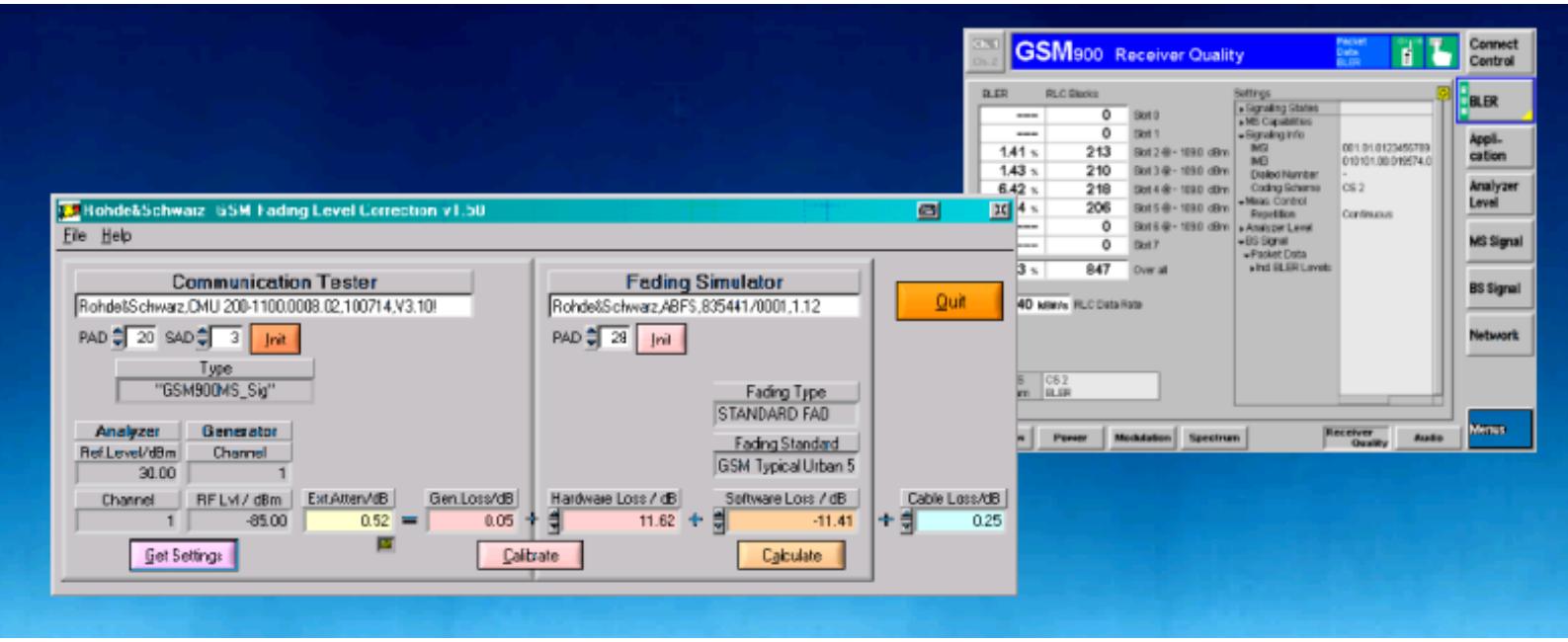

Products: CMU (B17), SMIQ (B14, B15), ABFS

GSM/GPRS/EDGE Receiver Tests Under Fading Conditions with CMU and SMIQ/ABFS

Application Note

This application note describes how to generate GSM signals for wide ranging receiver tests under fading conditions for GSM/GPRS/EDGE mobile and base station equipment. The test setup requires an R&S Universal Radio Communication Tester CMU with IQ-IF interface option CMU-B17 and an R&S vector signal generator SMIQ or baseband fading simulator ABFS. The GSMFadLevCor program included with this application note performs a semi automatic level correction of the power fed to the Device Under Test (DUT).

ROHDE&SCHWARZ

Subject to change – O.Gerlach 03.2003 - 1MA60_3E

Contents

1 Overview 3
2 Software Features 3
3 Hardware and Software Requirements 4
Hardware Requirements 4
Software Requirements 4
4 GSM Fading on Baseband Level (IQ) with CMU and ABFS / SMIQ 5
Connecting the Instruments 5
CMU and ABFS 5
CMU and SMIQ 5
Basics of Fading Tests with IQ IF Loop 6
Calibrating Hardware Loss 8
Installing the Level Correction Software 13
Running the Level Correction Software 13
Controls and Indicators 16
CMU 16
Generator 16
Analyzer 16
ABFS 17
Menu 18
File 18
Help 18
5 Testing MS Receiver Quality with BLER Measurements Under Fading Conditions 19
6 Additional Information 21
7 Ordering information 21

1 Overview

The signal strength and quality of signals received by Base Stations (BS) and Mobile Stations (MS) can be influenced by effects resulting from the movement of the mobile, and the overlay of numerous delayed signals caused by reflections. This phenonemon is called fading and is classified in profiles such as Constant Phase, Pure Doppler, Rice, Rayleigh and Moving Propagation fading. This application note describes how to connect a R&S Radio Communication Tester CMU with IQ-IF interface option CMU-B17 to an R&S SMIQ vector signal generator or R&S ABFS baseband fading simulator for generating GSM signals suitable for tests under fading conditions. The supplied program GSMFadLevCor calibrates the hardware attenuation of an external fading simulator ABFS or SMIQ connected to the CMU IQ loop. GSMFadLevCor can also calculate the mathematical signal loss resulting from various fading profiles and optionally perform an automatic level correction.

The following abbreviations are used in the following text for R&S test equipment:

- The R&S Universal Radio Communication Tester CMU200 and CMU300 are referred to as CMU.
- The R&S baseband fading simulator ABFS is referred to as ABFS.
- The R&S vector signal generator SMIQ ar referred to as SMIQ.

