

Products: CMU (B17), SMIQ (B14, B15), ABFS, CMU-Z11

# 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).



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### **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 phenomenon 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 are 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 <b>PS-B4</b> , 1006.6207.04, or National Instruments <b>AT-GPIB</b> , <b>PCI-GPIB</b> or <b>PCMCIA-GPIB</b> 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 <a href="http://www.natinst.com">http://www.natinst.com</a> for latest revision.
NI-VISA v2.5 (or above)	VISA driver from National Instruments. See <a href="http://www.natinst.com">http://www.natinst.com</a> for latest revision.
MICROSOFT INSTALLER	Versions for Windows 95/98/NT are available at <a href="http://www.rohde-schwarz.com">http://www.rohde-schwarz.com</a> . Not required for Windows 2000/XP.

## 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).

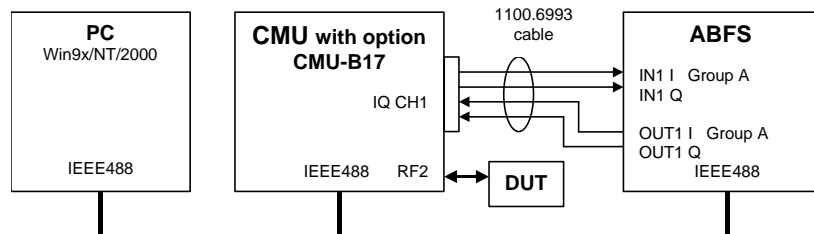


Fig. 1 CMU and ABFS Connection

#### 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.

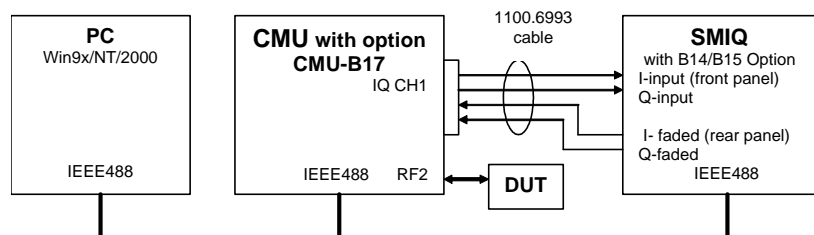


Fig. 2 CMU and SMIQ Connection

**Note:** SMIQs equipped with the option SMIQ-B17 Noise and Distortion Simulator require additional conditioning in order to be suited for this application note. Please contact [TM-Applications@rsd.rohde-schwarz.com](mailto:TM-Applications@rsd.rohde-schwarz.com) for further details.

### 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.

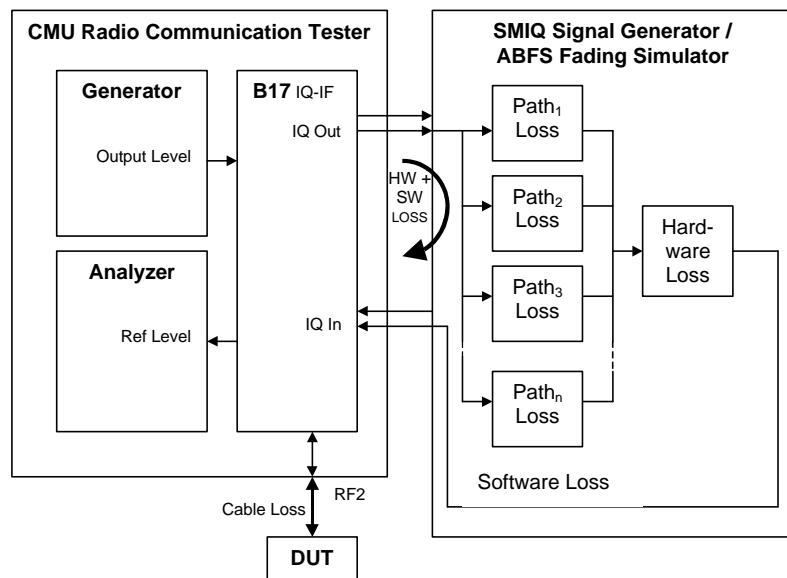


Fig. 3 Fading with IQ IF Loop

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

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

$P_nLoss$  = 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

## ***Receiver Tests under Fading with CMU and ABFS/SMIQ***

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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: Two active paths with 0dB and 6dB path loss and Raleigh fading type. The Hardware Loss has been measured according calibration routine described in the next section and the cable loss is usually specified by the manufacturer. The external attenuation is calculated as:

$$\text{ExtAtten} = \text{HardwareLoss} + \text{SoftwareLoss} + \text{CableLoss}$$

$$\text{ExtAtten} = 17.93\text{dB} - 10 * \log \left( 10^{\frac{-0}{10}} + 10^{\frac{-6}{10}} \right) \text{dB} + 0.20\text{dB} = 17.16\text{dB}$$

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

Note: The expected SMIQ hardware loss is approx. 18dB with only a SMIQ-B14 option (6 fading paths) installed and **INSERTION LOSS SETTING MODE -> NORMAL**. With **INSERTION LOSS SETTING MODE -> LOW\_ACP** the expected SMIQ hardware loss decreases to 12dB but also increases the risc of distortion. With the option SMIQ-B14 and SMIQ-B15 installed the hardware loss is approx. 12dB. The ABFS hardware loss is 12dB with **INSERTION LOSS SETTING MODE -> AUTO** and can be varied from 6 to 24dB with **INSERTION LOSS SETTING MODE -> MAN**ual.

