CDM-Toolbox

Digital Modulation in a simple way

Application Note

Products:

- R&S®SMW200A
- R&S®SMBV100A
- R&S®SMU200A
- R&S®SMJ100A
- R&S®SMATE200A

This application note provides a brief introduction into the capabilities of the R&S Vector Signal Generators (VSG) to create user defined digitally modulated signals called Custom Digital Modulation (CDM). Additionally an in depth description of the functions and the operation of the CDM-Toolbox is provided. The CDM-Toolbox is application software which allows an easy remote configuration of CDM signals on R&S VSGs but also the creation of data list and control list files which are most useful to further extend the application area of CDM signals.

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Application Note

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ROHDE&SCHWARZ

Table of Contents

The following abbreviations are used in this application note for Rohde & Schwarz products:

- The R&S®SMW200A vector signal generator is referred to as SMW
- The R&S®SMBV100A vector signal generator is referred to as SMBV
- The R&S®SMU200A vector signal generator is referred to as SMU
- The R&S®SMATE200A vector signal generator is referred to as SMATE
- The R&S®SMJ100A vector signal generator is referred to as SMJ

1 Introduction

This application note provides a brief introduction into the capabilities of the R&S Vector Signal Generators (VSG) to create user defined digitally modulated signals called Custom Digital Modulation (CDM). Additionally an in depth description of the functions and the operation of the CDM-Toolbox is provided.
The CDM-Toolbox is application software which allows an easy remote configuration of CDM signals on R&S VSGs but also the creation of data list and control list files which are most useful to further extend the application area of CDM signals.

1.1 Custom Digital Modulation (CDM)

All R&S Vector Signal Generators (VSGs) equipped with a realtime baseband generator (see [1], [2], [3], [4] and [5] for details) are able to generate digitally modulated baseband signals in realtime. The characteristic of these signals is either determined by a certain standard (e.g. communication standards) or is completely user definable. The later signal type is called **Custom Digital Modulation (CDM)**.
In CDM mode of operation nearly all baseband parameters and settings with an impact on the signal characteristics are under user control. The following figure provides an overview about the baseband functional blocks and processing steps to be run through when generating a CDM signal:

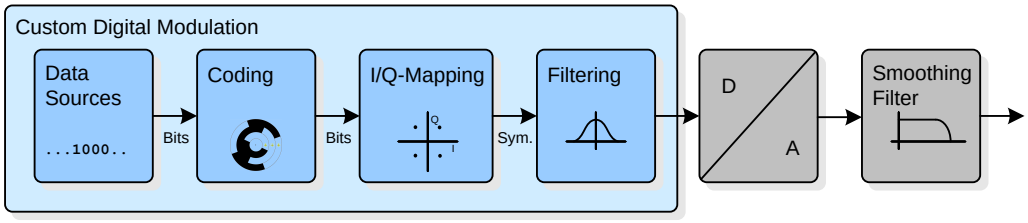


Figure 1: Custom Digital Modulation – Overview

The VSG CDM functional block provides a variety of **Data Sources** which may be used to internally generate bit sequences to be fed into the digital modulator. Simple data patterns like binary 0 (‘All 0’) or 1 (‘All 1’) are available but also variable bit sequences/patterns with a maximum length of 64 bits and also ITU compliant Pseudo Random Bit Sequences (PRBS).
Further on if users want to apply their own bit sequences (e.g. channel coded data bits) they may be provided to the VSG as binary data list files (see chapter 1.1.1).

In the following processing stage the provided data bits may be coded using different **Coding** techniques to improve the signal properties and thus to ease the decoding/demodulation on the receiver side. Since coding is required only when using certain types of modulation the available coding types are directly related to the selected modulation type (I/Q-Mapping). Therefore to get an overview about the coding/modulation combinations supported by the used R&S VSG refer to the specific operating or user manual [1]..[5].

After applied data coding (if applicable) the digital modulation takes place.
The R&S VSGs support a variety of predefined digital **Modulation Types (I/Q-Mapping)** like ASK (amplitude shift keying), FSK (frequency shift keying), PSK (phase shift keying) and QAM (quadrature amplitude modulation). Additionally user defined mappings, created with the R&S MapWiz [7] application, can be imported.

The digital modulation procedure is described by mapping of a data symbol (certain number of data bits) to a certain complex I/Q-constellation point in a so called constellation diagram. To get a first impression about constellation diagrams the following figures show the constellation of a 128QAM with 128 (2^7) constellation points and 7 bits per symbol and of an 8PSK with 8 (2^3) constellation points and thus 3 bits per symbol:

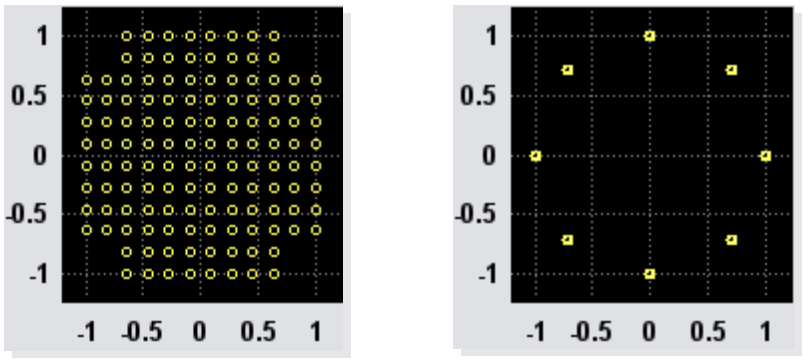


Figure 2: Constellation Diagrams (left: 128QAM, right: 8PSK)

The exact position of the symbols in the constellation diagram (I and Q values) is determined by the applicable mapping rules which are mostly specified by communication standards.
The maximum achievable symbol rate of the modulator depends on the used VSG, the installed HW/SW options and it also depends on the selected modulation types (I/Q-Mapping) and ranges from 15 to 600 MSymbols/s.

After the performed I/Q mapping the symbol stream (baseband signal) runs through a digital **Filter** to shape the signal in a well-defined way prior to the RF up-conversion. This is done to optimize the overall signal performance in the time domain (e.g. Inter Symbol Interference, ISI) and/or in the frequency domain (e.g. Adjacent Channel Leakage Ratio, ACLR). To fulfill a wide range of filter requirements, the R&S VSGs offer a variety of predefined baseband filters. All of these filters are originated from communication standards but most of them can be parameterized by one or more filter type specific parameters to align their characteristics with application specific needs. Exemplarily the following figures show the impulse response (time domain) of a rectangular filter and of a Gauss filter:

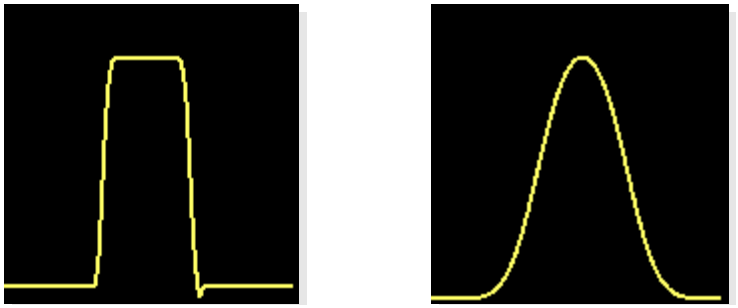


Figure 3: Impuls Response of Baseband Filters (left: Rectangular, right: Gauss)

Additionally user defined shaping filters, designed with the R&S FiltWiz [8] application, can be imported.

1.1.1 Data List

A data list may be used to provide data bits to the VSG CDM functional block if none of the available VSG internal data source (e.g. PRBS, pattern…) is applicable since user specific data sequences are required (e.g. channel coded data bits).

The name of a data list file is user defined; the file extension has to be `.dm_iqd`.
In general the maximum length of a data list (number of contained bits) is determined by the size of the data list memory of the used R&S VSG (see related data sheet). The data list size which may be processed by the CDM-Toolbox is limited to 250 Mbit.
Most R&S VSGs provide integrated functions to load existing (on the VSG memory) data lists, to create new data lists and also to edit existing ones. For a more convenient processing of data lists, especially in case of lists containing a huge amount of data the usage of the CDM-Toolbox is recommended.
In general a data list file consists of two main sections. The first section the so called header contains several mandatory and optional ASCII data list tags which are used to provide information about the data list file content but also to control the VSG. The second section holds the data bits in a binary format.
The following table summarizes all specified R&S data list tags and their meaning:

Data List – Header Tags		
Tag Name	**Mandatory**	**Meaning**
{**TYPE:***SMU-DL*,*0*}	Yes	Set the file format to data list. The format 'SMU-DL' is applicable for all R&S VSGs. The checksum is always zero for data lists. This tag must be the first one in the data list file.
{**COMMENT:***MyComment*}	No	For example comments regarding the data list content and/or usage.
{**COPYRIGHT:***MyCopyright*}	No	Copyright notes
{**DATE:***2017-06-03;21:51:00*}	No	Creation date of the data list
{**DATA BITLENGTH:***444*}	Yes	Number of valid data bits within the data list
{**DATA LIST**-*57*:#*bbbbb…*}	Yes	The binary data list: 8bit, MSB first. The length value is in full bytes and comprises the data bytes and the byte required for the #-mark. This tag must be the last one in the data list file.

Table 1: Data List – Header Tags

Example: The tags shown in the table above are applicable for an R&S data list file which contains 444 binary data bits. This amount of data bits to be hold by the data list results in 444/8 = 55.5 bytes of memory. Since the elementary unit for data storage is one byte the nearest integer number greater than 55.5 (56) is required to store the total amount of data bits. Including the memory of one byte needed for the leading # mark a data list length of 57 bytes is required.
Note: The last 4 data bits (0.5 byte) within the last data byte are ignored by the VSG.

1.1.2 Control List

Control lists may be used to modify the shape of the encoded and modulated CDM signal. Areas of lower RF signal level, Continuous Wave (CW) sections without modulation as well as bursts can be defined.
Additionally up to four marker signals can be activated or deactivated at any symbol position which may thus serve as trigger signals for external instruments or for the synchronization of multiple VSG baseband units.

The name of a control list file is user defined; the file extension has to be `.dm_iqc`.
Any VSG provides integrated functions to load already existing control lists, to create new control lists, to edit existing ones and to graphically show the contained marker and control signals.
For a more convenient processing of control lists the usage of the CDM-Toolbox is recommended.
In contrast to data list files a control list file consists of only one section with mandatory and optional ASCII control list tags. These tags are used to provide information about the control list file content and are essential to specify the marker and control signals.
The following table summarizes all specified R&S control list tags and their meaning:

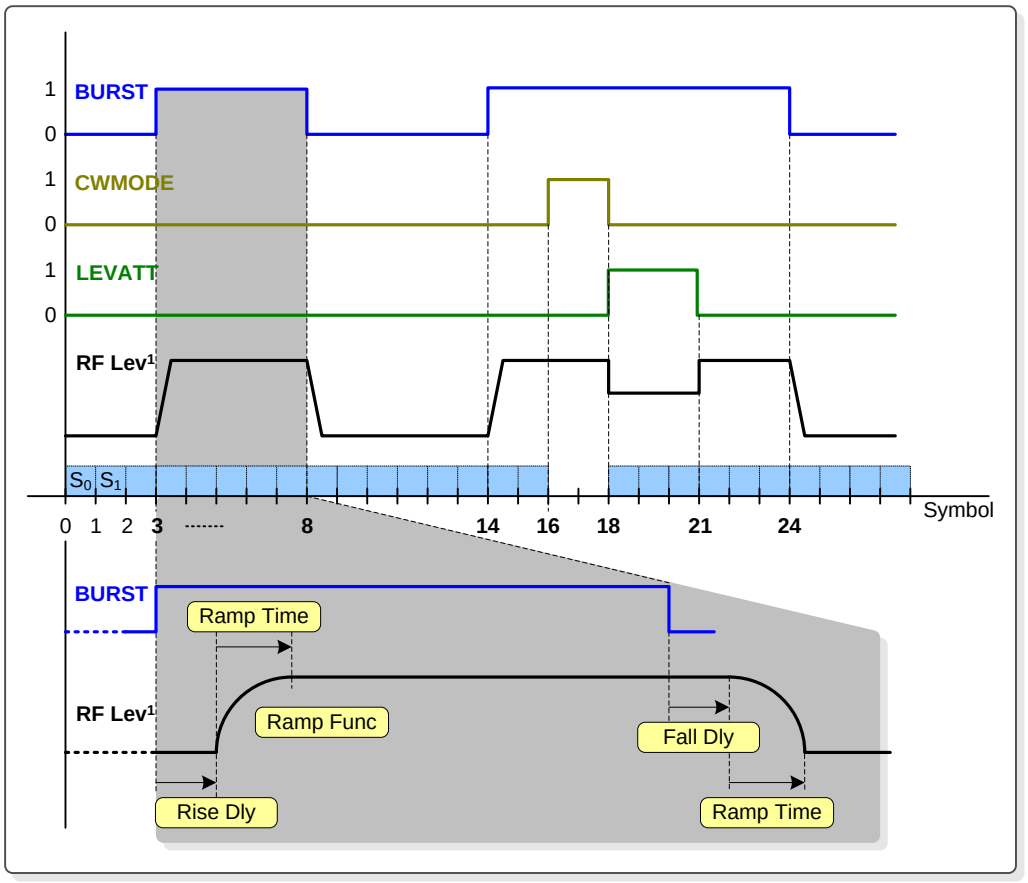
Control List – Tags		
Tag Name	**Mandatory**	**Meaning**
{**TYPE:***SMU-CL,0*}	Yes	Set the file format to control list. The format 'SMU-CL' is applicable for all R&S VSGs. The checksum is always zero for control lists. This tag must be the first one in the control list file.
{**COMMENT:***MyComment*}	No	For example comments regarding the control list content and/or usage.
{**COPYRIGHT:***MyCopyright*}	No	Copyright notes
{**DATE:***2017-06-03;21:54:01*}	No	Creation date of the control list
{CONTROL LENGTH:*100*}	Yes	Specifies the length (symbols) and thus the periodicity of the entire control list.
Marker Signals:		
{MARKER LIST 1:*1:1;20:0*}	No	Defines the slopes of marker signal 1 (Symbol number:State) and thus areas with active/inactive marker signal.
{MARKER LIST 2:*0:0*}	No	Defines the slopes of marker signal 2
{MARKER LIST 3:*0:0*}	No	Defines the slopes of marker signal 3
{MARKER LIST 4:*0:0*}	No	Defines the slopes of marker signal 4
Control Signals:		
{BURST LIST:*40:1;80:0*}	No	Defines the slopes for bursted signals (Symbol number:State) and thus areas with active/deactive RF signal. Note: Power ramping has to be activated
{LEVATT LIST 1:*50:1;80:0*}	No	Defines the slopes for level attenuation (Symbol number:State) and thus areas with enabled/disabled level attenuation. Note: Power ramping has to be activated
{CW MODE LIST:*60:1;80:0*}	No	Defines the slopes for deactivated modulation (Symbol number:State) and thus areas with activated/deactivated modulation.
{HOP LIST:*0:0*}	No	Defines the slopes for e.g. frequency hopping (Symbol number:State).

