R&S®SMBV-K131
LoRa
User Manual

ROHDE&SCHWARZ

This document describes the following software option:

- R&S®SMBV-K131
  1419.1783.02

This manual describes firmware version 4.70.108.xx and later of the R&S®SMBV100A.

The following abbreviations are used throughout this manual: R&S®SMBV100 is abbreviated as R&S SMBV.

Contents

1 Preface

1.1 About this Manual

This operating manual provides all the information **specific to the LoRa option R&S SMBV-K131**. All general instrument functions and settings common to all applications and operating modes are described in the main R&S SMBV operating manual.

The main focus in this manual is on the provided settings and the tasks required to generate a signal. The following topics are included:

- **Welcome to the LoRa option R&S SMBV-K131**
  Introduction to and getting familiar with the option

- **About the LoRa**
  Background information on basic terms and principles in the context of the signal generation

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

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

- **Glossary**
  Alphabetical list of reference material such as application notes and specifications

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

- **Index**

The functions specific to the discontinued products R&S®SMU200A, R&S®SMATE200A, R&S®SMJ100A and R&S®AMU200A are not described here.

Find the description of the corresponding option at the following page:

https://www.rohde-schwarz.com/product/SMU200A > "Downloads"

Contents and scope

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

Notes on screenshots

When describing the functions of the product, we use sample screenshots. These screenshots are meant to illustrate as much as possible of the provided functions and

possible interdependencies between parameters. The shown values may not represent realistic usage scenarios.

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

1.2 Documentation Overview

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

www.rohde-schwarz.com/manual/smbv100a

1.2.1 Quick Start Guide Manual

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

1.2.2 Operating Manual 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 quick start guide manual.
- Software option manual
  Contains the description of the specific functions of an option. Basic information on operating the R&S SMBV is not included.

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

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

1.2.3 Service Manual

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

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

1.2.4 Instrument Security Procedures

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

1.2.5 Basic Safety Instructions

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

1.2.6 Data Sheets and Brochures

The data sheet contains the technical specifications of the R&S SMBV. 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/smbv100a

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

See www.rohde-schwarz.com/firmware/smbv100a

1.2.8 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/smbv100a.

2 Welcome to the LoRa Option

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

The R&S SMBV-K131 features

- 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 operating 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 SMBV operating manual. The latest version is available at:

www.rohde-schwarz.com/manual/SMBV100A

2.1 Accessing the LoRa Dialog

To open the dialog with LoRa settings

► In the block diagram of the R&S SMBV, 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".

2.2 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 storing 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 configuring networks and remote operation
> - Using the common status registers
>
> For a description of such tasks, see the R&S SMBV operating manual.

2.3 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.

3 About the LoRa Option

3.1 Required Options

To play back a signal from a waveform file created by the simulation software R&S WinIQSIM2, the corresponding R&S WinIQSIM2 digital standard option must be installed.

For more information, see data sheet.

3.2 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.
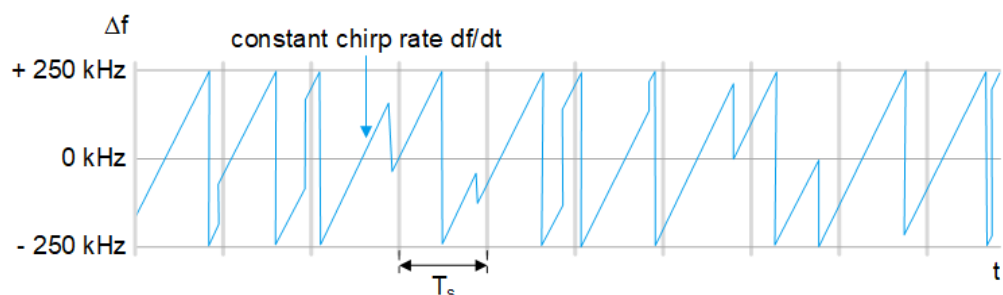
The higher the spreading factor, the lower the change in frequency per unit time.
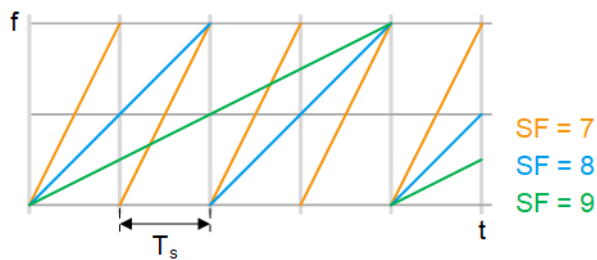
Chirp rate R_C, signal bandwidth Δf, spreading factor SF, sample rate R_S, symbol duration T_S, bit rate R_B and coding rate CR are linked as in the equations below. Further more, typical values are given for SF, Δf and CR.

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 20.

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 3-1: 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
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 4.1, "General Settings", on page 15.

