Versatile RF Fading Simulator
Application Note

Products:

- R&S®SMW200A
- R&S®SMU200A
- R&S®FSW
- R&S®FSQ
- R&S®FSV
- R&S®TSMW
- R&S®IQR

Fading in the baseband of the R&S®SMW200A signal generator is well proven and widely accepted for testing any mobile radio standard. However, there are applications where an RF signal must be faded.

A versatile RF Fading Simulator can easily be built using an R&S®FSW, R&S®FSQ, R&S®FSG, R&S®FSV signal analyzer with Digital Base Band Interface or with the instrument combination R&S® TSMW / R&S®IQR and an R&S®SMU signal generator with digital baseband inputs and fading simulator option. Note describes how.

Application Note

Minihold, R. Wagner
2.2015 - 1MA145-4e

ROHDE&SCHWARZ

Table of Contents

1 Abstract

Fading in the baseband of the R&S®SMW200A and R&S®SMU200A signal generators or R&S®AMU200A base band generator is well proven and widely accepted for testing i.e. mobile radio standards as well as other applications.

In most cases this is the better solution than RF fading simulators because signals are not degraded by the effects of the necessary multiple down- and up-conversions of an RF signal. Additionally, baseband fading is more economical.

However, there are various applications where there is no alternative to RF fading, perhaps a baseband signal is simply not accessible.

For example fading tests on actual transmissions from mobile radio base stations including signaling require a simulator for RF fading, or on military radio links with frequency hopping, on actual TV signals, or even on simple FM-signals.

A simulator for RF Fading can easily be built using a Signal Analyzer R&S®FSW R&S®FSQ, R&S®FSG or R&S®FSV with Digital Base Band Interface (which is used as a down converter) and a Signal Generator R&S®SMW200A with Digital Baseband Inputs and Fading option. If a R&S®FSV is used, additionally the option: “40 MHz Analysis Bandwidth” R&S®FSV-B70 is necessary.

The universal fading possibilities of the R&S®SMW200A, including superimposing AWGN, can be applied to an RF signal.

Compared to a standalone fading simulator, the R&S RF Fading Simulator is a cost effective solution. Particularly if an R&S®FSW, R&S®FSQ, R&S®FSG or an R&S®FSV signal analyzer and an R&S®SMW, R&S®SMU vector signal generator are already available.

As an alternative the Universal Radio Network Analyzer TSMW in combination with the IQR IQ data recorder can be used as digital IQ down-converter instead of a signal analyzer. The maximum demodulation bandwidth of this solution is limited by 20 MHz.

The following abbreviations are used in this Application Note:

R&S®SMW200A Vector Signal Generator: SMW

R&S®SMU200A Vector Signal Generator: SMU

R&S®FSW200A Signal & Spectrum Analyzer: FSW

R&S®FSQ Signal Analyzer: FSQ

FSV® Signal & Spectrum Analyzer: FSV

R&S®TSMW Universal Radio network Analyzer: TSMW

R&S® IQR I/Q Data recorder: IQR

In the following only the FSW and FSV is mentioned.

2 What is Fading?

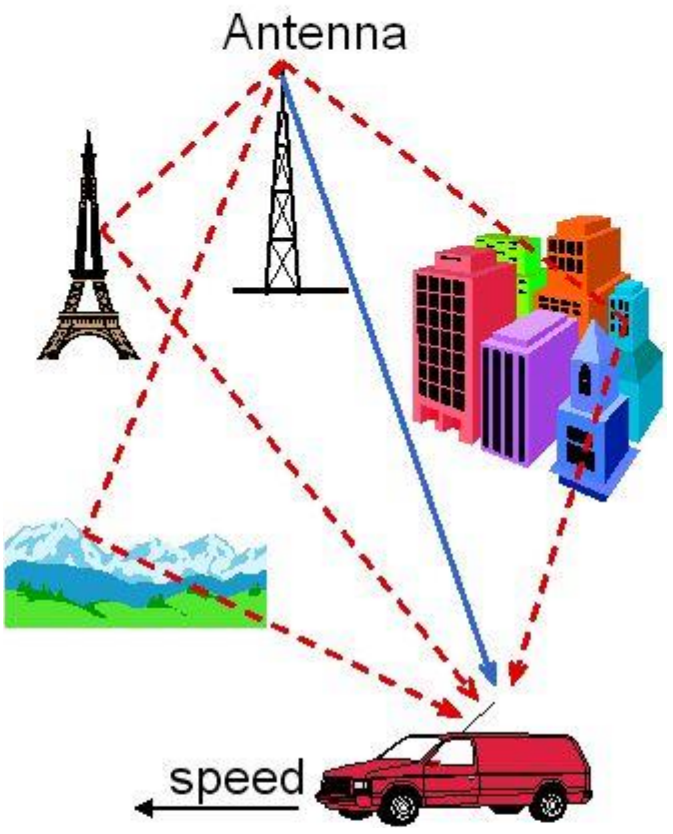


Fig. 2-1: Different signal paths from the transmitter antenna to the receiver

The reception of any RF signal transmitted over the air is subject to a range of fading effects. Multiple propagation paths may be superimposed on each other either constructively or destructively. The distance from transmitter to receiver creates a delay; the movement of the receiver relative to the transmitter creates a frequency shift.

When testing receivers, it is important to be able to simulate fading conditions in the lab.

3 The R&S Baseband Fading solution

The only efficient way to optimize receiver performance is testing it with signal having passed through a life-like channel emulation (or fading simulation). The channel emulator option of the SMW makes it easy to simulate fading conditions in the lab. Up to four of the powerful fading modules can be installed. These modules can simultaneously emulate as many as 16 fading channels. The maximum fading signal bandwidth (RF domain) is 160 MHz. As a result, the SMW can realistically map even higher-order MIMO scenarios such as 3x3 MIMO for WLAN IEEE 802.11.xx

Inside buildings, there are more reflections than in open terrain. The time difference between different echoes normally is in the range of only a few nanoseconds. Its time resolution of 2.5 ps and its ability to simulate up to 20 paths per fading channels enable the SMW to realistically simulate indoor fading scenarios. All in all, the SMW offers a fading performance that has so far only been achieved by significantly more expensive special instruments (e.g. RF faders).A precondition is that either the SMW generates the baseband signal itself or the baseband signal is fed to the SMW via analog or digital baseband input.