Table 2: Control List – Tags

Example: The tags shown in the table above are applicable for an R&S control list file with a control length/periodicity of 100 symbols. MARKER signal 1 is set to high at symbol 1 and reset to 0 at symbol 20. The MARKER signals 2-4 remain unused.
The BURST tag specifies that the RF signal has to be activated at symbol 40 and deactivated at symbol 80. According to the LEVATT tag an additional attenuation has to be applied on the RF burst level starting from symbol 50 till symbol 79. The CW MODE tag forces the deactivation of the modulation between symbol 60 and 79. Frequency hopping (via a RF List) is not needed and therefore the HOP signal which may be used to trigger an RF-List step remains unused.

1.1.2.1 Control Signal Definition

Most R&S VSGs support several control signals per baseband which are customizable via the control list. All of these signals are primarily used VSG internally to modify the shape of the RF signal.
The following figure gives an impression how these signals influence the RF signal after the control list activation:



1) 'Power ramping' has to be enabled and an 'Attenuation' value > 0 has to be set.

Figure 4: Control List – RF Signal Shaping

After activation of 'Power Ramping' only in areas with the BURST signal set to 1 a RF output signal with the specified RF level is generated. Burst areas with a LEVATT signal set to 1 undergo certain additional attenuation and in all areas with CW MODE set to 1 the modulation data is skipped which results in an unmodulated CW RF signal during this period.

Note: The user has to take care to provide dummy data bits during a CW MODE area since the data stream is not interrupted during this period of time but the data bits are discarded.

In case of burst definitions there are additional signal parameters that control the burst attenuation in certain areas but also the burst ramping shape, such as ramp function, rise and fall times as well as delays. These parameters are not directly set in the control list but by dedicated parameters provided by the VSG CDM power ramping functions or by the CDM-Toolbox (see chapter 3.4.2).
Besides the VSG internal usage of these control signals all of them are also available

for user specific external usage (e.g. for any kind of synchronization).
Also the HOP signal which may be used to trigger a frequency step in a RF list may be routed to VSG output ports.

The following table summarizes the assignment of these signals to the VSG outputs:

Control List – Control Signal/Output Assignment					
Control Signal	**Vector Signal Generator Output Port**				
	SMW[2]	**SMU**	**SMATE**	**SMJ**	**SMBV**
BURST A	T/M/(C)1..3[1]	AuxIO-Pin45	AuxIO-Pin45	AuxIO-Pin45	-
CW MODE A	T/M/(C)1..3[1]	AuxIO-Pin27 USER1..4[1]	AuxIO-Pin27 USER1..4[1]	AuxIO-Pin27 USER1..4[1]	-
LEVATT A	T/M/(C)1..3[1]	AuxIO-Pin26	AuxIO-Pin26	AuxIO-Pin26	-
HOP A	T/M/(C)1..3[1]	USER1..4[1]	USER1..4[1]	USER1..4[1]	-
BURST B	T/M/(C)4..6[1]	USER1..4[1]	USER1..4[1]	-	-
CW MODE B	T/M/(C)4..6[1]	USER1..4[1]	USER1..4[1]	-	-
LEVATT B	T/M/(C)4..6[1]	USER1..4[1]	USER1..4[1]	-	-
HOP B	T/M/(C)4..6[1]	USER1..4[1]	USER1..4[1]	-	-

1) Selection not supported by the CDM-Toolbox
2) Only SMW equipped with baseband generator type B10

Table 3: Control List – Control Signal/Output Assignment

1.1.2.2 Marker Signal Definition

Besides the control signals the R&S VSGs support up to 4 marker signals per baseband which may be configured in a versatile way via the control list. Some of these marker signals are assigned to specific output connectors others can be freely assigned to some of the general purpose input/output connectors.
The following table summarizes the marker signal to output assignment for the R&S VSGs:

Control List – Marker Signal/Output Assignment					
Marker Signal	**Vector Signal Generator Output Port**				
	SMW	**SMU**	**SMATE**	**SMJ**	**SMBV**
Marker 1A	USER1..6 T/M1..3[1,2]	MARKER1	MARKER1	MARKER1	MARKER1
Marker 2A	USER1..6 T/M1..3[1,2]	MARKER2	MARKER2	MARKER2	MARKER2
Marker 3A	USER1..6 T/M1..3[1,2]	AuxIO-Pin41	AuxIO-Pin41	AuxIO-Pin41	-
Marker 4A	-	USER1..4	USER1..4	USER1..4	-
Marker 1B	USER1..6 T/M4..6[1,2]	MARKER1B	MARKER1B	-	-
Marker 2B	USER1..6 T/M4..6[1,2]	AuxIO-Pin42	AuxIO-Pin42	-	-
Marker 3B	USER1..6 T/M4..6[1,2]	AuxIO-Pin43	AuxIO-Pin43	-	-
Marker 4B	-	USER1..4	USER1..4	-	-

1) Selection not supported by the CDM-Toolbox
2) Only SMW equipped with baseband generator type B10

Table 4: Control List – Marker Signal/Output Assignment

Each of the available marker signals can be used to trigger external instruments or the Equipment Under Test (EUT) as well as for the synchronization of multiple VSG basebands.

1.2 Custom Digital Modulation (CDM) – Toolbox

In general the CDM-Toolbox is intended to ease the operation of the powerful CDM functionality offered by the R&S VSGs.
It thus supports the definition and setup of application specific digitally modulated signals which includes the specification of the modulation data source, coding type, modulation type, symbol rate and baseband filter type.
Besides these elementary baseband functions the creation, activation and administration of data and control lists is covered, too. Further advantages are the included marker control functionality and the integrated means to remotely control basic RF parameters like frequency and level.
An in depth description of the CDM-Toolbox is provided by the following chapters.

2 Getting Started

This chapter provides in depth information about the available CDM-Toolbox features, summarizes the PC system requirements which have to be fulfilled to successfully install and run the CDM-Toolbox, guides through the installation process and gives an first impression how to operate the CDM-Toolbox.

2.1 Feature Overview

The CDM-Toolbox is a powerful and easy-to-use software tool with the following features:

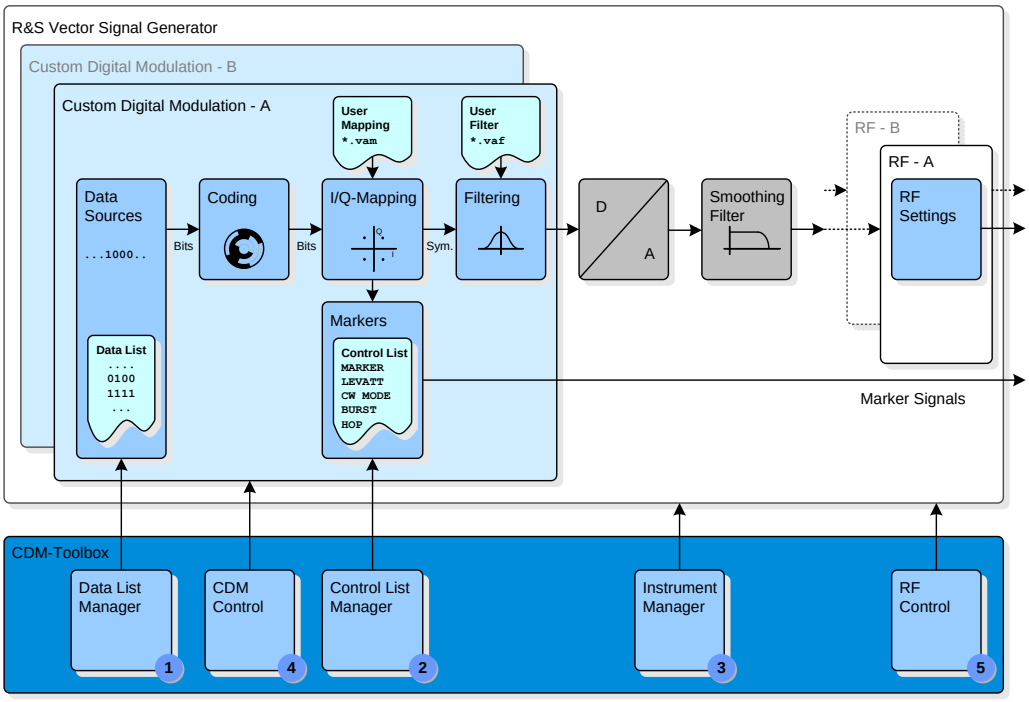


Figure 5: CDM-Toolbox – Overview

Main Features	
① Data List Manager	
Data lists up to a length of 250 Mbit can be:	
created	From the scratch by using bit patterns, predefined bit sequences, PRBS (9, 11, 15, 16, 20, 21, 23) and ASCII/binary data files.
imported	From already existing data list files.
concatenated	Either imported data list files or the internal data source of the CDM-Toolbox may be used.
modified	Any bit of a data list can be toggled.
displayed	The data list bits can be displayed as symbols (mapped bits) or as bytes (binary/hexadecimal).

Table 5: CDM-Toolbox – Main Features (Part 1)

Main Features	
① Data List Manager	
exported	Any data list can be exported/saved as ASCII data file or as a binary data list file.
transferred	Data lists which have been exported as data list files can be transferred to any assigned R&S VSG.
activated	Any data list file which was transferred to an R&S VSG can be selected/activated.
② Control Lists Manager	
Control lists can be:	
created	From the scratch.
imported	From already existing control list files.
modified	Any control list tag can be modified based on the user's needs.
exported	Any control list can be exported/saved as control list file.
transferred	Control lists which have been exported as control list files can be transferred to any assigned R&S VSG.
activated	Any control list file which was transferred to an R&S VSG can be selected/activated.
③ Instrument Manager	
R&S VSGs can be:	
connected	VSGs can be connected with the PC system running the CDM-Toolbox via GPIB, USB or LAN.
searched	The supported remote control interfaces can be scanned for connected VSGs.
assigned	Any VSG either manually specified or detected during an interface scan can be assigned to the CDM-Toolbox to allow remote control operation.
④ Custom Digital Modulation (CDM) Control	
Ease the operation of the powerful CDM functionality of the R&S VSGs on up to two baseband paths in parallel. The CDM section(s) of any assigned VSG can be:	
configured	The modulation data source, coding type, modulation type, symbol rate and the baseband filter type (incl. additional parameters) can be configured. Further on the power ramping of bursted signals and also the available marker signal can be configured.
activated	The VSG CDM section can be activated/deactivated.
⑤ RF Control	
The RF section of any assigned VSG can be:	
configured	The basic parameters of the RF section, the RF level and the RF frequency can be configured.
activated	The RF signal(s) can be activated/deactivated.

Table 6: CDM-Toolbox – Main Features (Part 2)

Auxiliary Features and Usability	
Simple and intuitive user interface	Every feature and user interface parameter has been designed to be intuitively and easily learned.
Tool tips	Each user interface parameter provides information about the required user input and if applicable also information about the parameter range.
Communication Log Window	Shows the remote communication with the connected VSG.
Trace Log Dialog	Shows the operation steps and status of the CDM-Toolbox and informs about critical situations (e.g. VSG not accessible).
Option List	The information about installed HW/SW options can be requested from the assigned VSG, displayed and exported as an ASCII list.

