This document describes the following software options:

- **R&S® SMBVB-K548**
  
  1423.8820.02

This manual describes firmware version FW 4.70.006.xx and later of the R&S® SMBV100B.

© 2019 Rohde & Schwarz GmbH & Co. KG
Mühlendorfstr. 15, 81671 München, Germany
Phone: +49 89 41 29 - 0
Fax: +49 89 41 29 12 164
Email: info@rohde-schwarz.com
Internet: www.rohde-schwarz.com

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Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol, e.g. R&S® SMBV100B is indicated as R&S SMBVB. Linux® is abbreviated as Linux.
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1 Preface

1.1 About this Manual

This user manual provides all the information specific to the options R&S SMBVB-K548. All general instrument functions and settings common to all applications and operating modes are described in the main R&S SMBV100B user 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 Crest Factor Reduction option R&S SMBVB-K548**
  Introduction to and getting familiar with the option

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

- **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 R&S SMBV100B user manual)
  Programming examples demonstrate the use of many commands and can usually be executed directly for test purposes

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

- **Index**

1.2 Documentation Overview

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

www.rohde-schwarz.com/manual/smbv100b

1.2.1 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.
1.2.2 User Manuals and Help

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

- Base unit manual
  Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance, instrument interfaces and error messages. Includes the contents of the getting started manual.

- Software option manual
  Contains the description of the specific functions of an option. Basic information on operating the R&S SMBV100B is not included.

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 SMBV100B 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 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
1.2.7 **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/smbv100b](http://www.rohde-schwarz.com/firmware/smbv100b)

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/smbv100b](http://www.rohde-schwarz.com/application/smbv100b)
2 Welcome to the R&S SMBVB-K548 Option

The R&S SMBVB-K548 is a software option that allows you to generate signals with reduced crest factor.

R&S SMBVB-K548 key features

- Reduces the crest factor of a baseband signal through clipping the high signal peaks and filtering the waveform afterwards.
- Can be applied to any waveform file loaded in the arbitrary waveform generator.
- It uses an iterative process to reach the desired crest factor delta.
- It is possible to adjust the filter characteristics. In simple mode, you can specify the channel spacing and signal bandwidth. Alternatively in the advanced filter mode you can specify the lowpass filter through passband and stopband frequencies.

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.

2.1 Accessing the Required Settings

1. In the block diagram of the R&S SMBV100B, select the "Baseband" > "ARB". A dialog box opens that displays the provided general settings.
2. Select "Load Waveform". Navigate to waveform file and load it.
3. Select "ARB > State > On".
4. Select "Crest Factor Reduction".

The signal generation is started. To apply the crest factor reduction 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 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.

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 Crest Factor Reduction

Communication standards utilizing higher order modulation techniques or using multiple carrier and complex signals consisting of the signals of more than one digital standard can feature a high crest factor. The signals of some digital standards can have high crest factors also particularly with many channels and long sequences.

The **crest factor** represents the ratio of the peak voltage value to the RMS voltage value, i.e. the peak to average ratio (PAR). The higher the crest factor and the resulting dynamics of a signal, the greater the requirement for a power amplifier fed by the signal to be linear. A high crest factor arises for instance, when in a multi carrier signal the carriers feature an identical start phase. This is based on the fact that the carriers are periodically superposed that leads to high peak voltages in relation to the RMS voltage values.

High crest factors entail two basic problems:

- The nonlinearity of the power amplifier (compression) causes intermodulation which expands the spectrum (spectral regrowth).
- Since the level of the D/A converter is relative to the maximum value, the average value is converted with a relatively low resolution. This leads to a high quantization noise.

Both effects increase the adjacent-channel power.

**Applying clipping and filtering**

A common and simple approach for achieving a lower PAR is the combination of clipping and filtering.

- **Clipping** is a technique that applies a wanted distortion to the signal. The principle includes specifying a threshold, finding out the signal peaks once the defined limits are exceeded and clipping them off. The level limit is specified as a percentage of the highest peak value. Because clipping is done before filtering, the procedure does not influence the spectrum. The error vector magnitude (EVM) however increases.
  However, signal clipping not only changes the peak value but also the average value and the effect on the crest factor is unpredictable.

- **After the clipping**, **filtering** is applied. The used filters are specially designed so that they filter out the distortion.
4 Crest Factor Reduction Settings

Prerequisite: An ARB file is loaded and enabled.

