LTE Bitstream Verification
Application Note

Products:

- R&S®SMW200A
- R&S®SMU200A
- R&S®SMx-K55
- R&S®SMx-K81
- R&S®FS-K10xPC
- R&S®FSW
- R&S®FSQ
- R&S®FSV
- R&S®FPS

Verification of baseband data is an important step in the early development phase of LTE/LTE-A-ready products. Comparison values for baseband data (test vectors) from other sources can be very useful in order to verify the correct implementation of the standard.
The option R&S®SMx-K81 for R&S®SMx Vector Signal Generators offers sample data for LTE at the bit level. The reference data enables users to test their own implementation of the specification.

The *LTE Bit Stream Verification* program shown here uses data generated by this option and offers a (bitwise) comparison with bit streams generated for an LTE downlink signal. Therefore, it demonstrates how easy the option R&S®SMx-K81 can be integrated into the simulation and design process during the development of LTE/LTE-A handsets or base stations.

Application Note

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ROHDE&SCHWARZ

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The following abbreviations are used in this Application Note for Rohde & Schwarz test equipment:

- The R&S®SMW200A and R&S®SMU200A Vector Signal Generators are referred to as the SMx.
- The R&S®FSW Signal and Spectrum Analyzer, the R&S®FSQ Signal Analyzer, the R&S®FSV Signal and Spectrum Analyzer and the R&S®FPS Signal and Spectrum Analyzer are referred to as the FSx.
- The option R&S®SMx-K55 is referred to as the -K55, the option R&S®SMx-K81 is referred to as the -K81.
- The option R&S®FSx-K100 is referred to as the -K100, the option R&S®FSx-K102 is referred to as the -K102, the option R&S®FSx-K104 is referred to as the -K104.

1 Introduction

Long Term Evolution (LTE) or *Evolved Universal Terrestrial Radio Access* (E-UTRA) as described by the Third Generation Partnership Project (3GPP) is the next step in pushing third-generation (3G) systems from WCDMA to HSPA and HSPA+ to the future.

Test and measurement (T&M) instruments such as signal generators and spectrum/signal analyzers test radio frequency signals and I/Q data. But baseband data from inside the signal processing chain is also of interest in the development of LTE/LTE-A-ready components, chipsets and base stations. Comparison data (test vectors) from other sources can be very useful for testing in-house implementations. Option -K81 (LTE Log File Generation) for the SMx offers reference data at the bit level for standard LTE.

The LTE Bit Stream Verification Program uses data generated from this option and offers a (bitwise) comparison with measured bit streams. Therefore, it demonstrates how easy the option -K81 can be integrated into the simulation and design process during the development of LTE/LTE-A handsets or base stations.

The program uses one single allocation in PDSCH in the downlink and offers various configuration opportunities such as FDD/TDD, MIMO, the use of multiple code words and a variable number of resource blocks (RB).

1.1 Option *LTE Log File Generation* for the SMx

The option -K81 enhances the option -K55 (EUTRA/LTE) to generate logging files containing intermediate results from the LTE signal generation process including the forward error correction (FEC) processing of the data. The intermediate results are stored in files – either as bit-stream or in I/Q sample format (depending on the type of logging point in the signal generation chain). Furthermore, summary log files can be generated containing additional information regarding the generated signal (e.g. DCI mapping information). The logging functionality is available for LTE downlink (PDSCH, PBCH, PCFICH, PHICH and PDCCH) as well as for the LTE uplink direction (PUSCH incl. UCI).

Please have a look into the manual [5] for more details.

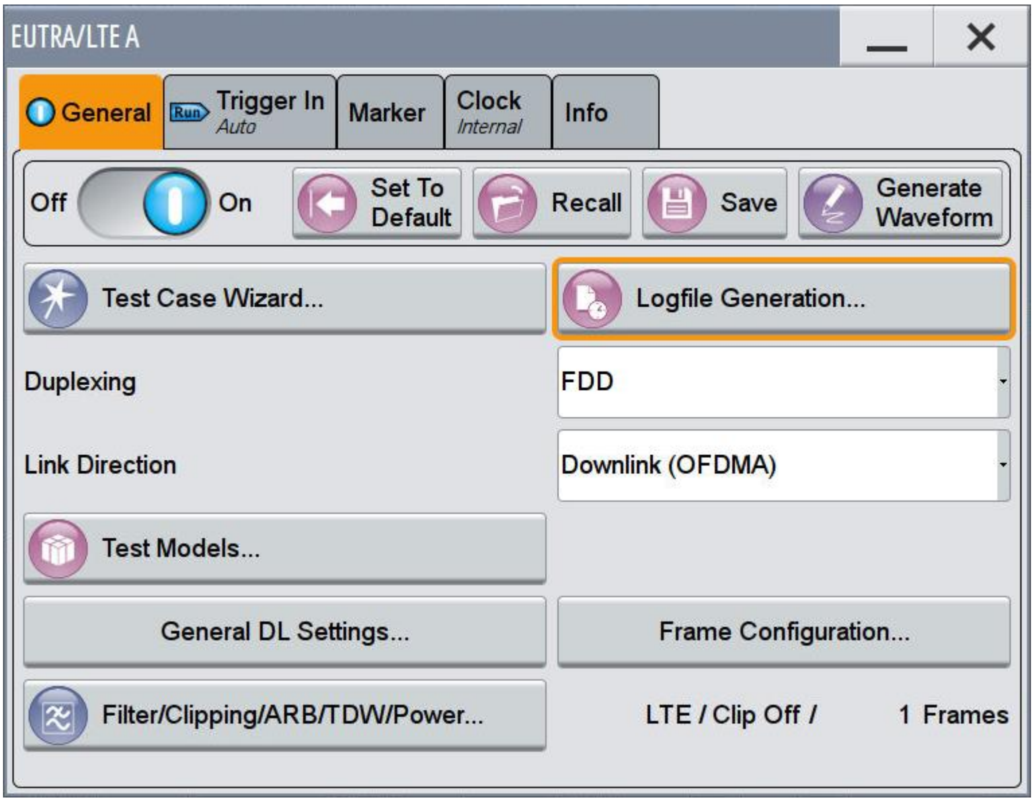

Figure 1: If the option **LTE Log File Generation** *is enabled, a button* **Logfile Generation** *is available in the LTE menu. Click to adjust the parameters.*

