Connectivity of Rohde & Schwarz Signal Generators

Application Note

Products:

R&S®SMW200A	R&S®SMU200A	R&S®SMA100A	R&S®SMBV100A
R&S®SMJ100A	R&S®AMU200A	R&S®SMF100A	R&S®SMC100A
R&S®SMATE200A	R&S®AFQ100B	R&S®SMB100A	R&S®AFQ100A

This application note describes how Rohde & Schwarz signal generators can be connected to system controllers and external PC peripherals such as USB memory sticks.

ROHDE & SCHWARZ

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Abbreviations

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

- The R&S®SMW200A vector signal generator is referred to as the SMW.
- The R&S®SMU200A vector signal generator is referred to as the SMU.
- The R&S®SMATE200A vector signal generator is referred to as the SMATE.
- The R&S®SMJ100A vector signal generator is referred to as the SMJ.
- The R&S®AMU200A baseband signal generator and fading simulator is referred to as the AMU.
- The R&S®AFQ100A and R&S®AFQ100B arbitrary waveform generators are referred to as the AFQ.
- The R&S®SMA100A signal generator is referred to as the SMA.
- The R&S®SMB100A signal generator is referred to as the SMB.
- The R&S®SMC100A signal generator is referred to as the SMC.
- The R&S®SMF100A signal generator is referred to as the SMF.
- The R&S®SMBV100A signal generator is referred to as the SMBV.

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1 Introduction

Rohde & Schwarz signal generators can be connected in various ways to system controllers (typically PCs) and external PC peripherals. Although most of these connection operations are also explained in the instrument manuals, it is not always easy to maintain an overview. Operating manuals commonly focus on explaining a dedicated feature of a single instrument. This application note examines a range of typical user tasks and how to solve them with the different instruments.
It is especially intended for:

- Customers who want to compare the different Rohde & Schwarz signal generators in terms of connectivity
- Users who want to integrate Rohde & Schwarz signal generators into a system
- Users who need to use older control software, drivers or interfaces
- Users who want to exchange large amounts of data

This application note covers the following areas:

- Remote control
  A system controller sends sequences of commands in order to perform automated tests. Typically, Virtual Instrument Software Architecture (VISA) interfaces are used (GPIB, LAN/VXI-11 or USB), either directly or supported by instrument drivers.
- Remote operation
  The user operates the instrument manually from a remote location, typically using an Internet browser.
- External PC peripherals
  Some peripherals known from the PC world can also be used with signal generators to ease operation or to exchange data.
- File transfer
  There are several ways to transfer files from or to the signal generator. Besides remote control (MMEM subsystem) or USB memory sticks, it is sometimes very helpful to get direct access to the instrument's file system at the operating system level.

2 Feature Overview

As regards connectivity, it is important to note that Rohde & Schwarz signal generators can be divided into two classes:

- Signal generators using the Linux operating system:
  SMW, SMA, SMB, SMC, SMF, SMBV
- Signal generators using the Microsoft Windows XP operating system:
  SMU, SMATE, SMJ, AMU, AFQ

Within their class, signal generators use the same code base, and therefore have the same features which can be used and configured the same way (see Table 1 and Table 2).

Feature	Remote control					Remote operation		
Instrument	GPIB	LAN-VXI-11	LAN Telnet Protocol	USB-TMC	RS232/ Bluetooth	Remote Desktop	VNC	LXI Class C
SMW	Yes	Yes	Yes	Yes	Yes[1]	No	Yes	No
SMU	Yes	Yes	Yes	No	No	Yes	No[2]	Yes
SMATE	Yes	Yes	Yes	No	No	Yes	No[2]	Yes
SMJ	Yes	Yes	Yes	No	No	Yes	No[2]	Yes
AMU	Yes	Yes	Yes	No	No	Yes	No[2]	Yes
AFQ	Yes	Yes	Yes	No	No	Yes	No[2]	Yes
SMA	Yes	Yes	Yes	Yes	Yes[1]	No	Yes	No
SMB	Yes	Yes	Yes	Yes	Yes[1]	No	Yes	No
SMC	Yes	Yes	Yes	Yes	Yes[1]	No	Yes	No
SMF	Yes	Yes	Yes	Yes	Yes[1]	No	Yes	No
SMBV	Yes	Yes	Yes	Yes	Yes[1]	No	Yes	No

Table 1: Feature overview, remote control and remote operation

Feature	External devices			File transfer	
Instrument	Display	Keyboard & Mouse	USB memory stick	SMB/Samba/ Windows shared folder	FTP
SMW	No	Yes	Yes	Yes	Yes
SMU	VGA	Yes	Yes	Yes	No
SMATE	VGA	Yes	Yes	Yes	No
SMJ	VGA	Yes	Yes	Yes	No
AMU	VGA	Yes	Yes	Yes	No
AFQ	DVI	Yes	Yes	Yes	No
SMA	No	Yes	Yes	Yes	Yes
SMB	No	Yes	Yes	Yes	Yes
SMC	No	Yes	Yes	Yes	Yes
SMF	No	Yes	Yes	Yes	Yes
SMBV	No	Yes	Yes	Yes	Yes

Table 2: Feature overview, external devices and file transfer

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[1] For RS232, the USB serial adapter R&S®TS-USB1 is required. For Bluetooth, a bluetooth dongle is required.
[2] Not part of the firmware, but can be installed manually (Ultr@VNC is recommended)

2.1 Security Aspects

Rohde & Schwarz signal generators can be connected in several ways, which enables many powerful applications. However, all connections that can be used by authorized users pose potential security risks as well. Please perform the following checks in order to reduce these risks:

► Change the security password! By default, it is "123456" and can be changed using the Setup/Security menu.

► Windows-based instruments: Change the user password (valid for remote desktop)! By default, it is "instrument" and can be changed at the operating system level (see operating manual) and by using the tool "Autologin", which is part of code_samples.zip (to be downloaded from the Rohde & Schwarz website).

► Linux-based instruments: Change the user password (valid for VNC, FTP and SMB/SAMBA)! By default, it is "instrument" and can be changed using the Setup/Security Menu.

► Do you use LAN connections? If not, deactivate "LAN Connections" in the security settings.

► Do you use USB devices beside mice and keyboards? If not, deactivate "USB Device" in the security settings.

► If you use LAN connections, do you need to use remote operation (VNC or remote desktop)? If not
- Windows-based instruments: Deactivate remote desktop (and VNC, if installed).
- Linux-based instruments: VNC can be deactivated, if a new firmware is installed. Otherwise set a very secure instrument password.

For all Rohde & Schwarz signal generators, there are detailed papers explaining all security aspects. At the instrument home page, please see Downloads/Security.
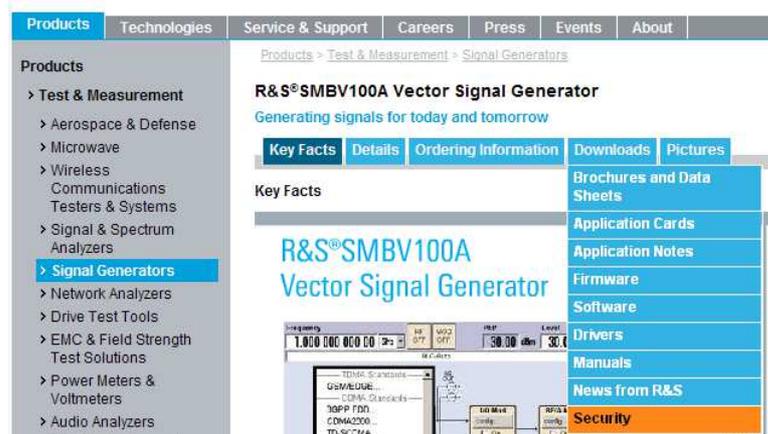
Fig. 1: Finding instrument security procedures (example for SMBV)

2.2 Identifying/Addressing the Signal Generator Using a LAN Connection

All Rohde & Schwarz signal generators can be addressed by either their IP address or their hostname. This is valid for all types of LAN connections including:

- Remote control using instrument drivers, directly VISA or the raw Ethernet / telnet protocol (see chapter 3)
- Remote operation using remote desktop, a VNC client or a web browser (see chapter 4)
- File transfer using FTP or SMB/SAMBA (see chapter 6)

All Rohde & Schwarz signal generators are delivered factory-preset to an individual hostname consisting of

- "rs" (stands for R&S®, not used with all instruments to avoid problems with NetBIOS name length restrictions)
- The name of the instrument
- Its serial number

Default hostname of Rohde & Schwarz signal generators	
Instrument	Hostname
SMW	RSSMW200A<serial number>
SMU	RSSMU200A<serial number>
SMATE	SMATE200A<serial number>
SMJ	RSSMJ100A<serial number>
AMU	RSAMU200A<serial number>
AFQ	AFQ100A<serial number>
SMA	rssma100a<serial number>
SMB	rssmb100a<serial number>
SMC	rssmc100a<serial number>
SMF	rssmf100a<serial number>
SMBV	smbv100a<serial number>

Table 3: Default hostnames of Rohde & Schwarz signal generators

The hostname is very convenient to use because it does not change (IP addresses do in DHCP networks) and is known (see table above) without checking the Network Settings Dialog (see next chapter).