Message and frame structure
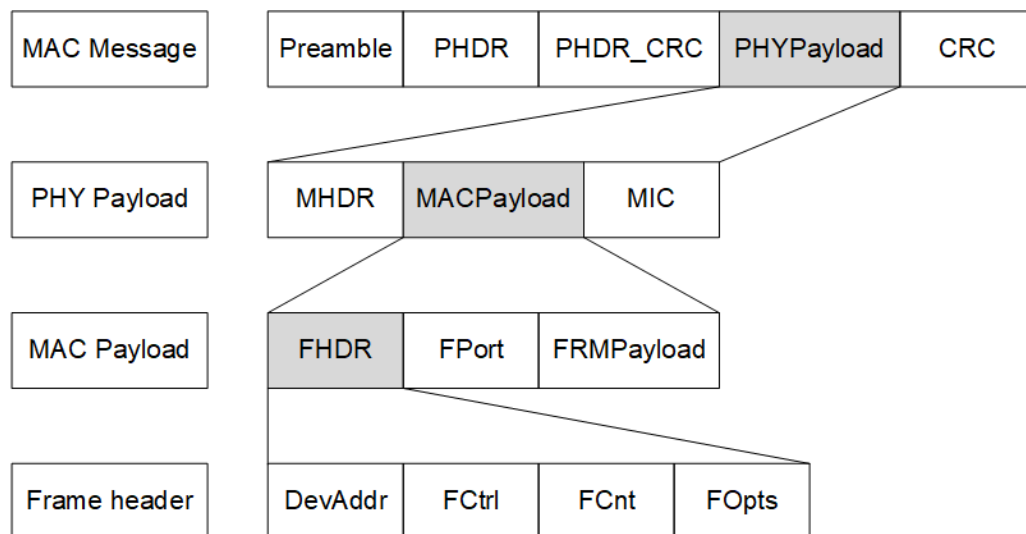
For related settings, see Chapter 4.2, "Frame Configuration Settings", on page 18.

3.3 About LoRaWAN

The LoRa Alliance, Inc. specifies a wide area network (WAN) stack for long range communication as shown in Figure 3-1 (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.
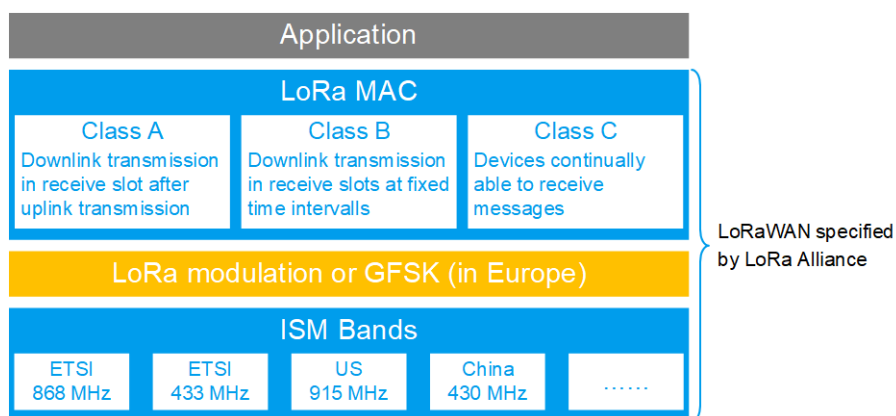
Figure 3-1: LoRaWAN stack

Network architecture

A LoRaWAN architecture has a star-shaped structure as shown in Figure 3-2 (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.
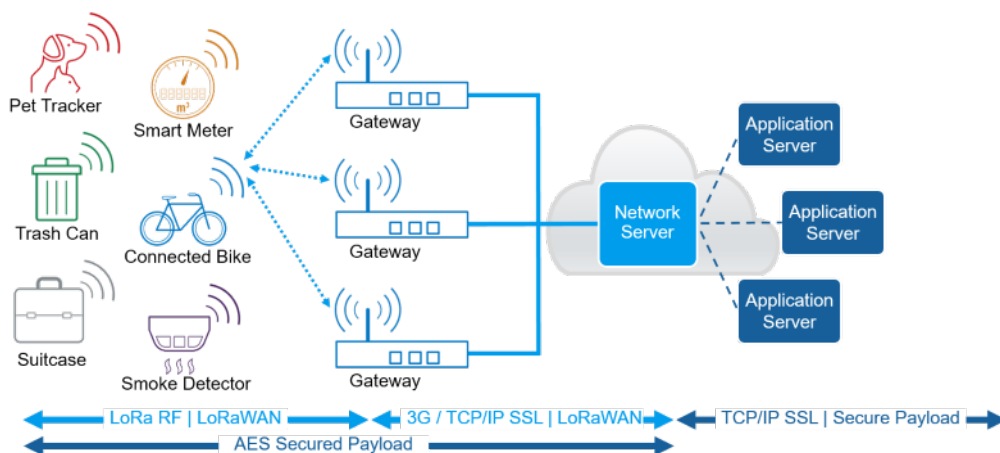

Figure 3-2: LoRaWAN network architecture

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 3-3: 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.
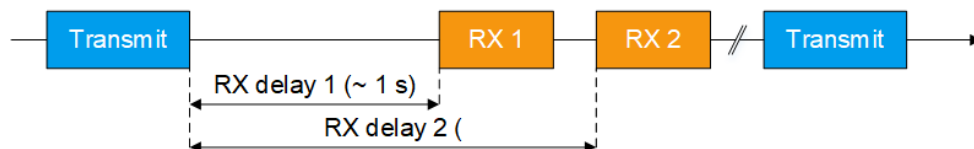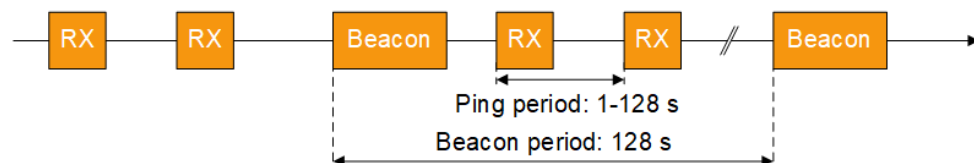