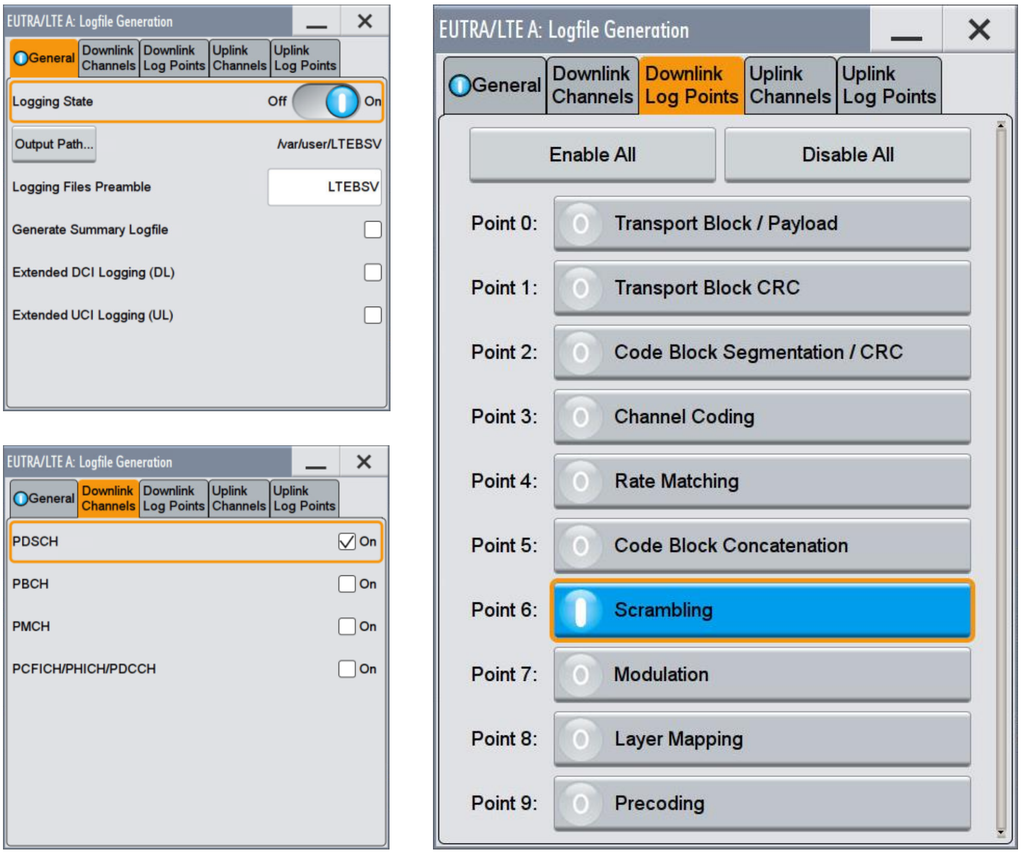

Figure 2: Overview of the logging parameters. The data of each logging point are saved as files in an adjustable path. In* LTE Bitstream Verification *the file with* PDSCH *data before respectively after the* Scrambling (Point 6) *is saved in the* Output Path. *The* Output Path *depends on the used instrument due to different file systems. In case of a SMW, the file is stored in* /var/user/LTEBSV, *respectively* D:/LTEBSV *for using a SMU.

1.2 Function Overview *LTE Bit Stream Verification*

The LTE Bit Stream Verification Program referred to as "the program" in the following, outputs the bit stream of an LTE subframe generated by the -K81 option. In addition, it measures an LTE signal of a connected device under test (DUT), e.g. of a base station, when a Rohde & Schwarz signal analyzer is used. Both are compared at the bit level to detect any discrepancies.

Fig. 3 shows a function overview.

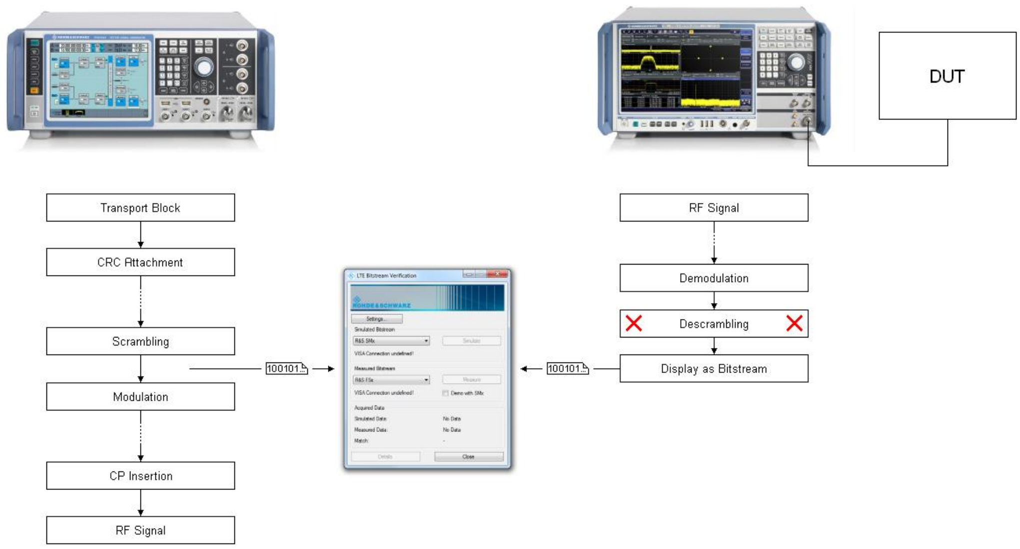

Fig. ***3: Function overview: LTE Bit Stream Verification***

The left side of *Fig.* 3 shows the block diagram of the generation of an LTE signal in the SMx. The -K81 option enables the user to assess the intermediate state of the generated signal after scrambling and before modulation as a test vector. The right side shows the block diagram of the measurement of an LTE signal with an FSx signal analyzer.

Descrambling is deactivated on the FSx in order to maintain comparable data streams. Both bit streams can now be compared by the program and should be identical if the test parameters are the same.

NOTE:
By deactivating the *Scrambling* in the settings of the software (see 3.1) and on the DUT, the state of the data *prior* to scrambling is compared.

2 Test Setup

The program uses various instruments as the source of the bit stream to be compared. In addition, stored files can be used.

SMx Vector Signal Generator
If options -K55 and -K81 are installed, the SMx delivers a bit stream as reference data with which other measurement data can be compared.

FSx Signal and Spectrum / Signal Analyzer
The FSx together with options -K100 (EUTRA/LTE FDD DL Measurements), -K102 (EUTRA/LTE DL MIMO Measurements), -K104 (EUTRA/LTE TDD DL Measurements) measures an LTE signal, demodulates it, and provides a bit stream.

This Application Note assumes usage of the LTE analysis software, which can be installed either on an external PC or on the FSx. If installed on a PC, the user must identify the PC as a VISA resource in the software, not the FSx. See also 2.2.1.

Measuring MIMO configurations requires two signal analyzers. In some cases, measurements can also be performed one after the other using only one FSx (sequential).

2.1 SISO Measurement

Fig. 4 shows the setup for the SISO case. One computer with the program installed controls both the SMx and the FSx via remote control over VISA. The signal to be measured is located at the RF input of the analyzer.