Access:
► Select the "Baseband > ARB > Crest Factor Reduction".

The remote commands required to define these settings are described in Chapter 5, "Remote-Control Commands", on page 15.

Settings:

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**State**
Enables the crest factor reduction calculation.

**Note:** You cannot activate the crest factor reduction and the notch filter simultaneously. Enabling the notched filter automatically disables the crest factor reduction.

Remote command:
[:SOURce<hw>]:BB:ARBItrary:CFR[:STATe] on page 16
Generate Waveform
With enabled signal generation, triggers the instrument to store the current settings in a waveform file. Waveform files can be further processed.

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

Remote command:
[::SOURce<hw>]:BB:ARBitrary:CFR:WAVeform:CREate on page 20

Algorithm
Displays the algorithm used for the crest factor reduction. The "Clipping and filtering" algorithm performs a hard clipping. It is followed by a low pass filtering of the result in an iterative manner until the target crest factor is reached. You can define the settings of the filter that is used for the calculation.

Remote command:
[::SOURce<hw>]:BB:ARBitrary:CFR:ALGorithm on page 17

Desired Crest Factor Delta
Sets the value difference by which you want to change your crest factor.

Remote command:
[::SOURce<hw>]:BB:ARBitrary:CFR:DCFDelta on page 17

Max Iterations
Sets the number of iterations that are used for calculating the resulting crest factor. The iteration process is stopped when the desired crest factor delta is achieved by 0.1 dB.

Remote command:
[::SOURce<hw>]:BB:ARBitrary:CFR:ITERations on page 18

Original Crest Factor
Displays the original crest factor of the waveform after the calculation of the resulting crest factor is completed. The original crest factor is calculated as an average over the whole waveform, including any idle periods that might be present in TDD waveforms.

Remote command:

Resulting Crest Factor
Displays the resulting crest factor of the waveform after the calculations are completed. The resulting crest factor is calculated as an average over the whole waveform, including any idle periods that might be present in TDD waveforms.

Remote command:
[::SOURce<hw>]:BB:ARBitrary:CFR:RCFactor? on page 19

Filter Mode
Selects which filter mode is used for the filtering.
"Simple" You can specify the RF bandwidth and channel spacing of the signal. The lowpass filter is designed to pass through frequency components inside the signal bandwidth and suppress components in the adjacent channel.

![Figure 4-1: Simple filter mode](image)

In the enhanced filter mode, you can specify the passband and stopband frequencies of the lowpass filter.

![Figure 4-2: Enhanced filter mode](image)

Remote command: [:SOURce<hw>]:BB:ARBitrary:CFR:FILTer on page 17

**Channel Spacing**
Available for "Filter Mode > Simple".
Sets the channel spacing.
Remote command: [:SOURce<hw>]:BB:ARBitrary:CFR:CSPacing on page 17

**Signal Bandwidth**
Available for "Filter Mode > Simple".
Sets the signal bandwidth. The value of the "Signal Bandwidth" should not be higher than the "Channel Spacing".
Remote command:
[:SOURce<hw>]:BB:ARBitrary:CFR:SBANwidth on page 19

Stopband Frequency
Available for "Filter Mode > Enhanced".
Sets the stopband frequency of the filter. Frequency components higher than the stopband frequency are filtered out by the lowpass filter.
Remote command:
[:SOURce<hw>]:BB:ARBitrary:CFR:SFReq on page 20

Passband Frequency
Available for "Filter Mode > Enhanced".
Sets the passband frequency. Frequency components lower than the passband frequency are passed through unfiltered.
Remote command:
[:SOURce<hw>]:BB:ARBitrary:CFR:PFReq on page 19

Maximum Filter Order
Available for "Filter Mode > Enhanced".
Sets the maximum filter order.
Remote command:
[:SOURce<hw>]:BB:ARBitrary:CFR:FORDer on page 18
5 Remote-Control Commands

The following commands are required to perform signal generation 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 user manual. Knowledge about the remote control operation and the SCPI command syntax is 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 remote commands:

<table>
<thead>
<tr>
<th>Suffix</th>
<th>Value range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOURce&lt;hw&gt;</td>
<td>1</td>
<td>Available baseband signals</td>
</tr>
</tbody>
</table>

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 (e.g. 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.

In all the examples, we assume that a remote PC is connected to the instrument, the remote PC and the instrument are switched on, a connection between them is established. We also assume that the security setting "System Config > Setup > Security > SCPI over LAN" is enabled.
Example: Configuring the CFR
Prerequisite: An ARB file is loaded and enabled.