2 Software Features

- Program and device configuration storage
- Auto detection of ABFS / SMIQ fading model and active paths
- Variable CMU GPIB secondary address setup
- Automatic IQ loss calibration routine

3 Hardware and Software Requirements

Hardware Requirements

The software runs on a PC with

CPU	Pentium 300MHz or better
RAM	64 MBytes or more
MONITOR	SVGA color monitor 800x600 or better
IEC/IEEE BUS	IEC/IEEE bus interface Rohde & Schwarz IEEE-488.2 bus interface **PS-B4**, 1006.6207.04, or National Instruments **AT-GPIB, PCI-GPIB** or **PCMCIA-GPIB** card.

Software Requirements

WINDOWS 9X/NT/2000/XP	Microsoft operating system
NI-488.2 V1.6 (or above)	IEC/IEEE – bus driver from National Instruments. See http://www.natinst.com for latest revision.
NI-VISA V2.01 (or above)	VISA driver from National Instruments. See http://www.natinst.com for latest revision.
MICROSOFT INSTALLER	Versions for Windows 95/98/NT are available at http://www.rohde-schwarz.com.

4 GSM Fading on Baseband Level (IQ) with CMU and ABFS / SMIQ

Connecting the Instruments

CMU and ABFS

Connect the controlling PC to the CMU and ABFS with a GPIB bus cable. The ABFS is additionally connected to the CMU in the IQ RX (mobile station) or TX (base station) loop with a 1100.6993 cable. The DUT (mobile telephone or base station) is connected to the RF2 connector of the CMU which is set to bidirectional operating mode (input/output).

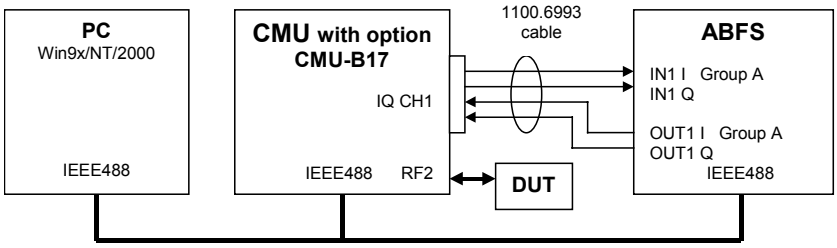

Fig. 1 CMU and ABFS Connection

CMU and SMIQ

Complete the connects as above with the additional detail that the SMIQ has separate I- and Q-faded outputs located on the rear panel.

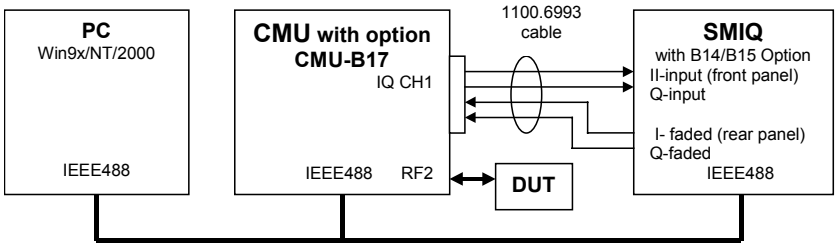

Fig. 2 CMU and SMIQ Connection

Note: GSMFadLevCor does not support the option for Noise/Distortion SMIQ-B17 since it normalizes the I/Q level for maximum accuracy. The output level is compensated by an internal offset which cannot be accessed remotely. If the Noise/Distortion option is installed, the hardware loss must be measured by applying a CW signal at the I- or Q-input (i.e. 7MHz, +7dBm = 0.5V at 50Ω), selecting the desired fading profile and measuring the power at the I- or Q-faded output manually (set software loss to 0.0dB). The expected SMIQ (ABFS) hardware loss with one active fading path (pure Doppler) at 0.0dB loss is approximately 18 (12) dB.

Basics of Fading Tests with IQ IF Loop

The ABFS / SMIQ adds fading effects to the CMU signal on the IQ level (baseband). When an ABFS / SMIQ is inserted into the CMU IQ loop by switching the CMU-B17 option the signal power decreases due to the losses on the switched path. The ABFS / SMIQ displays a general insertion loss depending on the number of active fading channels and appropriate channel losses which applies to the worst case (all channels turned on) to avoid overdrive at the CMU IQ input. In order to maintain a defined signal level at the DUT the CMU generator level setting must compensate the hardware loss. This can be achieved by setting the EXTERNAL ATTENUATION parameter of the CMU generator to the value of this hardware loss. The SMIQ signal generator and ABFS fading simulator support several GSM fading standards (GSM Typical Urban, GSM Hilly Terrain, etc.) with multiple paths and profiles (Rayleigh, Pure Doppler, etc.).

A power component (software loss) resulting from the sum of the power of each path must be added to the hardware loss in order to obtain the correct total insertion loss of the ABFS / SMIQ. The following schematic shows the signal paths and their calculation.

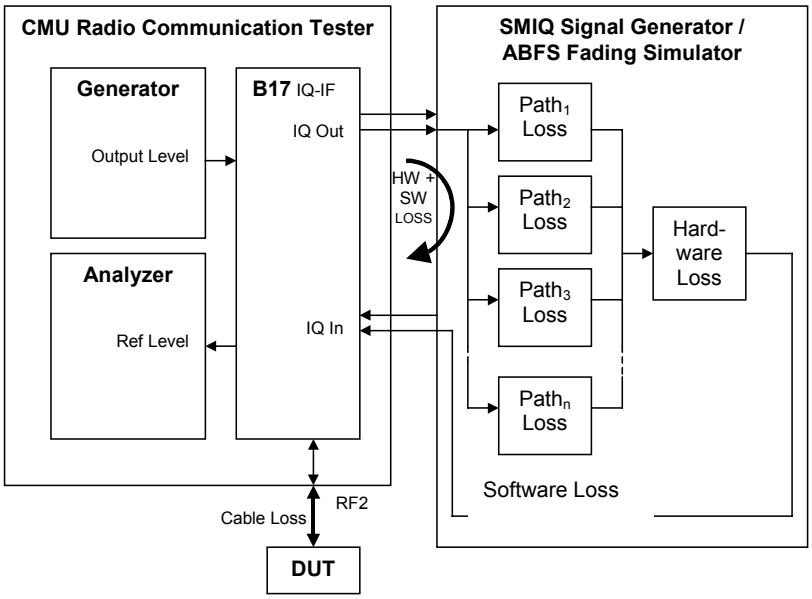

Fig. 3 Fading with IQ IF Loop

The software invoked portion of the insertion loss is calculated as:

$$SoftwareLoss = -10 * \log\left(\sum_{n=1}^{N} 10^{\frac{-PnLoss}{10}}\right)$$

P_nLOSS = Loss of n-th path. Must be calculated as negative amplification

Hardware LOSS = hardware attenuation of IQ path

N = 12 for ABFS or SMIQ with SMIQ-B14 and -B15 option, N = 6 in SMIQ with only SMIQ-B14 option

Since the paths are switched together parallel, the sum of the power amplification factors (delogarithmized path losses) must be added and the resulting sum logarithmized. **GSMFADLEVCOR** sets the CMU external generator attenuation to this value. The CMU generator output level display shows the power actually applied to the DUT.