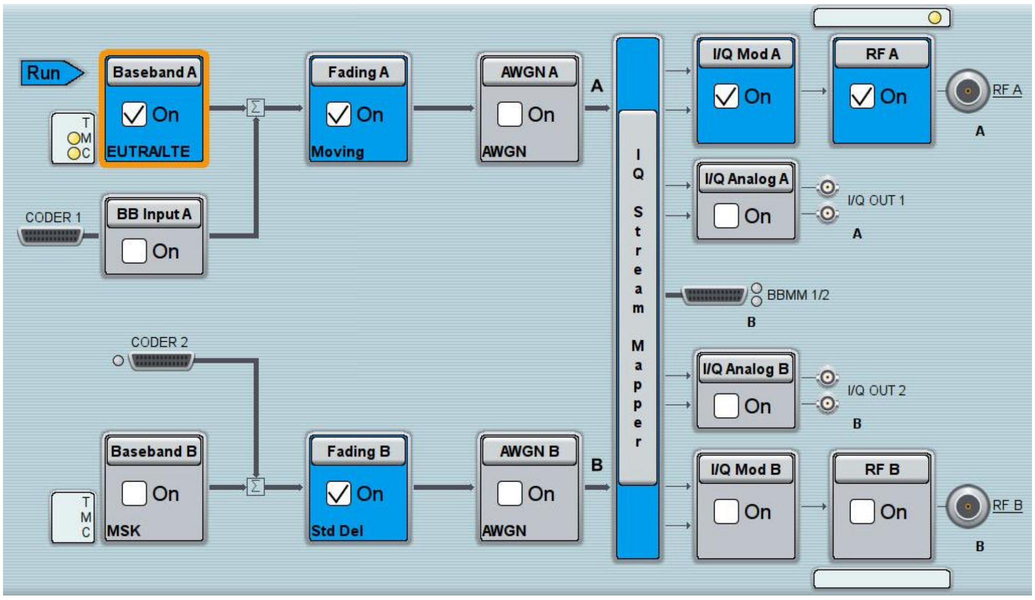


Fig. 3-1: Fading an internally generated baseband signal in the SMW

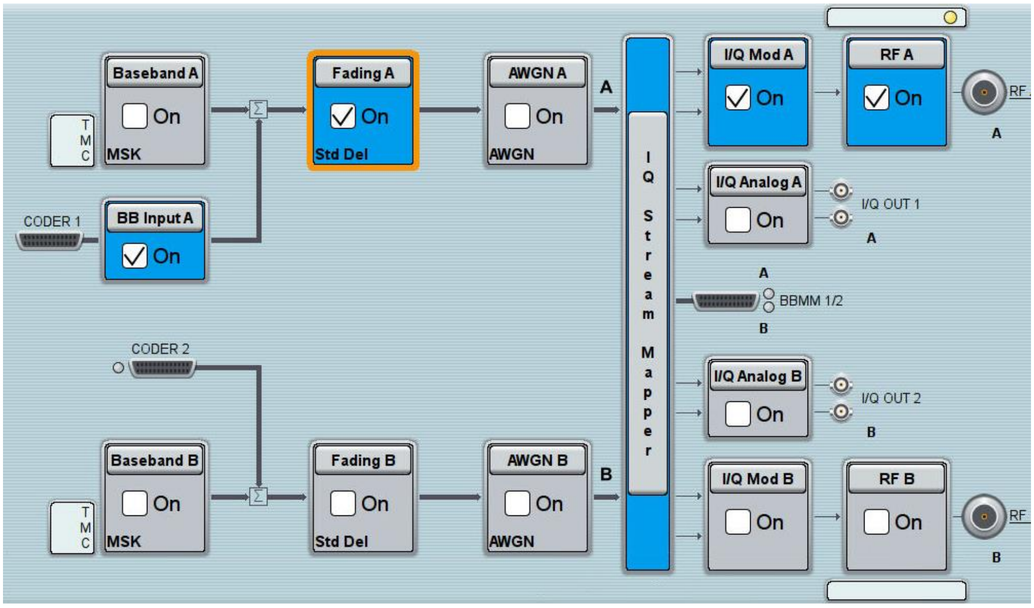


Fig. 3-2: Fading of externally generated baseband signal fed in via the digital baseband input

In order to fade an RF signal, an RF Fading Simulator is necessary. An RF Fading Simulator can be arranged using the SMW together with a compatible RF to IQ-baseband converter, such as the FSW with R&S®FSW-B17 Digital Baseband Interface with up to 160 MHz I/Q bandwidth as shown in the following section.

4 The R&S RF Fading solution

The R&S RF Fading solution requires an FSW,FSQ or FSV and SMW. The RF signal to be faded is fed into the FSW's, FSQ's or FSV's RF input. The FSW, FSQ or FSV work as a down-converter and digitizes its IF.

The Digital Baseband Interface R&S®FSW-B17 of the FSW or (optional) R&S®FSQ-B17 Digital Baseband Interface in the FSQ (or R&S®FSV-B17 in the FSV) outputs a digital baseband signal which is compatible to the SMW digital I/Q input. The FSW, FSQ's or FSV's digital baseband output signal is fed via the R&S® SMU-Z6 LVDS cable to the SMW's digital I/Q input.

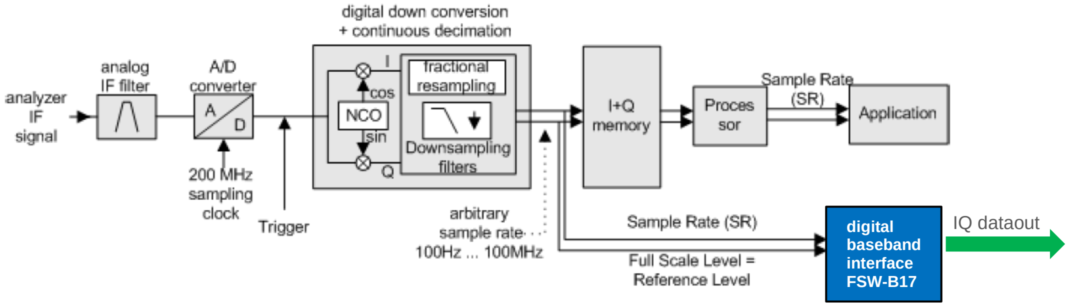


Fig. 4-1: Block diagram of the FSW I/Q down-converter

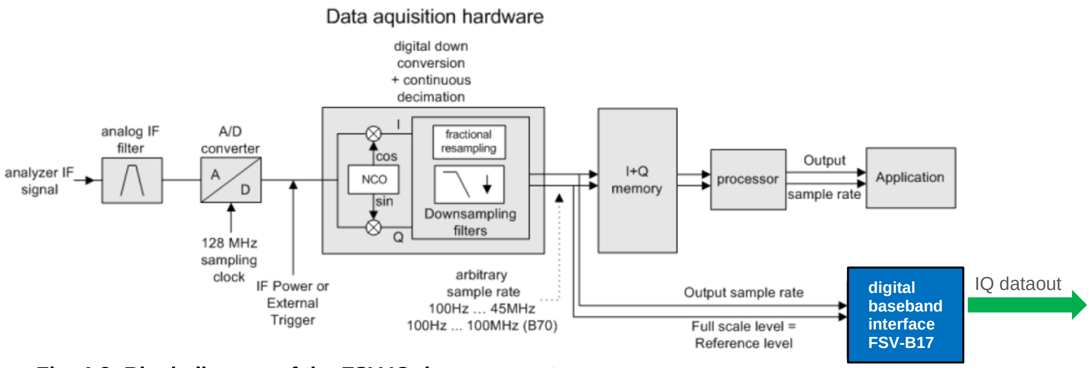


Fig. 4-2: Block diagram of the FSV IQ down-converter

If the SMW is set up correctly, it delivers an RF signal with the same level, modulation and frequency like the signal fed into the FSW, FSQ or FSV RF input. The universal baseband fading functions of the SMW, including superimposing Gaussian noise, can be applied to the SMW's baseband signal. The combination of the two instruments FSW, FSQ or FSV and SMW provides an RF Fading Simulator with a real-time bandwidth of 160 MHz. If an FSV is used instead of a FSW, a fading simulator with a real-time bandwidth of 40 MHz is provided (option “40 MHz Analysis Bandwidth FSV-B70” is necessary for the FSV), with an FSQ 28 MHz real-time bandwidth.

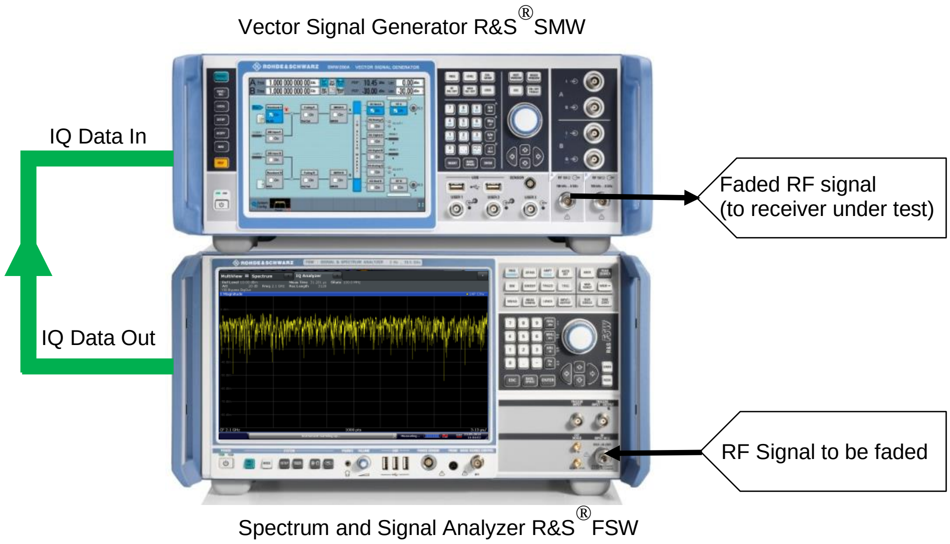


Fig. 4-3: The R&S RF Fading Simulator with an SMW and an FSW. With the option R&S®FSW-B160 (160 MHz Analysis Bandwidth) it provides a real-time bandwidth of 160 MHz.

With a frequency range up to 6 GHz and a real-time bandwidth of up to 160 MHz (even 40 MHz with the FSV), the R&S RF Fading simulator covers all current digital radio standards for both uplink and downlink signals, including contiguous LTE dual-carrier aggregation.

Using the FSW with the 160 MHz bandwidth option R&S®FSW-B160, the RF Fading simulator is well equipped for applications which require even higher bandwidths.

As an alternative, the Universal Radio Network Analyzer TSMW can be used as digital I/Q down-converter instead of a signal analyzer. The TSMW provides a maximum demodulation bandwidth of 20 MHz.