Figure 3-4: Class B communication

- **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.
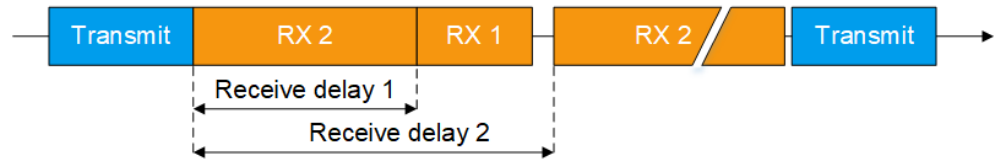
Figure 3-5: Class C communication

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.

4 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 33.

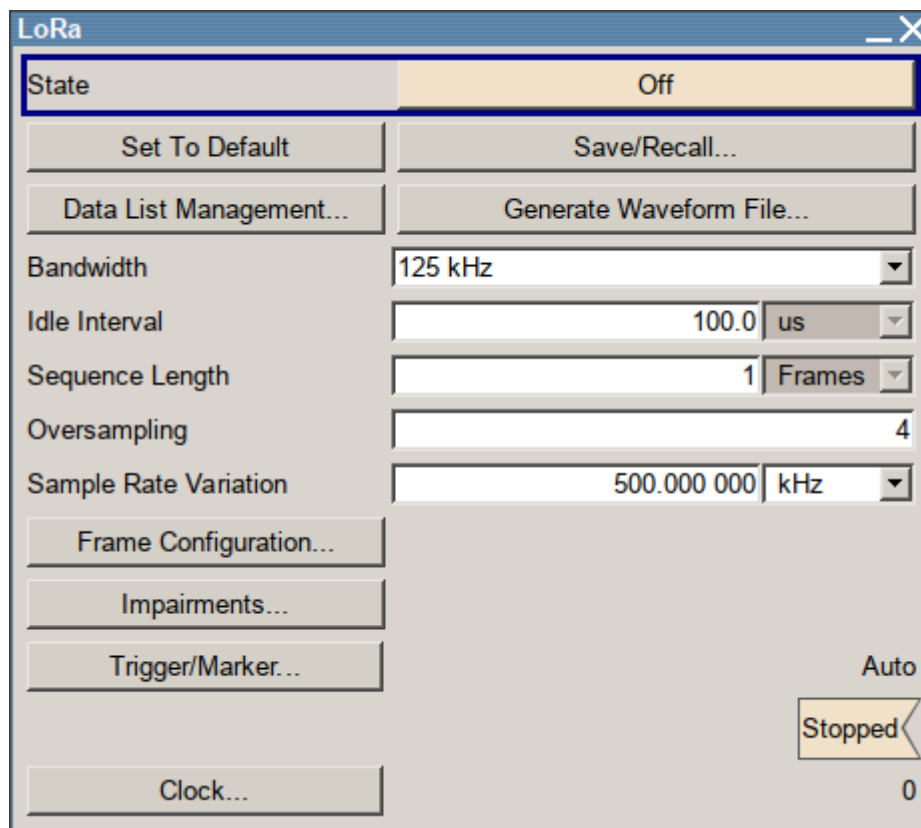**Settings:**

4.1 General Settings

Access:

► Select "Baseband > LoRa".

This 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 40

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 38

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 filename and the directory, in that the settings are stored, are user-definable; the file extension is however predefined.

Remote command:

[:SOURce<hw>]:BB:LORA:SETTing:CATalog on page 38

[:SOURce<hw>]:BB:LORA:SETTing:STORe on page 39

[:SOURce<hw>]:BB:LORA:SETTing:STORe:FAST on page 39
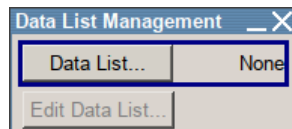
Data List Management

Accesses the "Data List Management" dialog. This menu is used to create and edit a data list.

All data lists are stored as files with the predefined file extension `*.dm_iqd`. The file name and the directory they are user-definable.

The data lists must be selected as a data source from the submenus under the individual function, e.g. in the channel table of the cells.

Note: All data lists are generated and edited by the `SOURce:BB:DM` subsystem commands. Files containing data lists usually end with `*.dm_iqd`. The data lists are selected as a data source for a specific function in the individual subsystems of the digital standard.

Example: Creating and editing the data list

`SOUR:BB:DM:DLIS:SEL 'd_list1'`

`SOUR:BB:DM:DLIS:DATA #B11110101010000001111....`

`SOUR:BB:DM:DLIS:DATA:APP #B11110101010000001111....`

Remote command:

Generate Waveform File

With enabled signal generation, triggers the instrument to store the current settings as an ARB signal in a waveform file. Waveform files can be further processed by the ARB and/or as a multi-carrier or a multi-segment signal.

The filename and the directory it is stored in are user-definable; the predefined file extension for waveform files is `*.wv`.

Remote command:

Bandwidth

Sets the channel bandwidth.

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

Remote command:

Idle Interval

Sets the time of the interval separating two frames.