2.2.1   Finding Hostname and IP Address

For all instruments running Windows (SMU, SMATE, SMJ, AMU and AFQ), hostname and IP address can be found in the LXI status dialog:
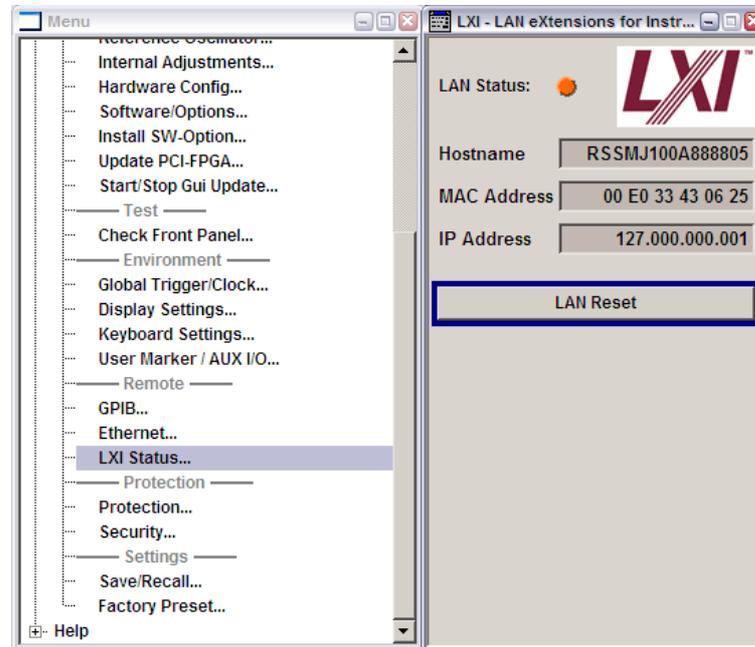
Fig. 2: Finding the hostname and IP address on Windows instruments

For all instruments running Linux (SMW, SMA, SMB, SMC, SMF, SMBV), this information can be found in the Network Settings dialog:
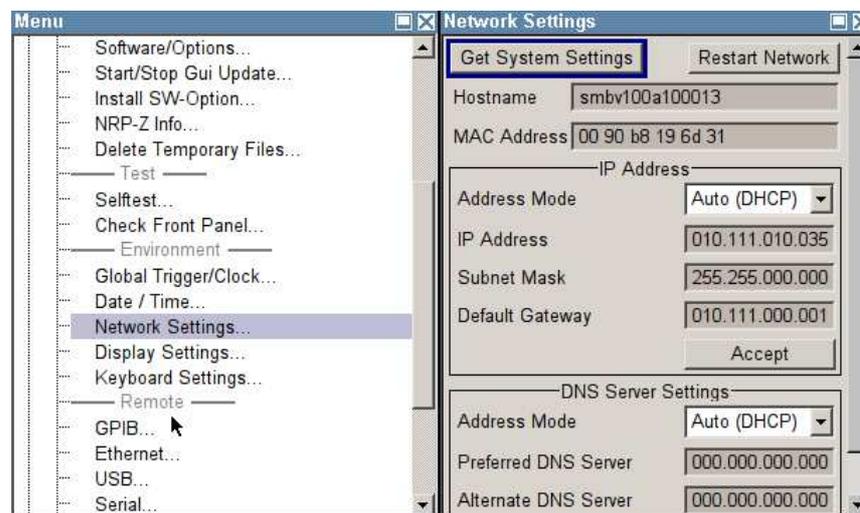
Fig. 3: Finding the hostname and IP address on Linux instruments

For SMW this information is found in the network tab of the Remote Channel Settings dialog.

2.2.2 Changing the Hostname

A hostname is the unique name by which a network-attached instrument (such as a Rohde & Schwarz signal generator) is known within a network. It is recommended not to change this name, in order to avoid violations of this uniqueness and the loss of simple identification.
However, if network policies require another name, it can be changed by following the instructions given in the operating manual.

For all instruments running Windows (SMU, SMATE, SMJ, AMU and AFQ):
- Connect mouse and keyboard
- Move the mouse to the bottom of the screen
- Select /instrument – right mouse button / properties
- Select tab "Computer Name" / Change …
- Enter the new name
- Press "OK" and restart the instrument
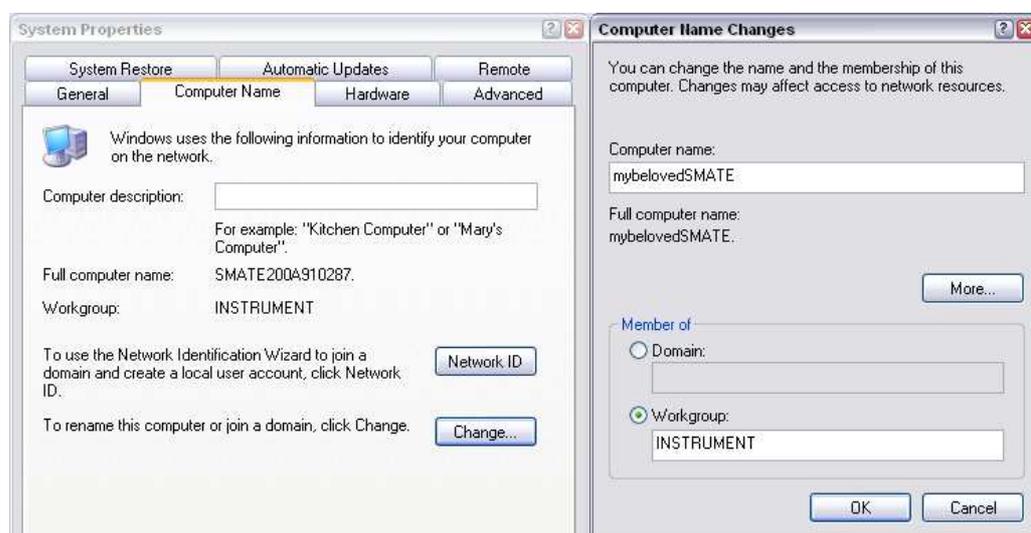
Fig. 4: Changing the hostname on Windows instruments

For all instruments running Linux (SMW, SMA, SMB, SMC, SMF, SMBV), the hostname can be changed as follows:
- Select Setup/Protection and set protection level 1 (123456)
- Enter the Network Settings Dialog
- Change the hostname and press "Enter" (no restart required)

2.2.3   Changing the IP Address

For all instruments running Windows (SMU, SMATE, SMJ, AMU and AFQ) the IP address can be changed at the operating system level, or, more elegantly, using the LXI web server (a description of LXI can be found in chapter 5).
Just start an Internet browser and enter the instrument address, for example:
http://rssmf100a100113
("http://" is obsolete for all modern browsers)

Fig. 5: Changing the IP address on Windows instruments

For all instruments running Linux (SMW, SMA, SMB, SMC, SMF, SMBV), the IP address can be changed in the Network Settings Dialog (SMW : Network tab of the Remote Channel Settings Dialog)

2.2.4   Direct LAN Connection between Signal Generator and Controller

If a Rohde & Schwarz signal generator is connected to the corporate network, it can automatically get an IP address from the Dynamic Host Configuration Protocol (DHCP) server and can be addressed by its hostname by the Domain Name Service (DNS) server.
However, operation within a corporate network is not always possible due to
- Restrictions from corporate IT security policies
- Missing network infrastructure

In these cases a direct link between controller and signal generator is supported:
- Use a standard LAN cable ("patch cable"); no crossover cable is needed
- DHCP still works, i.e. a DHCP-like service within the instrument will also assign a random IP address to it. If the network cable (connected to the controller) is plugged in during power on, this address assignment will be completed by the time the instrument has completely finished booting. If the network cable (connected to the controller) is plugged in later, it may take up to one minute.