SOURcel:BB:ARBArbitrary:CFR:FILTer SIMPle
SOURcel:BB:ARBArbitrary:CFR:STATe ON
//ON
//6
SOURcel:BB:ARBArbitrary:CFR:RCFactor?
//3
SOURcel:BB:ARBArbitrary:CFR:CREate "cfr"

Example: Setting up an Enhanced Filter

SOURcel:BB:ARBArbitrary:CFR:FILTer ENHanced
SOURcel:BB:ARBArbitrary:CFR:FORDer 100

The following commands specific to the R&S SMBVB-K548 option are described here:

[:SOURce<hw>:]:BB:ARBArbitrary:CFR[:STATe]
Enables the crest factor reduction calculation.

Parameters:

<table>
<thead>
<tr>
<th>&lt;ArbCfrState&gt;</th>
<th>0</th>
<th>1</th>
<th>OFF</th>
<th>ON</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>RST:</em></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example: See Example "Configuring the CFR" on page 16.

Manual operation: See “State” on page 11
[:SOURce<hw>]:BB:ARBitrary:CFR:ALGorithm <ArbCfrAlgorithm>
Displays the algorithm used for the crest factor reduction. The "Clipping and filtering" algorithm performs a hard clipping. It is followed by a low pass filtering of the result in an iterative manner until the target crest factor is reached. You can define the settings of the filter that is used for the calculation.

Parameters:
<ArbCfrAlgorithm> CLFiltering
*RST: CLFiltering

Example: See Example "Configuring the CFR" on page 16.
Manual operation: See "Algorithm" on page 12

[:SOURce<hw>]:BB:ARBitrary:CFR:CSPacing <ArbCfrChanSpac>
Sets the channel spacing, if [:SOURce<hw>]:BB:ARBitrary:CFR:FILTer is set to SIMPle.

Parameters:
<ArbCfrChanSpac> float
Range: 0 to depends on the sample rate of the loaded file
Increment: 0.1
*RST: 250E6

Example: See Example "Configuring the CFR" on page 16.
Manual operation: See "Channel Spacing" on page 13

[:SOURce<hw>]:BB:ARBitrary:CFR:DCFDelta <ArbCfrDCFDelta>
Sets the value difference by which you want to change your crest factor.

Parameters:
<ArbCfrDCFDelta> float
Range: -20 to 0
Increment: 0.1
*RST: -3

Example: See Example "Configuring the CFR" on page 16.
Manual operation: See "Desired Crest Factor Delta" on page 12

[:SOURce<hw>]:BB:ARBitrary:CFR:FILTer <ArbCfrFilterMod>
Selects which filter mode is used for the filtering.

Parameters:
<ArbCfrFilterMod> SIMPle | ENHanced
*RST: SIMPle

Example: See Example "Configuring the CFR" on page 16.
Manual operation: See "Filter Mode" on page 12

`[:SOURce<hw>]:BB:ARBitrary:CFR:FORDer <ArbCfrMaxFilOrd>`

Sets the maximum filter order, if `[:SOURce<hw>]:BB:ARBitrary:CFR:FILTer` is set to ENHanced.

Parameters:

- `<ArbCfrMaxFilOrd>`: integer
  - Range: 0 to 300
  - *RST: 100

Example: See Example "Configuring the CFR" on page 16.

Manual operation: See "Maximum Filter Order" on page 14

`[:SOURce<hw>]:BB:ARBitrary:CFR:ITERations <ArbCfrMaxIter>`

Sets the number of iterations that are used for calculating the resulting crest factor. The iteration process is stopped when the desired crest factor delta is achieved by 0.1 dB.

Parameters:

- `<ArbCfrMaxIter>`: integer
  - Range: 1 to 10
  - *RST: 5

Example: See Example "Configuring the CFR" on page 16.

Manual operation: See "Max Iterations" on page 12

`[:SOURce<hw>]:BB:ARBitrary:CFR:MEASure[:STATe]?`

Queries the state of the crest factor reduction calculation.

Return values:

- `<MeasureState>`: 0 | 1 | OFF | ON
  - OFF: the original and resulting crest factors are already calculated.
  - *RST: 0

Example: See Example "Configuring the CFR" on page 16.