## 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 the procedure described on the following pages:



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.

FREQ		948.000 000 0 MHz				LEVEL		-30.0 dBm	
						PEP		-30.0 dBm	
DIST FSIM		ALC-S&H							
FREQUENCY	PATH	1	2	3	4	5	6		
LEVEL	STATE	ON	OFF	OFF	OFF	OFF	OFF		
ANALOG MOD	PROFILE	CPHAS	CPHAS	CPHAS	CPHAS	CPHAS	CPHAS		
VECTOR MOD	DISCRETE COMP	OFF	OFF	OFF	OFF	OFF	OFF		
DIGITAL MOD									
DIGITAL STD									
ARB MOD									
NOISE/DIST	SPEED	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000 km/h
FADING SIM	DOPPLER FREQ	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0 Hz
BERT	PATH LOSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 dB
LF OUTPUT	DELAY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 μs

Fig. 5 ABFS/SMIQ Calibrating Mode



## Receiver Tests under Fading with CMU and ABFS/SMIQ

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

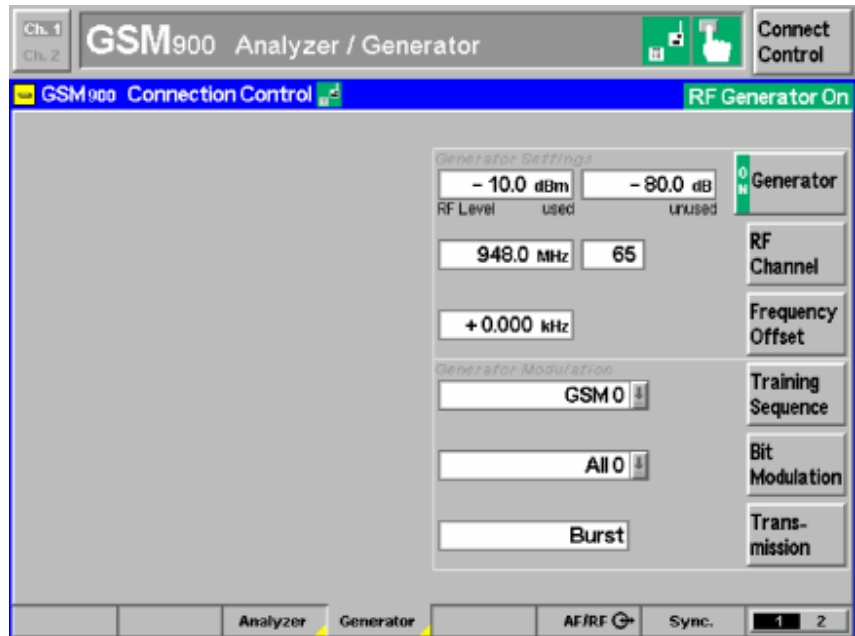


Fig. 6 CMU Generator Setup

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

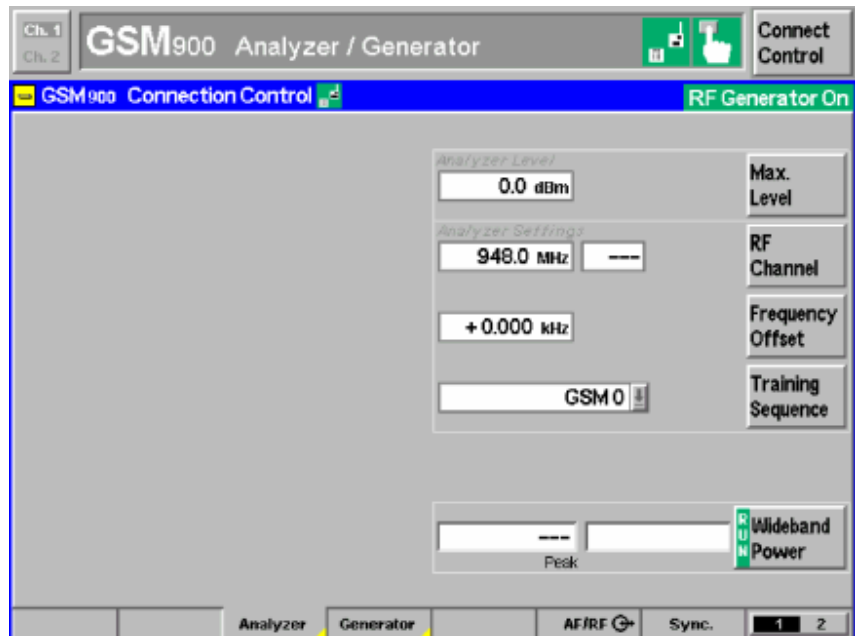


Fig. 7 CMU Analyzer Setup

## Receiver Tests under Fading with CMU and ABFS/SMIQ

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

