SOURce<hw>:BB:LORA:STATe`.

Example: See Example"Generating a LoRa signal" on page 37.

Usage: Event

Manual operation: See "Set to Default" on page 15

[:SOURce<hw>]:BB:LORA:SETTing:CATalog <Catalog>

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

Parameters:

<Catalog> <filename1>,<filename2>,...

Returns a string of filenames separated by commas.

Example: See Example"Storing current configuration" on page 37.

Manual operation: See "Save/Recall" on page 15

[:SOURce<hw>]:BB:LORA:SETTing:DELete <Filename>

Deletes the selected file from the default or the specified directory. Deleated are files with extension `*.lora`.

Parameters:

<Filename> "<filename>"

Filename or complete file path; file extension can be omitted

Example: See Example"Storing current configuration" on page 37.

Manual operation: See "Save/Recall" on page 15

[:SOURce<hw>]:BB:LORA:SETTing:LOAD <Filename>

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

Parameters:

<Filename> "<filename>"

Filename or complete file path; file extension can be omitted

Example: See Example"Storing current configuration" on page 37.

Manual operation: See "Save/Recall" on page 15

[:SOURce<hw>]:BB:LORA:SETTing:STORe <Filename>

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

Setting parameters:

<Filename> "<filename>"

Filename or complete file path

Example: See Example"Storing current configuration" on page 37.

Usage: Setting only

Manual operation: See "Save/Recall" on page 15

[:SOURce<hw>]:BB:LORA:SLENgth <SLength>

Sets the sequence length of the signal in number of frames. The signal is calculated in advance and output in the arbitrary waveform generator.

Parameters:

<SLength> integer

Range: 1 to dynamic
*RST: 1

Example: See Example"Generating a LoRa signal" on page 37.

Manual operation: See "Sequence Length" on page 16

[:SOURce<hw>]:BB:LORA:OSAMpling <OSampling>

Sets the oversampling factor of the generated waveform.

A reduced sample rate saves significantly the amount of memory or allows an increased signal cycle time, and vice versa.

Parameters:

<OSampling> integer

Range: 1 to 32
*RST: 4

Example: See Example"Generating a LoRa signal" on page 37.

Manual operation: See "Oversampling" on page 16

[:SOURce<hw>]:BB:LORA:SRATe:VARiation <Variation>

Sets the sample rate of the signal.

A variation of this parameter affects the ARB clock rate; all other signal parameters remain unchanged. When changing values of the affecting parameters, the sample rate is reset.

Parameters:

<Variation> float

Range: 4E2 to 20E6
Increment: 1E-3
*RST: 1E6

Example: See Example"Generating a LoRa signal" on page 37.

Manual operation: See "Sample Rate Variation" on page 16

[:SOURce<hw>]:BB:LORA:STATe <State>

Activates the standard and deactivates all the other digital standards and digital modulation modes in the same path.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Generating a LoRa signal" on page 37.

Manual operation: See "State" on page 15

[:SOURce<hw>]:BB:LORA:WAVeform:CREate <Filename>

Saves the current settings as an ARB signal in a waveform file (`*.wv`).

Setting parameters:

<Filename> string

Filename or complete file path; file extension is assigned automatically

Example: See Example"Storing current configuration" on page 37.

Usage: Setting only

Manual operation: See "Generate Waveform File" on page 15

6.3 Frame configuration commands

[:SOURce<hw>]:BB:LORA:FCONfiguration:BMODe:STATe <State>

Activates the burst mode of header data in the frame.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Burst Mode" on page 20

[:SOURce<hw>]:BB:LORA:FCONfiguration:CMODe:STATe <State>

Activates the compressed mode of the header data in the frame.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Compressed Mode" on page 20

[:SOURce<hw>]:BB:LORA:FCONfiguration:CRATe <CRate>

Sets the coding rate.

Parameters:

<CRate> CR0 | CR1 | CR2 | CR3 | CR4

CR<x> = 0 to 4

The coding rate R_{Coding} is calculated as follows:

R_{Coding} = 4 / (4 + CR<x>)
"CR0" corresponds to no coding, i.e. R_{Coding} = 1.

*RST: CR1

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Coding Rate" on page 18

[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA <Data>

Sets the data source for the payload data in a LoRa frame.