- For SMW, SMA, SMB, SMC, SMF and SMBV signal generators, DNS still works, meaning that the instrument can be found using its hostname.

3 Remote Control

A simplified layer model is helpful in understanding the possibilities of remote control:
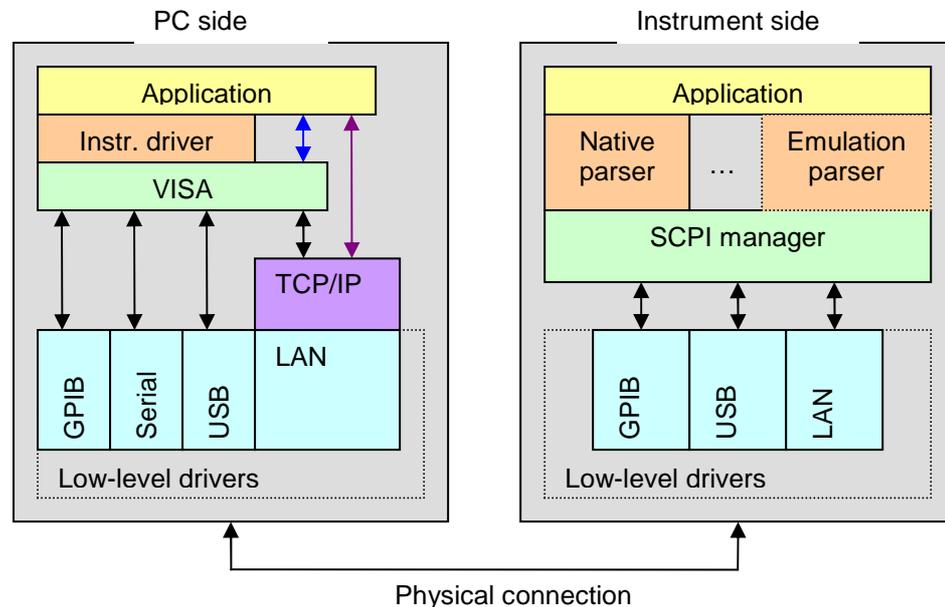
Fig. 6: Remote control layer model

3.1 Choosing the Right API

The application (yellow block) on the left-hand side stands for the software a system programmer writes to control the instrument. The other blocks are either part of the operating system (low-level drivers and TCP/IP stack) or can be downloaded from the instrument's website (instrument drivers). VISA (Virtual Instrument System Architecture) is delivered with all vector signal generators containing base band options. It can also be downloaded from http://www.ni.com/visa/. Please be aware that a valid license is needed to use VISA. Read the license terms carefully at the vendor's website.

3.1.1 Using Instrument Drivers

The instrument drivers offer the highest level APIs, and are recommended for most programming tasks. They can be downloaded from the instrument's website and are available for several programming environments.

A typical function call looks like this:

```
ViStatus _VI_FUNC rssma_confPowerResponseMeasurementDiagram
(ViSession instrSession,
 ViInt32 sense,
 ViReal64 frequencyYScaleMinimum,
ViReal64 frequencyYScaleMaximum,
 ViReal64 powerYScaleMinimum,
 ViReal64 powerYScaleMaximum,
 ViInt32 senseMode)
```

To make the programmer's life simpler, these driver functions handle not only the setting of the parameters but also
- Option checking (Is this command allowed with this instrument's configuration?)
- Range checking (Are the parameters within their valid range?)
- Error checking (Were the commands processed correctly?)

To learn more about these drivers and how they are used, please see application note 1MA153 and the documentation which can be found in the driver download area.

Fig. 7: Download area for instrument drivers

3.1.2 Directly Using VISA

Instrument drivers can be very convenient, especially when using the National Instruments LabVIEW environment or when high level functionalities are needed, for example for reading hard copies. However, bypassing these drivers may be the right choice as well:
- If brand-new firmware releases (or beta versions) are used and the drivers are not yet available
- If code size and/or speed is very critical
- If legacy code containing VISA calls has to be reused
- If SMW shall be controlled (with built-in code generator, see [2])

With most developing environments, code using driver calls and code using VISA directly can be mixed.

To learn more about VISA programming, please refer to the various resources which can be found at the websites of the VISA vendors. There is also a small demo program "VISAterminal" as part of code_samples.zip, which can be downloaded from the Rohde & Schwarz website. It shows how the basic functions of the VISA API can easily be wrapped by a C++ class and how this class can be used, for instance to build a VISA terminal program:
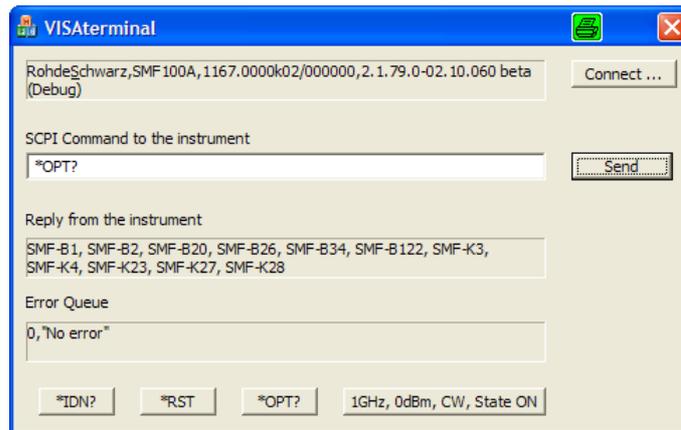
Fig. 8: Demo program "VISAterminal"

Three protocols are supported through the LAN interface:

Supported VISA LAN protocols		
Protocol	**Syntax of resource string (simplified)**	**Description**
VXI-11 (standard)	TCPIP::host address::**INSTR**	Standard LAN protocol recommended for standard applications. Most features known from GPIB are available, including service requests, polling the status byte and abort of transmission. Several ports are used to control data transmission.
Telnet/Socket	TCPIP::host address::**5025::SOCKET**	Alternative simple protocol based on one single port (5025). No support of the enhanced features mentioned above, but faster by a factor of 3 (typical)
HiSLIP	TCPIP::host address::**hislip0**	Fast as the raw socket protocol and more possibilities as VXI-11. This protocol can be considered as the successor of VXI-11. Not all instruments support this protocol. See [4] and the user manuals / release notes of the instrument for details.

Table 4: Supported VISA LAN protocols

3.1.3 Using the Telnet Protocol without VISA

The VISA library is a very useful software layer, especially for abstracting the hardware interface. It has been the standard API for T&M applications for several years, and is widely used. However, when using LAN there are some situations where this software layer cannot be used (or is not the best choice):

- VISA is generally not freeware, but must be licensed from National Instruments or other vendors. The license is included with National Instruments hardware or software and also with signal generator baseband options such as SMU-B10 and R&S®WinIQSIM™ options such as SMBV-K255.
- VISA is available for most operating systems, but not all.
- If code size and/or speed is very critical:
  The network protocol VISA normally uses ("VXI-11") is typically slower by a factor of 3 than the telnet protocol (but the VISA socket protocol is nearly equivalent in terms of speed).

In these cases, directly programming the telnet protocol (using a socket API) is the best choice. Chapter 3.2 gives detailed instructions on how to use this software interface.

3.1.4 Using Low-Level Drivers or Older APIs

Sometimes software developed a very long time ago must still be used.

Before VISA became the standard for remote control of measurement instruments, several different drivers/APIs were used. Typical representatives of this driver generation are

- GPIB NI488.2 for GPIB (also known as IEC625 or IEEE488)
  (the most important functions are ibfind(), ibwrite, ibread())
- The Windows API for serial communication (also known as RS232 or V24)
  (the most important functions are CreateFile(), WriteComm() and ReadComm())
- Programming the universal asynchronous receiver/transmitter (UART, hardware component) directly at the register level.

Often porting to VISA-API is the right way to go. The remote commands (SCPI strings such as "*RST" or "SOUR:BB:GSM:STAT ON") and the logical structure of the program can remain unchanged, so only the API calls have to be exchanged. For example, switching from NI-488.2 (ibfind(), ibwrite(), ibread(), …) to VISA (viOpen(), viWrite(), viRead(), …) is comparatively easy.

For new developments we urgently recommend not to use these low-level drivers or old APIs!

3.2 How to Use the Telnet Protocol / Socket API

This protocol is sometimes also referred to as "raw Ethernet interface" or "raw socket interface". The telnet protocol is a rather old Ethernet protocol between terminals and workstations, but it is still supported by all modern operating systems. By default it uses port 23, but for signal generators (and other Rohde & Schwarz instruments), port 5025 is used instead. Unlike with VXI-11, no VISA or other driver installation is necessary on the remote controller side, as all necessary components are included in the operating system.