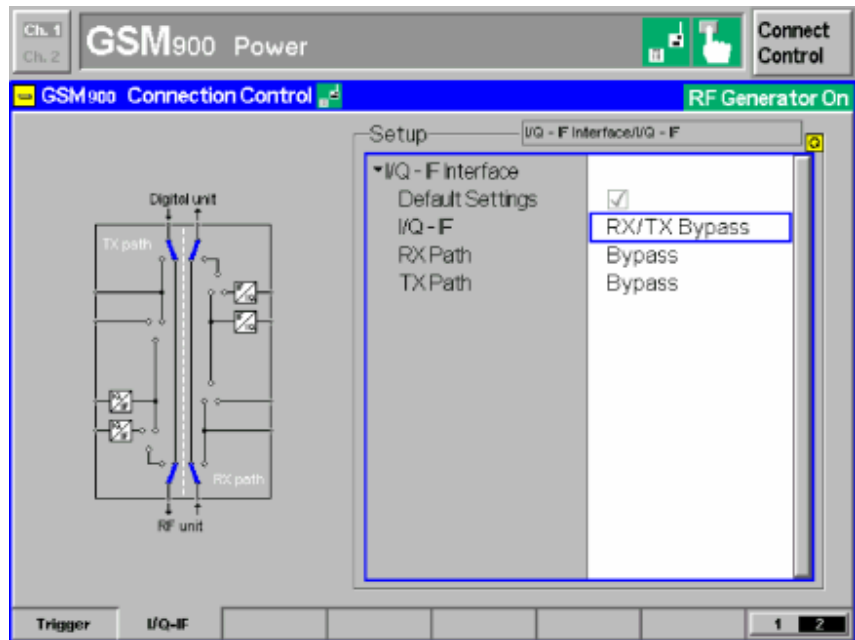


Fig. 8 IQ/IF Bypass Configuration

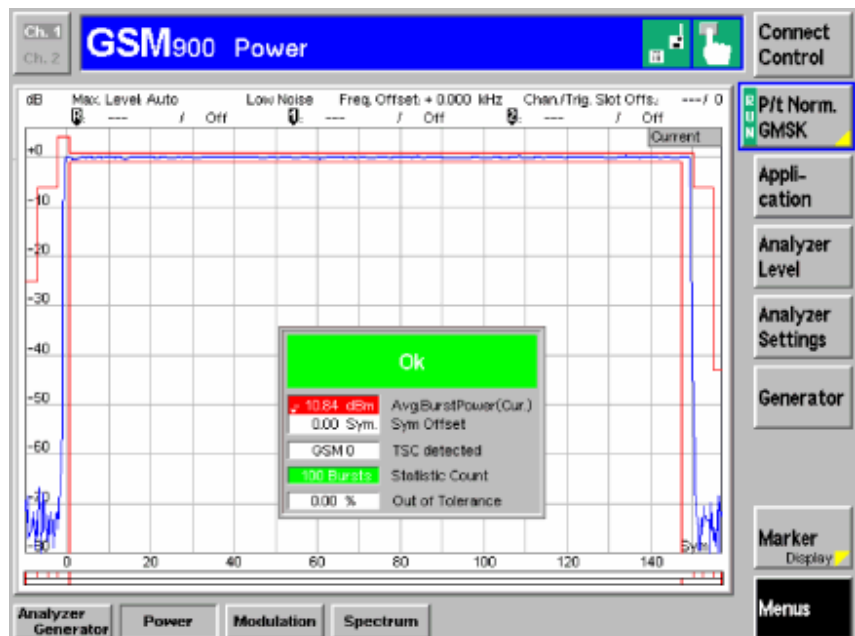


Fig. 9 Burst Power in Bypass Mode

## Receiver Tests under Fading with CMU and ABFS/SMIQ

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

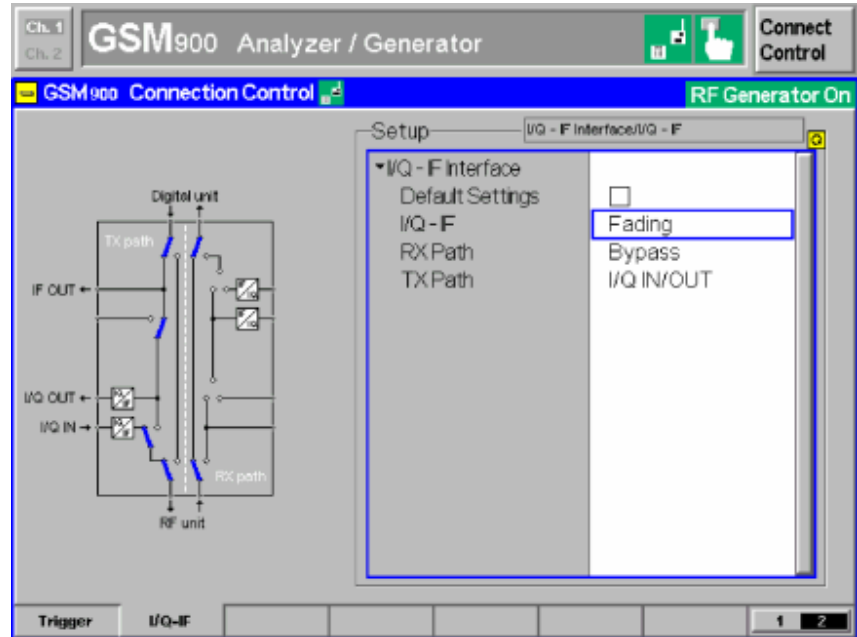


Fig. 10 IQ/IF Fading Configuration

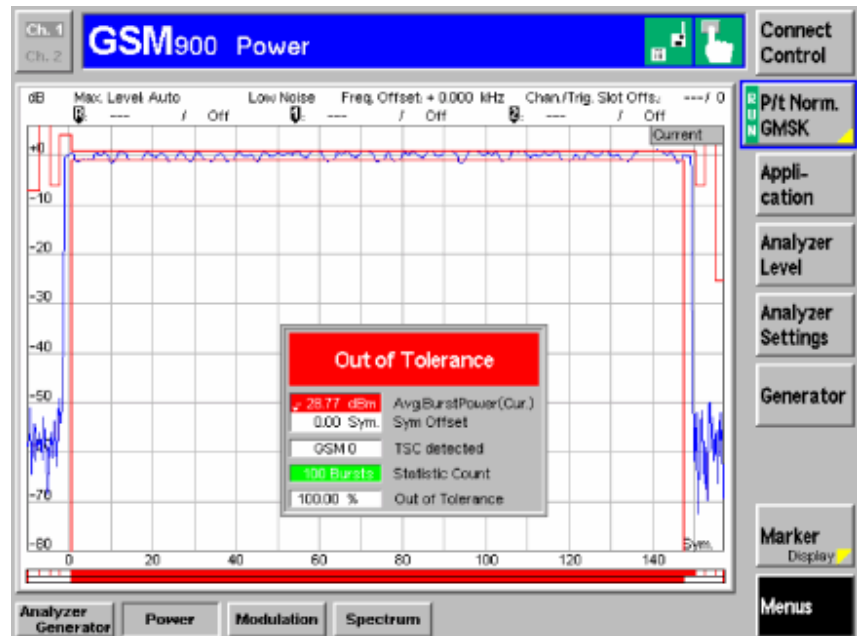


Fig. 11 Burst Power with Calibration Mode Standard Fading

6. The resulting Average Burst Power  $P_{MEAS}$  (Fig. 11) must be subtracted from the reference power  $P_{REF}$  (Fig. 9) to obtain the hardware attenuation of the IQ path.

$$\text{Hardware Loss} = P_{ref} - P_{meas} = -10.84\text{dBm} + 28.77\text{dBm} = 17.93\text{dB}$$

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

### 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 **GSMFADLEVCOR v1.xx.MSI** and select the installation directory. A new menu item **GSMFADLEVCOR** is created in **START -> PROGRAM FILES**. The installation directory contains the files named below:

<b>GSMFADLEVCOR.EXE</b>	Executable
<b>GSMFADLEVCOR.CFG</b>	Configuration file
<b>GSMFADLEVCOR.CHM</b>	Online help manual