Table 7: CDM-Toolbox – Auxiliary Features and Usability

2.2 System Requirements

Following requirements have to be fulfilled by a PC system to allow a successful installation and operation of the CDM-Toolbox:

System Requirements[1]	
Hardware	
Hard disc	>100 MByte
RAM	>1 GByte
Processor clock	>2 GHz (to allow fast data list processing)
Screen resolution	>1280x800
Remote control IF	LAN 100Mbit or 1Gbit
	USB 2.0 (optionally)
	GPIB/IEEE488 Interface (optionally)
Software	
OS	Microsoft Windows 7
VISA Library	NI VISA V5.1.1

1) Functionality was tested by R&S with following hardware and software components

Table 8: PC System Requirements to install/operate the CDM-Toolbox

The installation of the CDM-Toolbox requires approximately 25 MByte of free hard disc space. To allow the creation of data list files up to a maximum size of 250 MBit additional hard disc space should be available.
If the CDM-Toolbox has to be used without the offered remote control functionality (e.g. only for the creation of data list or control list files) the VISA library is not required and has thus not to be installed on the PC running the CDM-Toolbox. In this case the CDM toolbox has to be started with the applied command line parameter '`--no-visa`'.
For details how to apply command line parameter see chapter 2.4.1.1.

The following Rohde & Schwarz vector signal generators are fully supported for the use with the CDM-Toolbox: SMW200A, SMU200A, SMATE200A, SMJ100A and SMBV100A.

2.3 Installation Procedure

The CDM-Toolbox comes as a ready to use installer package. However, there are certain prerequisites/requirements (see chapter 2.2 for details) which have to be fulfilled to allow a proper installation and operation of the CDM-Toolbox.
Once these requirements are met the CDM-Toolbox can be installed by simply starting the installer.

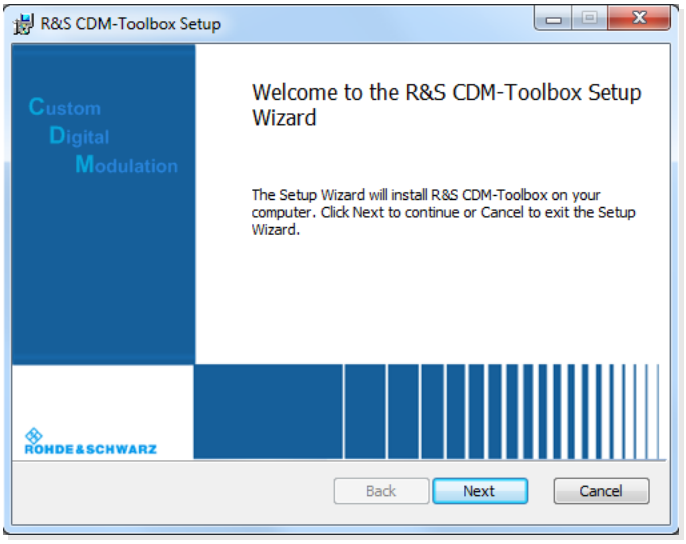


Figure 6: CDM-Toolbox – Installer (Start)

Follow the instructions ……and after completion of the installation….

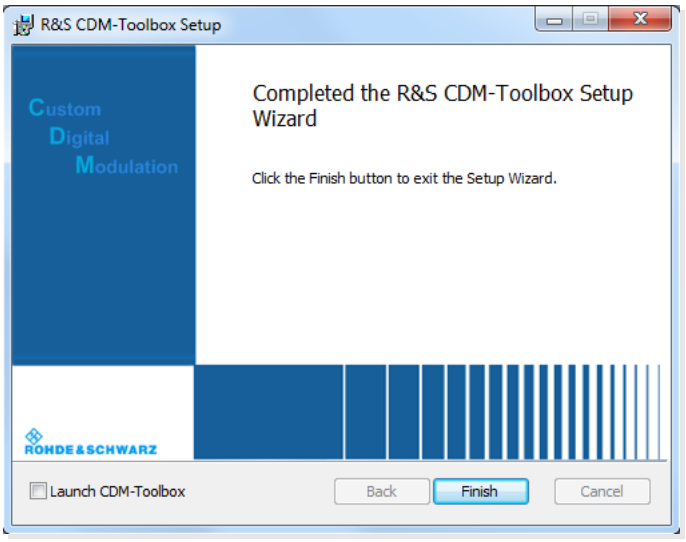


Figure 7: CDM-Toolbox – Installer (Completion)

….you will find the CDM-Toolbox program as a new entry in your Windows start menu and as an icon on the desktop.

2.4 First Steps

This paragraph provides some basic information to become familiar with the configuration and operation of the CDM-Toolbox.

2.4.1 CDM-Toolbox Start

The CDM-Toolbox is normally started via the related desktop icon or the start menu entry without any additional preparation steps.

However if the CDM-Toolbox has to be used without the offered remote control functionality (e.g. only for the creation of data list or control list files) and thus the VISA library was not installed the CDM toolbox has to be started with the applied command line parameter '**`--no-visa`**'. This will prevent the attempt of the CDM-Toolbox to load the VISA library.

To show extended logging information within the 'Trace Logs' dialog (see chapter 5.3 for details), the CDM-Toolbox has to be started with the command line parameters '**`--debug`**' or '**`--filedebug`**'.

Note: The latter parameters should only be used for debugging purposes (e.g. to provide additional information to the R&S customer support in case of malfunctions) since it slows down the application significantly.

2.4.1.1 Command Line Parameter

To apply the required command line parameter(s) the related 'Properties' dialog of the CDM-Toolbox has to be opened first. This is done by a right mouse click on the desktop icon (or the start menu entry) of the CDM-Toolbox followed by the selection of the 'Properties' item in the appearing context menu.
In a final step the command line parameter(s) have to be appended to the 'Target' parameter (CDM-Toolbox executable) provided by the 'Shortcut' tab of the 'Properties' dialog.

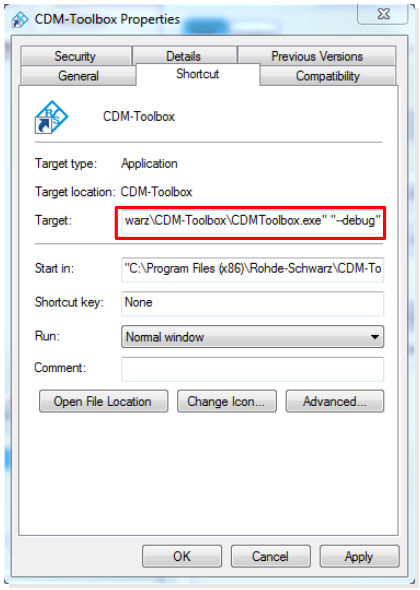


Figure 8: CDM-Toolbox – Start with Command Line Parameter (--debug)

2.4.2 CDM-Toolbox Operation

To speed up the familiarization with the operation of the CDM-Toolbox the following table provides references to the functional descriptions of commonly used functions/features of the CDM-Toolbox. Bold characters are used for functions of capital importance:

CDM-Toolbox Operation		
Operation	**Chapter**	**Page**
Create, save (export) and transfer a data list file	**4.1**	**26**
Create, save (export) and transfer a control list file	**4.2**	**34**
Search for available VSGs on a certain remote control interface	**5.1.1**	**40**
Announce a certain VSG to the CDM-Toolbox instrument pool manually		
Get information about VSGs announced to the CDM-Toolbox	5.1.2	41
Remove a VSG from the CDM-Toolbox instrument pool		
Assign a certain VSG to the CDM-Toolbox (to allow remote control)	**3.2**	**20**
Get information about the installed options on a assigned VSG	3.3	21
Perform CDM and RF configurations on an assigned VSG	**3.4**	**22**
Modify the CDM-Toolbox style and colors	5.2	42
Show trace log information	5.3	43

Table 9: CDM-Toolbox – Operation

2.4.3 CDM-Toolbox Settings Files

For convenience reasons the CDM-Toolbox makes use of two settings files which are intended to recover certain user specific settings after a restart of the CDM-Toolbox. Both of them are stored in the 'Users' directory:

`C:\Users\<UserName>\AppData\Roaming\Rohde-Schwarz\`

The CDM-Toolbox style and color settings (see chapter 5.2 for details) are saved in the color settings file:

`CDMToolbox-colors.ini`

All other settings (e.g. dialog positions, path information, instrument pool information...) are saved in the settings file:

`CDMToolbox.ini`

3 Main Window

The CDM-Toolbox '**Main Window**' shows up immediately after program start. It is broken up into four main areas, the ① '**Menu Bar**' and three instrument related sections. Those are the ② '**Instrument Assignment**' selection box, the ③ **Instrument** '**Option**' and '**Path**' tabs and the ④ '**Instrument Communication**' log window.

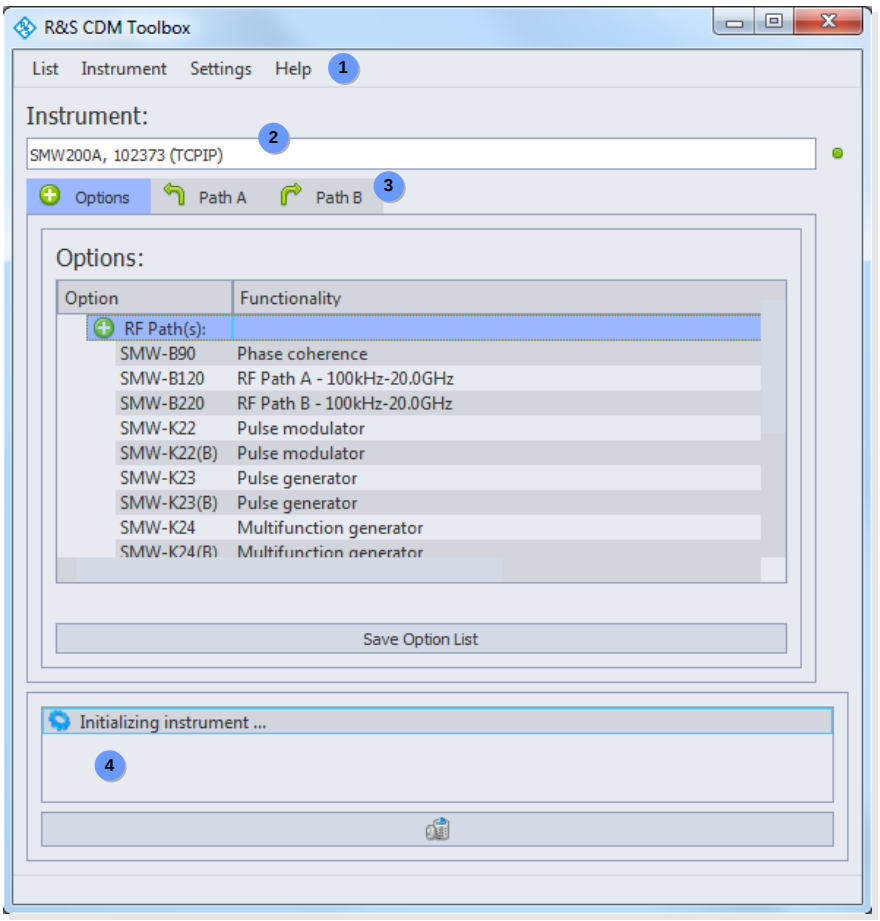
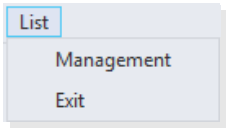


Figure 9: CDM-Toolbox – Main Window

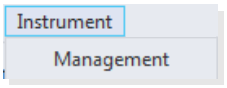
Note: Immediately after the first startup of the CDM-Toolbox all instrument related GUI elements are empty/disabled since in this operation phase no VSG is assigned to the CDM-Toolbox.

3.1 Menu Bar

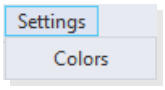
The menu bar provides access to different dialogs required to configure and operate the CDM-Toolbox.
Commands accessible via the menu bar are referenced using the *Menu Item → Command* notation (e.g. *Instrument → Management* means to click on the 'Instrument' menu item, and then click on the 'Management' command).



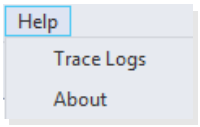
The '**List**' menu item provides commands to activate the 'List Management' dialog (see chapter 4 for details) and to 'Exit' the CDM-Toolbox.



The command to open the 'Instrument Management' dialog (see chapter 5.1 for details) is provided by the '**Instrument**' menu item.



The '**Settings**' menu item provides the command to open the 'Color' settings dialog (see chapter 5.2 for details).



The '**Help**' menu item allows access to the 'Trace Log' dialog (see chapter 5.3 for details) via the related command and also to some information 'About' the CDM-Toolbox software including the copyright, an email address for customer support and also some legal and software license related information.

Figure 10: Main Window – Menu Bar

3.2 Instrument Assignment

The '**Instrument Assignment**' selection box provides a list of VSGs which are currently announced to the 'Instrument Pool' (see chapter 5.1.2) and are thus available for an assignment to the CDM-Toolbox to allow remote control operations.

To get an overview about the available VSGs the selection box has to be opened by a left mouse click first.

Figure 11: Main Window – Instrument Assignment

To facilitate an easy selection of the desired VSG, identification parameters (type, serial number and remote control interface) of all ① VSGs are available. Furthermore the ② '**Instrument Assignment**' status indicator provides information about the assignment status at a glance.

Instrument Assignment – Status Indicator	
Indicator	**Meaning**
🔴	No (enabled) VSG available in the instrument pool for assignment.
🟡	At least one (enabled) VSG available for assignment
🟢	The top most VSG within the selection box is already assigned.