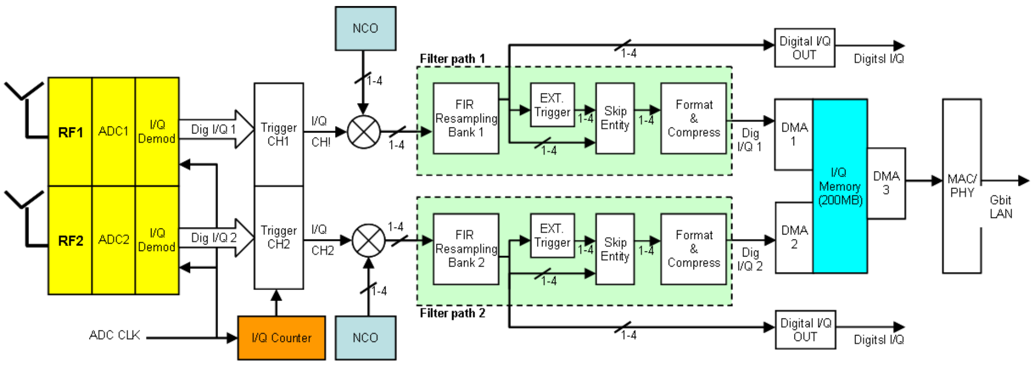


Fig. 4-4: Block diagram of the TSMW IQ down-converter. The second RF input (RF2) is optional.

The faceless TSMW can be controlled respectively configured with the I/Q Data Recorder IQR. The TSMW measures the signal of the transmitter station. Equipped with the Digital I/Q Interface R&S® TSMW-B1 the TSMW outputs a digital baseband signal which is compatible with digital I/Q input of the IQR. The I/Q data stream can be recorded via the IQR on-site. Back in the test laboratory, the recorded IQ data stream can be replayed (Fig. 4-5). The replayed I/Q data stream from the IQR is fed via the R&S® SMU-Z6 LVDS cable to the signal generator digital I/Q input.

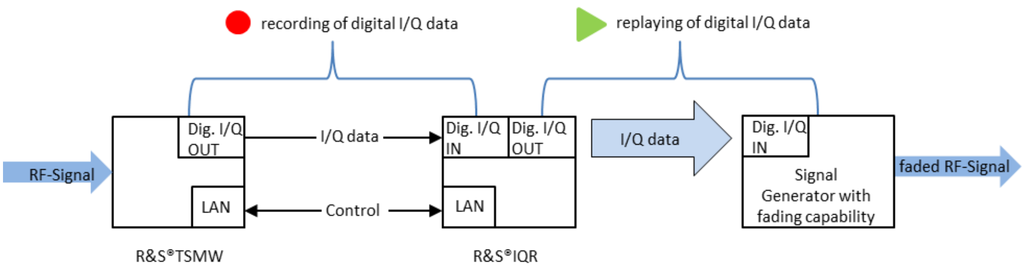


Fig. 4-5: Recording and replaying of digital I/Q data with the IQR

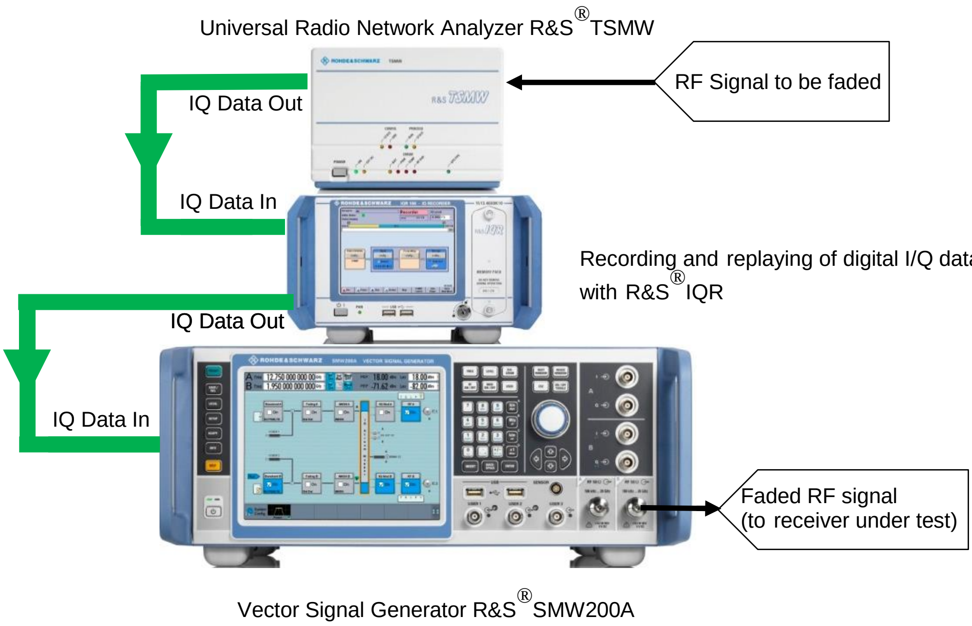


Fig. 4-6: The R&S RF Fading Simulator with an SMW, TSMW and IQR

If the SMW is set up correctly, it delivers an RF signal with the same level, modulation and frequency like the original signal as measured by the TSMW and recorded by the IQR. The universal baseband fading functions of the SMW, including superimposing Gaussian noise, can be applied to the SMW's baseband signal. The combination of the three instruments TSMW, IQR and SMW provides an RF Fading Simulator with a bandwidth up to 20 MHz.

4.1 Application examples and according test setups

4.1.1 Example 1: Fading tests on Mobile Radio Receivers with SMW and FSW

Fig. 4-7 shows a test setup for fading tests on a mobile radio receiver. Feed the base station's RF signal via a power attenuator into the RF input of the FSW. Setup the FSW and the SMW as channel emulator, and feed the SMW's output signal at the required level to the mobile radio receiver input. Apply a fading scenario according to your Mobile Radio Standard (GSM, 3GPP, LTE etc.) within the SMW.

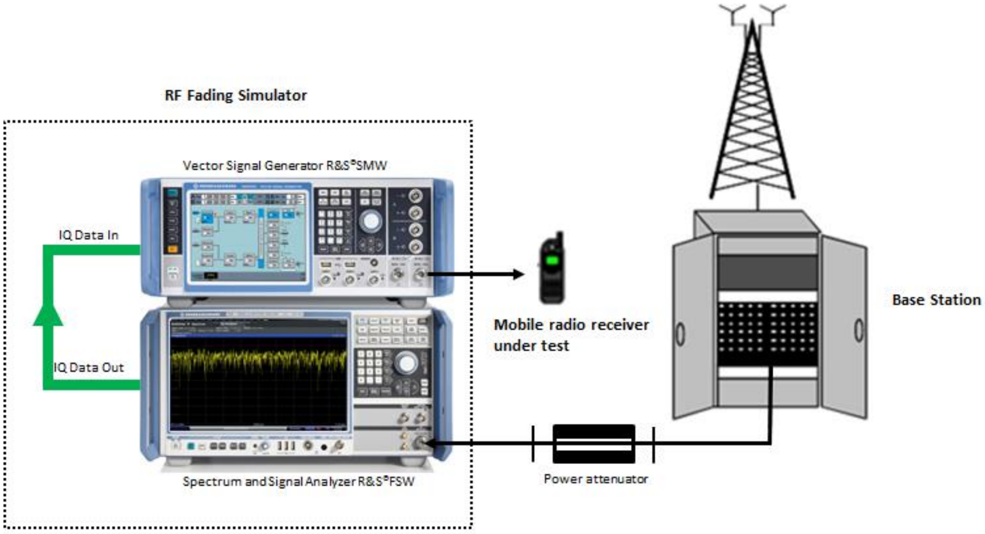


Fig. 4-7: Fading tests on a mobile radio receiver with an actual base station signal.

4.1.2 Example 2: Fading tests on Mobile Radio Receivers with TSMW, IQR and SMW

Fig. 4-8 and Fig. 4-9 show the test setup for fading tests on a mobile radio receiver by using the Universal Network Analyzer TSMW, an I/Q data recorder IQR and the SMW Vector Signal Generator. Feed the base station's RF signal via a power attenuator into the RF1 input of the TSMW and setup the IQR and TSMW as I/Q data recorder.

Setup the IQR as a I/Q data streaming source and the SMW as a fading simulator, and feed the SMW's output signal at the required level to the mobile radio receiver input.

Apply a fading scenario according to your Mobile Radio Standard (user-defined or acc. To GSM, 3GPP, HSPA+, LTE standards, etc.) within the SMW.