Parameters:

<Data> ZERO | ONE | PATTern | PN9 | PN11 | PN15 | PN16 | PN20 | PN21 | PN23 | DLISt

PNxx
The pseudo-random sequence generator is used as the data source. There is a choice of different lengths of random sequence.

DLISt
A data list is used. The data list is selected with the aid of command `SOURce:BB:LORA:DATA DLISt`.

ALL0 | ALL1
Internal 0 or 1 data is used.

PATTern
Internal data is used. The bit pattern for the data is defined with the aid of command `:SOURce:BB:LORA:DATA PATTern`.

*RST: PN9

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Data Source" on page 19

[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA:DPATtern <DPattern>, <BitCount>

Sets the data pattern, if the `data source PATT` is selected.

Parameters:

<DPattern> numeric

*RST: #H0

<BitCount> integer

Range: 1 to 64
*RST: 1

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Data Source" on page 19

[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA:DSELection <DSelection>

Selects an existing data list file from the default directory or from the specific directory.

The data list is only used, if the `data source DLIS` is selected.

Parameters:

<DSelection> string

Filename incl. file extension or complete file path

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Data Source" on page 19

[:SOURce<hw>]:BB:LORA:FCONfiguration:DLENgth <DLength>

Sets the data length of the payload in the frame.

Parameters:

<DLength> integer

Range: 1 to 255
*RST: 16

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Data Length" on page 19

[:SOURce<hw>]:BB:LORA:FCONfiguration:EACTive:STATe <State>

Activates encoding of the modulation symbols.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 1

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Encoder Active" on page 18

[:SOURce<hw>]:BB:LORA:FCONfiguration:HACTive:STATe <State>

Activates the header data in the frame.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 1

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Header Active" on page 20

[:SOURce<hw>]:BB:LORA:FCONfiguration:IACTive:STATe <State>

Activates the interleaver in the frame.

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

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Interleaver Active" on page 18

[:SOURce<hw>]:BB:LORA:FCONfiguration:PCRC:STATe <State>

Activates a cyclic redundancy check (CRC) of the payload.

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

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Payload CRC" on page 20

[:SOURce<hw>]:BB:LORA:FCONfiguration:PRCMode:STATe <State>

Activates the payload reduced coding mode.

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

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Payload Reduced Coding Mode" on page 17

[:SOURce<hw>]:BB:LORA:FCONfiguration:RBIT:STATe <State>

Enables the reserved bit in the frame header.

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

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Reserved Bit" on page 20

[:SOURce<hw>]:BB:LORA:FCONfiguration:SMODe <SMode>

Sets the synchronization mode of the preamble.

Parameters:
<SMode> PRIVate | PUBLic

PRIVate
A preamble with a public sync word is generated.

PUBLic
A preamble with a private sync word is generated.

*RST: PUBLic

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Sync Mode" on page 18

[:SOURce<hw>]:BB:LORA:FCONfiguration:SFACtor <Sf>

Sets the spreading factor for the modulation.

Parameters:
<Sf> SF6 | SF7 | SF8 | SF9 | SF10 | SF11 | SF12

*RST: SF7

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Spreading Factor" on page 18

[:SOURce<hw>]:BB:LORA:FCONfiguration:UPLength <PLength>

Sets the unmodulated preamble length.

Parameters:
<PLength> integer

Range: 6 to 8
*RST: 8

Example: See Example"Configuring LoRa frame parameters" on page 38.

Manual operation: See "Unmodulated Preamble Length" on page 17

6.4 Impairments commands

[:SOURce<hw>]:BB:LORA:IMPairments:FDDeviation <FDDeviation>

Sets the frequency deviation of the frequency drift.

Parameters:
<FDDeviation> integer

Range: -200E3 to 200E3
*RST: 0

Example: See Example"Configuring impairments to LoRa modulation" on page 38.

Manual operation: See "Deviation" on page 22

[:SOURce<hw>]:BB:LORA:IMPairments:FDRate <FDRate>

Sets the rate of the carrier frequency drift.

Parameters:

<FDRate> integer

Range: 160 to 1.6E3
*RST: 300

Example: See Example"Configuring impairments to LoRa modulation" on page 38.