Table 10: Instrument Assignment – Status Indicator

To initiate the assignment process of a certain VSG offered by the selection box the desired VSG has to be selected by a left mouse click.
During the assignment phase the CDM-Toolbox establishes the remote control connection to the chosen VSG and performs a VSG preset afterwards. Additionally several parameters regarding the instrument assembly (e.g. installed options) are retrieved to allow a proper configuration of the instrument tabs of the CDM-Toolbox 'Main Window'.

After a successful finalization of the VSG assignment the color of the status indicator changes to green and the instrument tabs are enabled to allow further remote control interaction with the assigned VSG.

Note: An established assignment can be released by either deleting/disabling of the VSG in the instrument pool or by assigning another VSG to the CDM-Toolbox.
The CDM-Toolbox takes care that the VSG baseband and RF functional unit(s) will be deactivated during the release process.

3.3 Options Tab

The instrument 'Options' tab as well as the 'Path A/B' tabs are related to the assigned R&S VSG and are thus enabled only after a successful VSG assignment (see chapter 3.2).
The 'Options' tab shows an ① '**Options**' list which covers all hardware and software options installed on the assigned R&S VSG and also the functionality to ② '**Save the Option List**' as a plain ASCII file.

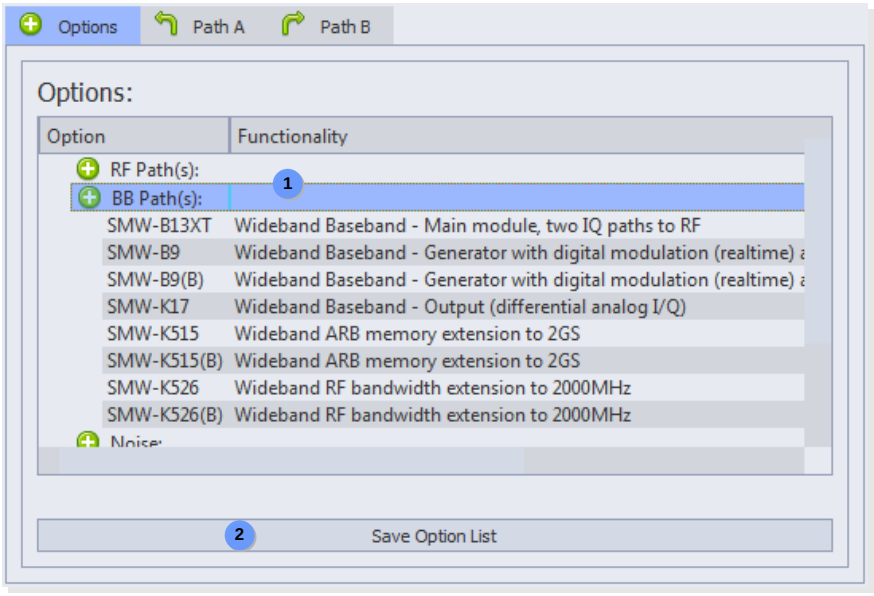


Figure 12: Main Window – Options Tab

To ease the location of a certain option the CDM-Toolbox specifies option categories:

Options Tab – Option Categories	
Option Category	**Meaning**
RF Path(s)	RF path related options
BB Path(s)	Baseband unit related hardware options
MIMO/Fading	MIMO/Fading simulator related options
Noise	AWGN related options
GNSS (internal)	GNSS (GPS, GLONASS…) related options, based on VSG internal signal calculation
Digital Standards (internal)	Digital standards related options, based on VSG internal signal calculation
Digital Standards (external)	Digital standards related options, based on external (e.g. WinIQSIM2) signal calculation
Miscellaneous	Options which do not belong to any option category above

Table 11: Options Tab – Option Categories

To increase the clarity a certain option category shows up only if at least one option belonging to this category is installed on the VSG. The options in detail (type, path and functionality) can be shown/hide by a mouse click on the triangle on the left side of each option category headline.

3.4 Path A Tab

The instrument 'Path A' tab as well as the 'Path B' and 'Options' tab are related to the assigned R&S VSG and are thus enabled only after a successful VSG assignment (see chapter 3.2).
The 'Path A' tab comprises the functionality to perform all VSG settings to generate a custom digitally modulated RF signal on path A.
The tab consists of two areas the ① '**RF**' section which is used to perform all basic RF settings and the ② '**Baseband/CDM**' section to configure the custom digital modulation baseband parameters.

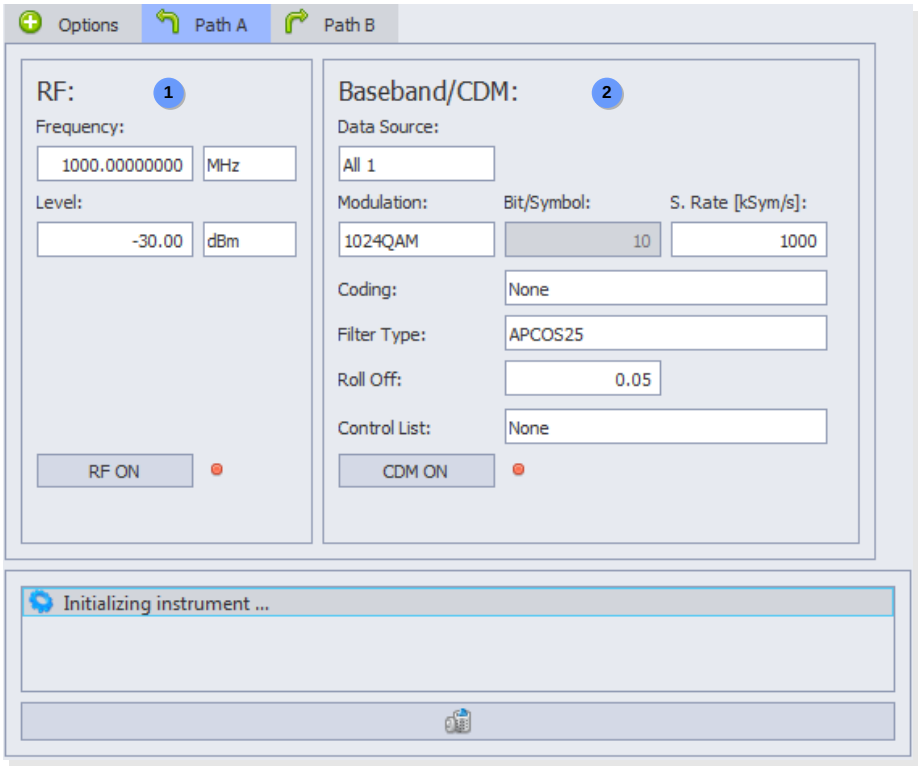


Figure 13: Main Window – Path A Tab

Note: To prevent any VSG configuration error all selection- and entry boxes are initialized based on the capabilities of the assigned VSG.
Additionally all entry boxes provide VSG specific information (tooltips) about the supported parameter range and perform a range check of all provided parameters. Parameters which exceed the specified range are ignored and are thus not sent to the assigned VSG.

3.4.1 RF

The ‘RF’ section is intended to specify the required ① ‘**RF Frequency**’ and the (RMS) ② ‘**RF level**’ but also to switch the RF signal ③ ‘**ON**’ or ④ ‘**OFF**’.

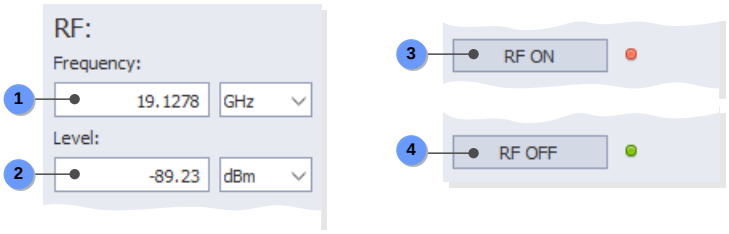


Figure 14: Path A Tab – RF Section

3.4.2 Baseband/CDM

The ‘Baseband/CDM’ section is used to configure the Custom Digital Modulation parameters offered by the assigned VSG. Since some of these parameters depend on each other (range and availability) the appearance of this section is not static but variable.

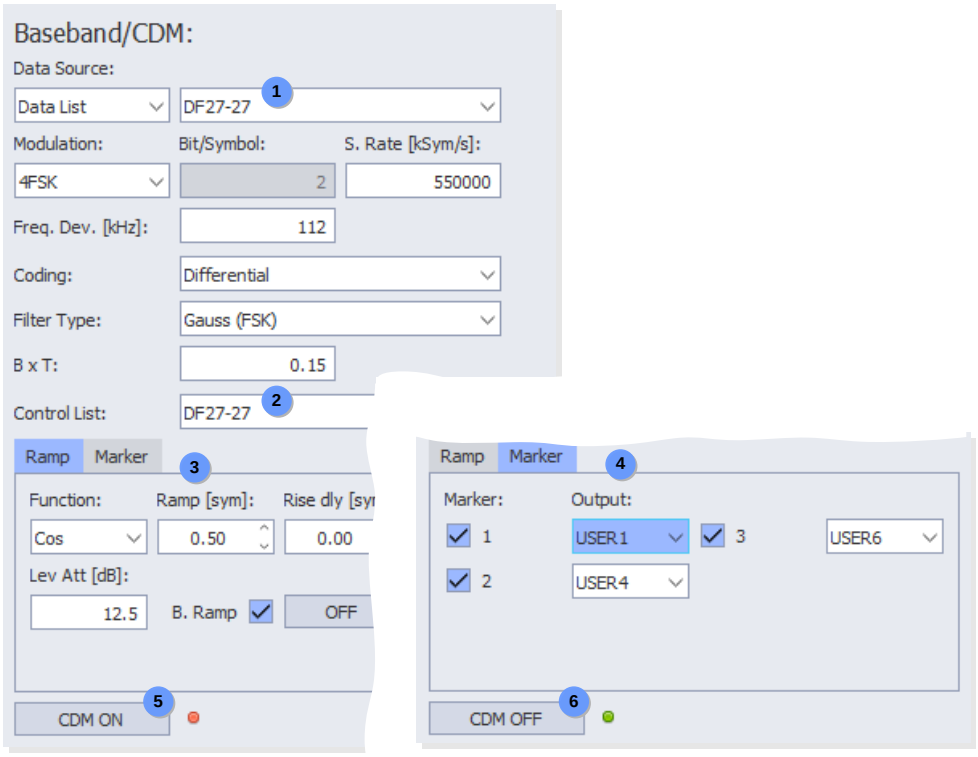


Figure 15: Path A Tab – Baseband/CDM Section

For details and background about this parameters refer to the VSG specific user- or operating manual [1]..[5].

The ① '**Data List**' selection box provides a list of all data lists available on the assigned VSG within the dedicated data list directory (see chapter 0 for details about data list creation).
In parallel the ② '**Control List**' selection box provides a list of all control lists available on the assigned VSG within the dedicated control list directory (see chapter 4.2.2 for details about control list creation).
After selection of a certain control list additional parameters show up at the bottom of the 'Baseband/CDM' section to allow the configuration of signal properties which are not solely specified by the control list (see chapter 1.1.2.1 for details about these parameters):
The ③ '**Ramp**' tab places all parameters at disposal which are required to control the burst shape, which is of interest if the burst tag is used within the selected control list.
The VSG output ports to be used for marker signals are defined within the ④ '**Marker**' tab.
To activate/deactivate a defined CDM signal the ⑤ '**ON**'/⑥ '**OFF**' button is used.

In case of a user defined modulation (mapping) and/or a user defined filter type related selection boxes are available to select the desired file.

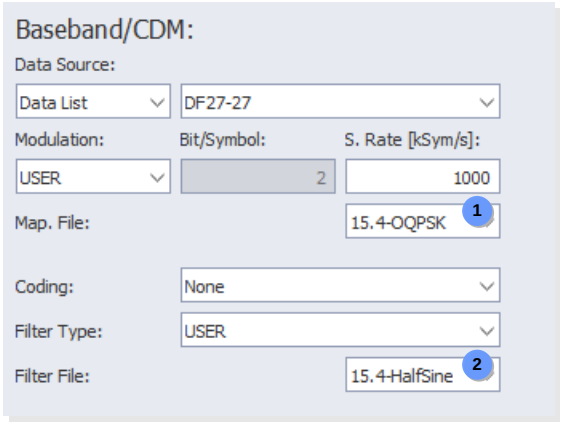


Figure 16: Path A Tab – Baseband/CDM Section – User Mapping/Filter

The ① '**Mapping File**' selection box provides a list of user specific modulation mapping files (*.vam) [7]. These files have to be saved in a specific directory of the assigned VSG.

Mapping Files – VSG Directory	
VSG Type	**Data List Directory**
SMW, SMBV	/var/user/Mappings
SMU, SMATE, SMJ	D:\Mappings

Table 12: Mapping Files – VSG Directory

User designed shaping ② '**Filter Files**' (*.vaf) [8] have to be saved in a specific directory of the assigned VSG.

Filter Files – VSG Directory	
VSG Type	**Data List Directory**
SMW, SMBV	/var/user/Filters
SMU, SMATE, SMJ	D:\Filters

Table 13: Filter Files – VSG Directory

3.5 Path B Tab

This tab is enabled automatically if a VSG was assigned which is equipped with a second RF-path and/or baseband unit.
It provides the same functionality as the 'Path A' tab.