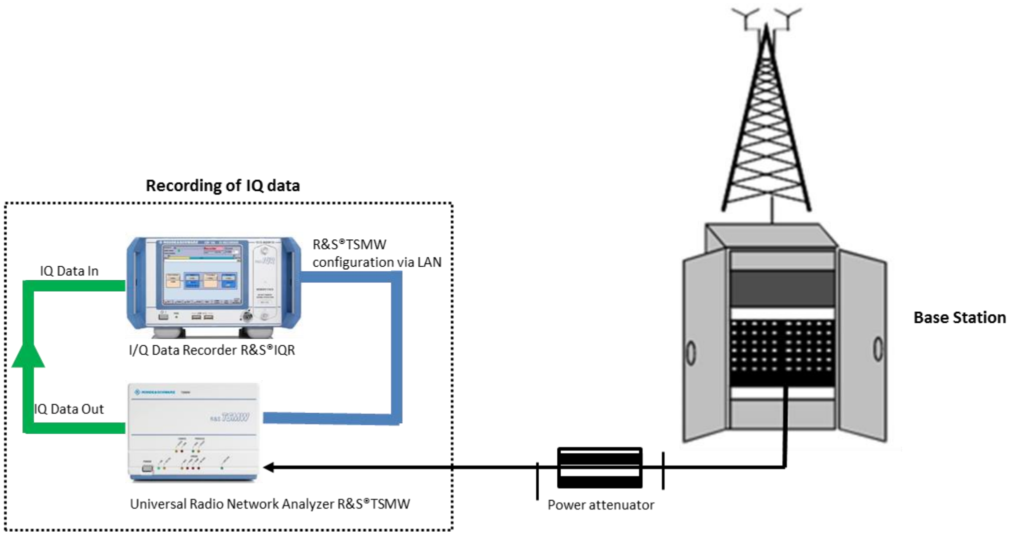


Fig. 4-8: Down conversion and I/Q data recording of an actual base station signal.

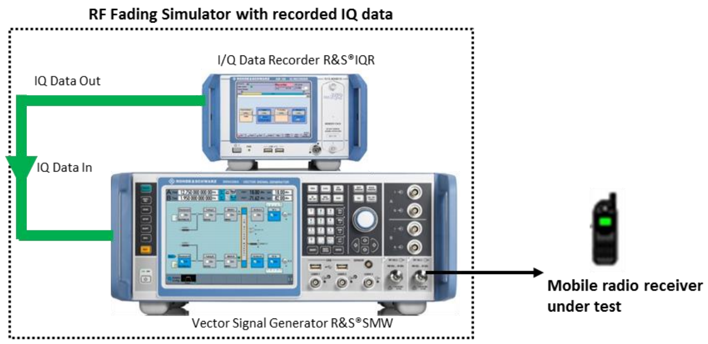


Fig. 4-9: Fading tests on a mobile radio receiver with a on site recorded base station signal.

4.1.3 Example 3: Fading tests on military airborne transceivers

Fig. 4-10 shows a test setup for military fast frequency-hopping airborne transceivers. The synchronization of the receiver (upper device) to the transmitter (lower device) is tested introducing signal delays of several milliseconds to the transmitted signal set by the fading option of the SMW. These delays occur in real world conditions when two aircraft communicating are separated by several 100 km. High aircraft speed differences can be simulated by applying Doppler shift to the transmitted signal.

Correct synchronization is checked by comparing the synchronization signals from the transceivers with an oscilloscope.

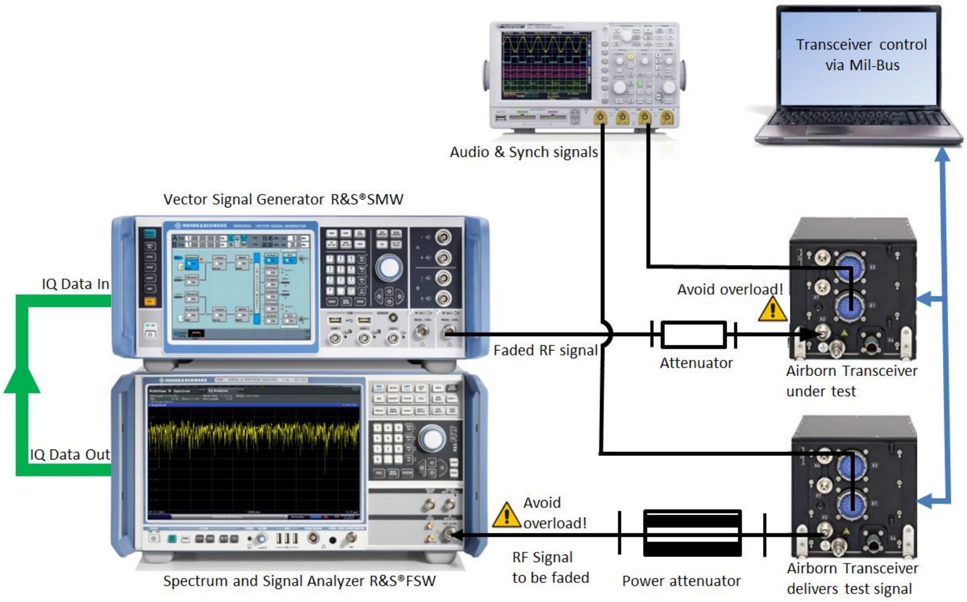


Fig. 4-10: Application example: Fading tests on airborne radio transceivers. The synchronization of the transceivers can be tested simulating distances of several hundred kilometers and high speed differences.

A distance of for example 400 km causes a delay of:
(400 km)/ (Speed of light) = (400 km)/ (3*10^ km/s) = 1335 µs which is set as the Basic Delay in the fading path table of the SMW.

Speed difference can be directly set as Speed (e.g. 4000 km/h in Fig. 4-11 below).

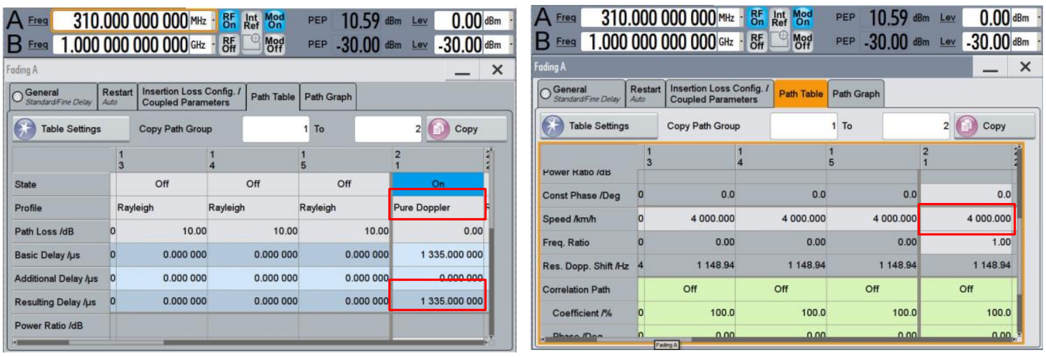


Fig. 4-11: Example: Setting fading on an SMW for simulating a distance of 400 km between transmitter and receiver and a speed difference of 4000 km/h. A direct receive path is assumed.

4.1.4 Setting up the instruments

Setting up the instruments for RF-fading can be either manually or remotely controlled which is even more convenient.

4.1.5 Setting up the instruments manually (for Example 1 and 3)

To set up the instruments manually:

Connect the signal to be faded to the RF input of the FSW, FSQ or FSV.
Caution: If the signal's peak level changes to higher values after the SMW's setup procedure (step: *BB Input A: Baseband Input Settings... : Input Level: Auto Level Set*) severe signal distortion will occur)

Setting up an FSW, FSQ or FSV is slightly different, use corresponding instructions:

FSW

- Press the *PRESET* button to set the basic operating mode
- Set Center Frequency equal to input frequency (or with hopping signals to center of frequency range). In the following example f= 310 MHz
- Set Reference Level at least 1 dB higher than the anticipated peak level of the input signal (Any peak input levels higher than the reference level set will cause severe signal distortion!)
- Set Input Attenuation to 0 dB for Reference Levels < 0dBm and to + 5 dB above Reference Level (in 5 dB steps) for Reference Levels ≥ 0dBm
  Examples: Reference Level = 9dBm ⇨ Attenuation = 10 dB,
  Reference Level = 10 dBm ⇨ Attenuation = 15 dB
- Press *MODE: IQ Analyzer: Data Acquisition: Analysis BW 80 MHz or 160 MHz*
- *Enter the corresponding sample rate 100 MHz or 200 MHz*
- Press *INPUT/OUTPUT: Output Config: Digital IQ: ON*

FSQ

- Press the *PRESET* button to set the basic operating mode

- Set Center Frequency equal to input frequency (or with hopping signals to center of frequency range). In the following example f= 310 MHz

- Set Reference Level at least 1 dB higher than the anticipated peak level of the input signal (Any peak input levels higher than the reference level set will cause severe signal distortion!)