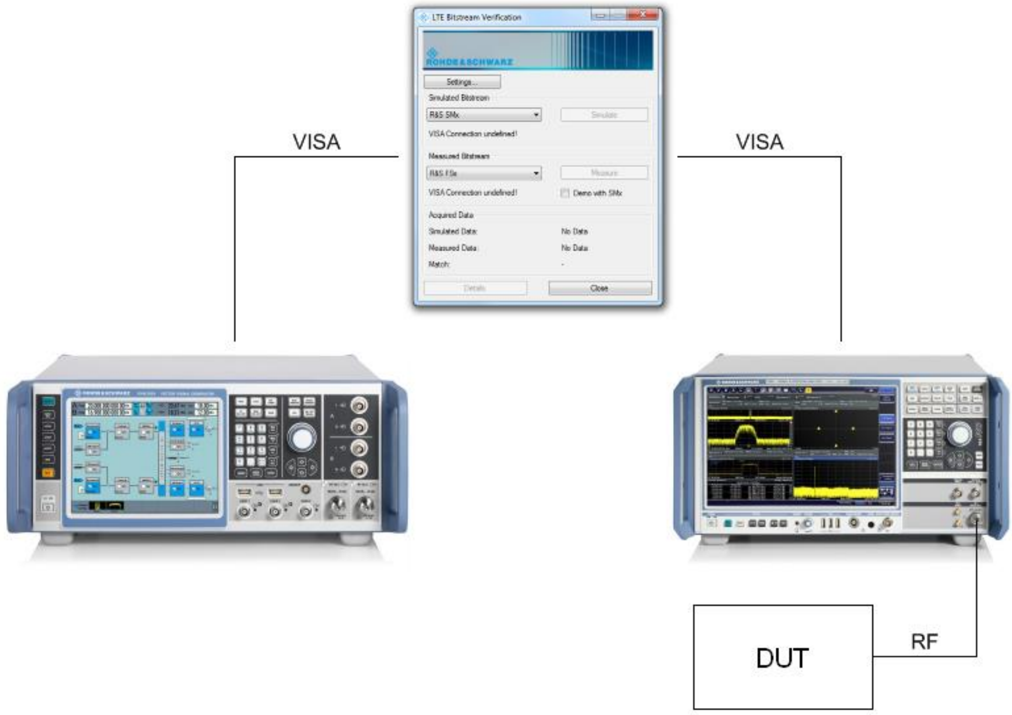

Fig. 4: Test setup SISO measurement

2.2 MIMO Measurement

The program supports MIMO measurements with one or two antennas. Many tests with the demodulation necessary for outputting the bit stream can be carried out with one FSx. But some tests require two FSx. For more information, see Application Note 1MA143 [3].

NOTE:
Using the SMW for MIMO measurements with two antennas requires two options –K81. Additionally bypassing fading simulator if fading is deactivated has to be enabled.

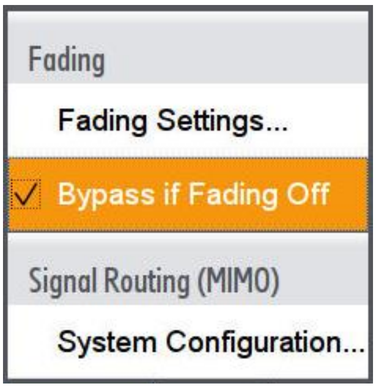

Fig. 5: Bypassing fading simulator

2.2.1 Measurement with two FSx

Fig. 6 shows the test setup using two FSx. A computer with the program controls both the SMx as well as the two FSx via remote control over VISA. The signal to be measured is located at the analyzers' two RF inputs. In addition, a trigger signal from the DUT to the analyzers is required.

NOTE:
Two FSx shall be coupled by the same reference clock. This has to be done manually.

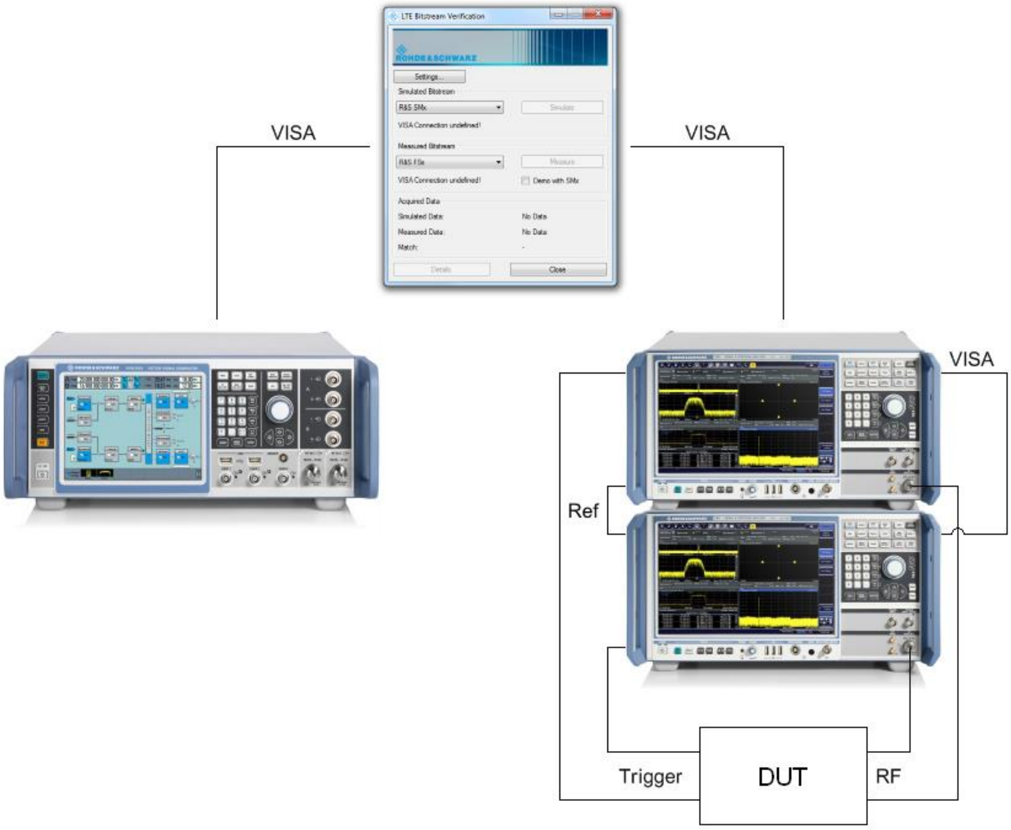

Fig. 6: Test setup MIMO measurement with two FSx

The second FSx does not need to have option -K100/-K102/-K104 installed, but it does require a VISA connection to the instrument on which the option is running.