Manual operation: See "Rate" on page 22

[:SOURce<hw>]:BB:LORA:IMPairments:FDRift:STATe <State>

Activates frequency drift settings in the payload.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 1

Example: See Example"Configuring impairments to LoRa modulation" on page 38.

Manual operation: See "State" on page 21

[:SOURce<hw>]:BB:LORA:IMPairments:FDTYpe <FDType>

Sets the frequency drift type.

Parameters:

<FDType> LINear | SINE

LINear
Generation of frequency drift is set linear.

SINE
Generation of frequency drift is set sinusoid.

*RST: LINear

Example: See Example"Configuring impairments to LoRa modulation" on page 38.

Manual operation: See "Type" on page 22

[:SOURce<hw>]:BB:LORA:IMPairments:FOFFset <FOffset>

Sets the frequency offset.

Parameters:

<FOffset> integer

Range: -200E3 to 200E3
*RST: 0

Example: See Example"Configuring impairments to LoRa modulation" on page 38.

Manual operation: See "Frequency Offset" on page 21

[:SOURce<hw>]:BB:LORA:IMPairments:STATe <State>

Activates impairments settings in the payload.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Configuring impairments to LoRa modulation" on page 38.

Manual operation: See "Impairments" on page 21

[:SOURce<hw>]:BB:LORA:IMPairments:STERror <STError>

Sets symbol timing error.

Parameters:

<STError> integer

Range: -300 to 300

*RST: 0

Example: See Example"Configuring impairments to LoRa modulation" on page 38.

Manual operation: See "Symbol Timing Error" on page 21

6.5 Trigger commands

[:SOURce<hw>]:BB:LORA[:TRIGger]:SEQuence <Sequence>

Sets the trigger mode.

Parameters:

<Sequence> AUTO | RETRigger | AAUTo | ARETrigger | SINGle

*RST: AUTO

Example: See Example"Trigger configuration" on page 39.

Manual operation: See "Mode" on page 24

[:SOURce<hw>]:BB:LORA:TRIGger:SOURce <Source>

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

- Internal triggering by a command (`INTernal`)
- External trigger signal via one of the User x connectors
  `EGT1`: External global trigger
- In primary-secondary instrument mode, the external baseband synchronization signal (`BBSY`)
- `EXTernal`: Setting only
  Provided only for backward compatibility with other Rohde & Schwarz signal generators.
  The R&S SMBV100B accepts this value and maps it automatically as follows:
  `EXTernal = EGT1`

Parameters:

<Source> INTernal|EGT1|EXTernal|BBSY

*RST: INTernal

Example: See Example"Trigger configuration" on page 39.

Manual operation: See "Source" on page 26

[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal]:SYNChronize:OUTPut <Output>

Enables signal output synchronous to the trigger event.

Parameters:

<Output> 1 | ON | 0 | OFF

*RST: 1

Example: See Example"Trigger configuration" on page 39.

Manual operation: See "Sync. Output to External Trigger/Sync. Output to Trigger" on page 26

[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal]:DELay <Delay>

Sets the trigger delay.

Parameters:

<Delay> float

Range: 0 to 2147483647
Increment: 0.01
*RST: 0

Example: See Example"Trigger configuration" on page 39.

Manual operation: See "External Delay/Trigger Delay" on page 27

[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal]:INHibit <Inhibit>

Specifies the duration by which a restart is inhibited.

Parameters:

<Inhibit> integer

Range: 0 to dynamic
*RST: 0

Example: See Example"Trigger configuration" on page 39.

Manual operation: See "External Inhibit/Trigger Inhibit" on page 27

[:SOURce<hw>]:BB:LORA:TRIGger:OBASeband:DELay <Delay>

Sets the trigger delay for triggering by the trigger signal from the other path.

Parameters:

<Delay> float

Range: 0 to 65535
Increment: 0.01
*RST: 0

Example: See Example"Trigger configuration" on page 39.

[:SOURce<hw>]:BB:LORA:TRIGger:OBASeband:INHibit <Inhibit>

For triggering via the other path, specifies the duration by which a restart is inhibited.

Parameters:

<Inhibit> integer

Range: 0 to 67108863
*RST: 0

Example: See Example"Trigger configuration" on page 39.

[:SOURce<hw>]:BB:LORA:TRIGger:ARM:EXECute

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

Example: See Example"Trigger configuration" on page 39.