3.2.1 Manual Control of Instruments

Manual control of the instrument requires only a telnet program (which is part of every operating system).

Example of communicating with an instrument having the address 10.111.10.208

Start telnet
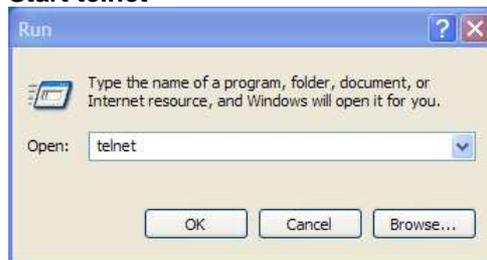
Fig. 9: Telnet - starting the program on Windows XP

Connect
Enter "open 10.111.10.84 5025" and press <ENTER>
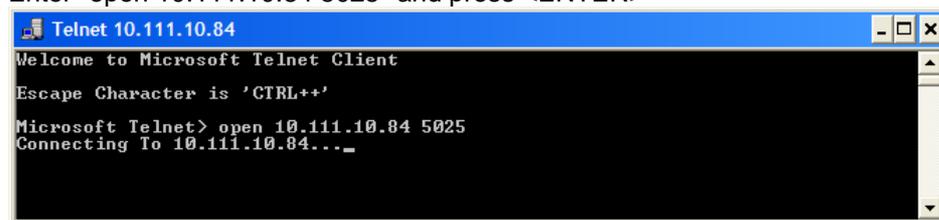
Fig. 10: Telnet – connecting to signal generator

Send commands
Enter the commands terminated with <ENTER>

Fig. 11: Telnet – sending SCPI commands

3.2.2 Programmatic Control of Instruments

This chapter shows how a simple command-line program can be written to send SCPI commands to the signal generator and display the response. The complete source can be found in the file code_samples.zip, which can be downloaded from the Rohde & Schwarz website.

The following sample code "EthernetRawCommand" is designed for Linux systems but can also be used with Windows (an example for Microsoft Visual Studio 2005 is included).

Linux is used in this example for the following reasons:
- Most Linux users prefer the telnet protocol due to the lack of a VISA for their Linux distribution
- The development environment (GNU suite) is a standard and can be seen as part of the operating system
- Compiling and linking are very simple

Components of EthernetRawCommand

Components of EthernetRawCommand	
Module	**What it does**
TcpClient.cpp/TcpClient.h	Implementation of the TcpClient class, which allows connecting, disconnecting, sending and receiving to/from signal generator (= server) These files can easily be repurposed for other applications.
EthernetRawCommand.cpp	Uses TcpClient to establish a connection to the signal generator, send a SCPI command and display the response in case of a query command.

Table 5: Components of EthernetRawCommand

Compiling and linking
This is very simple – just type the following:

```
g++ TcpClient.cpp EthernetRawCommand.cpp –o EthernetRawCommand.out
```

Using EthernetRawCommand
If your signal generator address is 10.111.10.208, ask for its IDN string by typing the following:

```
./EthernetRawCommand.out 10.111.10.208 *IDN?
```

Code_samples.zip contains another demo program showing how to program sockets with the QTCreator IDE. It is called Socket File Transmitter.
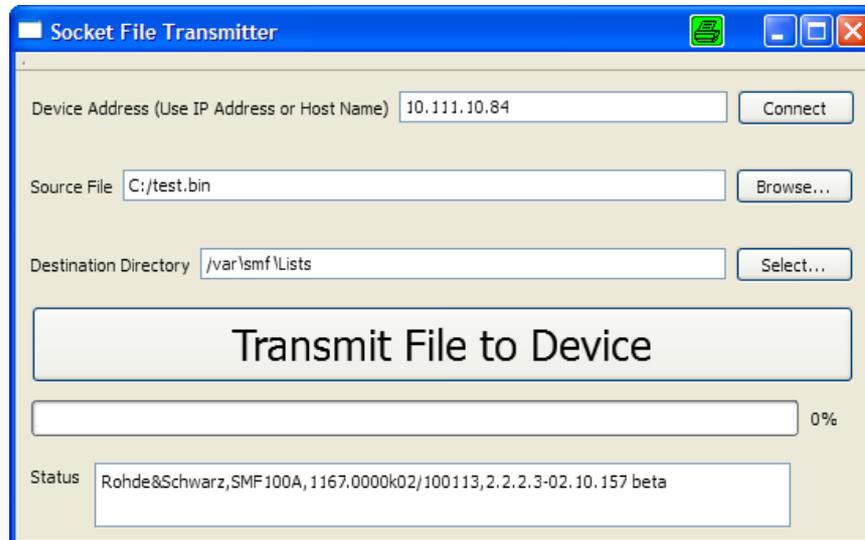
Fig. 12: Using the Socket File Transmitter

► Enter the device address and press "Connect".

► Press "Browse" and select a source file to transmit.

► Press the big "Transmit File to Device" button.

3.3 Using Serial and Bluetooth Connections

Serial connections (also known as RS232, COM port or V.24 connections) were very popular for instrument remote control before LAN and USB became the standard. Rohde & Schwarz instruments were equipped with serial interfaces for several years, so a lot of software exists to drive these instruments.

Often these older signal generators must be replaced with modern instruments, especially those listed on the cover of this application note, without changing the system software or hardware. Where remote command compatibility can be achieved with the help of emulation modes (see chapter 3.5), the lack of a serial (= RS232) interface is sometimes a critical problem for these applications.

For this reason, all the signal generators frequently used for replacement can be equipped with an external USB/serial adapter, which can be ordered from Rohde & Schwarz:

Designation	Type	Order No.
USB serial adapter for RS232 remote control	R&S®TS-USB1	6124.2531.00

The interface parameters can be set in the Remote Channels Settings menu:
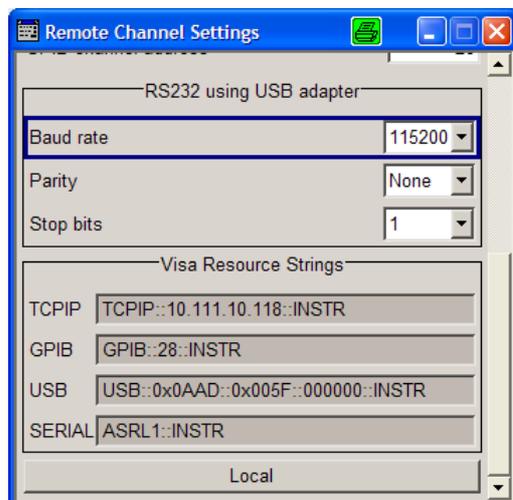
Fig. 13: Setting up the serial interface

Just connect the adapter to the Rohde & Schwarz signal generator (USB side) and a RS232 cable (as used before with the old signal generator.)

Of course, serial communication is not restricted to replacement applications. A serial API is part of every development environment and is also supported by the VISA layer. If you are using VISA (for example with the VISA terminal of chapter 3.1.2) please be aware that the standard baud rate is 9600, and set the signal generator to this value. However, we do not recommended using the serial interface for new developments, since LAN and USB are faster, cheaper and more reliable.

3.3.1   Bluetooth Remote Control

In spite of being no more than a legacy mode for traditional remote control, serial communication is still the key to a useful wireless remote control mode: Bluetooth. This mode is available for all Linux-based instruments: SMA, SMB, SMBV, SMC and SMF.
On the instrument side, a Bluetooth USB dongle must be connected (not available from Rohde & Schwarz but common in the PC world). On the PC side, Bluetooth is also required, either built-in or likewise using a USB dongle.

Depending on the Bluetooth hardware and the propagation conditions, range and data rate differ.