Note: The formula above applies to fading profiles consisting of non correlated signal paths (usually Raleigh). The calculated result will not be precise as soon as the fading profile contains at least two correlated paths (e.g. CPHAS), since their calculation is voltage instead of power based.

Example: 2 active paths with 0dB and 6dB path loss and Raleigh fading type. The basic ABFS hardware loss is 11.81dB as measured according to the IQ calibration routine described in the following section. The total external attenuation:

$$ExtAtt = GenLoss + HardwareLoss + SoftwareLoss + CableLoss$$

See chapter "Calibrating Hardware Loss" for a detailed description of GenLoss.

$$ExtAtt = -0.01 + 11.93 - 10 * \log\left(10^{\frac{-0}{10}} + 10^{\frac{-6}{10}}\right) + 0.00 = 10.95$$

This precise calculating method makes an a additional power measurement at the DUT input obsolete.

Calibrating Hardware Loss

The hardware invoked attenuation is device dependant and must be determined for the individual setup. This measurement setup uses RF2 as output and RF1 as input. The **CALIBRATE** button of the program **GSMFADLEVCOR** performs this procedure:

Fig. 4 Calibration Configuration

1. Switch the fading simulator to **STANDARD...** -> **CALIBRATION MODE** (1 path, CPHAS profile, 0.0dB path loss). This sets the digital loss to zero and the measured value will only reflect the hardware attenuation.