Usage: Event

Manual operation: See "Arm" on page 26

[:SOURce<hw>]:BB:LORA:TRIGger:EXECute

Executes a trigger.

Example: See Example"Trigger configuration" on page 39.

Usage: Event

Manual operation: See "Execute Trigger" on page 26

[:SOURce<hw>]:BB:LORA:TRIGger:RMODe <RMode>

Queries the signal generation status.

Parameters:

<RMode> STOP | RUN

*RST: STOP

Example: See Example"Trigger configuration" on page 39.

Manual operation: See "Running/Stopped" on page 25

[:SOURce<hw>]:BB:LORA:TRIGger:SLENgth <SLength>

Defines the length of the signal sequence that is output in the `SINGle` trigger mode

Parameters:

<SLength> integer

Range: 1 to dynamic

*RST: 1

Example: See Example"Trigger configuration" on page 39.

Manual operation: See "Signal Duration" on page 25

[:SOURce<hw>]:BB:LORA:TRIGger:SLUNit <SlUnit>

Defines the unit for the entry of the signal sequence length.

Parameters:

<SlUnit> SEQuence | SAMPle

*RST: SEQuence

Example:

```
SOURce1:BB:LORA:TRIGger:SEQuence SING

SOURce1:BB:LORA:TRIGger:SLUNit SEQ

SOURce1:BB:LORA:TRIGger:SLENgth 2
```

Manual operation: See "Signal Duration Unit" on page 24

[:SOURce<hw>]:BB:LORA:TRIGger:TIME:DATE <Year>, <Month>, <Day>

Sets the date for a time-based trigger signal. For trigger modes single or armed auto, you can activate triggering at this date via the following command:

`SOURce<hw>:BB:<DigStd>:TRIGger:TIME:STATe`

`<DigStd>` is the mnemonic for the digital standard, for example, `ARB`. Time-based triggering behaves analogously for all digital standards that support this feature.

Parameters:

<Year> integer
Range: 1980 to 9999

<Month> integer
Range: 1 to 12

<Day> integer
Range: 1 to 31

Example: See example "Configure a time-based trigger signal" in the subchapter "Trigger Commands" of the chapter "SOURce:BB:ARB subsystem" in the R&S SMBV100B user manual.

Manual operation: See "Trigger Time" on page 25

[:SOURce<hw>]:BB:LORA:TRIGger:TIME:TIME <Hour>, <Minute>, <Second>

Sets the time for a time-based trigger signal. For trigger modes single or armed auto, you can activate triggering at this time via the following command:

`SOURce<hw>:BB:<DigStd>:TRIGger:TIME:STATe`

`<DigStd>` is the mnemonic for the digital standard, for example, `ARB`. Time-based triggering behaves analogously for all digital standards that support this feature.

Parameters:

<Hour> integer
Range: 0 to 23

<Minute> integer
Range: 0 to 59

<Second> integer
Range: 0 to 59

Example: See example "Configure a time-based trigger signal" in the subchapter "Trigger Commands" of the chapter "SOURce:BB:ARB subsystem" in the R&S SMBV100B user manual.

Manual operation: See "Trigger Time" on page 25

[:SOURce<hw>]:BB:LORA:TRIGger:TIME[:STATe] <State>

Activates time-based triggering with a fixed time reference. If activated, the R&S SMBV100B triggers signal generation when its operating system time matches a specified time.

Specify the trigger date and trigger time with the following commands:

`SOURce<hw>:BB:<DigStd>:TRIGger:TIME:DATE`

`SOURce<hw>:BB:<DigStd>:TRIGger:TIME:TIME`

`<DigStd>` is the mnemonic for the digital standard, for example, `ARB`. Time-based triggering behaves analogously for all digital standards that support this feature.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See example "Configure a time-based trigger signal" in the subchapter "Trigger Commands" of the chapter "SOURce:BB:ARB subsystem" in the R&S SMBV100B user manual.

Manual operation: See "Time Based Trigger" on page 25

6.6 Marker commands

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:MODE <Mode>

Defines the signal for the selected marker output.

Parameters:

<Mode> RESTart | PULSe | PATTern | RATio | TRIGger | FRAMe

*RST: RESTart

Example: See Example"Configure and enable standard marker signals" on page 39.