Remote command:

[:SOURce<hw>]:BB:LORA:IINTerval on page 38

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 39

Oversampling

Sets the oversampling factor of the generated waveform. The ARB generator of the R&S SMBV 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 40

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:

● Impairments 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 40

Frame Configuration

Accesses the frame configuration dialog, see Chapter 4.2, "Frame Configuration Settings", on page 18.

Impairments

Accesses the impairments configuration dialog, see Chapter 4.3, "Impairments Settings", on page 22.

4.2 Frame Configuration Settings

Access:

► Select "Baseband > LoRa > Frame Configuration".
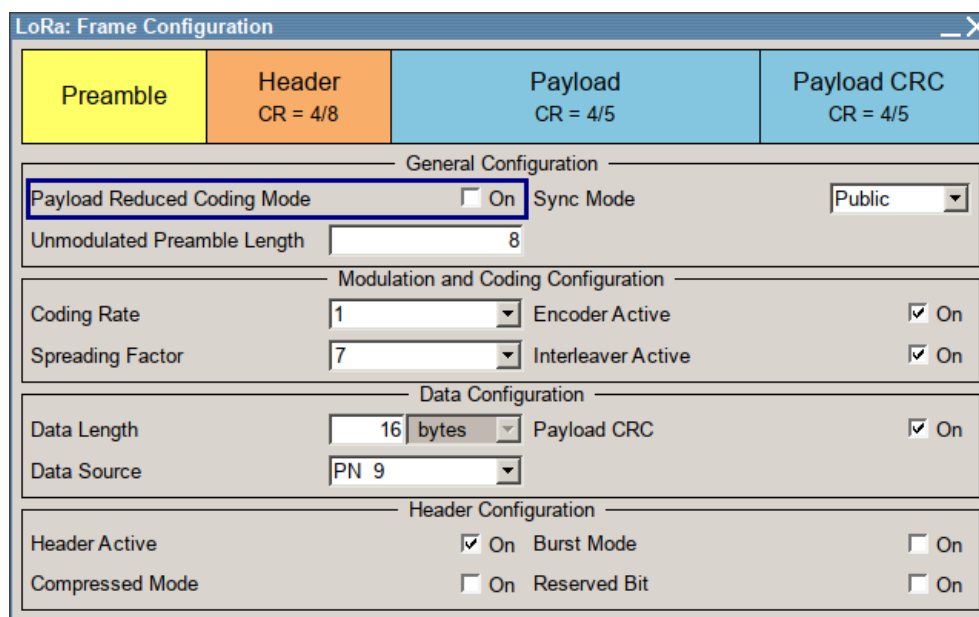
The dialog comprises the general and data settings to configure the frame structure.

Settings

General Configuration

Configures the general frame configuration parameters.

Payload Reduced Coding Mode ← General Configuration

Activates the payload reduced coding mode.

Remote command:

[:SOURce<hw>]:BB:LORA:FCONfiguration:PRCMode:STATe on page 44

Unmodulated Preamble Length ← General Configuration
Sets the unmodulated preamble length.

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

Sync Mode ← General Configuration
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 44

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 41

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

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

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

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

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

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

Data Configuration
Configures header and payload data settings.

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

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

Data Source ← Data Configuration

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 "Main Dialog > Data List Management".

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA on page 42
[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA:DPATtern on page 42
[:SOURce<hw>]:BB:LORA:FCONfiguration:DATA:DSELection on page 42

Payload CRC ← Data Configuration

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 44

Header Configuration ← Data Configuration

Configures the header information in the payload.

Header Active ← Header Configuration ← Data Configuration

Activates the header data in the frame.

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

Compressed Mode ← Header Configuration ← Data Configuration

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

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:CMODe:STATe on page 41

Burst Mode ← Header Configuration ← Data Configuration

Activates the burst mode of header data in the frame.

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:BMODe:STATe on page 41

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

Remote command:
[:SOURce<hw>]:BB:LORA:FCONfiguration:RBIT:STATe on page 44

4.3 Impairments Settings

Access:

► Select "Baseband > LoRa > Impairments".
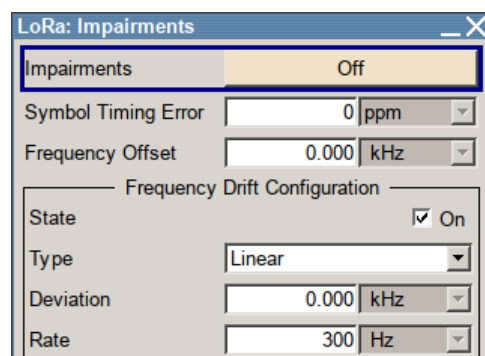
The dialog comprises impairments settings for the signal.

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 47

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 47

Frequency Offset
Sets the carrier frequency offset.

Remote command:
[:SOURce<hw>]:BB:LORA:IMPairments:FOFFset on page 46

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 46

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 46

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 45

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 46

5 Trigger/Marker/Clock Settings

The "Trigger In" section is where the trigger for the signal is set. Various parameters are provided for the settings, depending on which trigger source - internal or external - is selected. The status of signal generation ("Running" or "Stopped") is indicated for all trigger modes.

The "Marker Mode" section is where the marker signals at the MARKER 1/MARKER 2 output connectors are configured.

The "Marker Delay" section is where a marker signal delay can be defined, either without restriction or restricted to the dynamic section, i.e., the section in which it is possible to make settings without restarting signal and marker generation.

The "Clock Settings" section is where the clock source is selected and - in the case of an external source - the clock mode.