3.6 Instrument Communication Log

The 'Instrument Communication' log shows all remote control commands sent to the assigned VSG.

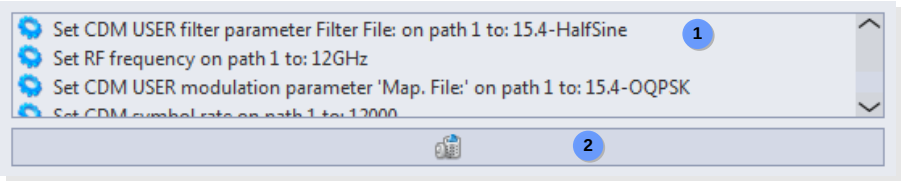


Figure 17: Main Window – Instrument Communication Log

Each communication log entry consists of a flag which is used to categorize the log entries and the logging information itself.

Instrument Communication Log – Flags	
Flag	**Meaning**
	Any successful action
	Error

Table 14: Instrument Communication Log – Flags

To clear the 'Instrument Communication' log (e.g. to get rid of outdated entries) the ② '**Clear**' button has to be pressed.

4 List Management Dialog

The 'List Management' dialog which is activated by the menu bar *List → Management* command includes all functions to create, modify, save and transfer R&S data and control lists. The tab based dialog offers two register tabs one to manage data lists and a second one to deal with control lists.

The following paragraphs provide a detailed explanation of the available list management functions and their usage. For additional detailed background information about R&S data- and control lists see chapter 1.1.

4.1 Data List Management

The data list management tab is split into two sections, one ① '**Data Input**' section to specify the input parameters to be used for the data list generation and a ② '**Data List**' section to visualize, modify (if applicable), save and transfer a generated data list.

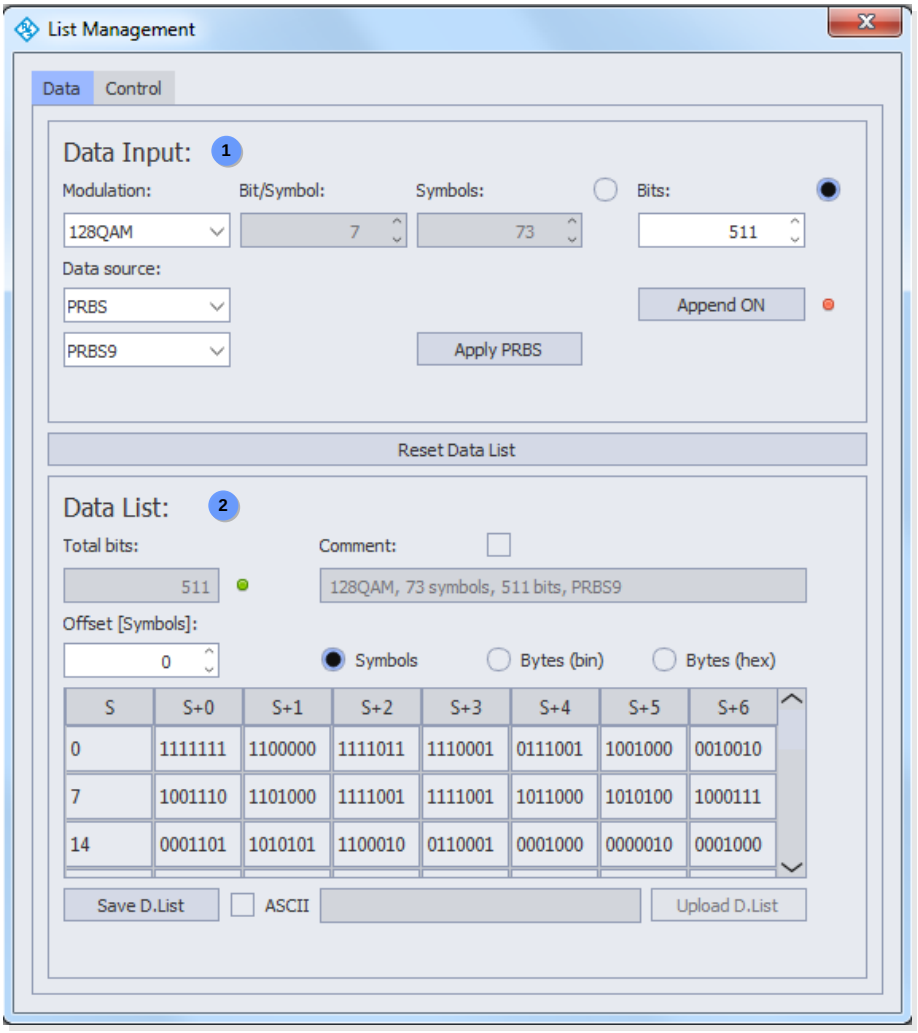


Figure 18: CDM-Toolbox – Data List Management Dialog

4.1.1 Data Input

The 'Data Input' section provides all functions to specify the data (content and amount) to be put into or to append to a data list. First of all the '**Modulation Type**' specific settings have to be made further on the '**Data Source**' has to be selected.

4.1.1.1 Modulation Type

With the ① '**Modulation Type**' selection box the required digital modulation scheme is selected. This setting does not directly affect the data list content but defines the number of ② '**Bit/Symbol**' and is thus essential for a proper determination of the list length (bit count).

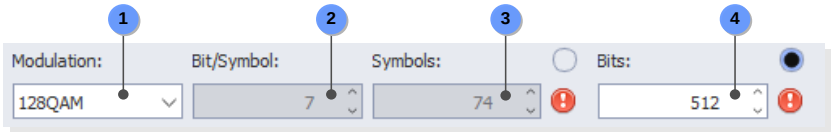


Figure 19: Data Input – Modulation Type Section

The amount of data to be put into a data list can be specified for some of the selectable data sources (Sequence, Pattern and PRBS; see chapter 4.1.1.2 for details) by a number of ③ '**Symbols**' or by a quantity of ④ '**Bits**'. For a file based data sources (Data file and Data list) the amount of data is determined by the number of data bits contained in the selected file and may thus not be modified manually. Note that the total data list length is limited to a maximum of 250 Mbit.
The decision about the desired data amount specification method (via Symbols or via Bits) is made via the checkboxes associated to the Symbols/Bits boxes.
If the number of specified bits results in a none integer number of symbols a warning symbols shows up next to the symbols box to indicate that this would prevent a proper determination of the vector constellation of the last symbol (some bits are missing).
Another warning shows up besides the bits box if a PRBS sequence was selected (see chapter 4.1.1.2) as data source and the specified number of data bits would result in a none integer number of 'used' PRBS sequences which may for example result in synchronization and/or bit error problems if the digitally modulated signal is used for receiver tests.

Example: In the figure shown above the bit count based data amount specification is activated. The specified number of 512 bits results (based on the modulation type specific 7 bits/symbol) in a none integer number of 73.1 symbols. This symbol/bit mismatch is indicated by the warning sign shown besides the symbols box.
The warning sign next to the bits box shows up since a PRBS9 (sequence length: 511 bits) was selected which would result in a none integer number of PRBS sequences.

4.1.1.2 Data Sources

A variety of data sources used to provide the data bits to be put into the data list can be selected via the ① '**Data Source**' selection box. In the following the different data sources are introduced:

Sequence:

The data source type ① '**Sequence**' should be selected if it is sufficient for the test application to provide a certain simple bit sequence. With the selection of this data source type a selection box is activated that provides several pre-defined ② '**Bit sequences**' which can be added to the data list by pressing the ③ '**Apply Sequence**' button. If the previously specified number of data bits (see chapter 4.1.1.1) exceeds the sequence length the sequence is repeated accordingly.

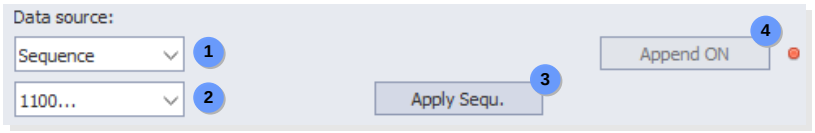


Figure 20: Data Input – Data Source Section (Sequence)

For applications which require a data list containing data from different sources the append mode has to be activated via the related ④ '**Append ON**' button (Available/enabled only if already any data was added to the data list).

Example: In the above figure the data sequence '1100' was selected. By pressing the 'Apply Sequence' button this sequence is added to the data list until the specified number of bits has been reached (e.g. 110011001100……110). The 'Append ON' button is disabled since currently no data is within the data list. The red indicator sign informs the user about the deactivated append mode.

Pattern:

Users may select the ① '**Pattern**' data source if only some bits have to be added to the data list but a greater flexibility in defining the bits as provided by the data source 'Sequence' is required. This mode allows to freely defining data patterns of flexible length. After selection of this data source an entry box shows up which enables the user to specify the needed ② '**Bit pattern**'.

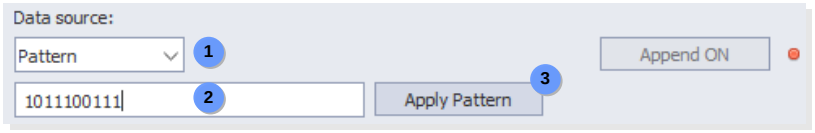


Figure 21: Data Input – Data Source Section (Pattern)

The specified number of bits (see chapter 4.1.1.1) of the given pattern is added to the data list by pressing the ③ '**Apply Pattern**' button. If the number of required/specified data bits exceeds the pattern length the pattern is repeated accordingly.

Example: In the above figure the data pattern '1011100111' was specified. By pressing the 'Apply Pattern' button the pattern is added to the data list until the specified number of bits has been reached. The 'Append ON' button is disabled since currently no data is within the data list.

PRBS (Pseudo Random Bit Sequences):
After selection of the ① '**PRBS**' data source the ② '**PRBS Type**' selection box shows up which allows the user to specify the PRBS type best fitting with the test application.

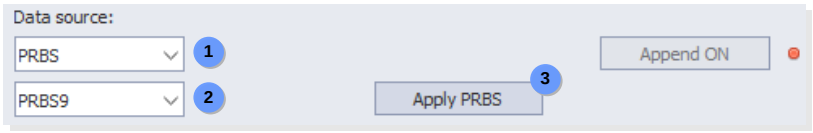


Figure 22: Data Input – Data Source Section (PRBS)

The ③ '**Apply PRBS**' button has to be used to add the specified number of bits (see chapter 4.1.1.1) of the selected PRBS type to the data list.

Example: In the figure above the 'PRBS9' was selected which will be added to the data list with the specified number of data bits after pressing the 'Apply PRBS' button. The 'Append ON' button is disabled since currently no data is within the data list.

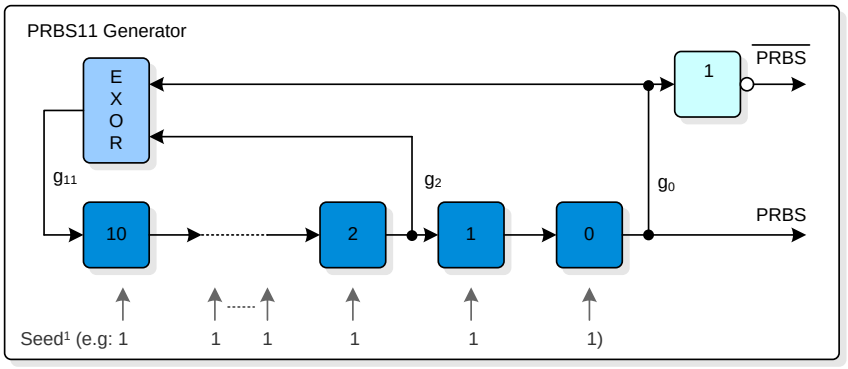
Following PRBS types of different length *N* may be selected as a data source for data list generation:

Data Sources – Supported PRBS Types					
Type *N*	**Sequence Length[1]**	**Standard**	**Feedback[2]**	**Seed**	**Inverted**
PRBS9	511 bits	[11], 2.1	4, 0	All 1	No
PRBS11	2,047 bits	[11], 2.2, [10], 2.1	2, 0	All 1	No
PRBS15	32,767 bits	[9], 2.1	1, 0	All 1	Yes
PRBS16	65,535 bits	-	5, 3, 2, 0	All 1	No
PRBS20	1,058,575 bits	[11], 2.3	3, 0	All 1	No
PRBS21	2,097,151 bits	-	2, 0	All 1	No
PRBS23	8,388,607 bits	[9], 2.2	5, 0	All 1	Yes

1) In case of data lists exceeding the length of a selected PRBS sequence the sequence is repeated.
2) Feedback after these taps/registers.

Table 15: Data Sources – Supported PRBS Types

All of these sequences (of maximum length) are generated by means of *N*-stage shift registers with appropriate feedback via an EXOR gate (modulo-2 addition).
The following figure provides an overview of the Fibonacci implementation principle (PRBS11 according to [11]) used by the CDM-Toolbox PRBS generator.



1) All CDM-Toolbox PRBS generator implementations use a seed (initial fill) of 'All 1'. This initial fill comprises the first *N* bits output from the generator (*N* x 1).