### Running the Level Correction Software

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

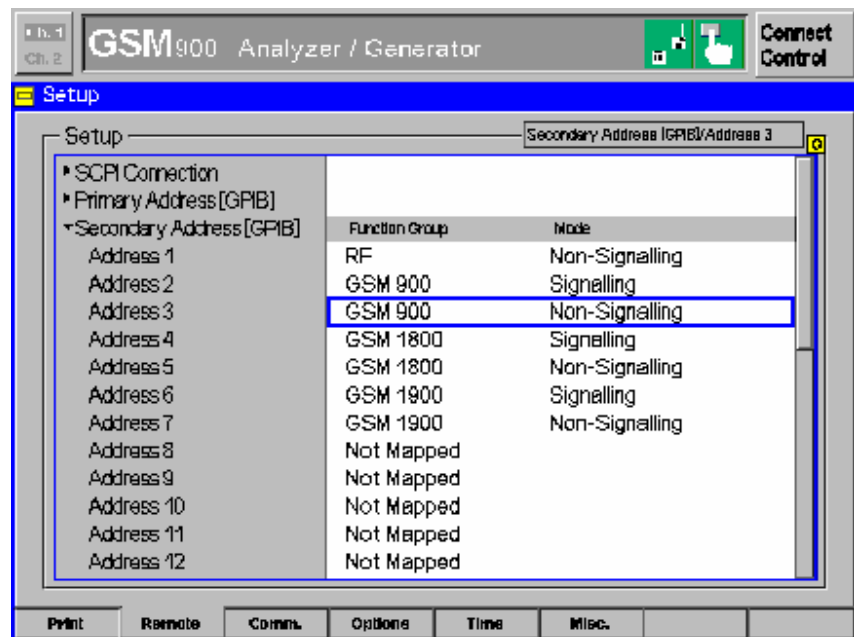


Fig. 12 CMU GPIB secondary address setup

## ***Receiver Tests under Fading with CMU and ABFS/SMIQ***

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Start **GSMFADLEVCOR.EXE** on the PC.

### **Menu**

#### **File**

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

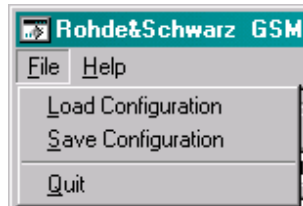


Fig. 13 Menu Items

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

X = last horizontal window position

Y = last vertical window position

CMU GPIB primary address

CMU GPIB secondary address of GSM non signalling module

CMU GPIB secondary address of GSM signalling module

ABFS/SMIQ GPIB primary address

Cable Loss

Hardware Loss

Calibration / Measurement Mode flag (0=Cal, 1=Meas)

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

### Devices

In the **DEVICES** menu the primary (**PAD**) and secondary non signalling and signalling secondary addresses (**SAD**) according to the CMU settings may be selected. Initialize the CMU and ABFS / SMIQ by pressing the corresponding **INIT** buttons.