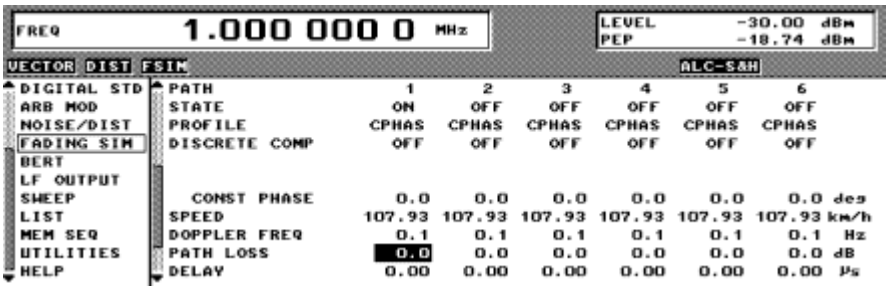

Fig. 5 ABFS/SMIQ Calibrating Mode

2. Configure the CMU generator to GSM900 non-signalling mode with the following generator settings.

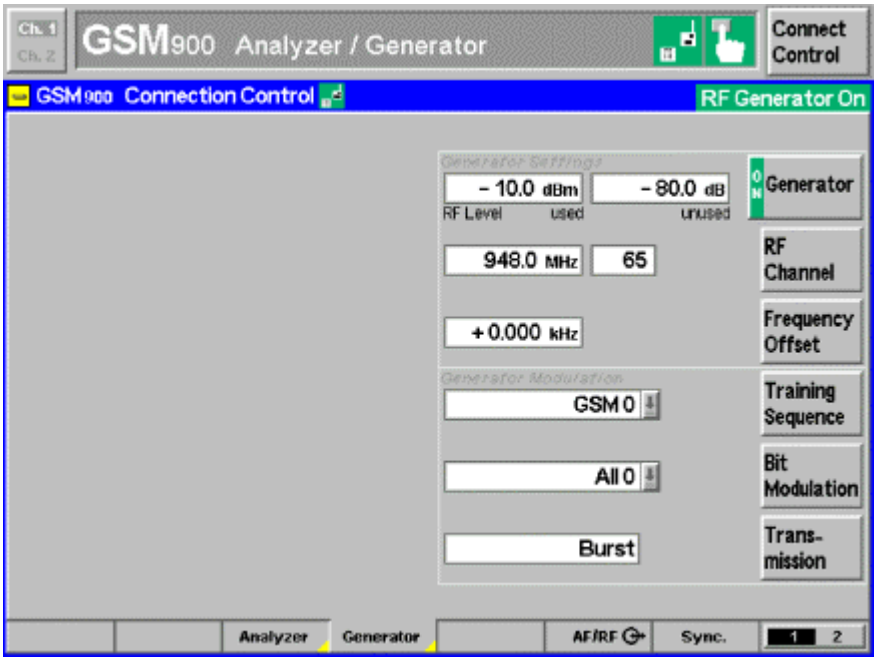

Fig. 6 CMU Generator Setup

3. Set the CMU analyzer to the same frequency (not channel) as the generator.

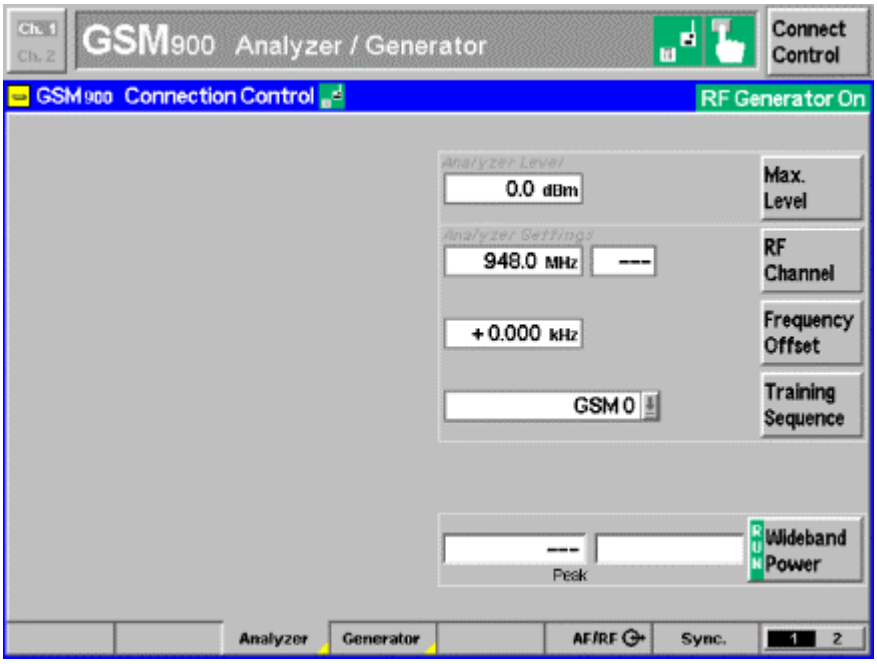

Fig. 7 CMU Analyzer Setup

4. Set the IQ/IF board to Bypass mode (Fig.8) in order to obtain the reference Average Burst Power **PREF** (Fig.9).

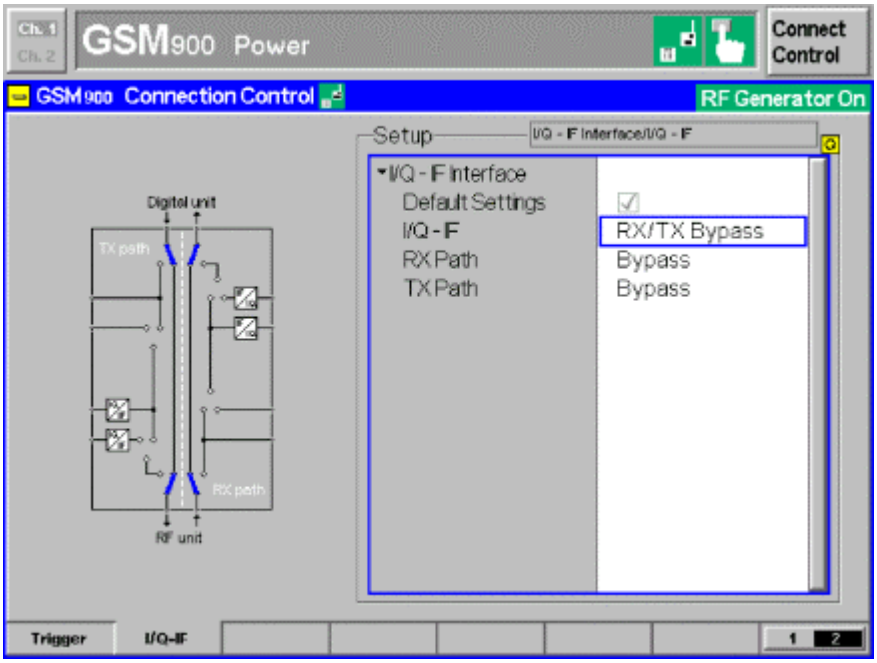

Fig. 8 IQ/IF Bypass Configuration

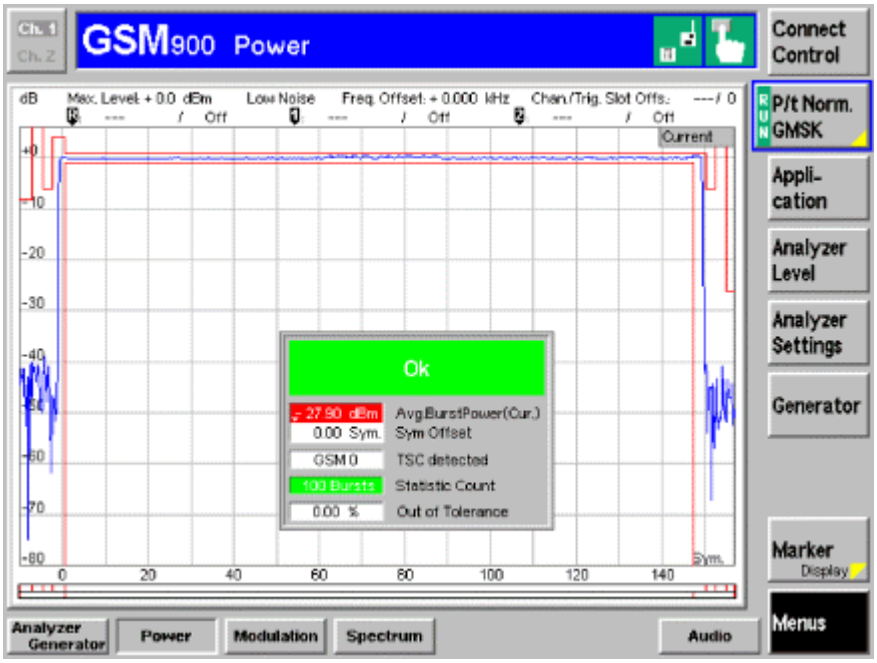

Fig. 9 Burst Power in Bypass Mode

5. Activate the IQ loop and send the signal through the fading simulator.

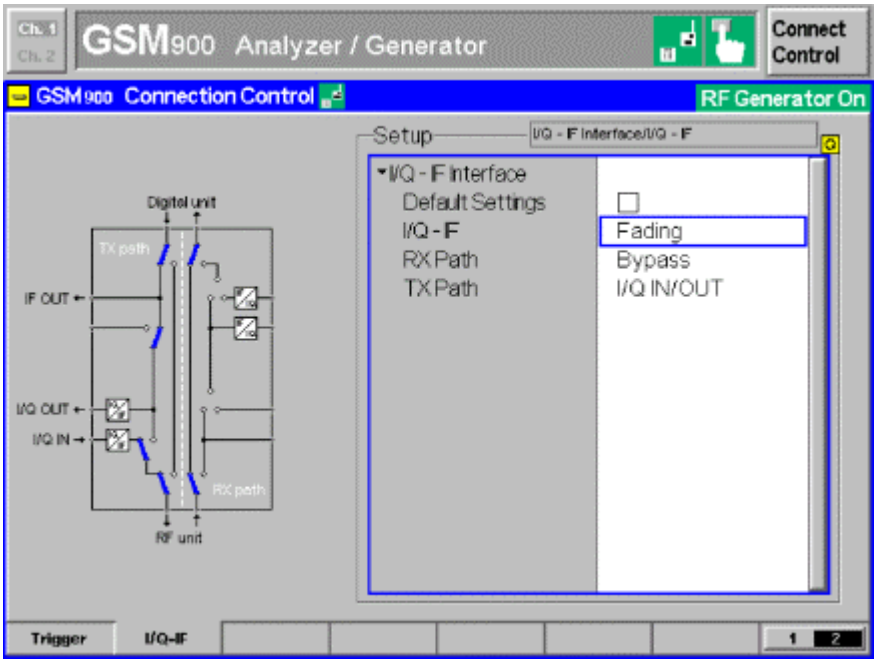

Fig. 10 IQ/IF Fading Configuration

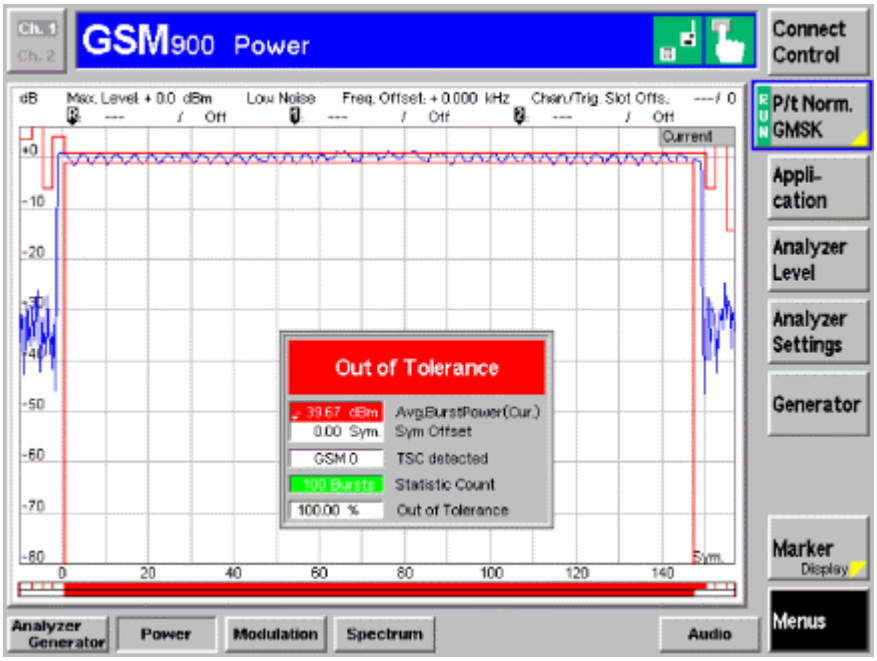

Fig. 11 Burst Power with Calibration Mode Standard Fading

6. The resulting Average Burst Power $\mathbf{P_{MEAS}}$ must be subtracted from the reference power $\mathbf{P_{REF}}$ to obtain the hardware attenuation of the IQ path.

   Hardware Loss = $P_{ref} - P_{meas}$ = -27.90dBm + 39.67dBm = 11.77dB

The **GSMFADLEVCOR** indicator **GEN LOSS** and the control **HARDWARE LOSS** can be automatically updated by pressing **CALIBRATE**; alternatively **HARDWARE LOSS** may be entered manually. This value is device dependant and is valid for signalling and non-signalling measurements.

Gen Loss is calculated as:

$$GenLoss = Genlev - \Pr ef - CabLoss$$

Installing the Level Correction Software

The following installation files are required to install the level correction software GSMFADLEVCOR on the controlling PC.

GSMFADLEVCOR V1.XX.MSI

DISTFILE.CAB

Execute GSM**FADLEVCOR V1.XX.MSI** and select the installation directory. A new menu item GSM**FADLEVCOR** is created in START -> PROGRAM FILES. The installation directory contains the files named below:

GSMFADLEVCOR.EXE	Executable
GSMFADLEVCOR.CFG	Configuration file
GSMFADLEVCOR.CHM	Online help manual

Running the Level Correction Software

1. On the CMU assign at least one of the desired GSM **SIGNALLING** or **NON-SIGNALLING** function groups to one or more of the 29 possible GPIB secondary addresses (1..29).