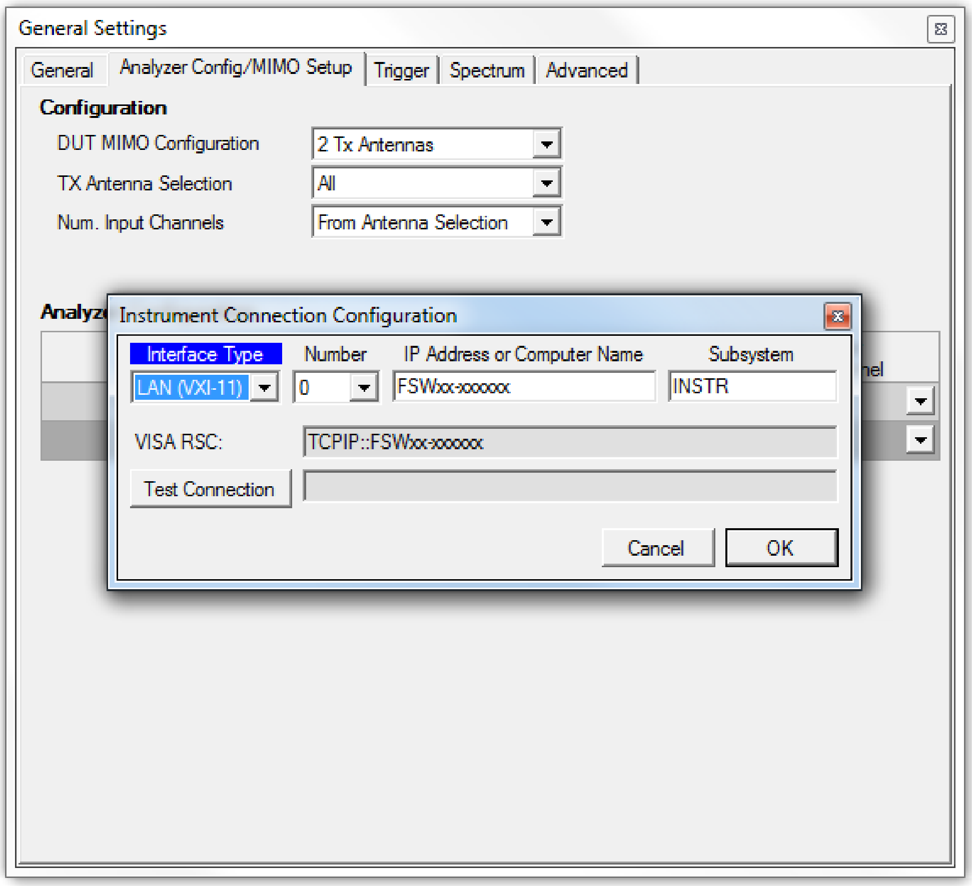

Fig. 7: VISA connection in FS-K10xPC

The first FSx must have a VISA connection to the second FSx. This connection can be set up under General Settings in Analyzer Config / MIMO Setup (see Fig. 7).

2.2.2 Measurement with one FSx

Fig. 8 shows the test setup using one FSx. A computer with the program controls both the SMx as well as the FSx via remote control over VISA. The two signals to be measured are located sequentially at the analyzer's RF input.

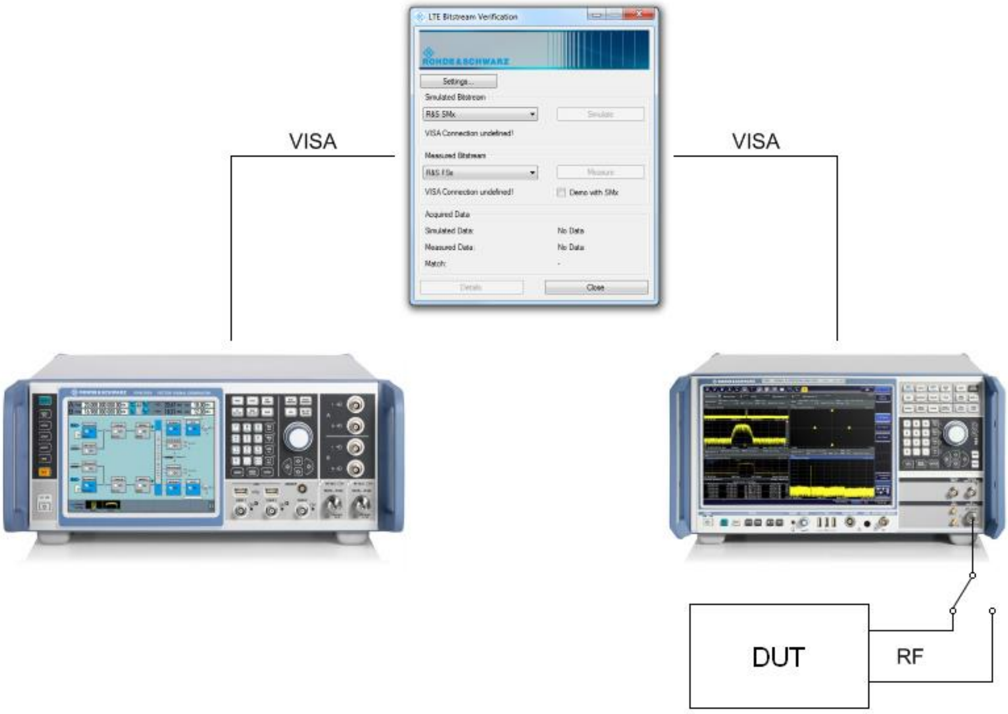

Fig. 8: Test setup MIMO measurement with one FSx

3 LTE Bit Stream Verification Program

Notes regarding PC requirements and installation are available in section 4.

After the program is started, the main window appears (Fig. 9).

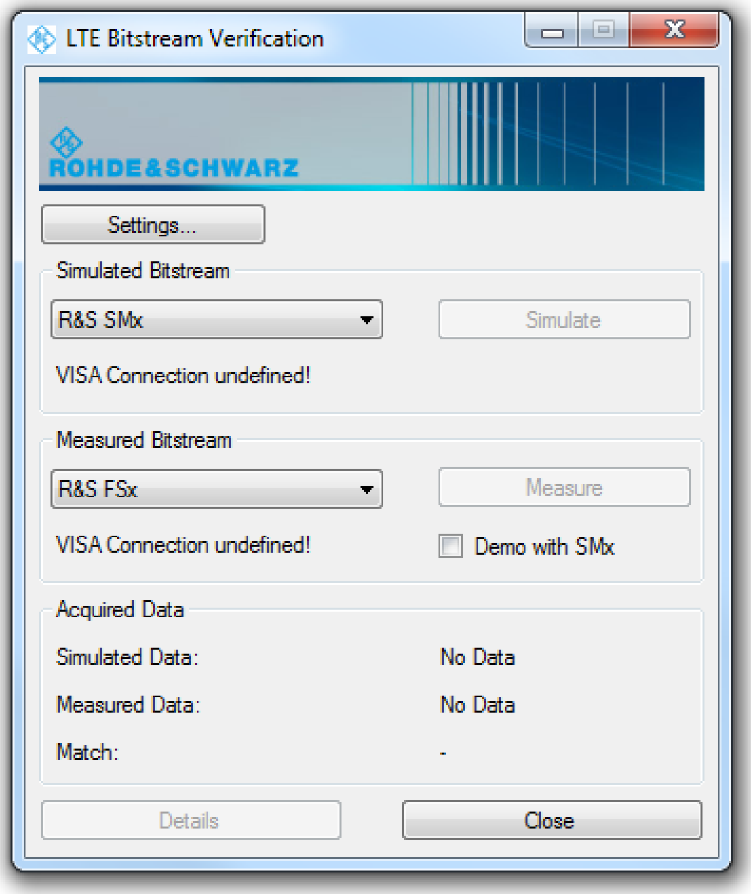

Fig. 9: Main window

The main window is divided into three sections:

- Basic settings can be defined via **Settings**.
- In the center, simulation and measurement can be controlled.
- The final section consists of the comparison of the bit streams.

All three sections are described in detail in the following.

Close closes the application.

3.1 Settings

A click on **Settings** opens a window with basic settings (Fig. 10).