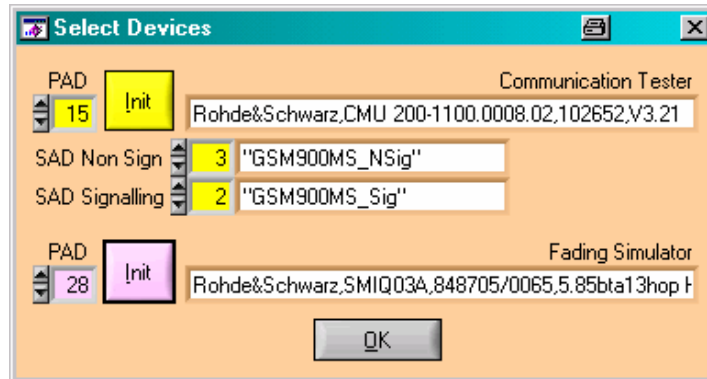


Fig. 14 Select Devices

- CT (communication tester) **PAD** – GPIB primary address of the CMU. Range: 0 to 30.
- CT **SAD Non Sign** – GPIB secondary address of the CMU option to be used for Calibration Mode. Range: 1 to 29.
- CT **SAD Signalling** – GPIB secondary address of the CMU option to be used for Measurement Mode. Range: 1 to 29.
- CT **INIT** – Checks for the presence of a device and displays the identification string of a device found in the text field.
- FS (Fading Simulator) **PAD** – GPIB primary address of the ABFS/SMIQ. Range: 0 to 30.
- FS **INIT** – Checks for the presence of a device and displays the identification string of a device found in the text field.

After both instruments have been initialized correctly the identification strings of the devices are displayed. By pressing **OK** the program returns to the main windows and also sets the ABFS / SMIQ RF frequency to the same frequency the CMU generator has in signalling mode.

### Help

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

### Controls and Indicators

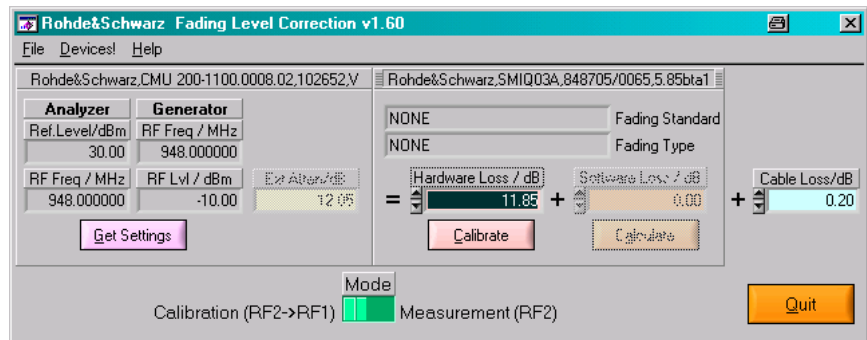
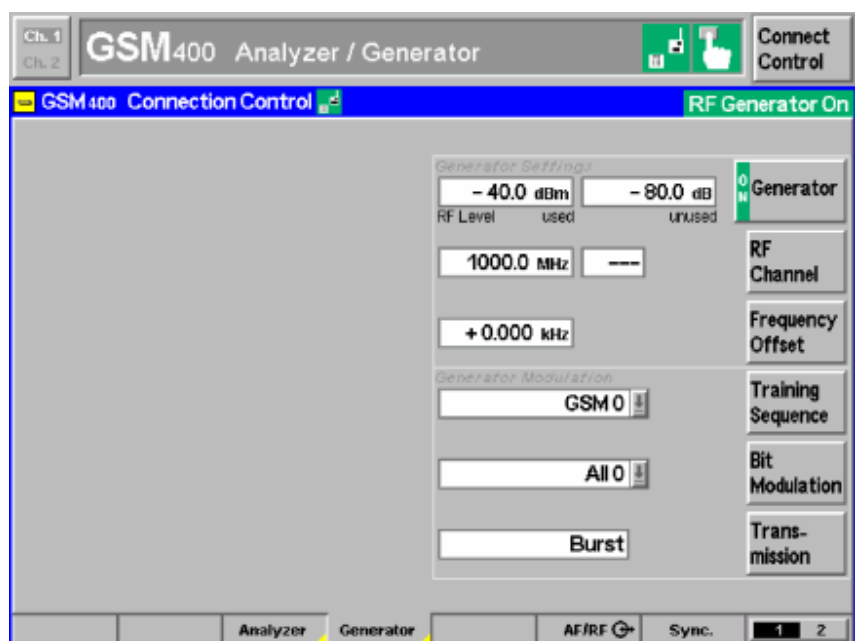


Fig. 15 Program Window

- **GET SETTINGS** reads the following CMU generator and analyzer settings.
  - Analyzer **RF FREQUENCY**
  - Analyzer **REFERENCE LEVEL**
  - Generator **RF FREQUENCY** (non signalling) or **CHANNEL** (signalling). The ABFS / SMIQ is automatically set to the RF frequency corresponding to the CMU generator CHANNEL in signalling mode.
  - GENERATOR **RF LEVEL** of used time slot (non signalling) or BCCH/TCH level (signalling).