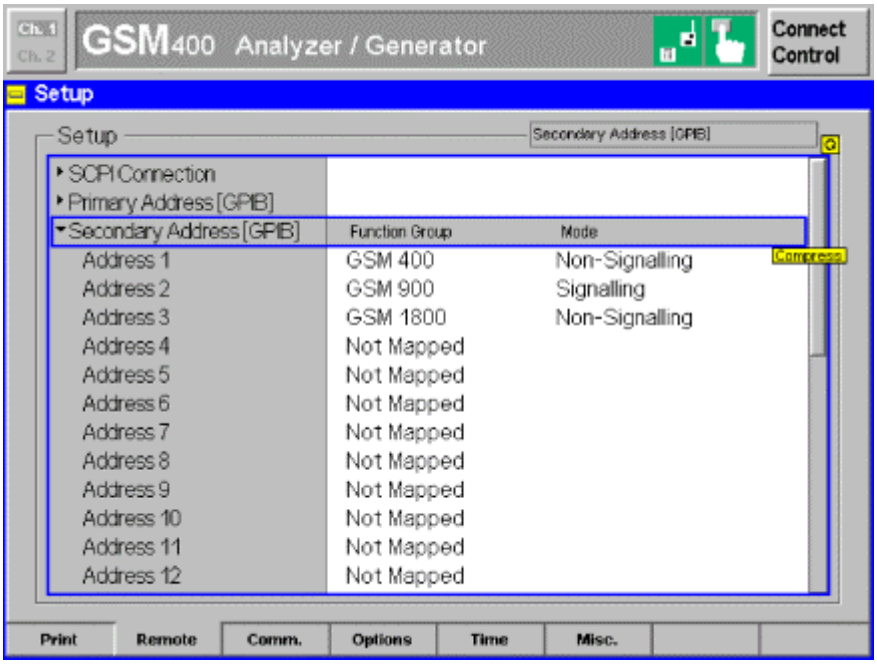

Fig. 12 CMU GPIB secondary address setup

2. Start **GSMFADLEVCOR.EXE** on the PC.
3. Set the primary GPIB addresses (**PAD**) according to the CMU settings.
4. Set the secondary GPIB address (**SAD**) according to the CMU settings.
5. Initialize the CMU and SMIQ or ABFS by pressing the corresponding **INIT** buttons. After both instruments have been initialized correctly the identification strings of the devices are displayed and the **GET SETTINGS**, **EXTERNAL ATTEN LED**, **CALIBRATE** and **CALCULATE** controls are high lighted.

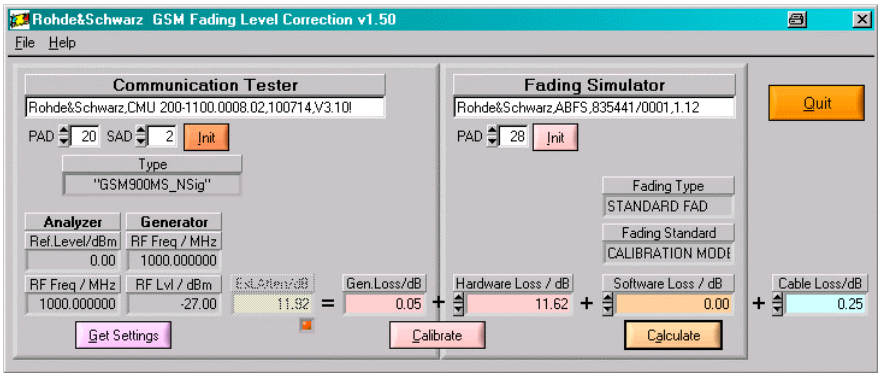

Fig. 13 Main Window

6. Press the **GET SETTINGS** button to read the current CMU generator and analyzer settings.
7. To determine **GEN LOSS** (= RF Level – Cable Loss with shortened CMU-B17) and **HARDWARE LOSS** of fading simulator press the **CALIBRATE** button.
8. Press the **CALCULATE** button to read the current ABFS/SMIQ fading configuration and update the **SOFTWARE LOSS** with the calculated value.
9. If the **ON/OFF** checkbox is active the CMU generator external attenuation parameter is automatically set to the **EXT ATT** value.

Note: The **EXT ATT** display is automatically updated when the **CALIBRATE** or **CALCULATE** buttons are pressed or the **HARDWARE LOSS**, **SOFTWARE LOSS** and **CABLE LOSS** values are changed manually. If the **EXT ATT** checkbox is active this value is immediately transfered to the CMU.

The GsmFADLEVCOR indicator **RF LEVEL** shows the CMU RF Level (used timeslot) in non-signalling mode.

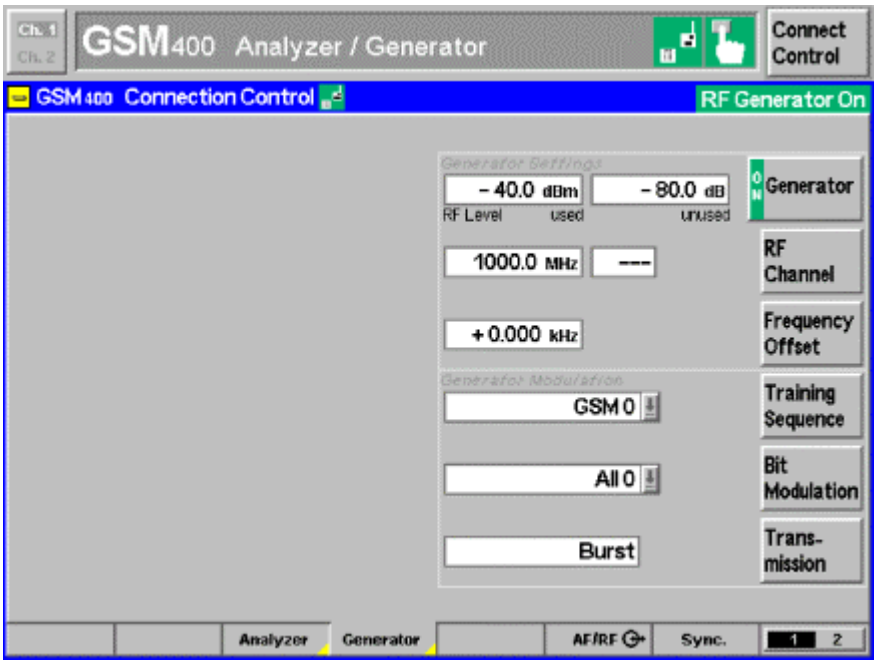

Fig. 14 GSM Non-Signalling RF Level used

In signalling mode **RF LEVEL** refers to the **BCCH and TCH** level.