Figure 23: Data Sources – PRBS Generator Overview (Example PRBS11)

Data File:
Sometimes users have ASCII or binary data files on hand containing data bits to be converted into an R&S data list file. These users should select the data source ① '**ASCII-file Bit**', '**ASCII-file Hex**' or '**Binary-file Hex**'

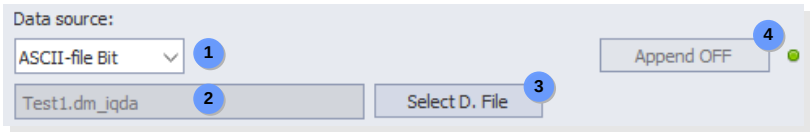


Figure 24: Data Input – Data Source Section (Data file)

In this mode of operation the user can select either ASCII files or binary files by pressing the ③ '**Select Data File**' button.
The name of each successfully loaded data file is shown in a related ② '**Data file name**' box and the file content is parsed by the CDM-Toolbox:

Data Sources – Data Files			
Type	**File Extens.**	**Content**	**Bits**
ASCII-file Bit	`*.txt` or `*.dm_iqda`	ASCII characters: "0" or "1"	1bit per character
ASCII-file Hex	`*.txt` or `*.dm_iqda`	ASCII characters: "0" … "F"	4 bit per character
Binary-file Hex	`*.bin`	Binary bytes 0x00…0xFF	8 bit per byte

Table 16: Data Sources – Data File Types

All determined bits are import to the data list immediately. Please keep in mind that the CDM-Toolbox does not include any means to differentiate between data bits and e.g. header data which may also be part of the imported data file. Therefore it is recommended to clip/remove any header part prior to the data file import. Otherwise 0/1 values or hexadecimal characters which are eventually used in the header part are treated as data bits which would result in falsified data lists and sometimes very interesting test results.
For applications which require a data list containing date from different sources the append mode has to be activated via the related ④ '**Append ON**' button (Available/enabled only if already any data was added to the data list).

Example: In the figure above the data file 'Test1.dm_iqda' was selected via the 'Select Data File' button. All contained data bits were assigned to the data list. After these actions the 'Append ON' button was automatically enabled since now data is available within the data list. The append mode was enabled by pressing the 'Append ON' button, which is indicated by the green indicator sign. Afterwards further data of any available data source may be appended to the data list.

Data List:
Sometimes an already existing R&S data list file shall be:

- Modified (toggling of bits e.g. simulate bit errors)
- Extended by additional data bits
- Appended to other data bits
- Evaluated (Binary file content is unknown)
- Transferred quick and easy to a R&S VSG

To foster all of these scenarios the CDM-Toolbox supports the import of data list files, too.

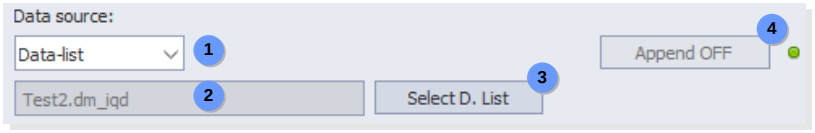


Figure 25: Data Input – Data Source Section (Data list)

For the import of data list files the data source ① '**Data list**' has to be selected.
Thereafter the user can select a data list file (`*.dm_iqd`) by pressing the ③ '**Select Data List**' button.
The name of a successfully loaded data list file is shown in the related ② '**Import-Data list file name**' box but also in the '**Export-Data list file name**' box of the 'Data List' section (see chapter 4.2.2). The binary file content is immediately parsed, imported and shown in the data list section.
Please keep in mind that the CDM-Toolbox performs some consistency checks of the data list file and the included header tags to evaluate if the selected data list file is compliant with the R&S data list file specification (see chapter 1.1.1). Therefore to avoid data list files to become invalid it is strictly recommended not to modify the binary data list files with any other file editor or tool then the CDM-Toolbox.
For applications which require a data list containing date from different sources the append mode has to be activated via the related ④ '**Append ON**' button (Available/enabled only if already any data was added to the data list).

Example: The figure above demonstrates the settings after a data list file named 'Test2.dm_iqd' was appended to data bits already included in the data list.
Since the data list contains at least data bits originating from two data sources and thus appending has taken place the 'Append OFF' button which would allow to switch off the append mode is disabled.

4.1.2 Data List

The ‘Data List’ section visualizes the data list bits in different shapes and provides all means to modify, save/export and transfer/upload the data list.

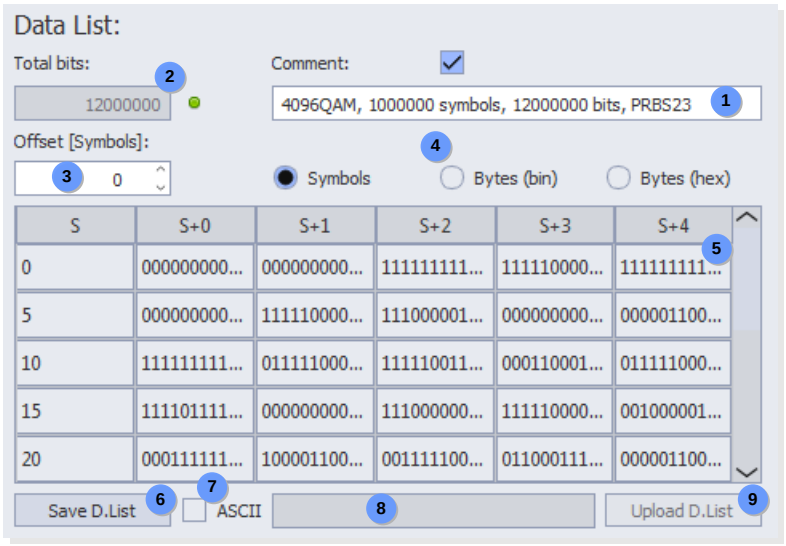


Figure 26: Data List Management – Data List Section

The content of the R&S data list file ‘Comment’ tag (see chapter 1.1.1 for details) is defined within the ① ‘**Comment**’ box. By default the ‘Auto Comment’ mode is activated which assures that comments are generated automatically by the CDM-Toolbox based on the specified ‘Modulation Type’ and ‘Data Source’.
In contrast the ‘Manual Comment’ mode is selected after activation of the append mode (see chapter 4.1.1) or may be selected by checking the box located above the ‘Comment’ box to allow user specific comments.
To keep track with the number of bits contained in the data list, which is of special interest in case of activated data list append mode, the ② ‘**Total number of bits**’ is displayed.
Only a portion of 500 data bits of the data list is shown at once to ease the handling of (huge) data lists. To display the data list cells of interest the related cell ③ ‘**Offset**’ has to be specified by a number of symbols or bytes, based on the currently selected data list format.
The data bits can be displayed in different ④ ‘**Data List Formats**’:

- Bits per symbol (depends on the selected modulation type, see chapter 4.1.1.1)
- Bits per byte (binary representation)
- Bits per byte (hexadecimal representation)

The bit content of each ⑤ ‘**Data list cell**’ (Symbol or byte) may be altered by the user if needed by selecting a certain cell via a double click with the mouse. This functionality may be helpful if a certain amount of bits have to be toggled to simulate a specific bit error rate (fault insertion).

An indicator sign within the total bit count box informs about the actual data list processing status:

Data List – Processing Status Indicator	
Indicator	**Meaning**
	Append mode OFF: Data list is empty Append mode ON: Data list contains only first portion of data
	Data bits from selected data source are currently added to the data list.
	Data list contains data bits and is thus ready for data modification and/or data export.

Table 17: Data List – Processing Status Indicator

After the data bits within the data list are in the required shape the data list can be saved on any mass memory available on the PC running the CDM-Toolbox by pressing the ⑥ '**Save Data List**' button. By default the data list is stored in the R&S data list format with ASCII header, binary data and the file extension `*.dm_iqd`.
If the user wants to export the data list in a plain ASCII file format (e.g. for further usage by other software tools) the ⑦ '**ASCII**' mode has to be activated by checking the related box. With this mode activated, the data list content without any header tag is stored in an ASCII file with file extension `*.dm_iqda`. Please keep in mind that this type of data list file cannot be transferred to the R&S VSG by the CDM-Toolbox.
The name of the data list file specified by the user is displayed in the ⑧ '**Export-Data list file name**' box.
Instantly after successful export of an R&S data list the ⑨ '**Transfer Data List**' button is enabled if an R&S VSG is already assigned to the CDM-Toolbox (see chapter 3.2). Assuming that this is the case the data list file can be directly transferred to a specific directory of the assigned VSG.
Additionally the data list file name is also appended to the data list selection box available on the 'Path A/B' tabs of the CDM Toolbox 'Main Window' (see chapter 3.4) to allow an immediate selection/activation of the data list file.

Data List – VSG Directory	
VSG Type	**Data List Directory**
SMW, SMBV	/var/user/DataLists
SMU, SMATE, SMJ	D:\DataLists

Table 18: Data List – VSG Directory

4.2 Control List Management

The control list management tab is split into two sections, one ① '**Data Input**' section to specify the input parameters to be used for the control list creation and a ② '**Control List**' section to specify the content of the supported control list tags and to modify (if applicable), save and transfer a generated control list.

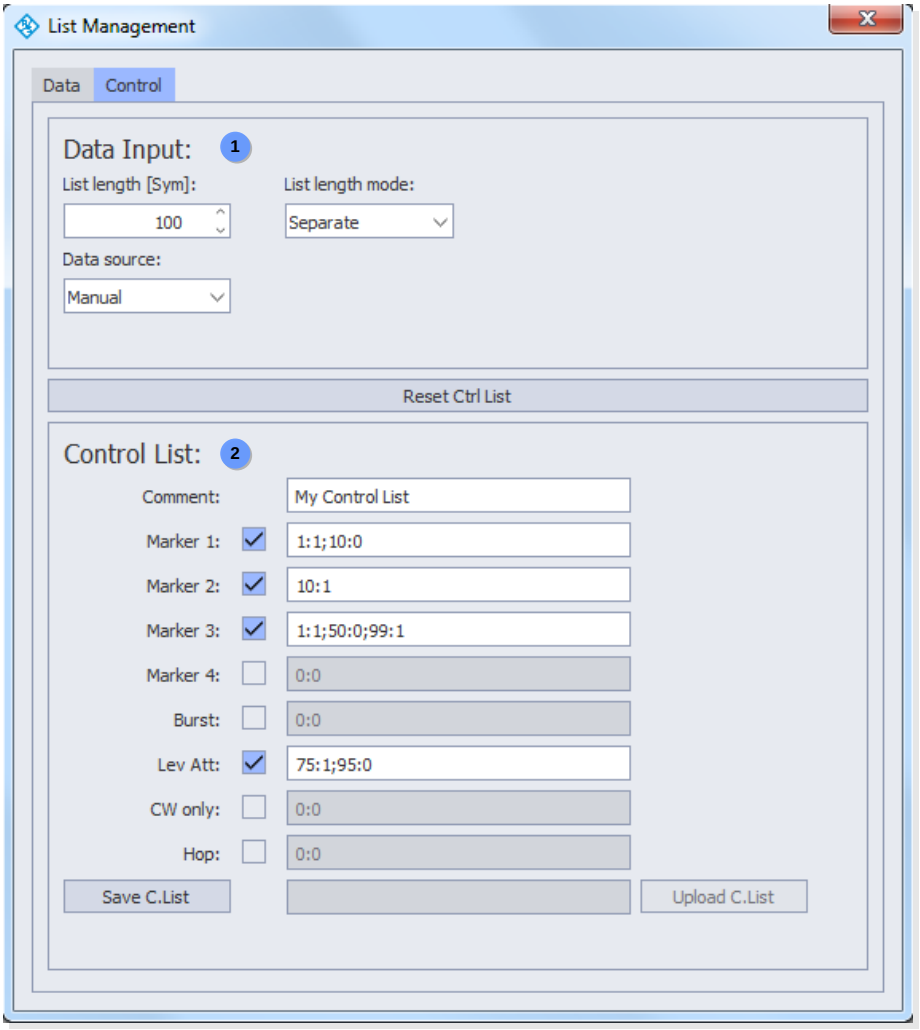


Figure 27: CDM-Toolbox – Control List Management Dialog

4.2.1 Data Input

The ‘Data Input’ section provides all functions to specify the control list (length and data source). First of all the ‘**List length**’ specific settings have to be made further on the ‘**Data Source**’ has to be selected.

4.2.1.1 List Length

In general the control list length, which is specified by a number of symbols (not bits!), determines the periodicity of the entire control list.
The CDM-Toolbox supports two modes to specify the control list length which can be selected by the ① ‘**List length mode**’ box. In the following the different modes are introduced:

Separate:
After selection of the list length mode ① ‘**Separate**’ the length of the control list can be specified user specific by simply modifying the ② ‘**List length**’ entry box.

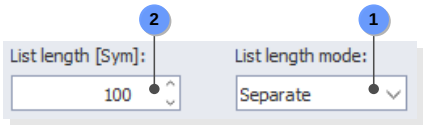


Figure 28: Data Input – List Length Section (Separate)

Coupled:
If a control list is specified and used in parallel with a data list the list length mode ① ‘**Coupled**’ should be selected.

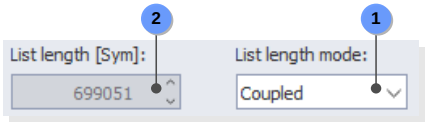


Figure 29: Data Input – List Length Section (Coupled)

In this mode of operation the control list length is directly coupled with the length of the data list which is currently under construction.