- Set Input Attenuation to 0 dB for Reference Levels < 0dB and to + 5 dB above Reference Level (in 5 dB steps) for Reference Levels ≥0dBm
  Examples: Reference Level = 9dBm ⇨ Attenuation = 10 dB,
  Reference Level = 10 dBm ⇨ Attenuation = 15 dB

- Press *MEAS:NEXT:IQ MODE: IQ MODE ON:*
  DIQ IQ OUT DEFAULT:
  DIQ IQOUT STREAM
  to provide a digital baseband data stream at the IQ output of the FSQ

FSV

- Press the *PRESET* button to set the basic operating mode

- Set Center Frequency equal to input frequency (or with hopping signals to center of frequency range). In the following example f= 310 MHz

- Set Reference Level at least 1 dB higher than the anticipated peak level of the input signal (Any peak input levels higher than the reference level set will cause severe signal distortion!)

- Set Input Attenuation to 0 dB for Reference Levels < -10dB and to + 15 dB above Reference Level (in 5 dB steps) for Reference Levels ≥0dBm
  Examples: Reference Level = 9dBm ⇨ Attenuation = 20 dB,
  Reference Level = 10 dBm ⇨ Attenuation = 25 dB

- Press MODE: *IQ Analyzer: Data Acquisition: Sample Rate 100 MHz: Close*
  Digital Output: Enable Digital Output: Close
  to provide a digital baseband data stream at the IQ output of the FSV

SMW

- Make sure that a firmware version ≥ 3.20.02.xx is installed
- Press the *PRESET* button to set the basic operating mode
- Set RF Frequency (normally equal to the Center Frequency of the FSW; f=310 MHz in this example)
- Set RF level (normally equal to input level of the FSW, so that the RF Fader has 0 dB attenuation)
- Press *RF ON*
- Select *BB Input A: Input:Baseband Input Settings:Sample Rate: Digital IQ In* to estimate the digital IQ input sample rate
- Select *BB Input A: Baseband Input Settings…:State ON* to switch the Digital Baseband input on
- Select *BB Input A:Baseband Input Settings…:Input Level: Auto Level Set* to initiate an auto leveling procedure
- Press *SETUP:Internal Adjustments:Adjust IQ Modulator:Current Frequency* to adjust the IQ modulator at the current frequency for max. spurious suppression
- Set up fading parameters according to your needs, as set below for Example 3 in section 4.1.3:
- Select *Fading A:Fading Settings: Path Table 1 1: State Off*
- Select *Path Table 2 1: Stat On* (Path table 2 offers a wider range of signal delays)
- Select *Profile Pure Doppler*
- Set *Path Loss/dB: 0*
- Set *Basic Delay/µs: 1335*
- Set *Freq Ratio: 1* (head on approach of both airplanes assumed)
- Set *Speed/km/h: 4000* (speed difference 4000 km/h)
- Set *State: ON*
- At the RF output of the signal generator the faded input signal from the signal analyzer is available and can be fed to a second spectrum analyzer to check the signal.

SMU

- Press the *PRESET* button to set the basic operating mode
- Set RF Frequency (normally equal to the Center Frequency of the FSW; 310 MHz in this example)
- Set RF level (normally equal to input level of the FSW, so that the RF Fader has 0 dB attenuation)

- Press *RF ON*
- Press *MENU:BB Input:Baseband Input Settings:Mode:Digital Input* to select the Digital Baseband input
- Press *MENU:BB Input:Baseband Input Settings:Sample Rate: Source User Defined*
- Select value and enter the same sampling rate like on the used spectrum analyzer
- Press *MENU:BB Input: Baseband Input Settings:State ON* to switch the Digital Baseband input on
- Press *MENU:BB Input:Baseband Input Settings:Auto Level Set* to initiate an auto leveling procedure
- Press *MENU:Setup:Internal Adjustments:Adjust IQ Modulator:Current Frequency* to adjust the IQ modulator at the current frequency for max. spurious suppression
- Set up fading parameters according to your needs, as set below for Example 2 in section 4.1.2: Press *MENU: Fading A:Fading Settings: Path Table 1 1: Stat Off*
- Press Path Table 2 1: *Stat On* (Path table 2 offers a wider range of signal delays)
- Press *Profile Pure Doppler*
- Set Path *Loss/dB: 0*
- Set *Basic Delay/µs: 1335*
- Set *Freq Ratio: 1* (head on approach of both airplanes assumed)
- Set *Speed/km/h: 4000* (speed difference 4000 km/h)
- Press *State: ON*
- At the RF output of the signal generator the faded input signal from the signal analyzer is available and can be fed to a second spectrum analyzer to check the signal.

4.1.6 Setting up the instruments manually (for Example 2)

To set up the instruments manually:

Connect the signal to be faded to the RF input of the TSMW. In order to control the TSMW a LAN connection with the IQR must be established.
Caution: If the signal's peak level changes to higher values after the SMW's setup procedure (step: BB Input A: Baseband Input Settings... : Input Level: Auto Level Set) severe signal distortion will occur)

SMW

- Make sure that a firmware version ≥ 3.20.02.xx is installed
- Press the *PRESET* button to set the basic operating mode

- Set RF Frequency (normally equal to the Center Frequency of the FSW (f=2.2 GHz in this example)
- Set RF level (normally equal to input level of the FSW, so that the RF Fader has 0 dB attenuation)
- Press *RF ON*
- Select *BB Input A: Input:Baseband Input Settings:Sample Rate: Digital IQ In* to estimate the digital IQ input sample rate
- Select *BB Input A: Baseband Input Settings…:State ON* to switch the Digital Baseband input on
- Select *BB Input A:Baseband Input Settings…:Input Level: Auto Level Set* to initiate an auto leveling procedure. Note: for performing the auto level procedure it is necesarry to stream the recorded IQ data from the IQR. How to stream the date is described in section "**IQR** (Play of IQ data)" below
- Press *SETUP:Internal Adjustments:Adjust IQ Modulator:Current Frequency* to adjust the IQ modulator at the current frequency for max. spurious suppression
- Set up fading parameters according to your needs e.g. fading. Rayleigh fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver of a mobile device.
- Select *Fading A:Fading Settings: Path Table 1 1: State Off*
- Select *Path Table 2 1: Stat On* (Path table 2 offers a wider range of signal delays)
- Select *Profile* Rayleigh
- Set *Path Loss/dB: 20 dB*
- Set *State: ON*

IQR

- Performing a preset: Press the tab *Open Main Menu* and select *Configuration File > Set to default..*.
- Press the tab *Goto recorder*
- For the configuration of the R&S TSMW press the *TSMW-Control* tab

TSMW

- Select the *Front Ends* tab and activate the FrontEnd 1 via the checkbox
- Select the right filter bandwidth for the signal to be measured (20 MHz (no filter), 10 MHz, 5 MHz or 2.5 MHz)
- Enter the signal frequency (= center frequency)
- Press the FE1 ▸ tab and start the TSMW measurement
- Return to the IQR Settings by pressing the *IQR* button

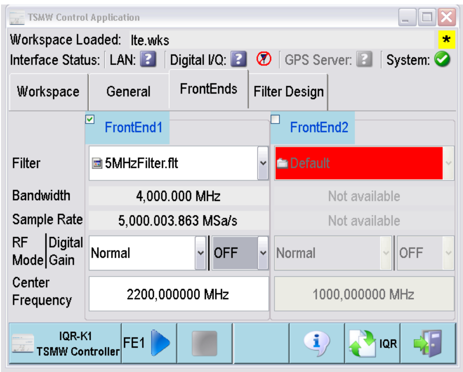


Fig. 4-12: Example: Settings of the TSMW via the R&S®IQR-K1 SMW Controller

IQR (Record of IQ data, test setup see Fig. 4-8)

- Press tab *Goto recorder*
- Press *storage config…*
- Press Save Stream Data, select a destination folder and enter the file name e.g. RFfader, press ok.
- Press *Terminate Recording On* and select the preferred terminating conditions e.g. *Max Rec Duration* , press close
- Press the *Rec* button