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



## ***Receiver Tests under Fading with CMU and ABFS/SMIQ***

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Fig. 16 GSM Non-Signalling RF Level used



## Receiver Tests under Fading with CMU and ABFS/SMIQ

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

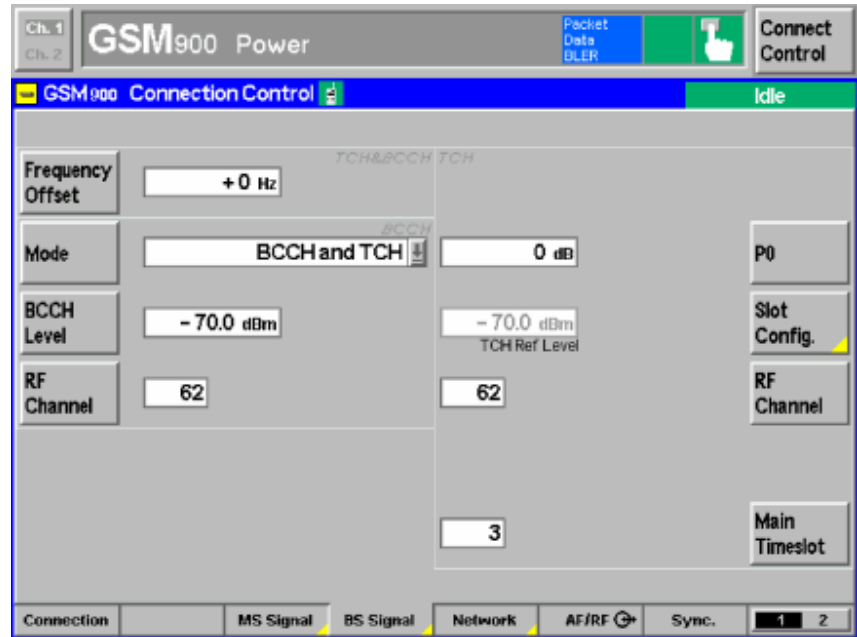


Fig. 17 GSM Signalling BCCH and TCH Level

- **CABLE LOSS** – the user specified attenuation for the cable from the RF2 connector to the DUT. The **CABLE LOSS** is added to the level offset **EXT ATTEN**.
- **MODE** – chooses between **CALIBRATION** and **MEASUREMENT** Mode. The ABFS / SMIQ is automatically set to the RF frequency corresponding to the CMU generator CHANNEL in signalling mode.

In **CALIBRATION MODE** the **HARDWARE LOSS** and **CALIBRATE** controls are high lighted and the CMU **EXTERNAL ATTENUATION** is turned **OFF**.

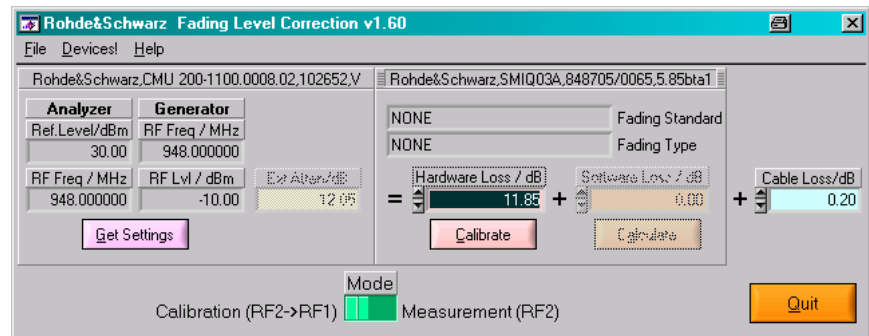


Fig. 18 Main Window Calibration Mode

- **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.

## Receiver Tests under Fading with CMU and ABFS/SMIQ

In **MEASUREMENT MODE** the **CALCULATE** and **SOFTWARE LOSS** controls are high lighted and the CMU **EXTERNAL ATTENUATION** is turned **ON**.

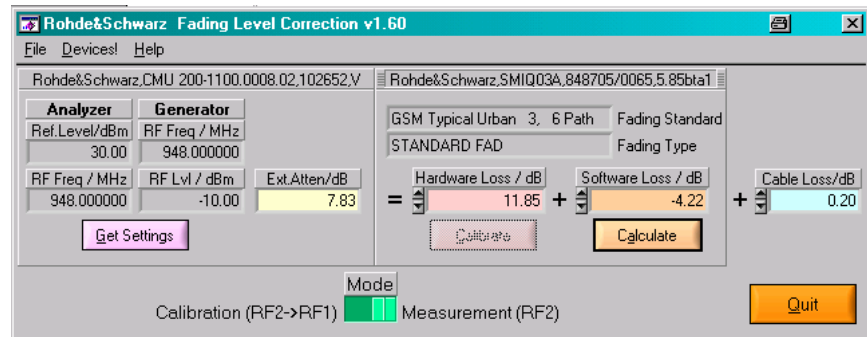


Fig. 19 Main Window Measurement Mode

- **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.
- **FADING TYPE** – Displays current fading type after pressing Calculate. Range: STANDARD FAD.
- **FADING STANDARD** – Displays current fading standard after pressing **CALCULATE**. The GSM fading profiles can be selected on the ABFS / SMIQ by pressing.

### GROUP A 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

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.

## ***Receiver Tests under Fading with CMU and ABFS/SMIQ***

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- **EXT ATTEN** – Indicator for level offset which is applied to the output power to compensate for **HARDWARE LOSS**, **SOFTWARE LOSS** and **CABLE LOSS**.

$$ExtAtt = HWLoss + SWLoss + CableLoss$$

The maximum value depends on the device specification. GSMFADLEVCOR displays the following error message in case the CMU generator exceeds its maximum output level due to the **EXT ATTEN** value.