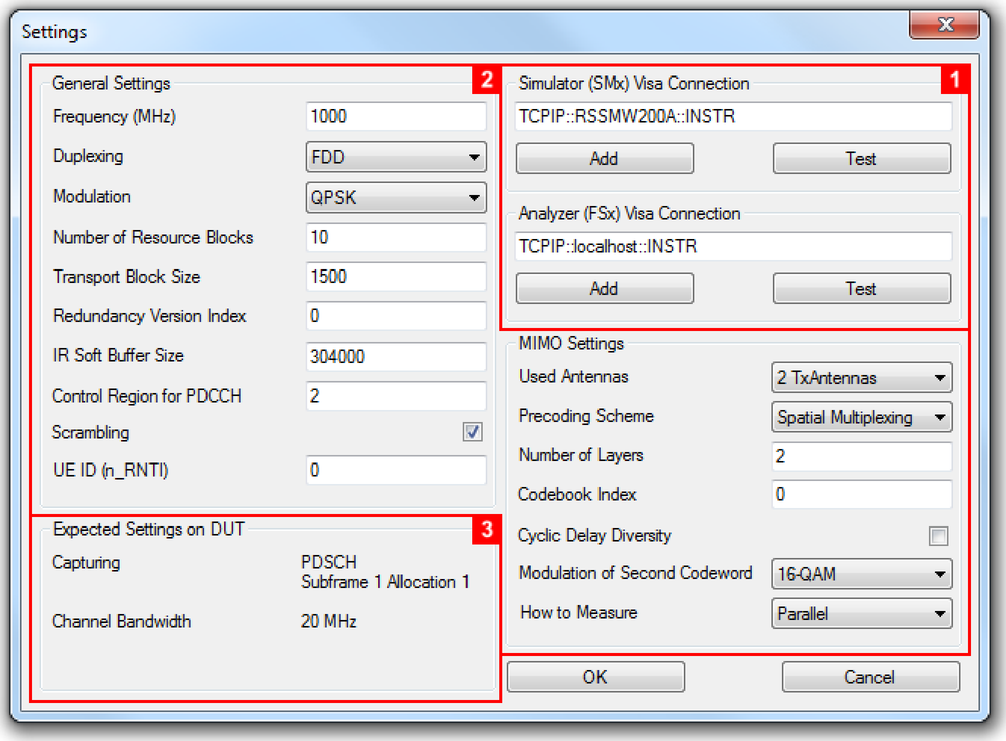

Fig. 10: Settings window

Settings for Remote Control (section **1** in Fig. 10)
The VISA connections for both the SMx and the FSX are established here. This can be done by clicking *Add* or by manually entering the VISA address or, directly, the TCPIP address. *Test* is used to test the connections.

If the LTE analysis software is to be run on the R&S FSx, the user must manually enter "::inst1" before "::INSTR". Example: If the VISA address for an FSQ is *TCPIP::FSWxx-xxxxxx::INSTR*, it must be changed to *TCPIP::FSWxx-xxxxxx::INST1::INSTR*. However, if the LTE analysis software is running on a PC, its network address must be entered. Example: *TCPIP::localhost::INSTR* if the option is used on the same PC as the software.

In the case of a MIMO measurement with a second FSx, the program itself does not require any VISA connections to the second FSx defined. The second FSx is controlled directly via VISA from the first FSx.

General Settings
All parameters required for setting up the bit stream can be set in the boxes titled *General Settings* and *MIMO Settings* (section **2** in Fig. 10). The program uses an LTE downlink signal and a channel bandwidth of 20 MHz.

Expected Settings on DUT
The most important criteria of the existing configuration in the DUT are shown in the box *Expected Settings on DUT* (section **3** in Fig. 10), including the position of the PDSCH allocation to be measured.

Because the PBCH is also transmitted in the first subframe (subframe 0 in the SMx), the bit stream comparison is performed in each case using the second subframe (subframe 1 in the SMx) (Fig. 11) for FDD. For TDD, subframe 4 is chosen.

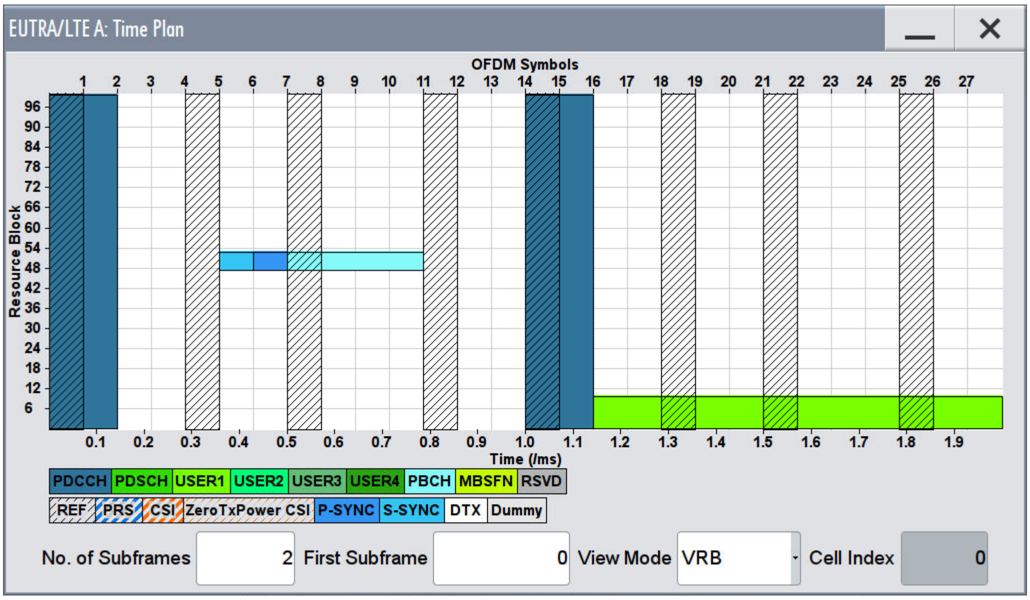

Fig. 11: Time plan of the SMx with subframes 0 and 1

Fig. 12 shows the frame configuration in the SMx, which is configured by the program. Subframe 1 and allocation 1 (PDSCH) are used. Here, the M*odulation* and the *Number of Resource Blocks* are set.

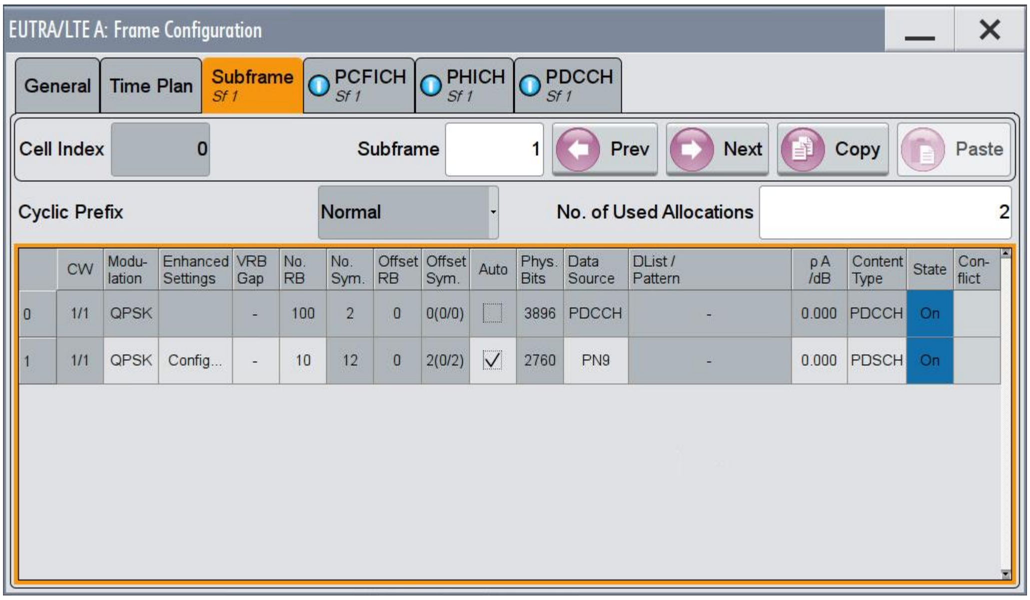

Fig. 12: Downlink frame configuration

Fig. 13 shows the detailed settings such as *Precoding* for MIMO with two antennas, *Scrambling* and *Channel Coding* with *Transport Block Size / Payload*, *Redundancy Version Index* and *IR Soft Buffer Size*.