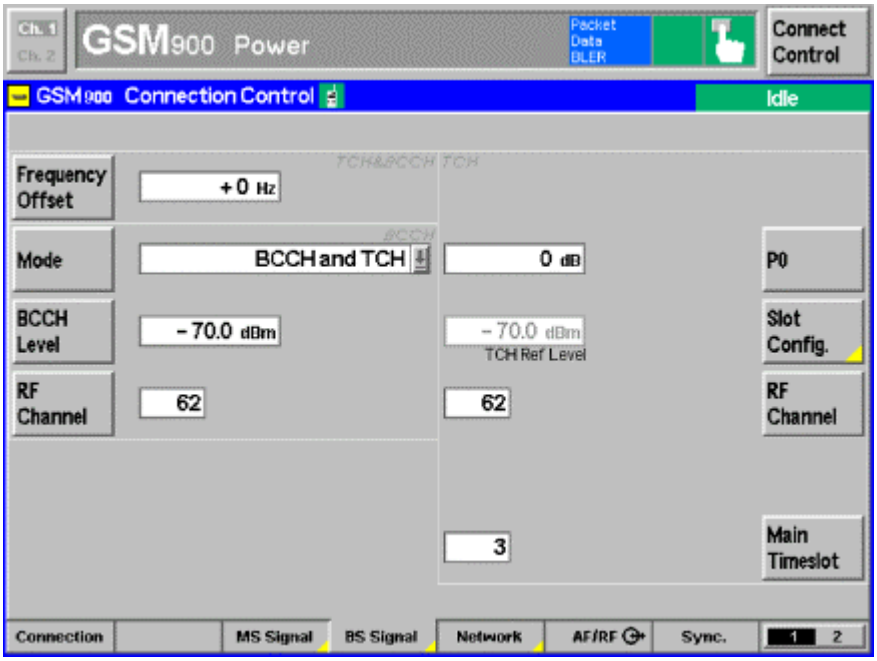

Fig. 15 GSM Signalling BCCH and TCH Level

Controls and Indicators

CMU

- **PAD** – GPIB primary address of the CMU. Range: 0 to 31.
- **SAD** – GPIB secondary address of the active CMU option **GSM 400**, **GSM 850**, **GSM 900**, **GSM 1800 SIGNALLING** and **NON SIGNALLING**. Range: 1 to 29.
- **INIT** – Checks for the presence of a device and displays the identification string of a device found in the text field.

Generator

- **RF FREQUENCY** – displays current RF frequency of the CMU generator.
- **RF LEVEL** – RF Level of used TimeSlot. Range: -137.0 to –10 dBm.
- **CABLE LOSS** – The Attenuation set for the cable from the RF2 connector to the DUT. The CABLE LOSS is added to the level offset EXT ATT.
- **EXT ATT** – The level offset applied to output power to compensate for cable loss, generator loss, and hardware loss, software loss.

$$ExtAtt = GenLoss + HWLoss + SWLoss + CableLoss$$

The maximum value depends on the device specification. GSMFADLEVCOR displays the following error message in case the Ext Att value exceeds its maximum.

Fig. 16 Level Warning

- **ON/OFF** – Activates/deactivates CMU external attenuation.

Analyzer

- **RF FREQUENCY** – displays the current RF frequency of the CMU analyzer.
- **LEVEL** – Current reference level of the CMU analyzer.

ABFS

- **PAD** – GPIB primary address of the ABFS. Range: 1 to 32.
- **INIT** – Checks for the presence of a device and displays the identification string of a device found in the text field.

The GSM fading profiles can be selected on the SMIQ / ABFS by pressing

GROUPA FSIM (ABFS) / **FADING SIM** (SMIQ)

STANDARD FAD -> STANDARD

GSM TYPICAL URBAN 3, 6 PATH

GSM TYPICAL URBAN 3, 12 PATH

GSM TYPICAL URBAN 50, 6 PATH

GSM TYPICAL URBAN 50, 12 PATH

GSM HILLY TERRAIN 100, 6 PATH

GSM HILLY TERRAIN 100, 12 PATH

GSM RURAL AREA 250, 6 PATH

GSM EQUAL TEST 50, 6 PATH

GSM EQUAL TEST 100, 6 PATH

- **TYPE** – fading type indicator. Range: STANDARD FAD.

  Note: Keep in mind that GSMFADLEVCOR supports only GSM signal generation on the CMU. It makes no sense to choose a different fading standard other than GSM on the ABFS / SMIQ.
- **STANDARD** – Indicator for predefined fading profiles, see list above.
- **HARDWARE LOSS** – Attenuation of the IQ path as determined manually or by pressing the **Calibrate** button (see section 'CALIBRATING HARDWARE LOSS' on page 6).
- **CALIBRATE** – Performs full automatic calibration and update of the **HARDWARE LOSS** indicator.
- **SOFTWARE LOSS** – Fading path loss inserted by the fading simulator. It is calculated by pressing **CALCULATE** as shown in the section 'Basics of Fading Tests with IQ/IF Loop' (page 5).
- **CALCULATE** – Reads the current fading parameters and updates the appropriate indicators as necessary. **SOFTWARE LOSS** is updated with the calculated value.

Menu

File

All program and device specific data can be saved and loaded from a configuration file.

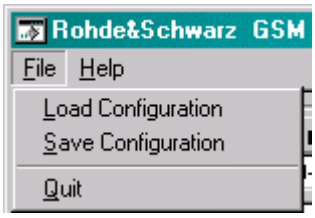

Fig. 17 Menu Items

- **LOAD CONFIGURATION** - the default file extension is **.cfg*. The configuration file contains the following parameters:

  1. X = last horizontal window position
  2. Y = last vertical window position
  3. CMU GPIB primary address
  4. CMU GPIB secondary address of GSM xxxx module
  5. SMIQ / ABFS GPIB address
  6. External loss
  7. Software Loss Attenuation

- **SAVE CONFIGURATION** - the default file extension is **.cfg*. Similar file dialog as *Load Configuration*.

Help

- **HELP** – Displays online help
- **ABOUT** – displays revision and copyright information

5 Testing MS Receiver Quality with BLER Measurements Under Fading Conditions

A criteria for MS or BS receiver quality is the bit error rate (BER) or block error rate (BLER) which are therefore specified in the GSM/GPRS/EDGE test standards for base and mobile stations. The following example describes a BS BLER measurement under fading conditions.

1. Connect **RF2$_{OUT}$** with **RF1$_{IN}$** on the CMU.
2. Start **GSMFADLEVCOR.EXE**, **INIT** devices and determine **GEN LOSS** and **HARDWARE LOSS** by pressing the **CALIBRATE** button.