Fig. 20 Level Warning

Note: The **EXT ATTEN** 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. In **MEASUREMENT** Mode the **EXT ATTEN** value is immediately transferred to the CMU.

## 5 Testing MS Receiver Quality with BER Measurements Under Fading Conditions

A criteria for MS or BS receiver quality is the bit error rate (BER), the average Bit Error Rate (BER Average), Neighbor Cells or BLock Error Rate (BLER) which are specified in the GSM/GPRS/EDGE test standards for base and mobile stations. The following example describes a MS BER measurement under fading conditions.

1. Connect **RF2<sub>OUT</sub>** with **RF1<sub>IN</sub>** on the CMU.
2. Start **GSMFADLEVCOR.EXE** and **INIT** devices.
3. Switch to **CALIBRATION MODE**.
4. Set equal CMU generator and analyzer frequencies, e.g. 948MHz.
5. Set CMU generator level to -10dBm.
6. Determine the **HARDWARE LOSS** by pressing the **CALIBRATE** button.

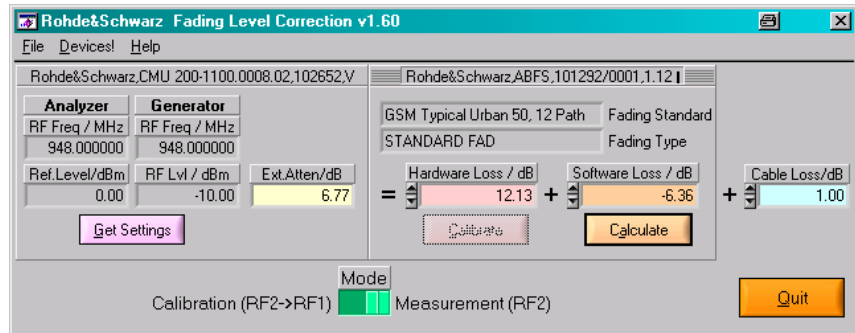


Fig. 21 GSMFadLevCor Setup

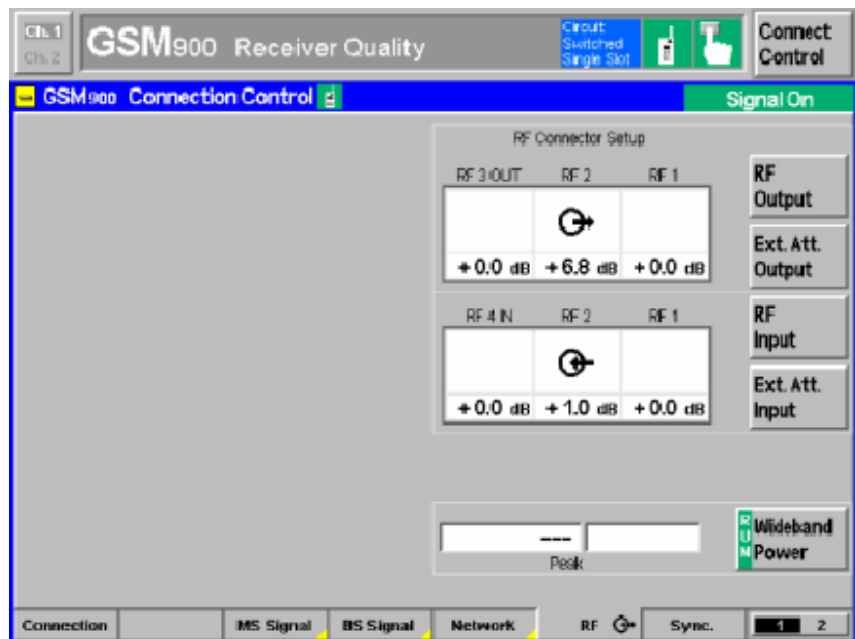


Fig. 22 Connection Control

## Receiver Tests under Fading with CMU and ABFS/SMIQ

7. Switch to **MEASUREMENT MODE** which automatically updates the CMU external attenuation with the **EXT ATTEN** value.
8. **IMPORTANT!!** Set the ABFS / SMIQ to the same RF frequency as the CMU generator in order to obtain reproducible BER values later on.  
ABFS: **GROUPA FSIM -> STANDARD FAD -> RF FREQUENCY -> e.g. 948MHZ.**  
SMIQ: **FREQ -> e.g. 948MHZ**
9. Select the desired fading profile on the ABFS / SMIQ, e.g. **GSM TYPICAL URBAN 50**.
10. Calculate the **SOFTWARE LOSS** by pressing the **CALCULATE** button.
11. Optionally edit the **CABLE LOSS**, e.g. 1.00dB.
12. Switch the CMU to **RF<sub>2</sub><sub>INOUT</sub>** mode and connect the MS to RF2.
13. When changing the fading profile repeat the procedure starting with step 8.)
14. To select the BER Average test choose **GSM900 SIGNALLING** mode -> **RECEIVER QUALITY -> APPLICATION -> BER Average** on the CMU.