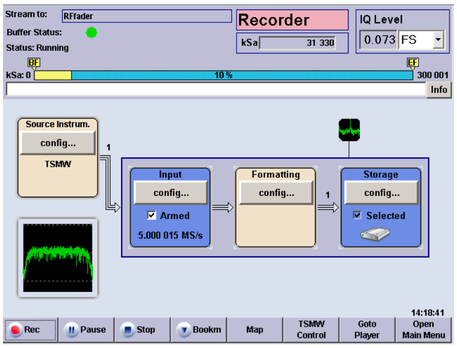


Fig. 4-13: IQ data recording of a 5 MHz-wide 3GPP signal with the R&S®IQR

IQR (Play of IQ data, test setup see Fig. 4-9)

- Press tab *Goto Player*
- Press Mass Storage *config…* and *select Streaming*
- Press Load Waveform and select the recorded File "RFfader"
- Press *ok*, press *close*
- For starting the IQ data transmission to the SMW press the *Play* button

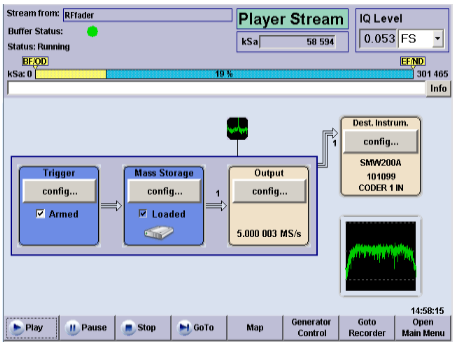


Fig. 4-14: Transmission of the IQ data to the SMW

- At the RF output of the signal generator the faded input signal from the IQR is available and can be fed to a second spectrum analyzer to check the signal like it is shown in Fig. 4-15.

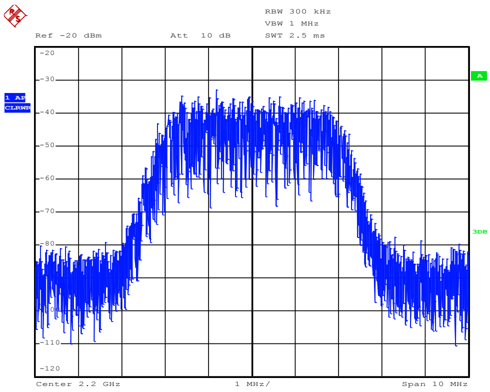


Fig. 4-15: SMW output UMTS single carrier RF-spectrum of the recorded IQ Data with fading

4.1.7 Setting up the instruments remotely

The R&S®Forum tool is designed for easy and powerful remote control of R&S®Instruments with scripts. It allows users to run and edit example script sequences and to write their own script files. Script files can range from simple command sequences (Winbatch syntax) to complex programs using the programming language Python.

R&S®Forum application uses the VISA interface, which allows remote control of instruments via LAN, GPIB, USB. R&S®Forum runs on Windows® XP, Vista, 7, 8.

R&S®Forum Key Features:

- Stand-alone tool with installer
- Multiple remote connections are supported.
- Python shell prompt for interactive remote control.

- Integrated Debugger: Breakpoints, stepping through source code, inspecting variables.
- Macros: Assign code snippets to buttons in the GUI.
- Window manager: Docking windows allow for user-defined window layout.
- Easy integration of custom python libraries.
- Graphics: matplotlib and numpy are integrated.

Installation

The R&S®Forum application must be installed on a Windows® PC. See application note 1MA196 for details. This application note comes with an installer, which includes the:

- Forum application
- Python interpreter

Please note:

For communication with instruments, R&S®Forum application uses VISA interface, which is not included in the installer. National Instruments VISA, available on the National Instruments® homepage (www.ni.com/visa), is recommended.

The Python interpreter is installed locally and used for Forum only. An eventually already installed Python version is not used or touched and remains unchanged for normal use.

Getting started

- Copy the example script file "RF_Fader_FSW_SMW.i3e" e.g. into a subdirectory of the Forum installation (e.g.\Rohde-Schwarz\Forum\RF-Fader\). This script file for FSW and SMW includes the remote control commands for the in chapter 4.1.5 described settings.
- Load the mentioned file: *File -> Open…*

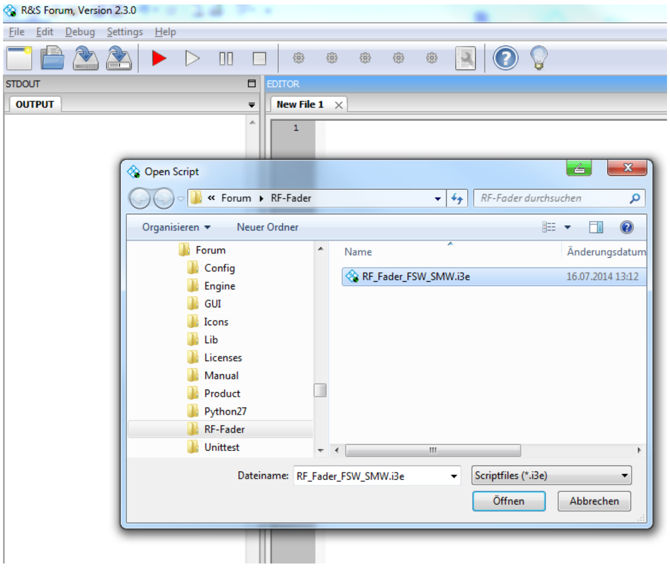


Fig. 4-16: This application note comes with an example script file which allows to set up the SMW and FSW quick and simple.

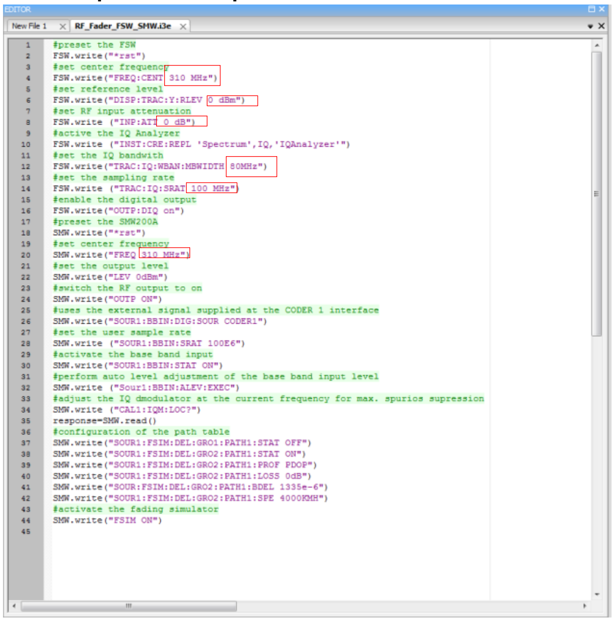


Fig. 4-17: With the R&S Forum editor it is very easy to customize the instrument settings for center frequency, reference level IQ bandwidth etc.

- Configure the used remote control devices. In this case the FSW and SMW200A (Fig. 4-18): *Select Settings -> Instruments* …. Enter the Resource ID (usefully the name of the instrument), the corresponding IP address and the time for the timeout. In addition select the interface type, in this case the VISA connection with the VX11 interface is used. As an alternative you can also use the HiSLIP-, LAN Socket-, GPIB-, Serial- or USB-Interface.

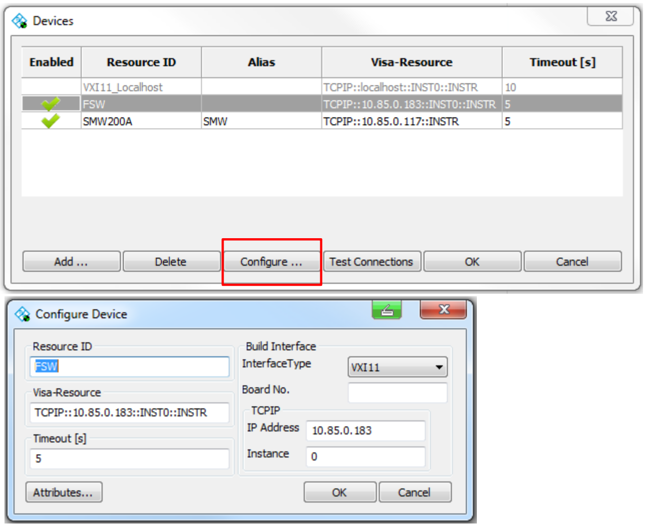


Fig. 4-18: Remote control configuration of the used instruments

- After the configuration activate the two remote control connections for the FSW and SMW via a mouse click into the *Enable* field

- Select the configured devices successively and press the *Test Connections* key. If a remote control connection does not work correctly the not working device will be displayed in red color like in Fig. 4-19 below.