4.2.1.2 Data Sources

The data sources used to provide the control information to be put into the control list can be selected by the ① '**Data Source**' box. In the following the different data sources are shown:

Manual:

The data source type ① '**Manual**' should be selected by the user if a new control list has to be setup from the scratch. After selection of this mode the required control information has to be provided manually via the 'Control List' section (for details see chapter 4.2.2).

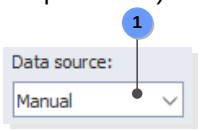


Figure 30: Data Input – Data Source Section (Manual)

Control List:

Sometimes an already existing R&S control list file shall be:

- Modified
- Extended by additional tags (e.g. markers)
- Evaluated
- Transferred quick and easy to a R&S VSG

To foster all of these scenarios the CDM-Toolbox supports the import of control list files, too.

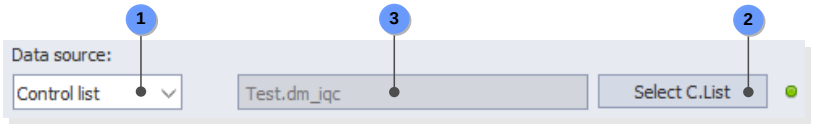


Figure 31: Data Input – Data Source Section (Control list)

For the import of control list files the data source ① '**Control list**' has to be selected. Thereafter the user can select a data list file (*.`dm_iqc`) by pressing the ② '**Select Ctrl List**' button.
The name of a successfully loaded control list file is shown in the related ③ '**Import-Control list file name**' box

Please keep in mind that the CDM-Toolbox performs some consistency checks of the control list file and the included tags to evaluate if the selected control list file is compliant with the R&S control list file specification (see chapter 1.1.2). Therefore to avoid control list files to become invalid it is strictly recommended not to manipulate the files with any other file editor or tool then the CDM-Toolbox.

Example: The figure above demonstrates the settings after a control list file named 'Test.dm_iqc' was successfully imported.

4.2.2 Control List

The ‘Control List’ section visualizes the control list tag definition (see chapter 1.1.2 for details) and provides all means to modify, save/export and transfer/upload the control list.

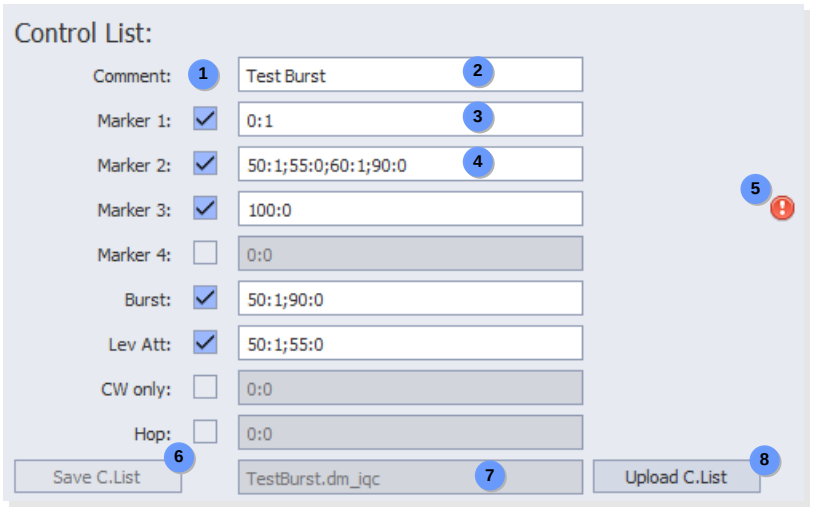


Figure 32: Control List Management – Control List Section

All control list tags (with exception of the ‘Comment’ tag) which shall be configured have to be activated via the related ① ‘**Activation**’ checkbox first. The content of the ‘Comment’ tag is defined within the ② ‘**Comment**’ box. All other control tags are specified in the related tag specific box by using the control list syntax. Based on this syntax a single control slope is defined by the ③ **symbol number** followed by a colon and the **binary control signal level** (0/1). If ④ **several control slopes** have to be assigned to a certain tag they have to be separated by a semicolon.

Example: The tags shown in the control list section above are imported from a control list file named TestBurst.dm_iqc.
MARKER tag 1 is set to high at symbol 0. The MARKER tag 2 has several control slops. It is set to high at symbol 50 and 60 and back to low at symbol 55 and 90.
MARKER tag 3 was newly added. By mistake the tag is set to low at symbol 100. Since a control list length of ≤100 is specified a warning symbol shows up and the ‘Save Ctrl List’ button is disabled. MARKER tag 4 remains unused.
The BURST tag specifies that the RF signal has to be activated at symbol 50 and deactivated at symbol 90. According to the LEVATT tag an additional attenuation has to be applied on the RF burst level starting from symbol 50 till symbol 55.
The CW MODE tag and the HOP tag remain unused.

The CDM-Toolbox performs some basic syntax checks of any created/modified control tag to prevent the generation of control lists which are not in accordance with the specified R&S control list syntax. Therefore if any severe syntax violation is detected the current control tag content is deleted. If the defined symbol number exceeds the specified control list length a ⑤ **Warning symbol** shows up and the ⑥ ‘**Save Ctrl List**’ button is disabled.
After the control tags are configured as required for a certain test application the control list can be saved on any mass memory available on the PC running the CDM-Toolbox by pressing the ⑥ ‘**Save Ctrl List**’ button. The control list is stored in the R&S control list format and the file extension `*.dm_iqc`.

The name of the control list file specified by the user is displayed in the ⑦ '**Export-Control list file name**' box.
Instantly after successful export of an R&S control list the ⑧ '**Upload Ctrl List**' button is enabled if an R&S VSG is already assigned to the CMD-Toolbox (see chapter 3.2). Assuming that this is the case the control list file is transferred to a specific directory of the assigned VSG.
Additionally the control list file name is also appended to the control list selection box available on the 'Path A/B' tabs of the CDM Toolbox 'Main Window' (see chapter 3.4) to allow an immediate selection/activation of the control list file.

Control List – VSG Directory	
VSG Type	**Data List Directory**
SMW, SMBV	/var/user/ControlLists
SMU, SMATE, SMJ	D:\ControlLists

Table 19: Control List – VSG Directory

5 Auxiliary Dialogs

Besides the important 'List Management' dialog of the CDM-Toolbox several other dialogs are available to control the CDM-Toolbox behavior and interaction with connected R&S VSGs.

5.1 Instrument Management Dialog

The 'Instrument Management' dialog is shown by the menu bar *Instrument → Management* command. It is split into two sections, one section, the so called ① '**Instrument Announcement**', offers a bundle of functions to determine R&S VSGs reachable by the CDM-Toolbox via the supported remote control interfaces (GPIB, USB and LAN) and to announce these generators to the CDM-Toolbox.
The ② '**Instrument Pool**' section is used to manage the already announced VSGs, the so called instrument pool.

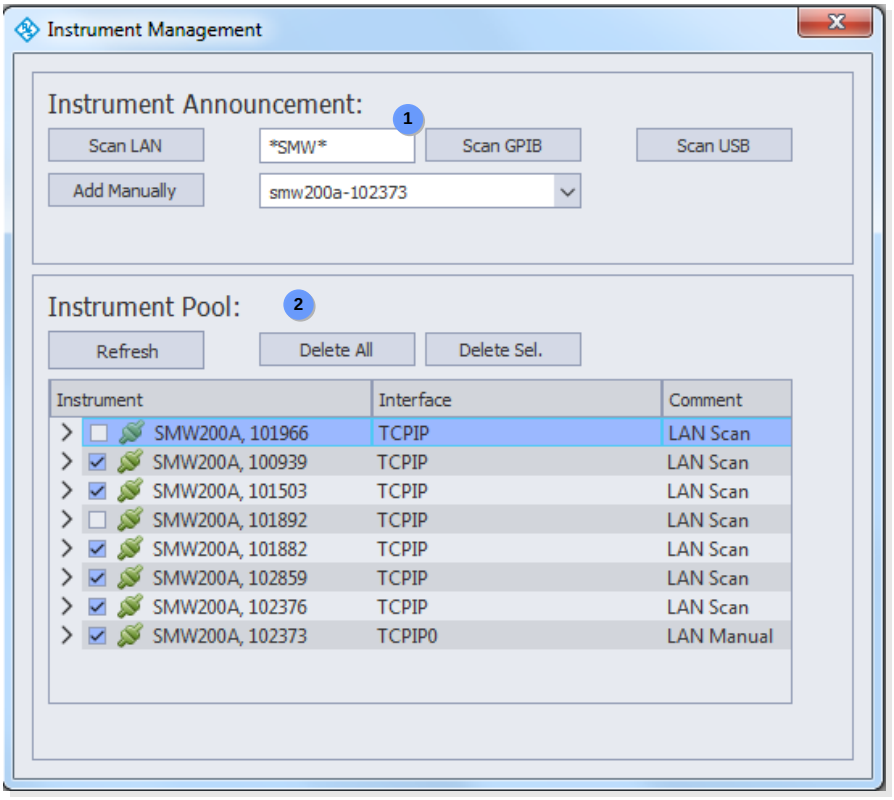


Figure 33: CDM-Toolbox – Instrument Management Dialog

The following paragraphs provide a detailed explanation of the available instrument announcement and instrument pool features and their usage.

5.1.1 Instrument Announcement

Any VSG which has to be assigned to the CDM-Toolbox to allow remote control operation via the supported remote control interfaces (GPIB, USB and LAN) has to be announced to the CDM-Toolbox instrument pool first.
All means required for the announcement are provided by the 'Instrument Announcement' section.

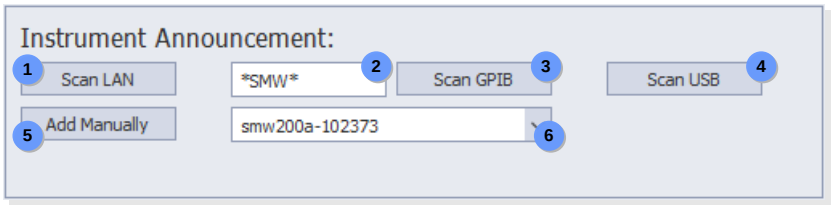


Figure 34: Instrument Announcement Section

The most convenient way to announce VSGs to the CDM-Toolbox is by means of the integrated remote interface scan functionality. This feature allows searching for certain/all VSGs connected to the CDM-Toolbox via any remote control interface.

VSGs connected to CDM-Toolbox via LAN can be searched by pressing the ① '**Scan LAN**' button if a DNS server is available in the scanned network. This button initiates a scan for connected R&S VSGs within the IPv4 subnet (only the first detected subnet) of the PC running the CDM-Toolbox.
The search process is controlled via the provided ② '**Hostname**' specifier. If not all characters of the VSG's hostname are well known they may be replaced by question marks. To search for a variety of VSGs the wild-card (*) character can be used.
After a successful LAN scan all VSGs with a hostname fitting with the 'Hostname' specifier are listed in the 'Instrument Pool' section and are thus available to be assigned to the CDM-Toolbox.

If the GPIB interface is used to remotely interact with VSGs the ③ '**Scan GPIB**' button has to be pressed to search the GPIB interface 0 (GPIB0) for any connected R&S VSG. All detected R&S VSGs are listed in the 'Instrument Pool' section.

To search for R&S VSGs connected to USB ports 0-9 of the PC running the CDM-Toolbox the ④ '**Scan USB**' button has to be pressed. Any detected R&S VSG is listed in the 'Instrument Pool' section.

If a certain VSG must not be announced by an automatic interface scan but manually this can be done by providing an appropriate interface specific ⑥ '**Resource Specifier**' followed by pressing the ⑤ '**Add Manually**' button.

Add Manually – Resource Specifier	
Interface	**Resource Specifier**
GPIB	VISA Resource String (e.g. GPIB0::29::INSTR)
USB	VISA Resource String (e.g. USB0::0x0AAD:0x005F:257839::INSTR)
LAN	VISA Resource String (e.g. TCPIP0::rssmw200a100957::INSTR)
	Hostname (e.g. rssmw200a100957)
	IP-Address (e.g. 10.111.12.60)

Table 20: Add Manually – Resource Specifier

5.1.2 Instrument Pool

The 'Instrument Pool' section is used to manage all R&S VSGs which are already announced to the CDM-Toolbox.