The buttons in the last section lead to submenu for general trigger, clock and mapping settings.

Contents

5.1 Trigger In

Access:

► Select "Main Menu > Trigger/Marker".

The "Trigger In" section is where the trigger for the signal is set. Various parameters are provided for the settings, depending on which trigger source - internal or external - is selected. The status of signal generation ("Running" or "Stopped") is indicated for all trigger modes.

Trigger 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 47

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 50

Signal Duration

Enters the length of the signal sequence to be output in the "Single" trigger mode.

Use this parameter to output part of the signal deliberately, an exact sequence of the signal, or a defined number of repetitions of the signal.

Remote command:

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

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 50

Arm

Stops the signal generation until subsequent trigger event occurs.

Remote command:

[:SOURce<hw>]:BB:LORA:TRIGger:ARM:EXECute on page 49

Execute Trigger

Executes trigger manually.

A manual trigger can be executed only when an internal trigger source and a trigger mode other than "Auto" have been selected.

Remote command:

[:SOURce<hw>]:BB:LORA:TRIGger:EXECute on page 49

Trigger Source

Selects trigger source. This setting is effective when a trigger mode other than "Auto" has been selected.

- "Internal"
  The trigger event is executed by "Execute Trigger".
- "Internal (Baseband A/B)"
  (two-path instruments)
  The trigger event is the trigger signal from the second path
- "External"
  The trigger event is the active edge of an external trigger signal, supplied at the TRIGGER connector.
  Use the "Global Trigger/Clock Settings" dialog to define the polarity, the trigger threshold and the input impedance of the trigger signal.

Remote command:

[:SOURce<hw>]:BB:LORA:TRIGger:SOURce on page 48

Sync. Output to External Trigger

(for "Trigger Source > External")

Enables/disables output of the signal synchronous to the external trigger event.

For two or more R&S SMBVs that work in a master-slave mode, configure this parameter depending on the provided system trigger event and the properties of the output signal. See the table below for an overview of the required settings.

Table 5-1: Typical applications

System trigger	Application	"Sync. Output to External Trigger"
Common External Trigger event for the master and the slave instruments	All instruments are synchronous to the external trigger event	On
	All instruments are synchronous among themselves but starting the signal from first symbol is more important than synchronicity with external trigger event	Off
Internal trigger signal of the master R&S SMBV for the slave instruments	All instruments are synchronous among themselves	Off

"On"   Corresponds to the default state of this parameter.
   The signal calculation starts simultaneously with the external trigger
                        event but because of the instrument's processing time the first sam-
                        ples are cut off and no signal is outputted. After elapsing of the inter-
                        nal processing time, the output signal is synchronous to the trigger
                        event.
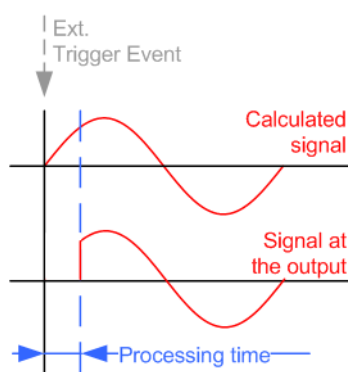
"Off"   The signal output begins after elapsing of the processing time and
                        starts with sample 0, i.e. the complete signal is output.
                        This mode is recommended for triggering of short signal sequences
                        with signal duration comparable with the processing time of the
                        instrument.
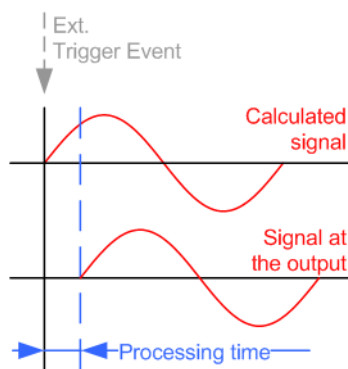
Remote command:

`[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal]:SYNChronize:OUTPut`
on page 48

Trigger Delay

Delays the trigger event of the signal from:
- The external trigger source
- The other path

Use this setting to:
- Synchronize the instrument with the device under test (DUT) or other external devices

Remote command:

`[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal<ch>]:DELay` on page 48

`[:SOURce<hw>]:BB:LORA:TRIGger:OBASeband:DELay` on page 49

Trigger Inhibit

Sets the duration for inhibiting a new trigger event subsequent to triggering. The input is to be expressed in samples.

In the "Retrigger" mode, every trigger signal causes signal generation to restart. This restart is inhibited for the specified number of samples.

This parameter is only available on external triggering or on internal triggering via the second path.

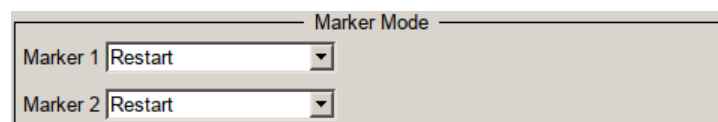For two-path instruments, the trigger inhibit can be set separately for each of the two paths.

Remote command:

`[:SOURce<hw>]:BB:LORA:TRIGger[:EXTernal<ch>]:INHibit` on page 48

`[:SOURce<hw>]:BB:LORA:TRIGger:OBASeband:INHibit` on page 49

5.2 Marker Mode

Access:

► Select "Main Menu > Trigger/Marker".

The marker output signal for synchronizing external instruments is configured in the marker settings section "Marker Mode".

The R&S SMBV supports two marker signals.