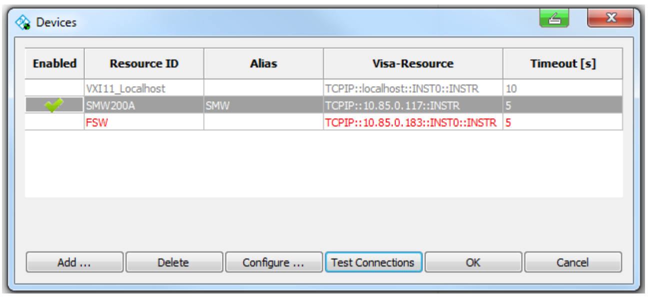


Fig. 4-19: The result of connection test shows that only one connection works correct.

- As soon all remote control devices are configured correctly, the script file can be executed by pressing the withe play button or if necessary the red play button with debugging. The output and logger window show whether the script file was running correctly (Fig. 4-20).

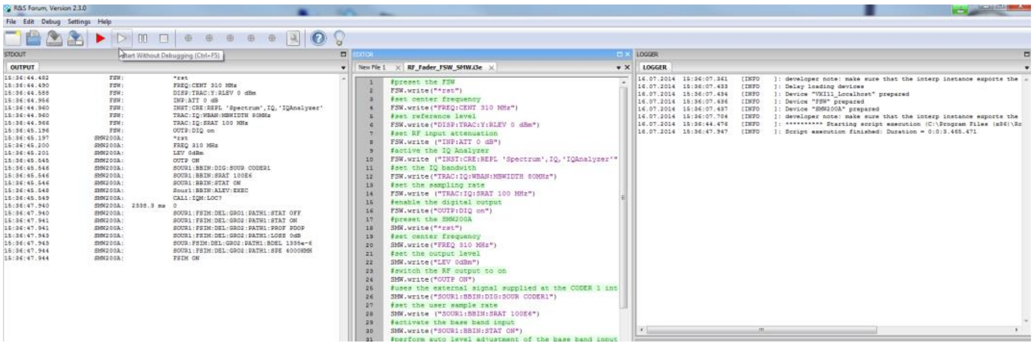


Fig. 4-20: Output and Logger result after running the "RF_Fader_FSW_SMW.i3e" script file

5 Spectral Performance of the R&S RF Fader

The R&S RF Fading solution has an excellent spectral performance in terms of phase noise, dynamic range and spurious suppression. This ensures that the performance of the receiver under test is not disguised by the RF fader's spectral characteristic and is a result of the applied fading profiles.

Fig. 5-1 shows the spectral performance of the output signal by applying a full range CW signal with 2.1GHz at the FSW's center frequency 2.1 GHz. The phase noise of the output signal is typically -137 dBc/Hz.

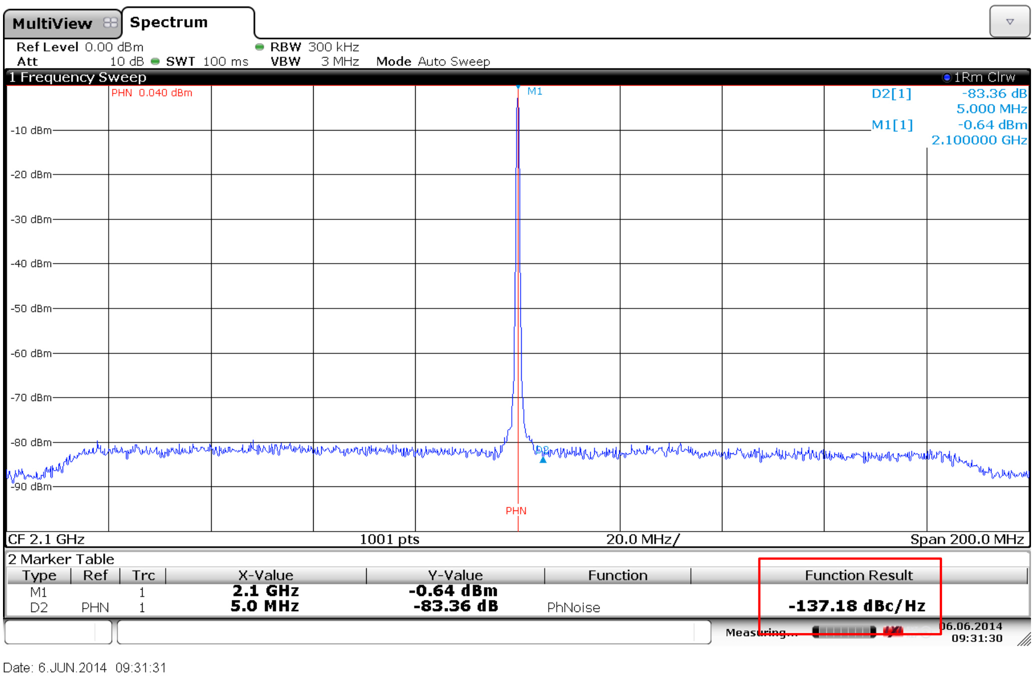


Fig. 5-1: Output spectrum of the RF Fader. Setup with a CW signal with 0 dBm at 2.1 GHz is input at the FSW RF input. The SMW is set also to a frequency of 2.1 GHz and 0dBm output level.

Fig. 5-2 shows the spectral performance of the RF fader's output signal using an FSW by applying a full range clean CW signal with 20 MHz offset from the FSW's center frequency 2.1 GHz. Spurious emissions (carrier feedthrough and 2nd sideband) are typically < -64 dB.

Fig. 5-3 shows the RF fader's output spectrum with a LTE Downlink signal with 20 MHz Bandwidth 11.5 dB crest factor, 0 dBm and 50 MHz offset at the FSW' RF input.

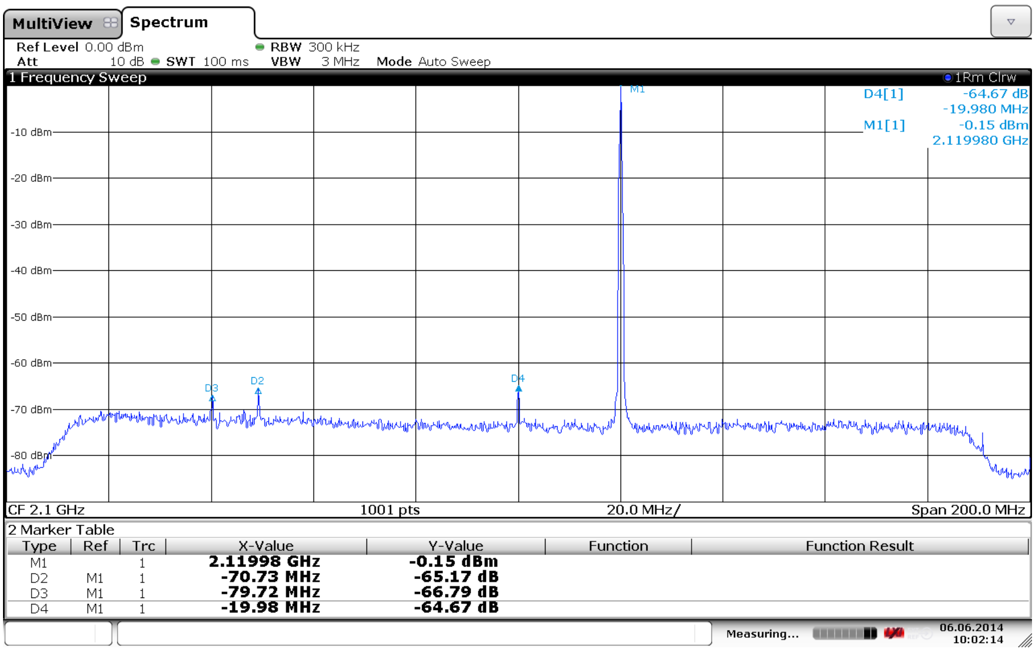
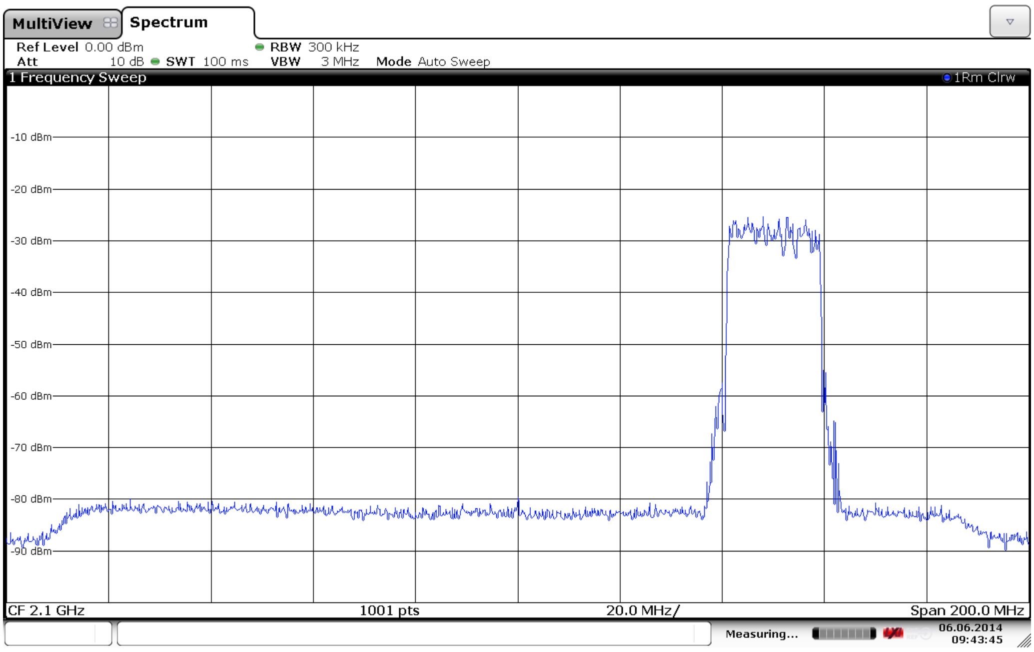