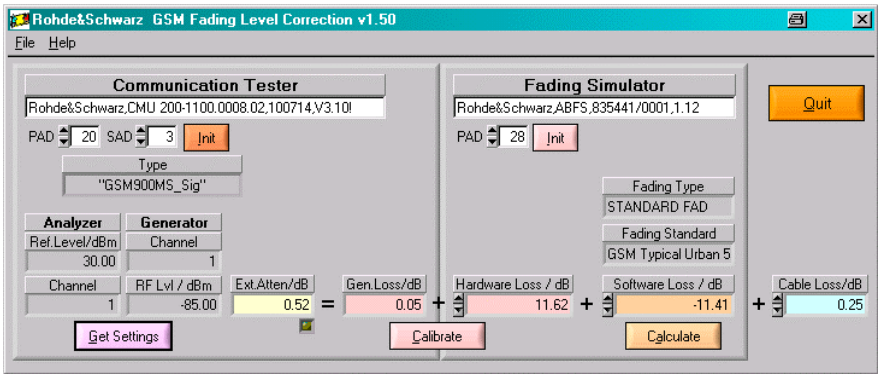

Fig. 18 GSMFadLevCor Setup

3. Select the desired fading profile on ABFS / SMIQ, e.g. **GSM TYPICAL URBAN 50**.
4. Optionally edit the **CABLE LOSS**, e.g. 0.25dB.
5. Calculate the **SOFTWARE LOSS** by pressing the **CALCULATE** button.

6. Transfer the **EXT. ATT** value to the CMU by activating the **ON/OFF** checkbox (e.g. **EXT. ATT** 8.39dB = **GEN LOSS** 0.05dB + **HARDWARE LOSS** 11.62dB + **SOFTWARE LOSS** –3.52dB + **CABLE LOSS** 0.3dB).

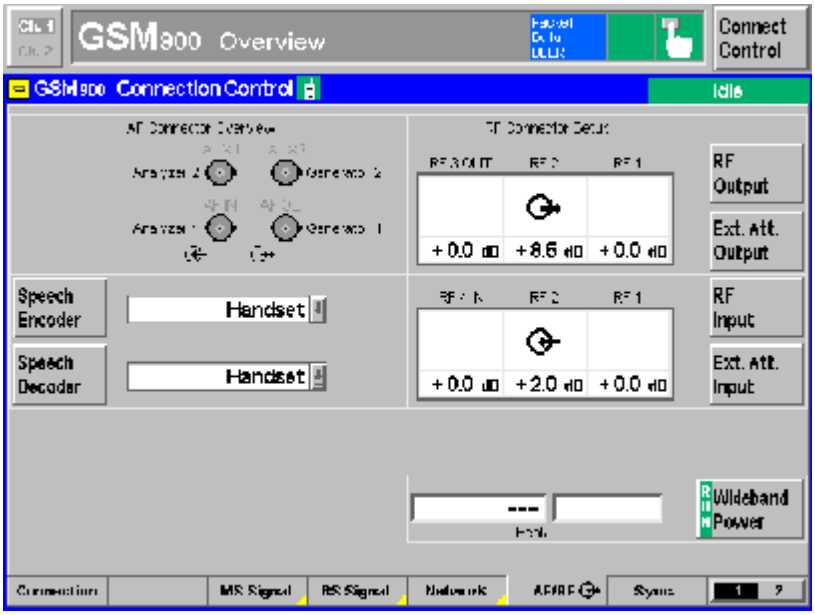

Fig. 19 Connection Control

7. Switch the CMU to **RF2$_{INOUT}$** mode and connect the MS.
8. When changing the fading profile repeat the procedure starting with step 3.).
9. To select the BLER test choose for example **GSM900 SIGNALLING** mode -> **RECEIVER QUALITY** -> **APPLICATION** -> **BLER**.

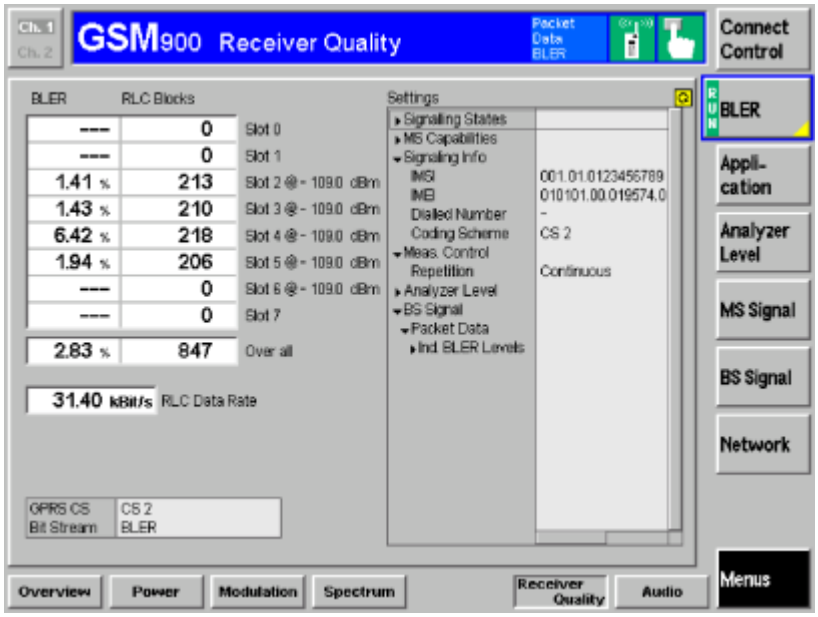

Fig. 20 BLER Measurement

10. The generator **RF LEVEL** can be varied manually as shown on page 15.

6 Additional Information

Please contact TM-Applications@rsd.rohde-schwarz.com for comments and further suggestions.

7 Ordering information

Communication Tester		
CMU 200		1100.0008.02
CMU 300		1100.0008.03
Vector Signal Generator		
SMIQ02B	(300 kHz to 2.2 GHz)	1125.5555.02
SMIQ03B	(300 kHz to 3.3 GHz)	1125.5555.03
SMIQ03HD	(300 kHz to 3.3 GHz)	1125.5555.33
SMIQ04B	(300 kHz to 4.4 GHz)	1125.5555.04
SMIQ06B	(300 kHz to 6.4 GHz)	1125.5555.06
Fading Simulator		
ABFS Fading Simulator		1111.8506.02
Options		
CMU-B17 IQ-IF Interface		1100.6906.02
SMIQ-B14	Fading simulator 6 path, mandatory	1085.4002.02
SMIQ-B15	2nd Fading simulator, optional	1085.4402.02

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