Marker Mode

Selects a marker signal for the associated "Marker" output.

"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 53
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:PULSe:FREQuency?` on page 53

"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 52

"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 52
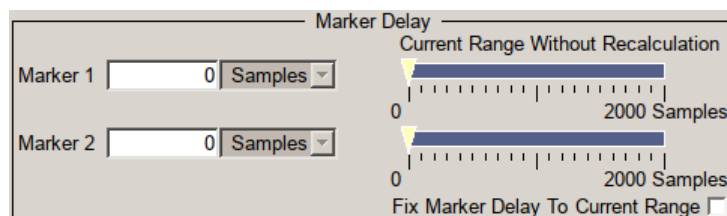`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:OFFTime` on page 52

Remote command:
`[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:MODE` on page 51

5.3 Marker Delay

Access:

► Select "Main Menu > Trigger/Marker".

The delay of the signals on the MARKER 1/MARKER 2 outputs is set in the "Marker Delay" section.

The R&S SMBV supports two marker signals.

Marker x Delay

Enters the delay between the marker signal at the marker outputs and the start of the frame or slot.

The input is expressed as a number of symbols/samples. If the setting "Fix marker delay to dynamic range" is enabled, the setting range is restricted to the dynamic range. In this range, the delay of the marker signals can be set without restarting the marker and signal.

Remote command:

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:DELay on page 51

Current Range without Recalculation

Displays the dynamic range within which the delay of the marker signals can be set without restarting the marker and signal.

The delay can be defined by moving the setting mark.

Remote command:

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:DELay:MAXimum?
on page 51
[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut<ch>:DELay:MINimum?
on page 52

Fix marker delay to current range

Restricts the marker delay setting range to the dynamic range. In this range, the delay can be set without restarting the marker and signal.
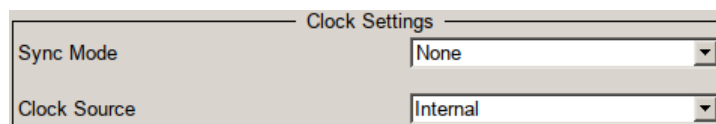
Remote command:

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut:DELay:FIXed on page 51

5.4 Clock Settings

Access:

► Select "Main Menu > Trigger/Marker".

The Clock Settings is used to set the clock source and a delay if necessary.

Sync. Mode
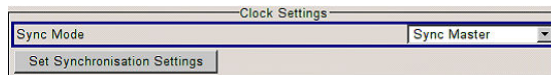
Selects the synchronization mode.

This parameter is used to enable generation of precise synchronous signal of several connected R&S SMBVs.

Note: If several instruments are connected, the connecting cables from the master instrument to the slave one and between each two consecutive slave instruments must have the same length and type.
Avoid unnecessary cable length and branching points.

"None"   The instrument is working in standalone mode.

"Sync. Master" The instrument provides all connected instrument with its synchroni-zation (including the trigger signal) and reference clock signal.

"Sync. Slave"   The instrument receives the synchronization and reference clock sig-nal from another instrument working in a master mode.

Remote command:

[:SOURce<hw>]:BB:LORA:CLOCk:SYNChronization:MODE on page 55

Set Synchronization Settings
Performs automatically adjustment of the instrument's settings required for the syn-chronization mode, selected with the parameter Sync. Mode.

Remote command:

[:SOURce<hw>]:BB:LORA:CLOCk:SYNChronization:EXECute on page 54

Clock Source
Selects the clock source.

"Internal"   The internal clock reference is used to generate the chip clock.

"External"   The external clock reference is fed in as the chip clock or multiple thereof via the [Clock] connector.
                The chip rate must be correctly set to accuracy of (2 % (see data sheet).
                The polarity of the clock input can be changed with the aid of "Global Trigger/Clock Settings".
                In the case of two-path instruments, this selection applies to first path.

Remote command:

[:SOURce<hw>]:BB:LORA:CLOCk:SOURce on page 54

Clock Mode
Sets the type of externally supplied clock.

Remote command:

[:SOURce<hw>]:BB:LORA:CLOCk:MODE on page 54

Clock Multiplier
Enters the multiplication factor for clock mode "Multiple".

Remote command:

[:SOURce<hw>]:BB:LORA:CLOCk:MULTiplier on page 54

Measured External Clock
Provided for permanent monitoring of the enabled and externally supplied clock signal.

Remote command:
`CLOCk:INPut:FREQuency?`

5.5 Global Settings

This section provides access general trigger, clock and mapping settings.

Global Trigger/Clock Settings
Accesses the "Global Trigger/Clock/Input Settings" dialog.

This dialog is to set the trigger threshold, the input impedance and the polarity of the clock and trigger inputs.

The parameters in this dialog affect all digital modulations and standards, and are described in chapter "Global Trigger/Clock/Input Settings" in the operating manual.

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 SMBV has already been set up for remote operation in a network as described in the R&S SMBV 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 SMBV operating manual.

Common suffixes

The following common suffixes are used in the remote commands:

Suffix	Value range	Description
SOURce<hw>	1	Available baseband signals
OUTPut<ch>	1 .. 2	Available markers R&S SMBV supports two markers
EXTernal<ch>	1	External trigger connector

Using SCPI command aliases for advanced mode with multiple entities

You can address multiple entities configurations by using the SCPI commands starting with the keyword SOURce or the alias commands starting with the keyword ENTity.