► On the signal generator side, plug in a Bluetooth USB dongle

► Open the Security dialog and enter the Pin (any four-digit number)
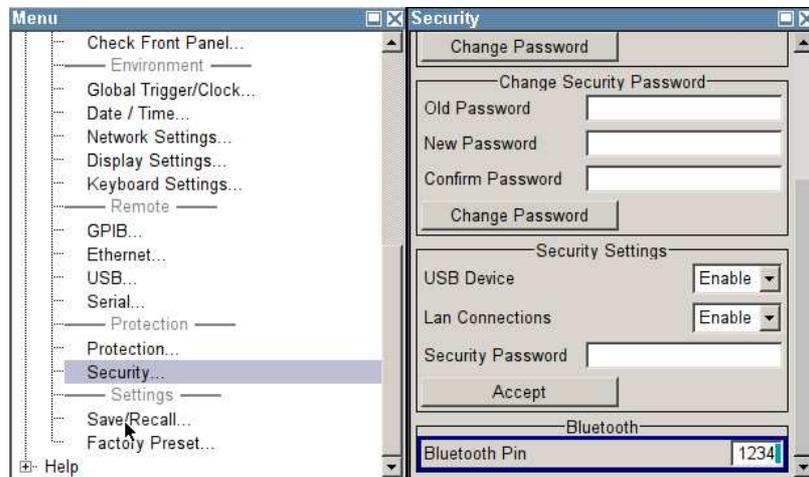
Fig. 14: Input of the Bluetooth pin

► At the PC side, plug in another Bluetooth USB dongle (if not built-in, as in a notebook)

The Bluetooth icon will appear on the taskbar.

► Double-click the icon to start a configuration program (manufacturer-dependent)
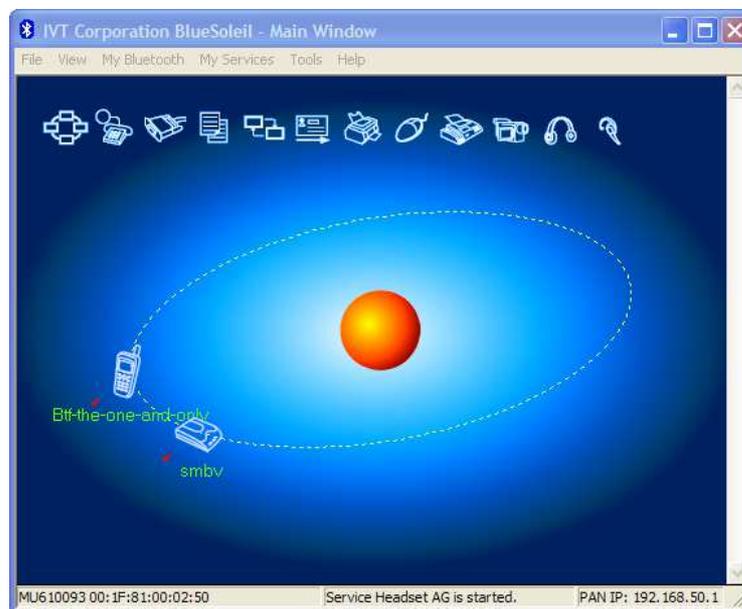
Fig. 15: Searching for Bluetooth devices

All discovered Bluetooth devices will be shown, including your signal generator (here: smbv).

► Double-click smbv.

► Enter the Pin you used previously in the security dialog above.
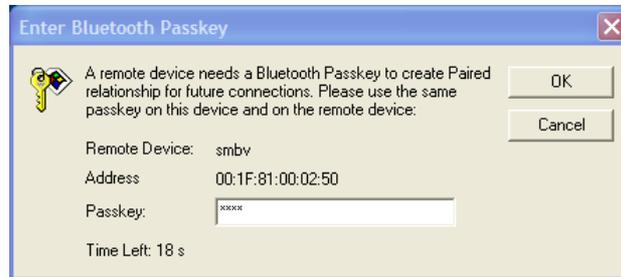
Fig. 16: Pin input on PC side

The serial port service icon will turn yellow.
► Double-click this icon.

► Enter the same Pin you used before.

► Right-click smbv and select "Status …"
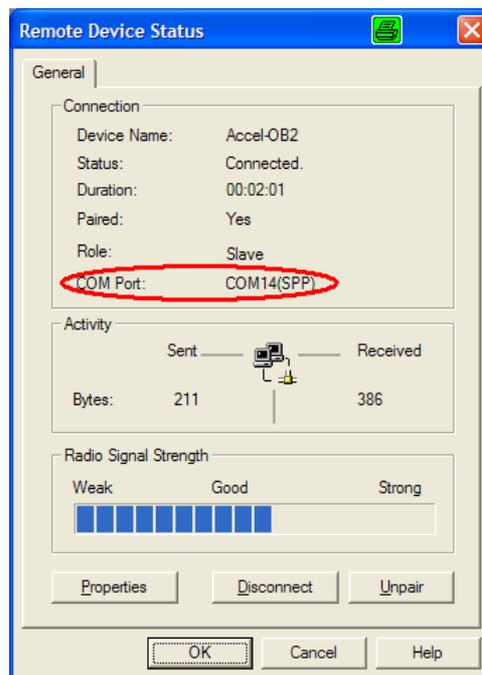
Fig. 17: Detecting the active COM port

The COM port which must be used for serial communication is shown (usually this will be 14 or 15).

From now on, all programs designed for serial communication (except those programming the UART directly) will also work with Bluetooth. This is especially the case for all VISA-based programs, including "VISAterminal" (see code_samples.zip).

The VISA resource string is accordingly ASRL14::INSTR or ASRL15::INSTR.

Fig. 18: Using the VISA terminal with Bluetooth

If no VISA programming API can be used, it is highly recommended to use a library such as QExtSerialPort (http://sourceforge.net/projects/qextserialport/).

3.4 Comparing Speed

Choosing the right API often involves selecting the most appropriate physical interface for remote transmission. Next to cabling costs, maximum distance, reliability, availability and security requirements, speed is the most important criterion.
Transmission speed is determined by

- The maximum physical speed the hardware (interface chips) is capable of
- The performance of the software layers on the instrument and controller sides
- Overhead caused by higher layer protocols
- Processing speed of instrument and controller
- Size of the payload (the data to be sent or read)

The following values are typical for SMBV, and are also a good approach for the bandwidth we can see with other signal generators:

Speed comparison of remote control interfaces		
Interface	**Time for *IDN? (including reading the answer)**	**Transfer rate for big waveforms (using MMEM commands)**
VISA VXI-11	1.8 ms	1.7 Mbyte/s
VISA socket / telnet	0.9 ms	7 Mbyte/s
GPIB	1.0 ms	0.6 Mbyte/s
USB	1.2 ms	3.6 Mbyte/s
VISA Serial 9600 baud	100 ms	0.001 Mbyte/s
VISA Serial 115200 baud	29 ms	0.012 Mbyte/s
VISA Serial Bluetooth	10 ms to 70 ms	Up to 0.1 Mbyte/s

Table 6: Speed comparison of remote control interfaces

For a detailed speed comparison, see [4].

3.5 Emulation of Other Instruments

Replacing existing instruments with new instruments can lead to serious difficulties if the instruments are remotely controlled. In most cases the command sets differ, and changing the system software can be tricky, especially for very old systems.
To overcome this issue, Rohde & Schwarz signal generators can emulate other signal generators at the remote command level. This is done by changing the remote control language from SCPI (the native command set explained in the manual and online help) to that of other instruments (non-SCPI and SCPI).
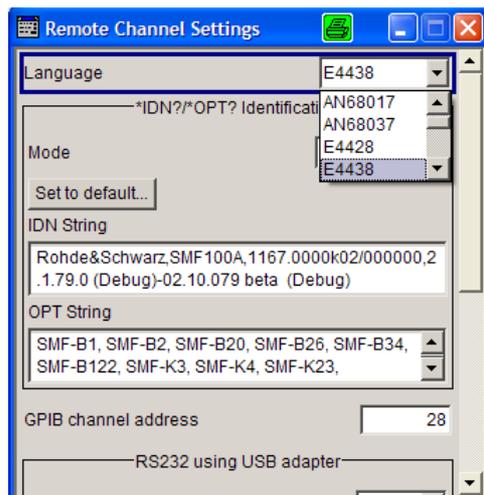
Fig. 19: Choosing an emulation mode

Each language corresponds to a dedicated command parser able to process this specific command set. Important: all languages/parsers can be combined with every hardware interface (GPIB, LAN or USB).

Available emulations (January 2010)				
Emulation language	SMA	SMB/SMC	SMBV	SMF
AF2023/AF2024	X	X	X	
AF2030/AF2031/AF2032	X	X	X	
AF2040/AF2041/AF2042	X	X	X	
AF2050/AF2051/AF2052	X	X	X	
AN680XX				X
E4428	X	X	X	X
E8257	X	X	X	X
HP8340				X
HP8360				X
HP8373				X
HP8642	X			

HP8643	X	X	X	
HP8648	X	X	X	
HP8657		X	X	
HP8662	X			X
HP8663	X			X
HP8665	X			X
HP8673				X
N5181	X	X	X	X
RC3102	X			X
RSSMGU	X			
RSSML		X	X	

Table 7: Available remote emulations

To learn more about remote emulation, please see application note 1GP71.