Fig. 5-2: Output spectrum of the RF Fader. Setup with a input signal at 320 MHz (FSW used as RF to baseband converter, 12 MHz offset to FSW Center frequency). Carrier feedthrough and spurious are typically < -64 dB.



Date: 6.JUN.2014 09:43:45

Fig. 5-3: Output spectrum of the RF Fader. Setup with a LTE Downlink Signal with 20 MHz Bandwidth and 50 MHz offset at the FSW input.

6 Literature

[1] Rohde & Schwarz: Operating Manual: Vector Signal Generator R&S®SMU200A

[2] Rohde & Schwarz: Fading Simulation Options for R&S® Signal Generators Software Manual

[3] Rohde & Schwarz: Operating Manual: Vector Signal Generator R&S®SMW200A

[4] Rohde & Schwarz: Operating Manual: Fading Simulation R&S®SMW-B14/-K71/-K72/-K74

[5] Rohde & Schwarz: Operating Manual: Vector Signal Analyzer R&S®FSQ

[6] Rohde & Schwarz: Operating Manual: Signal and Spectrum Analyzer R&S®FSW

[7] Rohde & Schwarz: Operating Manual: R&S®FSW I/Q Analyzer and I/Q Input Interfaces

[8] Rohde & Schwarz: Operating Manual: Digital Baseband Interface R&S®FSQ-B17

[9] Rohde & Schwarz: Operating Manual: Vector Signal Analyzer R&S®FSV

[10] Rohde & Schwarz: Operating Manual: I/Q Data Recorder R&S®IQR

[11] Rohde & Schwarz: Operating Manual: Universal Radio Network Analyzer R&S®TSMW

[12] Rohde & Schwarz: R&S®TSMW Interface & Programming Manual R&S®TSMW-K Software Manual

[13] Rohde & Schwarz: Application Note 1MA196: Using the R&S®Forum Application for Instrument Remote Control, www.rohde-schwarz.com/appnote/1MA196

7 Ordering Information

Designation	Type	Order No.
Signal and Spectrum Analyzers		
Signal and Spectrum Analyzer up to 8, 13.6, 26.5, 43.5, 50, 67 GHz	R&S®FSW	1312.8000.xx
Digital Baseband Interface	R&S®FSW-B17	1313.0784.02
28 MHz Analysis Bandwidth	R&S®FSW-B28	1313.1645.02
40 MHz Analysis Bandwidth	R&S®FSW-B40	1313.0861.02
80 MHz Analysis Bandwidth	R&S®FSW-B80	1313.0878.02
160 MHz Analysis Bandwidth	R&S®FSW-B160	1313.1668.02
Signal Analyzer Up to 3.6, 8, 26.5 or 40 GHz	R&S®FSQ	1313.9100.xx
Signal Analyzer, up to 8, 13.5 GHz	R&S®FSG	1309.0002.xx
Digital Baseband	R&S®FSQ-B17	1310.9568.02
Signal and Spectrum Analyzer up to 4, 7, 13, 30, 40 GHz	R&S®FSVx	1321.3008.xx
Digital Baseband Interface	R&S®FSV-B17	1310.9568.02
40 MHz Analysis Bandwidth	R&S®FSV-B70	1310.9645.02
Radio Network Analyzer		
Universal Radio Network Analyzer	R&S®TSMW	1503.3001.03
R&S® Digital I/Q Interface	R&S®TSMW-B1	1514.4004.02
Gigabit LAN I/Q Interface	R&S®TSMW-K1	1503.3960.02
GSM/WCDMA Scanner Option	R&S®TSMW-K21	1503.4514.02
LTE Scanner Option	R&S®TSMW-K29	1503.4550.02
Power Supply	R&S®TSMW-Z1	1503.4608.02
Vector Signal Generator		
Vector Signal Generator	R&S®SMW200A	1412.0000.02
Frequency Options, RF path A		
100 kHz to 3 GHz	R&S®SMW-B203	1413.0804.02
100 kHz to 6 GHz	R&S®SMW-B206	1413.0904.02
100 kHz to 12.75 GHz	R&S®SMW-B112	1413.0204.03
100 kHz to 20 GHz	R&S®SMW-B120	1413.0404.02

Designation	Type	Order No.
Baseband Generator with ARB(64 Msample) and Digital Modulation (realtime), 120 MHz RF bandwidth	R&S®SMW-B10	1413.1200.02
Baseband Main Module, one I/Q path to RF	R&S®SMW-B13	1413.2807.02
Baseband Extension to 160 MHz RF bandwidth	R&S®SMW-B10	1413.1200.02
Fading Simulator	R&S®SMW-B14	1413.1500.02
Enhanced Fading Models	R&S®SMW-K72 (optional)	1413.3584.02
Vector Signal Generator	R&S®SMU200A	1141.2005.02
Fading Simulator	R&S®SMU-B14	1160.1800.02
1st RF path	R&S®SMU-B10x	
Fading Simulator Extension	R&S®SMU-B15 (optional)	1160.2288.02
AWGN	R&S®SMU-K62 (optional)	1159.8511.02
Baseband Input (analog/digital)	R&S®SMU-B17	1142.2880.02
IQ Data Recorder		
I/Q Data Recorder,basic, 1 × I/Q channel; max. 20 Msample/s, 80 Mbyte/s	R&S®IQR20	1513.4600.02
I/Q Data Recorder, high speed, 1 × I/Q channel; max. 87.5 Msample/s, 350 Mbyte/s	R&S®IQR100	1513.4600.10
2 Tbyte HDD Memory Pack, up to 80 Mbyte/s	R&S®IQR-B020	1513.4700.20
0.96 Tbyte SSD Memory Pack, up to 400 Mbyte/s	R&S®IQR-B109F	1513.4723.09
1.9 Tbyte SSD Memory Pack, up to 400 Mbyte/s	R&S®IQR-B119F	1513.4723.19
Import/Export of I/Q and Meta Data Files via Ethernet or USB Interface (optional)	R&S®IQR-K101	1513.5001.02
Software for configuring the R&S®TSMW via LAN (R&S®TSMW-K1 and R&S®TSMW-B1 required)	R&S®IQR-K1	1513.4730.02
Accessories		
LVDS Cable TVR290	SMU-Z6	1415.0201.02

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.

Regional contact

Europe, Africa, Middle East
+49 89 4129 12345
customersupport@rohde-schwarz.com

North America
1-888-TEST-RSA (1-888-837-8772)
customer.support@rsa.rohde-schwarz.com

Latin America
+1-410-910-7988
customersupport.la@rohde-schwarz.com

Asia/Pacific
+65 65 13 04 88
customersupport.asia@rohde-schwarz.com

China
+86-800-810-8228 /+86-400-650-5896
customersupport.china@rohde-schwarz.com

Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

PAD-T-M: 3573.7380.02/02.01/EN/

Rohde & Schwarz GmbH & Co. KG
Mühldorfstraße 15 | D - 81671 München
Phone + 49 89 4129 - 0 | Fax + 49 89 4129 – 13777

www.rohde-schwarz.com