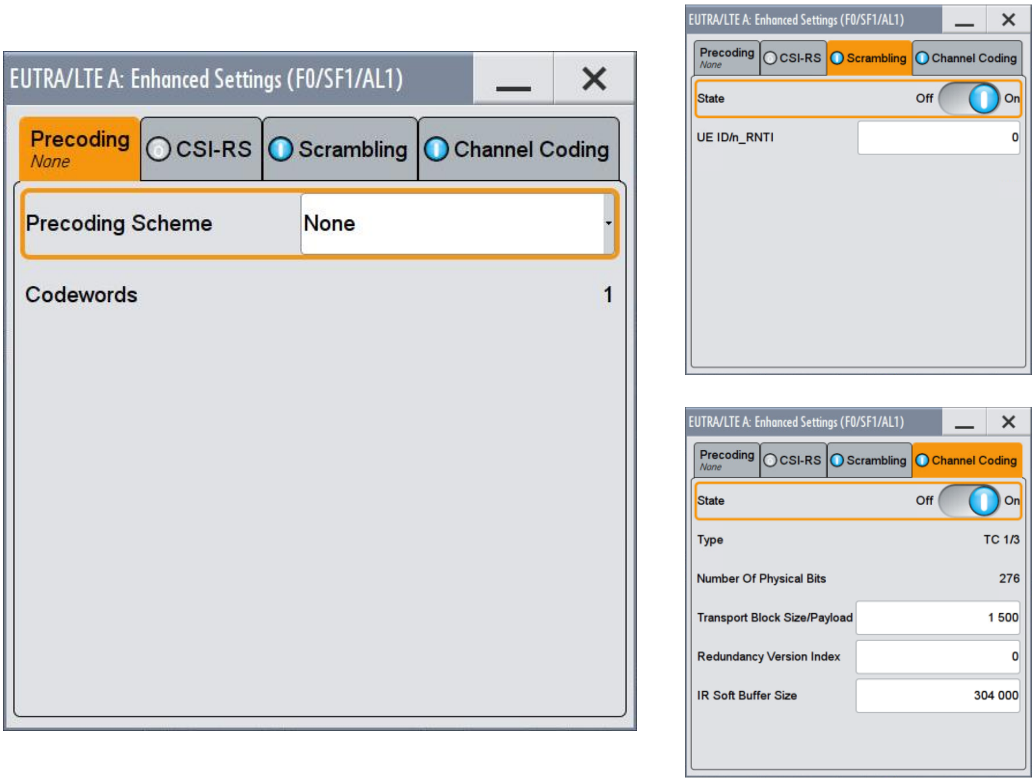

Fig. 13: Enhanced settings

MIMO Settings
In this section, the MIMO settings are defined. If *2 TxAntennas* is set under *Used Antennas*, additional parameters such as *Precoding Scheme, Number of Layers*, *Code Book Index*, *Cyclic Delay Diversity* and *Modulation of Second Code Word* can be set.

If a sequential measurement using one FSx is possible by the used settings, *How to Measure* enables the user to choose between both sequential measurement with one FSx or parallel with two FSx. For more information, see Application Note 1MA143 [3].

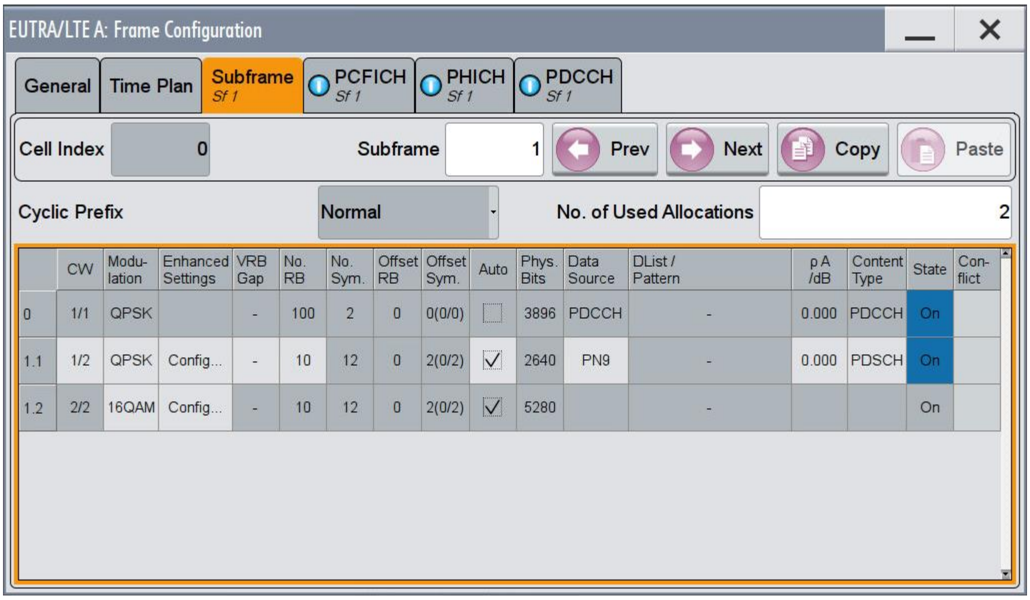

Fig. 14: Downlink frame configuration with MIMO spatial multiplexing

3.2 Execution

If the DUT and the program have been configured accordingly, the measurement can be performed via the main window.

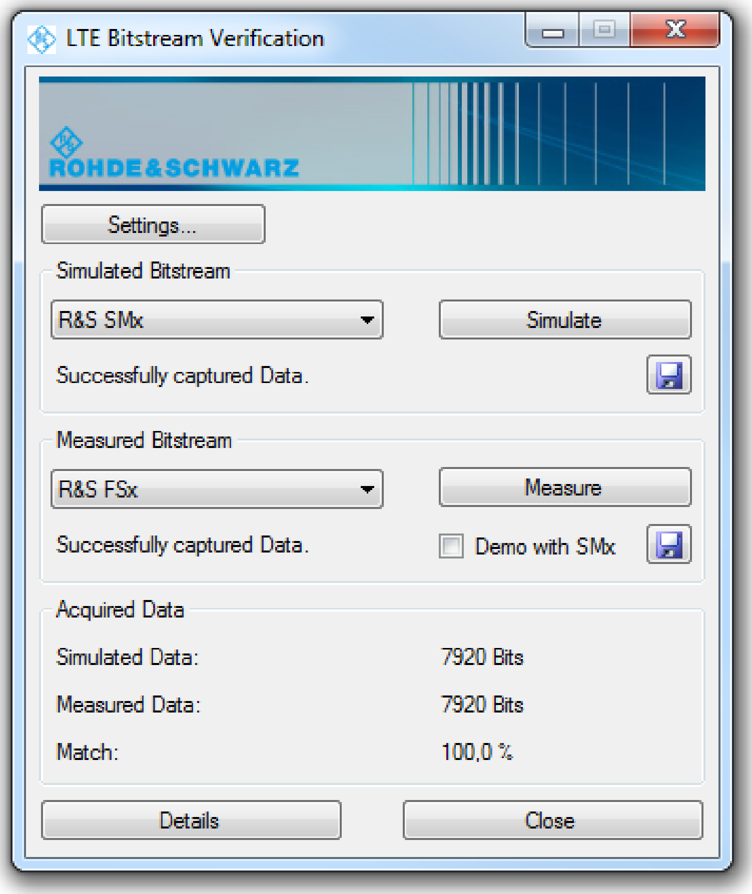

Fig. 15: Execution

Simulation and measurement function fully independently of one another, and once data has been obtained, it can be used until it is overwritten with new data or the program is terminated. Therefore, simulation can be performed, for example, only once and then several measurements are carried out, all of which are compared with the simulated data.