Usage: Query only

`[:SOURce<hw>]:BB:ARBitrary:CFR:OCFactor?`

Queries the original crest factor of the waveform after the calculation of the resulting crest factor is completed. The original crest factor is calculated as an average over the whole waveform, including any idle periods that might be present in TDD waveforms.
Return values:
<ArbCfrOCrestFac> float
Range: 1 to 100
Increment: 0.01
*RST: 6

Example: See Example "Configuring the CFR" on page 16.
Usage: Query only
Manual operation: See "Original Crest Factor" on page 12

Sets the passband frequency, if [:SOURce<hw>]:BB:ARBItrary:CFR:FILTer is set to ENHanced. Frequency components lower than the passband frequency are passed through unfiltered.
Parameters:
<ArbCfrPassBFreq> float
Range: 0 to depends on the sample rate of the loaded file
Increment: 0.1
*RST: 250E6

Example: See Example "Setting up an Enhanced Filter" on page 16.
Manual operation: See "Passband Frequency" on page 14

[:SOURce<hw>]:BB:ARBItrary:CFR:RCFactor?
Queries the resulting crest factor of the waveform after the calculations are completed. The resulting crest factor is calculated as an average over the whole waveform, including any idle periods that might be present in TDD waveforms.

Return values:
<ArbCfrResCreFac> float
Range: 1 to 100
Increment: 0.1
*RST: 6

Example: See Example "Configuring the CFR" on page 16.
Usage: Query only
Manual operation: See "Resulting Crest Factor" on page 12

[:SOURce<hw>]:BB:ARBItrary:CFR:SBANdwidth <ArbCfrSignalBw>
Sets the signal bandwidth, if [:SOURce<hw>]:BB:ARBItrary:CFR:FILTer is set to SIMple.
The value of the signal bandwidth should not be higher than the channel spacing ([:SOURce<hw>]:BB:ARBItrary:CFR:CSPacing).
Parameters:
<ArbCfrSignalBw> float
  Range: 0 to depends on the sample rate of the loaded file
  Increment: 0.1
  *RST: 250E6

Example: See Example "Configuring the CFR" on page 16.

Manual operation: See "Signal Bandwidth" on page 13

[:SOURce<hw>]:BB:ARBitrary:CFR:SFReq <ArbCfrStopBFreq>

Sets the stopband frequency of the filter, if [:SOURce<hw>]:BB:ARBitrary:CFR:FILTer is set to ENHanced. Frequency components higher than the stopband frequency are filtered out by the lowpass filter.

Parameters:
<ArbCfrStopBFreq> float
  Range: 0 to depends on the sample rate of the loaded file
  Increment: 0.1
  *RST: 250E6

Example: See Example "Setting up an Enhanced Filter" on page 16.

Manual operation: See "Stopband Frequency" on page 14

[:SOURce<hw>]:BB:ARBitrary:CFR:WAVeform:CREate <CreateWvFile>

With enabled signal generation, triggers the instrument to store the current settings in a waveform file. Waveform files can be further processed.

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

Setting parameters:
<CreateWvFile> string

Example: See Example "Configuring the CFR" on page 16.

Usage: Setting only

Manual operation: See "Generate Waveform" on page 12
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</tr>
<tr>
<td>[:SOURce&lt;hw&gt;]:BB:ARBitrary:CFR:CSPlacing</td>
<td>17</td>
</tr>
<tr>
<td>[:SOURce&lt;hw&gt;]:BB:ARBitrary:CFR:DCFDelta</td>
<td>17</td>
</tr>
<tr>
<td>[:SOURce&lt;hw&gt;]:BB:ARBitrary:CFR:FILTer</td>
<td>18</td>
</tr>
<tr>
<td>[:SOURce&lt;hw&gt;]:BB:ARBitrary:CFR:FORDer</td>
<td>18</td>
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<td>[:SOURce&lt;hw&gt;]:BB:ARBitrary:CFR:ITERations</td>
<td>18</td>
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<tr>
<td>[:SOURce&lt;hw&gt;]:BB:ARBitrary:CFR:MEASure[:STATE]?</td>
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<td>18</td>
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</tr>
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<td>19</td>
</tr>
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<td>19</td>
</tr>
<tr>
<td>[:SOURce&lt;hw&gt;]:BB:ARBitrary:CFR:SFReq</td>
<td>20</td>
</tr>
<tr>
<td>[:SOURce&lt;hw&gt;]:BB:ARBitrary:CFR:WAVeform:CREate</td>
<td>20</td>
</tr>
<tr>
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