4 Remote Operation

Remote operation is not only a must for instruments without display – it is also helpful for all instruments for the following reasons:

- Offsite operation and equipment-sharing among multiple users
- Long-distance maintenance and trouble-shooting without shipping, i.e. fast and cheaply
- Extended screen size
- Easy generation of screen shots for documentation
- Connection to video projectors and printers

For remote operation the instrument (server) must have a LAN connection to the PC (client). Two different methods are possible, depending on the signal generator (strictly speaking its operating system) and the PC: remote desktop and VNC.

Valid combinations (**preferred**):

Combinations of signal generators and remote operation clients		
Signal generators ➔ **Client Operating System**	**SMU, SMJ, SMATE, AFQ, AMU**	**SMW, SMA, SMB, SMC, SMF, SMBV**
Windows XP / Vista	**Remote Desktop** VNC (manually installed)	VNC
Linux	**VNC** (Remote desktop clients available, for example "rdesktop")	VNC
Mac OS	**VNC** (Remote desktop clients available, for example "Microsoft Remote Desktop Connection Client for Mac")	VNC

Table 8: Available remote operation clients

To access the hard keys of the signal generator (such as PRESET, SETUP, FREQ and all others), right-click on the block diagram. A menu bar appears, with buttons for all instrument keys:

Fig. 20: The menu bar simulating the hard keys (SMW design)

4.1 Using Remote Desktop

Remote desktop uses the Microsoft RDP protocol, based on ITU-T T.128 (also known as T.SHARE). This is the standard protocol for clients running on Microsoft operating systems, and is available without any additional installation. Clients also exist for Linux and Mac OS; just search the Internet for the tools mentioned above (Table 1).

4.1.1 Activating and Deactivating the Remote Desktop Server on the Instrument

By default, the remote desktop is deactivated for security reasons. It must be activated manually at the operating system level. It then remains activated until

- It is deactivated again manually
- A new operating system is installed (by Rohde & Schwarz service)

A firmware update does not alter the remote desktop settings.

This step is explained at length in the operating manual ("Manual Operation" chapter). The most important steps are:

► Open Properties of the system
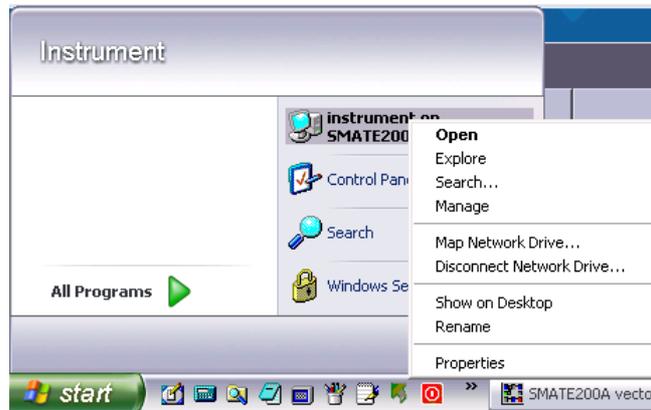
Fig. 21: Enabling remote desktop access (step 1)

► Activate switch "Allow users to connect remotely to this computer"
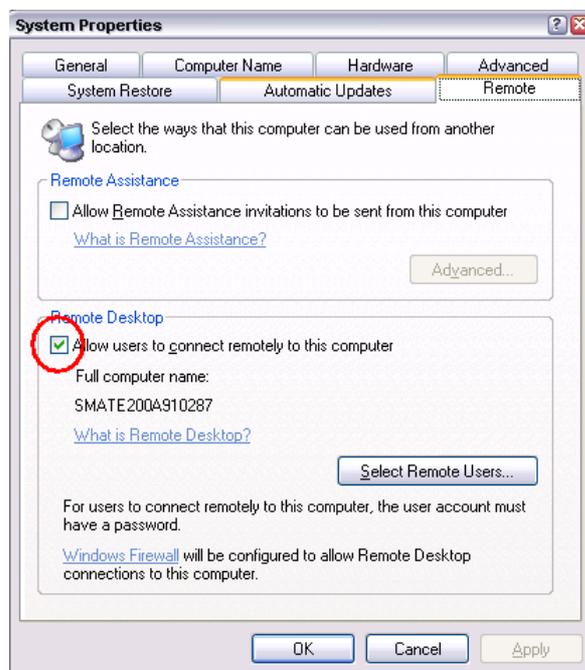
Fig. 22: Enabling remote desktop access (step 2)

The remote desktop can be deactivated by simply disabling the checkbox.

4.1.2 Starting the Remote Desktop Client

On the PC side (Windows PC), the remote desktop is started with
Start/All Programs/Accessories/Communications/Remote Desktop Connection.
Enter the hostname of the signal generator.
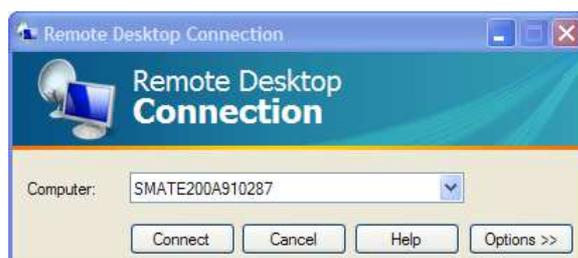
Fig. 23: Enabling remote desktop access (step 1)

Now press Connect.

Fig. 24: Enabling remote desktop access (step 2)

Enter the password (by default "instrument") and press OK.

4.2 Using VNC

Virtual Network Computing (**VNC**) is a graphical and platform-independent desktop sharing system for remotely controlling another computer. Multiple clients can connect to a VNC server simultaneously. Unlike with remote desktop, the instrument remains locally operable during remote operation. Therefore VNC is ideally suited for remote technical support and similar applications.

4.2.1 Activating the VNC Server on the Instrument

All signal generators based on Linux (SMW, SMA, SMB, SMC, SMF, SMBV) have a built-in VNC server, which is always running. It does not need to be activated. This server uses port 80, which is the standard HTTP port.
All signal generators based on Windows (SMU, SMATE, SMJ, AMU, AFQ) **do not** have a VNC server on delivery. It must be installed using the following procedure:
1.   Download UltraVNC (http://www.uvnc.com/download/index.html)

2. Install it on the instrument with default settings (using port 5800 for HTTP)
3. Grant permission in the firewall setting (Unblock)

Fig. 25: Unblock VNC

4. Set password

4.2.2   Starting a VNC Client

On the PC side, there are basically three options for displaying the instrument display:
1. Use the VNC client software (also downloadable from the same website as the server)
2. Use any web browser (Java runtime is installed)
3. Use a web browser supporting HTML5 / web sockets (no Java runtime needed)

Enter the instrument address for instance
smate200a910287:5800
rssmw200a123456

The password is the user password, which is "instrument" by default and should be changed:

- For Windows instruments: at the operating system level
- For Linux instruments: in the security settings

VNC connections can also be established from computers running Mac OS or Linux or from mobile devices like smart phones and tablet PCs.

4.2.3 Comparison of the three ways to establish a VNC connection

Comparing the three types of VNC connections			
Client device	**VNC Client**	**Requirements**	**Remarks**
Desktop system running Windows, Mac OS or Linux	UltraVNC or other dedicated client software	Must be installed	Very fast, several options like full screen mode or auto-login
	Web browser with Java runtime	Java runtime must be installed and activated in browser settings	Fast and convenient, just enter instrument address in address line (but Java runtime is sometimes considered as security concern)
	Web browser with HTML5 / web socket support	Browser must support web sockets, no extra installation or activation needed	Slower than the other modes but no extra installation and no security concern
Tablet PC /smart phone	Dedicated client app	Must be installed	Very fast, several options like full screen mode or auto-login
	Web browser with HTML5 / web socket support	Browser must support web sockets	Slower than dedicated app but support of QR code scanning "VNC tp go" (see next chapter)

Table 9: Comparing the three types of VNC connections

4.2.4 VNC to go (SMW only)

As mentioned in the last chapter, also mobile devices can be used for VNC remote operation. SMW has a built in a special support to transmit the instrument address to the client:

Fig. 26: The instrument address displayed as QR code (SMW only)

To use this:

1. Install a QR scanner app on your mobile device
2. Update your web browser to the latest version
3. Start the scanner app and hold your mobile device close to the QR code
4. The scanner app will read the instrument address and then automatically start the web browser
5. Enter the instrument password (by default : instrument)