For demonstration purposes enable the box *Demo with SMU*. In this case, the DUT can be represented by the SMx. The SMx now delivers both the reference bit stream by means of option -K81 and simultaneously also the RF signal to be measured by the FSx.

3.2.1 Simulation

To generate a sample bit stream using option -K81, the user must select *R&S SMx* from the dropdown menu in the *Simulated Bitstream* box and click *Simulate*. The bit stream is now generated with the SMx using the setting under *Settings* and then output. If no error occurs, a message appears and the entire scope of output bits will be displayed in the *Acquired Data* box.

NOTE:
Once the simulation data has been loaded, it will remain in memory until overwritten by new data. If the settings are also changed, the simulation results will remain loaded in memory with the old settings until a new simulation is executed with a further click on *Simulate*. This procedure also allows bit streams generated under differing parameters to be compared. In such a case, the program also outputs a related warning message.

After a successful simulation, the bit stream that has been output can be stored for later use in a file with the extension **.lbc* by clicking the button that has the disk symbol. Stored files can then once again be loaded by selecting *File* and *Load* (see Fig. 16).

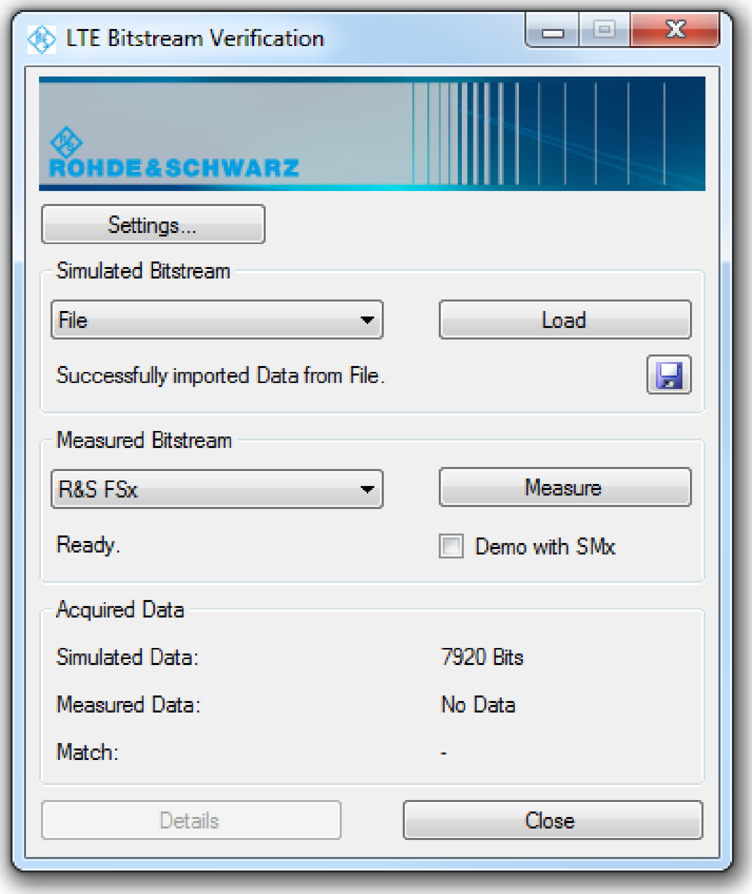

Fig. 16: Load file

3.2.2 Measurement

For a measurement with R&S FSx, select *R&S FSx* from the dropdown menu in the box titled *Measured Bitstream*. In the case the SMx is not already correctly set by an earlier simulation, **Set up SMx** can also be selected.

Now click *Measure*.
The software now prompts the R&S FSx to perform the measurement and to transmit. In the case of a sequential MIMO measurement, a window indicates when the user must switch the cable from antenna 1 to antenna 2.

As long as no error has occurred, all output bits will now be displayed in the *Acquired Data* box.

NOTE:
Once the measurement data has been loaded, it remains in memory until overwritten with new data. Therefore, if the settings are changed, the measurement results will still be loaded with the old settings until the user performs a new measurement by clicking *Measure* a second time. This approach also enables the user to compare the bit streams which have been set under various parameters. In one such case, the software also outputs a corresponding warning notice.

After a successful measurement, the output bit stream can be stored for later use in one file with an ending of **.lbc* with just one click of the button that shows the disk symbol. Stored files can be reloaded by selecting *File* and *Load* (see Fig. 16).

3.2.3 Import from File

Both the data from the simulation as well as from the measurement can be stored in files. These files can also be loaded again.

Moreover, any other bit stream can be imported as long as stored in text files, and as long as the bits can be displayed using the text characters 0 and 1. This requires the user to choose *File* from the box titled *Simulated Bit Stream* or *Measured Bit Stream* and then to click *Load*. The subsequent file load dialog enables the user to select the files wanted.

NOTE:
In the programs own format (**.lbc*), the measurement parameters are also stored in order to be able to output a warning notice in the case of comparisons under different conditions. In the case of imported data, which provides no information about the origins of the bit stream, no warning notice nor information regarding the allocation in the case of a detailed comparison is displayed. Also in the case of a foreign format, only one single bit stream is imported. Thus, a comparison with a detailed second code word in MIMO is not possible.

3.3 Comparison

The measured and simulated bit streams need to be compared. An initial comparison is performed automatically.

Automatic Comparison
Fig. 17 shows the output of the automatic comparison.

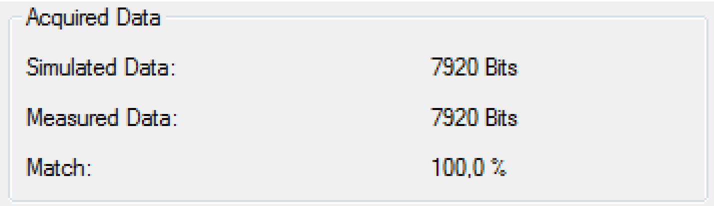

Fig. 17: Automatic comparison

As soon as both bit streams have been loaded — whether through simulation, measurement or import from a file — they are automatically compared with one another. This comparison also occurs when the bit streams are measured under different parameters, in which case a warning is also displayed.

Owing to the comparison, the *Acquired Data* box is used to display the number of bits and *Match* is used to display the similarity of the two bit streams in percent format.

NOTE:
During a MIMO measurement, the bit streams are measured individually on each antenna.