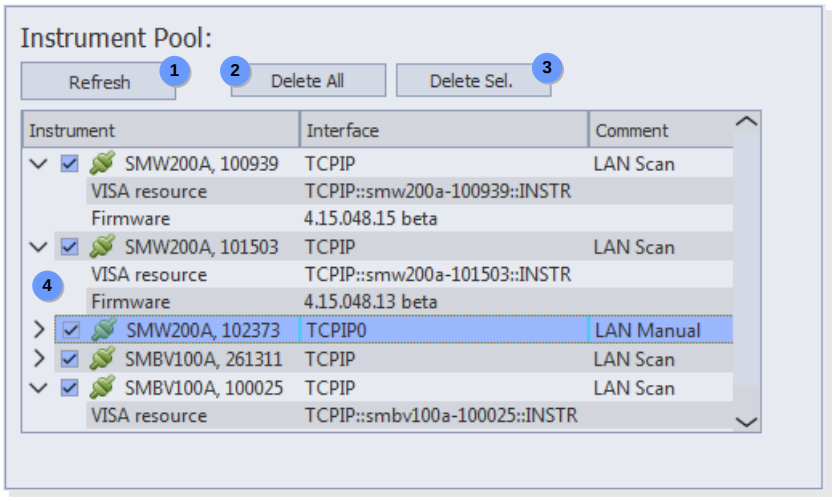


Figure 35: CDM-Toolbox – Instrument Pool Section

Several functions are available to deal with the pool of announced VSGs.
To initiate an immediate verification of the connection status of all VSGs within the pool the ① '**Refresh**' button has to be pressed. If a connection status change is discovered the VSG related 'Connection Status' icon (see *Table 21*) is changed accordingly.
Certain VSGs can be removed from the instrument pool by selecting them with a mouse click followed by pressing the ② '**Delete Selected**' button.
To clear the overall instrument pool the ③ '**Delete All**' button must be used.
Besides these functions to manage the VSGs belonging to the instrument pool several connection status and instrument related parameters are provided:

Instrument Pool – Instrument and Connection Status Parameters	
Column	**Parameter**
Instrument	④**Enabling status** checkbox: -Checked: VSG is enabled for remote control by the CDM-Toolbox -Unchecked: VSG is not allowed to be remote controlled **Note**: The remote control connection to a VSG which is currently assigned to the CDM-Toolbox is promptly terminated if the enable check box is unchecked.
	Connection status icon: : VSG is available and may be remote controlled : VSG is currently assigned to the CDM toolbox for remote control : Connection to VSG is lost (e.g. VSG switched of or interface cable unplugged). This status information is only provided for manually added VSGs.
	VSG type and **serial number**
Interface	**Interface** used to connect the VSG
	VISA resource string[1]
	VSG FW version[1]
Comment	Information how a certain VSG was added to the instrument pool

1) Will by shown/hide by pressing the grey triangle in the 'Instrument' column

Table 21: Instrument Pool – Parameters

5.2 Color Settings Dialog

The ‘Color Settings’ dialog is activated by the menu bar *Settings → Color* command. This dialog is intended to enable the user to slightly modify the GUI appearance in accordance with the personal preferences.

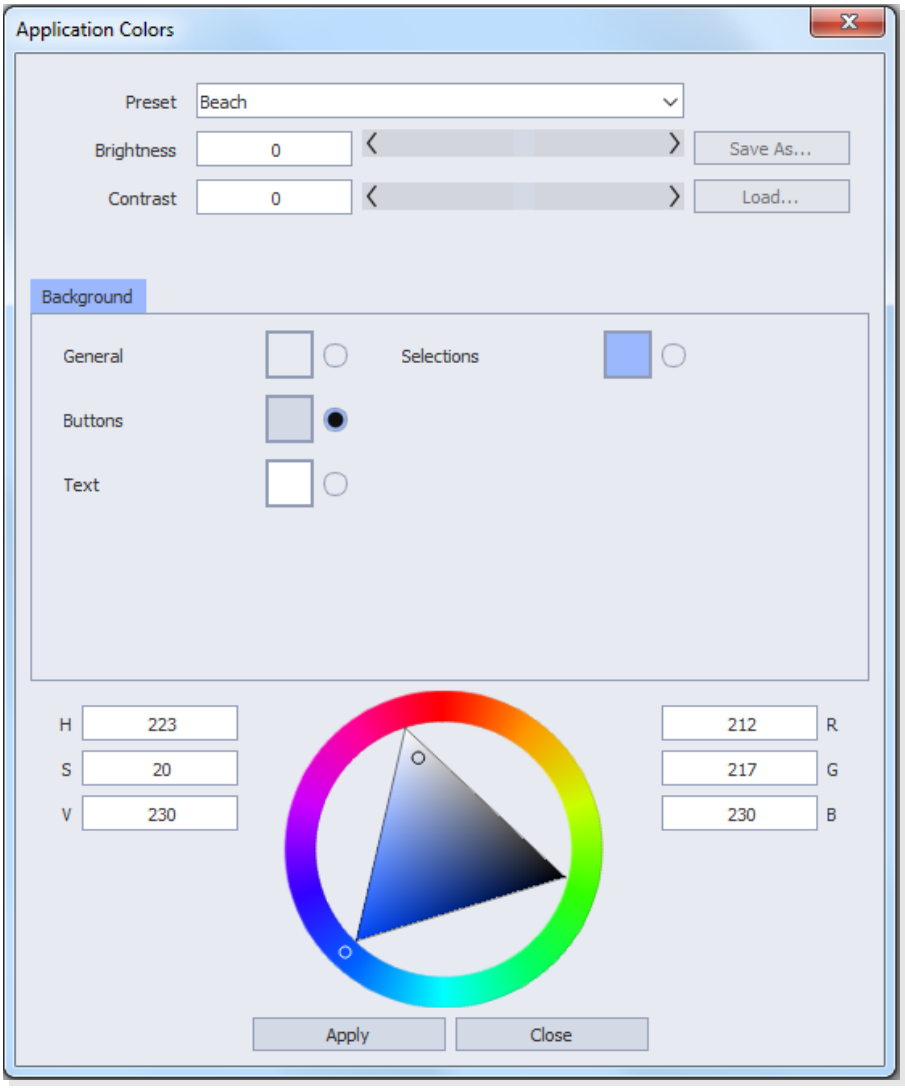


Figure 36: CDM-Toolbox – Color Settings Dialog

Note: Any modification of the color settings are saved in a color settings file which is applied at any CDM-Toolbox restart (see chapter 2.4.3 for details).

5.3 Trace Logs Dialog

The ‘Trace Logs’ dialog is activated by the menu bar *Help* → *Trace Logs* command or automatically if any problem (e.g. during the connection establishment with a VSG) is detected by the CDM-Toolbox.
It is useful to get ① background information about the functional steps performed by the CDM-Toolbox, especially if a certain action was not performed as expected.

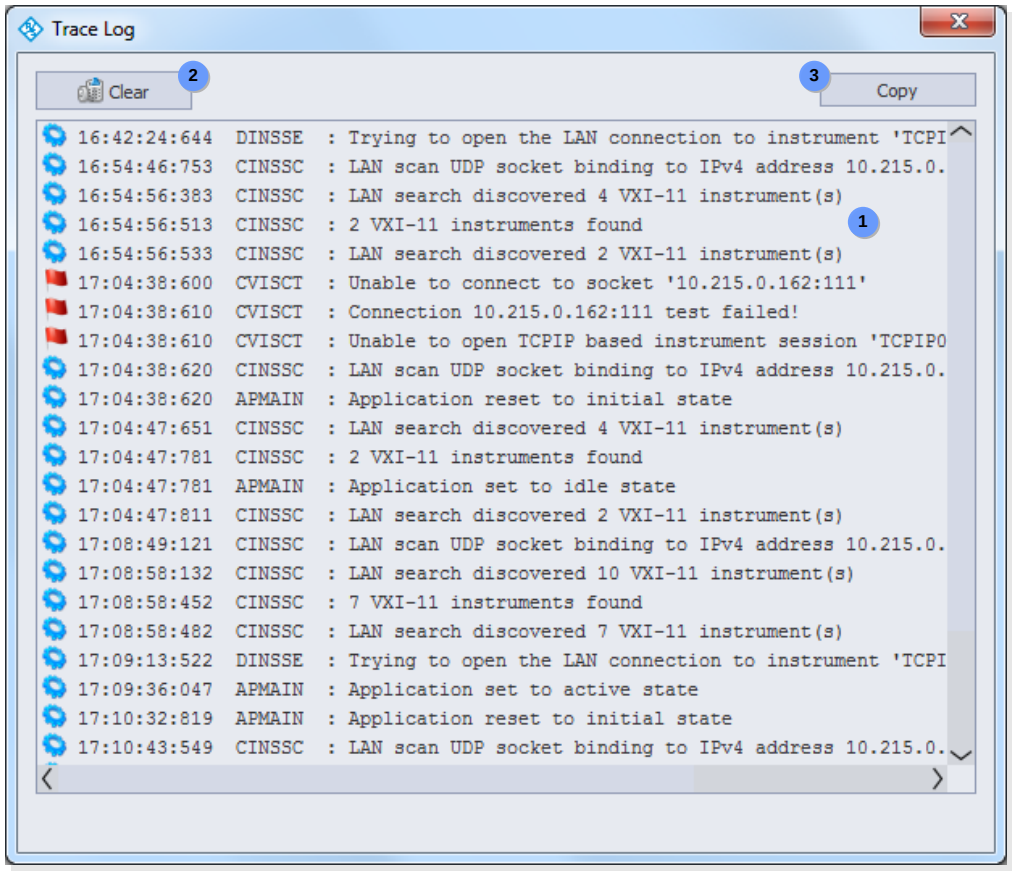


Figure 37: CDM-Toolbox – Trace Logs Dialog

Each trace log entry consists of a flag which is used to categorize the trace log entries, a timestamp, information about the CDM-Toolbox SW module which caused the log entry and last but not least the logging information itself.

Trace Log – Flags	
Flag	**Meaning**
	Any successful action
	Any successful action (extended information, ‘`--debug`’ parameter appended
	Error

Table 22: Trace Log – Flags

To clear the ‘Trace Log’ dialog (e.g. to get rid of outdated entries) the ② ‘**Clear**’ button has to be pressed.

The ③ ‘**Copy**’ button must be used if the content of the ‘Trace Log’ dialog has to be transferred to the clipboard. If it is required to save the trace log entries continuously within a file the CDM-Toolbox has to be started with applied ‘`--filedebug`' command line parameter. The created log file is stored in the ‘Users’ directory:
e.g.: `C:\Users\<UserName>\CDMToolbox.log`

To extend the shown logging information (further details) the ‘`--debug`' parameter has to be appended.

Note: This parameters should only be used for debugging purposes (e.g. to provide additional information to the R&S customer support in case of malfunctions), since it slows down the application significantly.

For details how to apply command line parameter see chapter 2.4.1.1.

6 Abbreviations

ASK	Amplitude Shift Keying
CDM	Custom Digital Modulation
CW	Continuous Wave
FSK	Frequency Shift Keying
GPIB	General Purpose Interface Bus
LAN	Local Area Network
PN	Pseudo Noise
PRBS	Pseudo Random Bit Sequence
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
SCPI	Standard Commands for Programmable Instrumentation
USB	Universal Serial Bus
VISA	Virtual Instrument Software Architecture
VSG	Vector Signal Generator

7 References

Manuals:

[1] R&S, SMW200A User Manual
[2] R&S, SMU200A Operating Manual
[3] R&S, SMATE200A Operating Manual
[4] R&S, SMJ100A Operating Manual
[5] R&S, SMBV100A Operating Manual

Application Notes:

[6] R&S, 1GP99, ARB Toolbox Plus
[7] R&S, MapWiz, Modulation mapping wizard
[8] R&S, FiltWiz, Shaping filter design wizard

Standards:

[9] CCITT Recommendation O.151, 10/1992
[10] CCITT Recommendation O.152, 10/1992
[11] CCITT Recommendation O.153, 10/1992

8 Appendix

8.1 Release Notes

8.1.1 Version 1.4.0 (Initial release)

Released: October 2013

Functional improvements:

- Not applicable

Fixed Issues:

- Not applicable

8.1.2 Version 1.5.0

Released: January 2014

Functional improvements:

- Modulation type 4096QAM added (SMW only)
- Maximum data list length extended to 250 MBit

Fixed Issues:

- Modulation type specific maximum symbol rates corrected

8.1.3 Version 1.5.1

Released: June 2014

Functional improvements:

- New SMW hardware options added to the option list
- New SMW software options added to option list
- VISA read buffer size (VI_READ_BUF) increased to 8192 byte to allow the query of long option strings

Fixed Issues:

- The control list length calculation with activated ‘Coupled’ mode is now based on the total number of data symbols within the current data list

8.1.4 Version 1.6.0

Released: August 2014

Functional improvements:

- Support of all modulation type specific parameters (e.g. modulation depth)
- User defined modulation mappings (*.vam)
- User defined shaping filters (*.vaf)
- Import of hex based data files

8.1.5 Version 1.6.1

Released: December 2014

Functional improvements:

- New SMW hardware options added to the option list
- New SMW and SMBV software options added to option list

Fixed Issues:

- User Modulation and User Filter file selection issue corrected
- Data list file import issue corrected

8.1.6 Version 1.7.0

Released: July 2015

Functional improvements:

- LAN scan functionality optimized for networks without DNS and/or DHCP server

8.1.7 Version 1.7.5702.3657

Released: August 2015

Functional improvements:

- New Windows installer

8.1.8 Version 2.0.6414.6353

Released: July 2017

Functional improvements:

- GUI design modified (proper scaling for high resolution monitors)
- Signal generator option related info updated (SMW and SMBV)
- Import of binary data files supported

Fixed Issues:

- Hidden marker label indices (List Management dialog, Control tab) shown

9 Ordering Information

Please visit the Rohde & Schwarz product websites at www.rohde-schwarz.com for ordering information on the following Rohde & Schwarz products:

- R&S®SMW200A vector signal generator
- R&S®SMBV100A vector signal generator
- R&S®SMU200A vector signal generator
- R&S®SMATE200A vector signal generator
- R&S®SMJ100A vector signal generator

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