Manual operation: See "Mode" on page 28

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:DELay <Delay>

Defines the delay between the signal on the marker outputs and the start of the signals.

Parameters:

<Delay> float

Range: 0 to 16777215
Increment: 1
*RST: 0
Default unit: Samples

Example: See Example"Configure and enable standard marker signals" on page 39.

Manual operation: See "Delay" on page 29

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:ONTime <OnTime>
[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:OFFTime <OffTime>

Sets the number of samples during which the marker output is on or off.

Parameters:

<OffTime> integer

Range: 1 to 16777215
*RST: 1

Example: See Example"Configure and enable standard marker signals" on page 39.

Manual operation: See "Mode" on page 28

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:PATTern <Pattern>, <BitCount>

Sets the bit pattern defining the marker signal.

Parameters:

<Pattern> numeric

*RST: #H2

<BitCount> integer

Range: 1 to 64
*RST: 2

Example: See Example"Configure and enable standard marker signals" on page 39.

Manual operation: See "Mode" on page 28

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:PULSe:DIVider <Divider>

Set the pulse divider for marker mode `PULSe`.

Parameters:

<Divider> integer

Range: 2 to 1024
*RST: 2

Example: See [:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:PULSe:FREQuency? on page 56.

Manual operation: See "Mode" on page 28

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:PULSe:FREQuency?

Queries the pulse frequency.

The return value depends on the pulse divider, which is the sample rate divided by the pulse divider.

Return values:

<Frequency> float

Range: 2 to 1024
Increment: 1E-3
*RST: 2

Example:

```
SOURce1:BB:LORA:TRIGger:OUTPut1:MODE PULSe
SOURce1:BB:LORA:TRIGger:OUTPut1:PULSe:DIVider 4
SOURce1:BB:LORA:SRATe:VARiation?
// 500000
SOURce1:BB:LORA:TRIGger:OUTPut1:PULSe:FREQuency?
// 125000
```

Usage: Query only

Manual operation: See "Mode" on page 28

6.7 Clock commands

[:SOURce<hw>]:BB:LORA:CLOCk:SOURce <Source>

Selects the clock source:

- INTernal: Internal clock reference

Parameters:

<Source> INTernal

*RST: INTernal

Example: See Example"Clock settings" on page 39.

Manual operation: See "Clock Source" on page 30

Glossary: Abbreviations and definitions

C

CEPT: European Conference of Postal and Telecommunications Administrations

CSS: Chirp Spread Spectrum

CW: Continous Wave

E

ECO: European Communications Office

ERC: European Radiocommunications Committee

ETSI: European Telecommunications Standards Institute

F

FCC: Federal Communications Commission

I

IoT: Internet of Things

L

LoRa: Longe Range

LoRaWAN: Longe Range Wide Area Network

P

PER: Packet Error Rate

PHY: Physical layer

R

REC: Physical layer

W

WAN: LoRaWAN

Glossary: Specifications and references

Symbols

1MA295: Rohde&Schwarz
Application Note 1MA295: Characterization of LoRa Devices
https://www.rohde-schwarz.com/appnote/1MA295

C

CEPT/ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)"
Available at ECO data base
https://www.ecodocdb.dk/download/25c41779-cd6e/Rec7003e.pdf

E

ETSI Specification EN 300 220-1: "Short Range Devices (SRD) operating in the frequency range 25 MHz to 1000 MHz"
https://www.etsi.org/deliver/etsi_en/300200_300299/30022001/

F

FCC Specification 47 Part 15.247: "47 CFR 15.247 - Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz."
https://www.govinfo.gov/content/pkg/CFR-2010-title47-vol1/pdf/CFR-2010-title47-vol1-sec15-247.pdf

L

LoRaWAN Regional Parameters Specification: "LoRaWAN™ 1.1 Regional Parameters"
https://lora-alliance.org/resource-hub/lorawantm-regional-parameters-v11ra

LoRaWAN Specification: "LoRaWAN™ 1.1 Specification"
https://lora-alliance.org/resource-hub/lorawantm-specification-v11

R

R&S SGMA-GUI Software: Software for control of R&S SGS
https://www.rohde-schwarz.com/software/sgs100a/

R&S SGS100A user manual: https://www.rohde-schwarz.com/manual/sgs100a/

List of commands

Index

M

O

P

R

S

T

U

V

W