Detailed Comparison
For a detailed comparison, click the *Details* button to open a window that enables the user to analyze in detail the differences of the bit streams (Fig. 18).

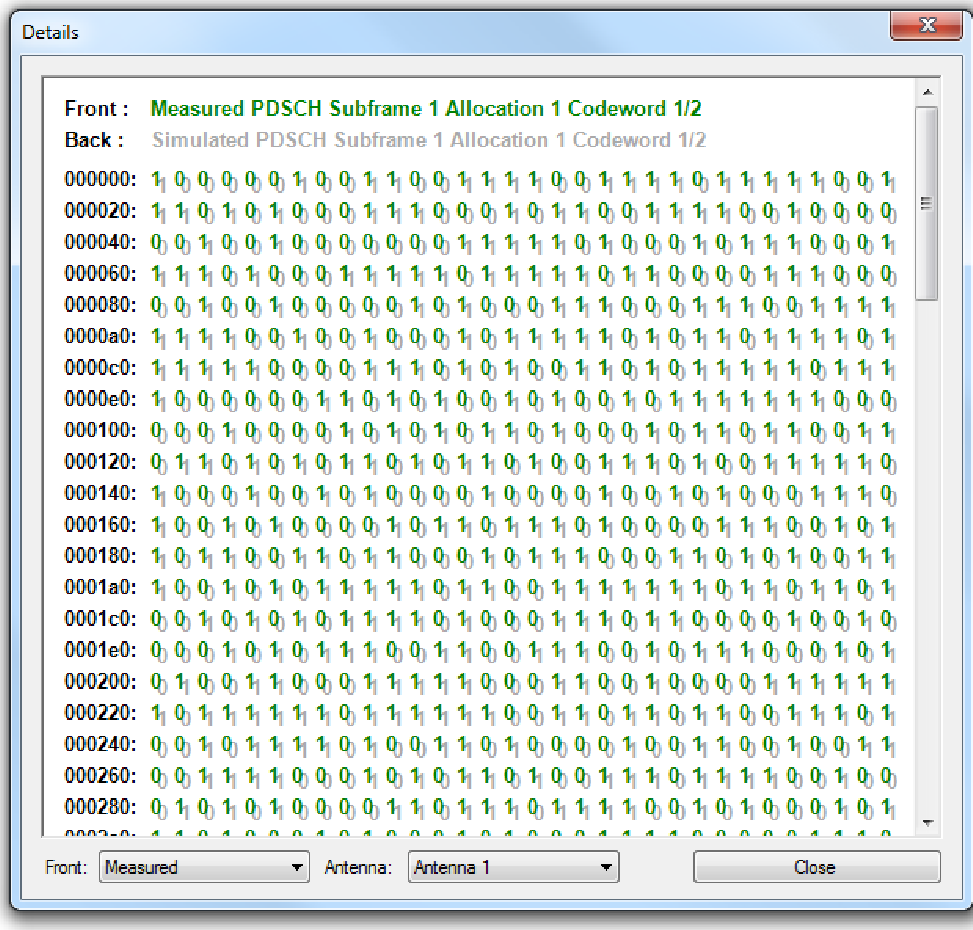

Fig. 18: Detailed comparison

The two bit streams are displayed at the same time in the window, one in the foreground (color) and the other in the background (gray). The point where the two streams intersect is shown in green in the foreground, and otherwise red. The user can therefore easily detect the non-conforming points.

The dropdown menu *Front* enables the user to interchange the two bit streams. As standard, the measured stream is displayed in the foreground. If a MIMO measurement is performed using two code words, the user can choose by the *Antenna* dropdown menu which code word is to be displayed.

4 Appendix

4.1 PC Requirements

Recommended system configuration:

- **Operating system:**
  - Microsoft Windows XP / Vista / Windows 7
  - .NET Framework 2.0 or higher
- **General PC requirements:**
  - 1 GHz Processor or faster
  - 1 GByte RAM
  - 100 MByte Hard-Drive Space
  - XGA Monitor (1024x768)
- **Remote control interface:**
  - National Instrument's VISA
  - LAN Connection

4.2 Installation

The file 1MA161_<version number>.ZIP is required in order to install the programs on the controlling PC.
Execute the installation program `(LTE_Bitstream_Verification_v1.0.exe)` and select the installation directory.

4.3 References

[1] Technical Specification Group Radio Access Network; E-UTRA Base station conformance testing, Release 8; **3GPP TS 36.141 V 8.9.0**, December 2010

[2] Rohde & Schwarz: **UMTS Long Term Evolution (LTE) Technology Introduction**, Application Note 1MA111, September 2008

[3] Rohde & Schwarz: **LTE Downlink MIMO Verification**, Application Note 1MA143, August 2009

[4] Rohde & Schwarz: **RF Chipset Verification for UMTS LTE with SMU200A and FSQ**, Application Note 1MA138, November 2008

[5] Rohde & Schwarz: **R&S®xxx-K55/-K255/-K69/-K81/-K84/-K284/-K85/-K285 EUTRA LTE**, Operating Manual, June 2014

[6] Technical Specification Group Radio Access Network; E-UTRA Base station conformance testing, Release 8; **3GPP TS 36.211 V 8.11.0**, December 2010

[7] Rohde & Schwarz: **LTE Base Station Tests according to TS 36.141**, Application Note 1MA154, November 2009

[8] Rohde & Schwarz: **LTE Base Station Performance Tests according to TS 36.141,** Application Note 1MA162, February 2010

4.4 Additional Information

Please send your comments and suggestions regarding this Application Note to

TM-Applications@rohde-schwarz.com

5 Ordering Information

Ordering Information		
Vector Signal Generator		
R&S®SMW200A		**1412.0000.02**
R&S®SMW-B10	Baseband Generator	1413.1200.02
R&S®SMW-B13	Baseband Main Module	1413.2807.02
R&S®SMW-K55	Digital Standard LTE/EUTRA	1413.4180.02
R&S®SMW-K81[1]	LTE Log File Generation	1413.4439.02
Signal and Spectrum Analyzer		
R&S®FSW	**8, 13, 26, 43, 50 or 67 GHz**	**1312.8000Kxx**[2]
R&S®FSx-K100	EUTRA/LTE FDD Downlink	1313.1545.02
R&S®FSx-K102	EUTRA/LTE DL MIMO	1313.1560.02
R&S®FSx-K104	EUTRA/LTE TDD Downlink	1313.1574.02
Measurement Software		
R&S®FS-K10xPC		
R&S®FS-K100PC	EUTRA/LTE DL FDD Software	1309.9916.06
R&S®FS-K102PC	EUTRA/LTE DL MIMO Software	1309.9939.06
R&S®FS-K104PC	EUTRA/LTE DL TDD Software	1309.9951.06
R&S®FSPC	Licence Dongle	1310.0002.03

[1] requiring two options -K81 for MIMO measurements with two antennas

[2] xx stands for the different frequency ranges (e.g. 1312.8000K67 up to 67 GHz)

Available options are not listed in detail. The use of the R&S®SMU200A Vector Signal Generator, R&S®FSQ Signal Analyzer, R&S®FSV Signal and Spectrum Analyzer and R&S®FPS Signal and Spectrum Analyzer is also possible. Please contact your local Rohde & Schwarz sales office for further assistance.

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Environmental commitment
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- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

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