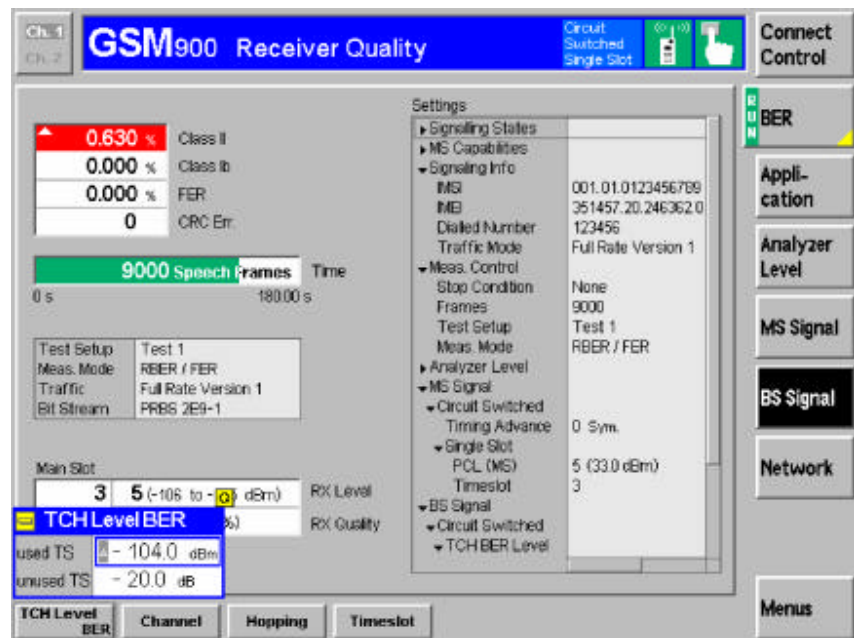


Fig. 23 BER Measurement

15. Establish a GSM call by turning the MS on and dialing a number, or by pressing **CONNECTION -> CONNECT MOBILE** on the CMU and accepting the call on the MS.
16. Optionally set **BER -> STOP CONDITION -> NONE** in case precise measurement values are required for statistical reasons.
17. Set **BER -> FRAMES -> i.e 9000 FRAMES** for conformance tests.
18. The BS output level control may be accessed by pressing **BS SIGNAL -> TCH LEVEL BER** on the CMU.

## Receiver Tests under Fading with CMU and ABFS/SMIQ

19. The resulting **CLASS IB** and **CLASS II** BER is displayed on the CMU.

A common BER application is the **CLASS II BER** vs. MS input level **TCH** (Transport Channel) under fading conditions. The example below shows a TCH level sweep from -90 dBm to -110 dBm and was performed with a CMU200, SMIQ + SMIQ-B15 and a CMU-Z11 shielded chamber for the MS. The fading profile used is **Typical Urban 50 km/h, 6 paths (TU50 6)**.

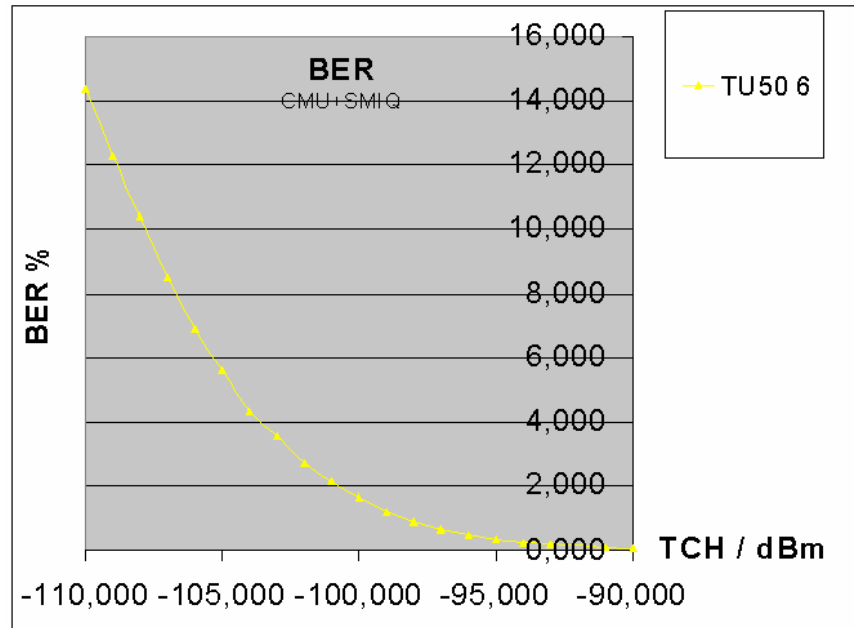


Fig. 24 Class II BER vs. TCH

**Note:** In order to obtain correct, reproducible BER values it is essential that the ABFS / SMIQ is set to the RF frequency corresponding to the CMU generator channel in signalling mode.

## 6 Additional Information

Please contact [TM-Applications@rsd.rohde-schwarz.com](mailto:TM-Applications@rsd.rohde-schwarz.com) for comments and further suggestions.

## 7 Ordering information

<b>Communication Tester</b>		
CMU 200		1100.0008.02
CMU 300		1100.0008.03
<b>Vector Signal Generator</b>		
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
<b>Fading Simulator</b>		
ABFS Fading Simulator		1111.8506.02
<b>Options</b>		
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
<b>Accessories</b>		
CMU-Z11	Shielded Chamber for Mobile Stations	1150.1008.02

*Note:* SMIQs equipped with the option SMIQ-B17 Noise and Distortion Simulator require additional conditioning in order to be suited for this application note. Please contact [TM-Applications@rsd.rohde-schwarz.com](mailto:TM-Applications@rsd.rohde-schwarz.com) for further details.



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*This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.*