4.3   Comparison of Remote Desktop with VNC

Comparing remote desktop with VNC		
	Remote desktop	**VNC**
Usable with Windows PCs	Windows-based instruments: 😀 Linux-based instruments: 😠	Windows-based instruments: 😐 Linux-based instruments: 😀
Usable with non-Windows PCs and controllers	Windows-based instruments: 😐 Linux-based instruments: 😠	Windows-based instruments: 😐 Linux-based instruments: 😀
Simultaneous operation locally and one client	Only one user at a time 😠	Supported 😀
Simultaneous operation of two or more remote clients	Only one remote client at a time 😠	Supported, but operation slows down 😐
Remote client logoff	Before the instrument can be operated locally, a keyboard must be connected to enter the password (or the instrument must be rebooted) 😠	Without notification, the instrument can be used before and after logoff 😀
Security	High; remote access can be restricted by:	Medium; remote access can be restricted by:

	- deactivating LAN - changing the instrument password In addition, unauthorized access is visible in the display 🙂	- deactivating LAN - changing the instrument password Unauthorized access is not visible in the display 😐 (SMW: 🙂)
Performance	High; The protocol is vector oriented, i.e. graphic commands are transmitted 🙂	Medium; The protocol is raster oriented, i.e. (partial) screenshots are transmitted 😐

Table 10: Comparison of remote desktop with VNC

5 Using PC Peripherals

All currently available Rohde & Schwarz signal generators are based on PC-like architectures and can therefore be extended with PC peripherals. Of course, in the tradeoff between flexibility and security, some of the possible modes have been restricted.

5.1 External Displays

External screens (including video projectors) are helpful for enlarging the display, to ease operation or for presentations. For signal generators without on-board display (SMATE and AFQ), this is the only way to operate them without LAN connection to an external PC.

As regards the display connector, Rohde & Schwarz signal generators can be divided into three groups:
- VGA connector
- DVI connector
- No video connector

5.1.1 VGA Connector

This type of connector is used with the SMU, SMJ, SMATE and AMU, which are also known as the "SMU Family".

Fig. 27: Monitor / VGA connector on the rear panel

The 15-pin Sub-D female connector is in accordance with industry standard, so all commercial VGA devices can be used.

Older instruments use the FMR6 controller (check Setup/Hardware Config/Common Assembly). These devices cannot detect an external display except during booting. To use the external display, connect it before booting.

Newer instruments, using the controller FMR7, are able to drive both displays simultaneously with different resolutions. The external display can be connected at any time.

5.1.2   DVI Connector

This connector is used with the AFQ100A and AFQ100B.

Fig. 28: Monitor analog connector on the rear panel

The connector complies with industry standard DVI-A, so all commercial DVI-A and DVI-I devices can be used. In addition, VGA devices can also be connected using a passive adapter plugged between the devices.

5.1.3   No Video Connector

All other signal generators (SMA, SMF, SMB, SMC and SMBV) are not equipped with a connector for external displays. LAN remote operation (see

Remote Operation) must be used if you wish to enlarge the display or connect it to a video projector.

SMW is equipped with a DVI connector but the firmware does not (yet) support it. To deliver the video signal to a big screen or video projector, connect a desktop computer over LAN and run a VNC client.

5.2 Mice, Touchpads and Other USB Pointing Devices

All such external devices can be connected to all Rohde & Schwarz signal generators as long as they comply with the USB Human Interface Device (HID) Class.
No additional driver installation is necessary.
An emulation of the hardkeys can be activated by pressing the right mouse button. If working with Windows-based instruments such as the SMU, problems may occur when switching between different applications where only parts of the user interface are visible. This can be repaired as follows:

- Right-click
- Select "DIAGRAM"

5.3 External Keyboards

The use of an external USB keyboard can make it easier to enter alphanumeric strings, for instance for file names. Numerous different national keyboard layouts are available for all Linux-based instruments:
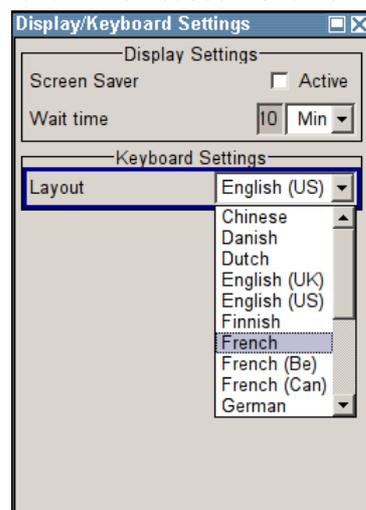
Fig. 29: Select layout of external keyboard

For Windows-based instruments the selection is limited to English and German layouts.

5.4 USB Mass Memory Devices

USB mass memory devices such as USB flash sticks or USB hard disks can be connected to the signal generators, for instance to transfer setups or to perform software updates.

For Linux-based instruments, the connected USB mass memory devices are listed after the /var/user folder:
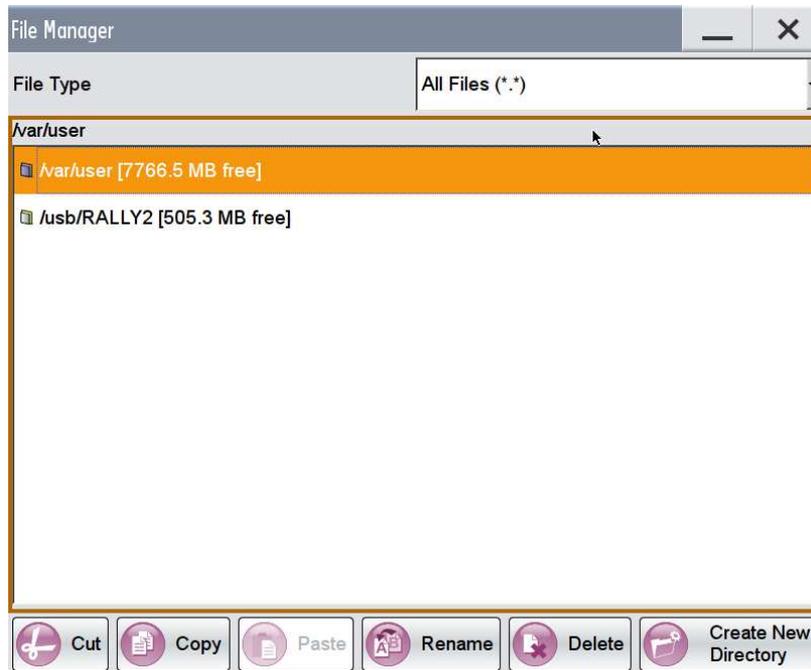
Fig. 30: Appearance of USB memory sticks in the file manager (SMW style)

For Windows-based instruments these USB devices are enumerated starting with "E:"

ATTENTION	USB ports can pose a security threat, especially in high-security locations. Generally, this threat comes from small USB pen drives (a.k.a. memory sticks, keychain drives, etc) which can be very easily concealed, yet can quickly read/write several Gbytes of data. The USB ports can be deactivated in the Security menu.

6 File Transfer / File Sharing

All Linux-based signal generators are equipped with a file transfer protocol (FTP) server and an SMB/SAMBA server. Both enable easy access to the file system of the instrument. Please be aware that access is restricted to user files (/var/user and /var/hdd), i.e. files which can also be created, deleted, modified and used from the firmware. System files cannot be accessed.

All Windows-based signal generators also contain the SMB/SAMBA server (which is part of all Windows operating system's "shared folders"). The folder to be shared must be set up manually for these instruments.

Combinations of signal generators and file transfer / file sharing protocols		
Signal generators → client operating system	SMU, SMJ, SMATE, AFQ, AMU	SMW, SMA, SMB, SMC, SMF, SMBV
Windows XP / Vista / Windows 7	SMB/SAMBA	SMB/SAMBA FTP
Linux	SMB/SAMBA	SMB/SAMBA FTP
Mac OS	SMB/SAMBA	SMB/SAMBA FTP
Almost all others, including Windows 3.1 and DOS		FTP

Table 11: Available file transfer / file sharing protocols

6.1 Using FTP File Sharing

FTP (which stands for "file transfer protocol") is a quite old method of accessing files on a remote system. It is available for all (client) operating systems, graphically (for instance as part of explorer) and on command line level.