Note that the meaning of the keyword SOURce<hw> changes in the second case.

For details, see section "SCPI Command Aliases for Advanced Mode with Multiple Entities" in the R&S SMBV operating manual.

Placeholder <root>

For commands that read out or save files in the default directory, the default directory is set using command MMEM:CDIRectory. The examples in this description use the place holder <root> in the syntax of the command.

- D:\ - for selecting the internal hard disk of a Windows instrument
- E:\ - for selecting the memory stick which is inserted at the USB interface of a Windows instrument
- /var/user/ - for selecting the internal flash card of a Linux instrument
- /usb/ - for selecting the memory stick which is inserted at the USB interface of a Linux instrument.

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

In particular, the tasks include:

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

For a description of such tasks, see the R&S SMBV operating manual.

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

6.1 Programming Examples

The corresponding sections of the same title provide simple programming examples for the R&S SMBV. 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 SMBV 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

// SOURce:BB:LORA:TRIGger:SOURce INTB
// The internal trigger signal from the other path must be used.
// SOURce:BB:LORA:TRIGger:OBASeband:DELay 25
// SOURce:BB:LORA:TRIGger:OBASeband:INHibit 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 ELCL
SOURce1:BB:LORA:CLOCk:MODE SAMP
CLOCk:INPUt:FREQuency?
// 1000000
```

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 35.

Manual operation:　See "Bandwidth" on page 17

[: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 35.
Manual operation:	See "Idle Interval" on page 17

[: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 35.
Usage:	Event
Manual operation:	See "Set to Default" on page 16

[: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 35.
Manual operation:	See "Save/Recall" on page 16

[: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 35.
Manual operation:	See "Save/Recall" on page 16

[: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 35.

Manual operation: See "Save/Recall" on page 16

[: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 35.

Usage: Setting only

Manual operation: See "Save/Recall" on page 16

[:SOURce<hw>]:BB:LORA:SETTing:STORe:FAST <Fast>

Determines whether the instrument performs an absolute or a differential storing of the settings.

Enable this function to accelerate the saving process by saving only the settings with values different to the default ones.

Note: This function is not affected by the "Preset" function.

Parameters:

<Fast>   0 | 1 | OFF | ON

                              *RST: 1

Manual operation: See "Save/Recall" on page 16

[: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 35.

Manual operation: See "Sequence Length" on page 18

[: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 35.

Manual operation: See "Oversampling" on page 18

[: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 35.

Manual operation: See "Sample Rate Variation" on page 18

[: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>   0 | 1 | OFF | ON

*RST: 0

Example: See Example "Generating a LoRa signal" on page 35.

Manual operation: See "State" on page 16

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

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

Parameters:

<Filename>   string

Filename or complete file path; file extension is assigned automatically

Example: See Example "Storing current configuration" on page 35.

Usage: Setting only

Manual operation: See "Generate Waveform File" on page 17

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>   0 | 1 | OFF | ON

                       *RST: 0

Example: See Example "Configuring LoRa frame parameters" on page 35.

Manual operation: See "Burst Mode" on page 21

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

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

Parameters:

<State>   0 | 1 | OFF | ON

                       *RST: 0

Example: See Example "Configuring LoRa frame parameters" on page 35.

Manual operation: See "Compressed Mode" on page 21

[: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 35.
Manual operation:	See "Coding Rate" on page 20

[: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 35.
Manual operation:	See "Data List Management" on page 17

[: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 35.
Manual operation:	See "Data Source" on page 21

[: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 35.

Manual operation: See "Data List Management" on page 17

[: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 35.

Manual operation: See "Data Length" on page 20

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

Activates encoding of the modulation symbols.

Parameters:

<State>	0	1	OFF	ON	
	*RST:	1

Example: See Example "Configuring LoRa frame parameters" on page 35.

Manual operation: See "Encoder Active" on page 20

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

Activates the header data in the frame.

Parameters:

<State>	0	1	OFF	ON	
	*RST:	1

Example: See Example "Configuring LoRa frame parameters" on page 35.

Manual operation: See "Header Active" on page 21

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

Activates the interleaver in the frame.

Parameters:

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

Example: See Example "Configuring LoRa frame parameters" on page 35.

Manual operation: See "Interleaver Active" on page 20

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

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

Parameters:

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

Example: See Example "Configuring LoRa frame parameters" on page 35.

Manual operation: See "Payload CRC" on page 21

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

Activates the payload reduced coding mode.

Parameters:

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

Example: See Example "Configuring LoRa frame parameters" on page 35.

Manual operation: See "Payload Reduced Coding Mode" on page 19

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

Enables the reserved bit in the frame header.

Parameters:

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

Example: See Example "Configuring LoRa frame parameters" on page 35.

Manual operation: See "Reserved Bit" on page 22

[: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 35.
Manual operation:	See "Sync Mode" on page 20

[: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 35.
Manual operation:	See "Spreading Factor" on page 20

[: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 35.
Manual operation:	See "Unmodulated Preamble Length" on page 20

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 36.
Manual operation:	See "Deviation" on page 23

[: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 36.