The fastest way to access an instrument using ftp is to enter the address (or hostname) in the address line of the explorer:

Fig. 31: establishing a ftp connection (example Windows 7)

Enter
- Log on anonymously must be off
- User name = "instrument"

- Password = "instrument" (can be changed in the security dialog of the instrument)

Then you can access the instrument like any other folder on your computer:
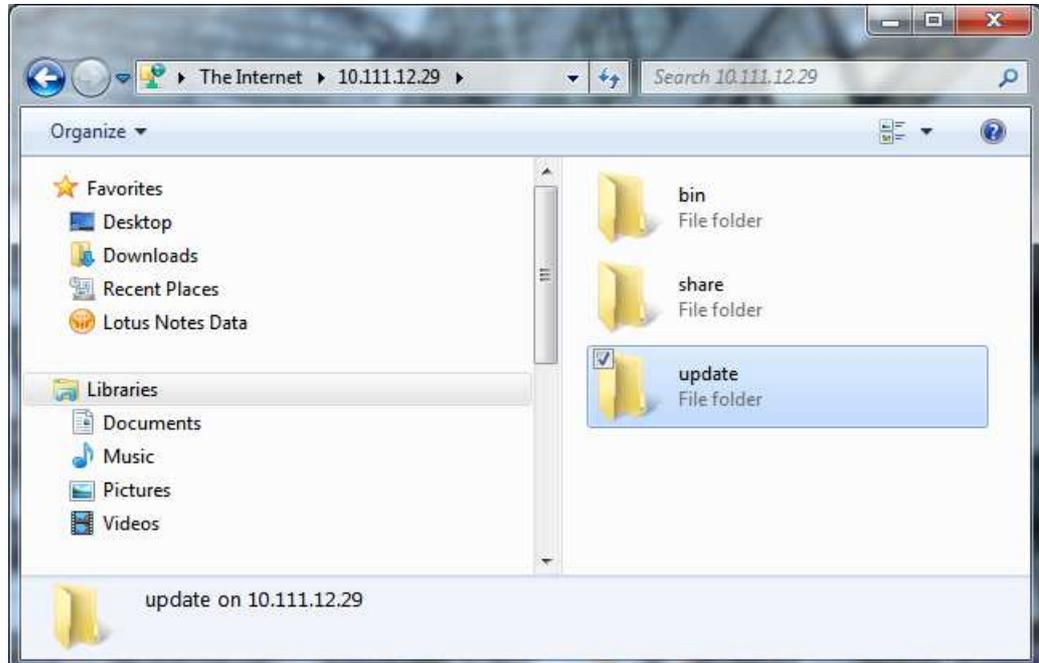
Fig. 32: accessing ftp folders (example Windows 7)

The share folder refers to the /var/user folder on the instrument. Files can be transferred in both directions.
The update folder is used for network updates of the firmware. Just put an rsu file there and the update starts automatically.

This method to establish a ftp connection works fine for all operating systems. The connection is available as long as the user session persists. The way to set up a ftp connection which is automatically reestablished after logon, depends on the operating system. Two examples:

Windows XP

Start / My Network Places / Add Network Place
Network Address = ftp://<address or hostname>

The hostname can be found in the Network Setting dialog of the instrument.

Enter
- User name = "instrument"
- Password = "instrument" (can be changed in the security dialog of the instrument)

The hard drive and the internal flash drive will be visible.

Ubuntu 8.10

Different Linux versions have slightly different ways of establishing permanent FTP access.

► From the menu, select Places/Connect to Server

Fig. 33: Establishing an FTP connection (step 1)

► Enter the hostname (= Server) of the instrument

► Enter the password and press Connect

Fig. 34: Establishing an FTP connection (step 2)

► Press Connect

The remote folders will now become available.

6.1.1 Using SMB/SAMBA with a Windows Client

Use Explorer and select Map Drive:
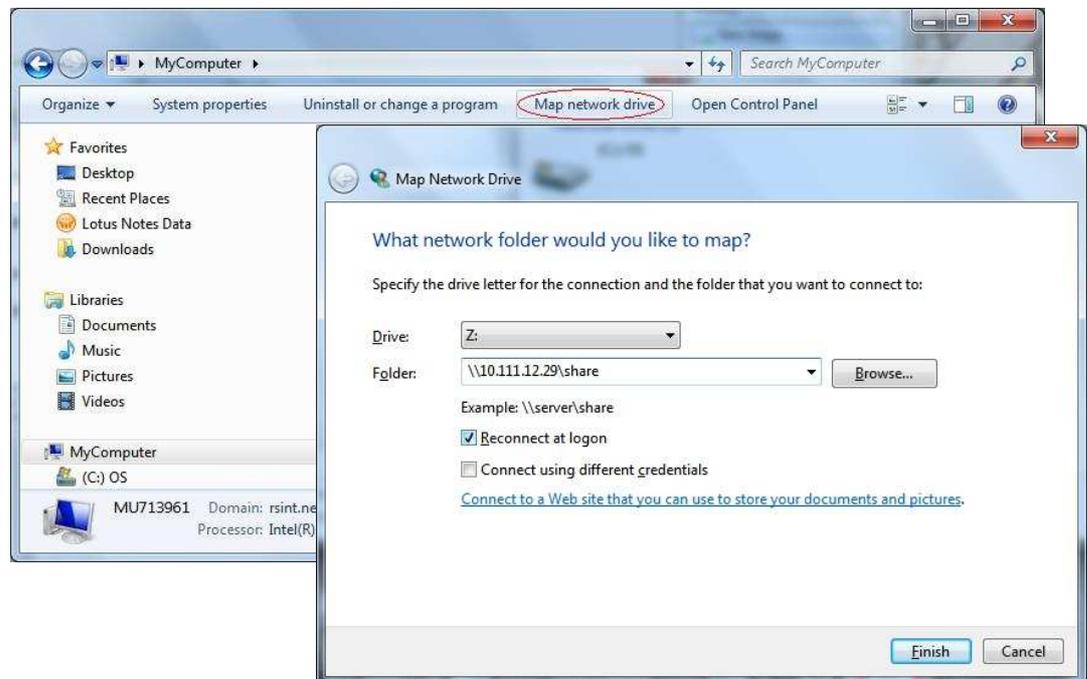
Fig. 35: Map a network drive to an SMB/SAMBA folder

Select a unused drive and enter the instrument address with trailing "\share".
After pressing "Finish", user name "instrument" and password ("instrument" by default) have to be entered.
Now a new drive (for instance Z:) is available which refers to /var/user on the instrument.

Mapping the update folder instead of share is possible with the same procedure.

6.1.2 Using SMB/SAMBA with a Linux Client

Different Linux versions have slightly different ways of establishing permanent SMB access. The following applies to Ubuntu 8.10.

► From the menu, select Places/Connect to Server

Fig. 36: Establishing a SMB/SAMBA connection (step 1)

► Enter the hostname (=Server) of the instrument

► Fill in the other fields as shown above

► Press Connect

Fig. 37: Establishing an SMB/SAMBA connection (step 2)

► Enter the password and press Connect

The share folder refers to /var/user on the instrument.
Mapping the update folder instead of share is possible with the same procedure.

6.2 Using SMB/SAMBA to Share Files with SMU, SMJ, SMATE, AMU and AFQ

To access the file system of a Windows-based signal generator, first the top folder needs to be declared as shared:

► Connect a mouse to the signal generator

► Start the explorer 🔵 start

► Right-click the folder to be shared

► Activate the option "Share this folder"

Fig. 38: Sharing a folder on a Windows-based instrument

Make a note of the share name ("DATA (D)") in the example above. It is different from the folder name ("DATA (D:)").

This folder can be accessed/mapped to the network drive as explained in chapters 1.1. and 1.1.

7 Abbreviations

Abbreviation	Meaning
API	Application programming interface
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name Service
FTP	File transfer protocol
GPIB	General purpose instruction bus (parallel bus also known as IEEE488/IEC625 bus)
IP address	Unique network address within a network
LAN	Local area network (also known as Ethernet)
PC	Personal computer typically running Microsoft Windows
SMB/SAMBA	Server message block (file transfer protocol, also known as Netbios protocol)
TCP/IP	Transmission Control Protocol / Internet Protocol
USB	Universal serial bus (standard connector for PCs and peripherals)
USB-TMC	Test and Measurement Class for USB instruments. These instruments can be controlled using VISA.
VISA	Virtual Instrument Software Architecture (software layer for remote control)
VNC	Virtual network controlling (remote operation)
VXI-11	Standard LAN protocol for remote control of measurement instruments

8 References

Application Notes:

[1]	R&S, 1MA153,	Development Hints and Best Practices for Using Instrument Drivers
[2]	R&S, 1GP98,	SCPI-Recorder
[3]	R&S, 1GP71,	MATLAB Toolkit for R&S Signal Generators
[4]	R&S, 1MA208,	Fast Instrument Control with HiSLIP

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established more than 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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