Manual operation: See "Rate" on page 23

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

Activates frequency drift settings in the payload.

Parameters:

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

Example: See Example "Configuring impairments to LoRa modulation" on page 36.

Manual operation: See "State" on page 23

[: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 36.

Manual operation: See "Type" on page 23

[: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 36.
Manual operation:	See "Frequency Offset" on page 23

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

Activates impairments settings in the payload.

Parameters:

<State>	0 | 1 | OFF | ON
	*RST: 0
Example:	See Example "Configuring impairments to LoRa modulation" on page 36.
Manual operation:	See "Impairments" on page 22

[: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 36.
Manual operation:	See "Symbol Timing Error" on page 22

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 36.

Manual operation: See "Trigger Mode" on page 25

[: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)

Parameters:

<TrigSource>	*RST:	INTernal

Example: See Example "Trigger configuration" on page 36.

Manual operation: See "Trigger Source" on page 26

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

Enables signal output synchronous to the trigger event.

Parameters:

<Output>	0 | 1 | OFF | ON
	*RST: 1

Example: See Example "Trigger configuration" on page 36.

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

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

Sets the trigger delay.

Parameters:

<Delay>	float	
	Range:	0 to 65535
	Increment:	0.01
	*RST:	0

Example: See Example "Trigger configuration" on page 36.

Manual operation: See "Trigger Delay" on page 28

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

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 36.

Manual operation: See "Trigger Inhibit" on page 28

[: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 36.

Manual operation: See "Trigger Delay" on page 28

[: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 36.

Manual operation: See "Trigger Inhibit" on page 28

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

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

Example: See Example "Trigger configuration" on page 36.

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 36.

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 36.

Manual operation: See "Running/Stopped" on page 26

[: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 36.

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 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 37.

Manual operation: See "Marker 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
	*RST: 0
	Default unit: Samples

Example: See Example "Configure and enable standard marker signals" on page 37.

Manual operation: See "Marker x Delay" on page 30

[:SOURce<hw>]:BB:LORA:TRIGger:OUTPut:DELay:FIXed <Fixed>

Enables/disables a fixed delay between the signal on the marker outputs and the start of the signals.

Parameters:

<Fixed>	0 | 1 | OFF | ON
	*RST: 0

Example: See Example "Configure and enable standard marker signals" on page 37.

Manual operation: See "Fix marker delay to current range" on page 30

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

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

Return values:

<Maximum>	float
	Range: 0 to 16777215 Increment: 1E-3 *RST: 2000

Example:	See Example "Configure and enable standard marker signals" on page 37.
Usage:	Query only
Manual operation:	See "Current Range without Recalculation" on page 30

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

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

Return values:

<Minimum>	float
	Range: 0 to 16777215 Increment: 1E-3 *RST: 0

Example:	See Example "Configure and enable standard marker signals" on page 37.
Usage:	Query only
Manual operation:	See "Current Range without Recalculation" on page 30

[: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 37.
Manual operation:	See "Marker 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 37.

Manual operation: See "Marker 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 53.

Manual operation: See "Marker 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 "Marker Mode" on page 28

6.7 Clock Commands

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

Selects the clock source:

- INTernal: Internal clock reference

Parameters:

<ClockSour>   *RST: INTernal

Example: See Example "Clock settings" on page 37.

Manual operation: See "Clock Source" on page 31

[:SOURce<hw>]:BB:LORA:CLOCk:MODE <Mode>

Sets the type of externally supplied clock.

Parameters:

<Mode>   SAMPle | MSAMple

                         *RST: SAMPle

Example: See Example "Clock settings" on page 37.

Options:

Manual operation: See "Clock Mode" on page 31

[:SOURce<hw>]:BB:LORA:CLOCk:MULTiplier <Multiplier>

Parameters:

<Multiplier>   integer

                         Range: 1 to 64
                         *RST: 4

Manual operation: See "Clock Multiplier" on page 31

[:SOURce<hw>]:BB:LORA:CLOCk:SYNChronization:EXECute

Performs automatically adjustment of the instrument's settings required for the synchronization mode, set with the command BB:LORA:CLOC:SYNC:MODE.

Example: BB:LORA:CLOC:SYNC:MODE MAST
                         the instrument is configured to work as a master one.
                         BB:LORA:CLOC:SYNC:EXEC
                         all synchronization's settings are adjusted accordingly.

Usage:	Event
Manual operation:	See "Set Synchronization Settings" on page 31

[:SOURce<hw>]:BB:LORA:CLOCk:SYNChronization:MODE <Mode>

Selects the synchronization mode.

This parameter is used to enable generation of precise synchronous signal of several connected R&S SMBVs.

Note: If several instruments are connected, the connecting cables from the master instrument to the slave one and between each two consecutive slave instruments must have the same length and type.

This applies for all connections, the REF OUT to REF IN connection, the MARKER 1 to TRIGGER connection and the CLOCK OUT to CLOCK IN connection. Avoid unnecessary cable length and branching points.

Parameters:

<Mode>	NONE | MASTer | SLAVe
	NONE The instrument is working in stand-alone mode.
	MASTer The instrument provides all connected instrument with its synchronization (including the trigger signal) and reference clock signal.
	SLAVe The instrument receives the synchronization and reference clock signal from another instrument working in a master mode.
	*RST: NONE
Example:	`:BB:LORA:CLOC:SYNC:MODE MAST` The instrument is configured to work as a master one.
Manual operation:	See "Sync. Mode" 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^{TM} 1.1 Regional Parameters"

https://lora-alliance.org/resource-hub/lorawantm-regional-parameters-v11ra

LoRaWAN Specification: "LoRaWAN^{TM} 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

O

P

Q

R

S

T

U

W