Products: R&S®CMU, R&S®ABFS, R&S®CMU-B17, R&S®CMU-B69, R&S®CMU-Z10, R&S®CMU-Z11

UTRA-FDD Receiver Tests Under Fading Conditions with R&S® CMU and R&S® ABFS

Application Note

This application note describes how to generate UTRA-FDD signals for receiver tests under fading conditions for UTRA-FDD mobile and base station equipment. The test setup requires an R&S®CMU200 Universal Radio Communication Tester with option R&S®CMU-B17 IQ-IF interface and an R&S®ABFS Base Band Fading Simulator. The UtraFddFadCal program included with this application note performs an automatic level correction of the power fed to the User Equipment (UE) by adding a RF power offset equivalent to the IQ path loss.

ROHDE & SCHWARZ

Contents

1 Overview

The signal strength and quality of signals received by 3GPP Base Stations (Node-B) and Mobile Stations (User Equipment or UE) 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 Fine Delay, Moving Propagation and Birth-Death propagation fading. This application note describes how to connect a R&S®Radio Communication Tester CMU with IQ-IF interface option CMU-B17 to a R&S®ABFS baseband fading simulator for generating UTRA-FDD signals suitable for tests under fading conditions according to specification 3G 34121-531. The supplied program UtraFddFadCal calibrates the attenuation of an external fading simulator R&S®ABFS connected to the R&S®CMU IQ loop. UtraFddFadCal can also calculate the mathematical signal loss resulting from various fading profiles and noise influence and automatically adds an equivalent offset to the R&S®CMU RF power.

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

- The R&S®CMU200 Universal Radio Communication Tester is referred to as CMU.

- The R&S®ABFS Base Band Fading Simulator is referred to as ABFS.

- R&S®means Rohde & Schwarz GmbH und Co KG

2 Software Features

- Program and device configuration storage

- Auto detection of ABFS fading model and active paths

- CMU GPIB secondary address setup

- Automatic Insertion Loss calibration routine

- Quick calculation of the RF power compensation factor affected by fading effects and Additive Gaussian White Noise.

3   Hardware and Software Requirements

Hardware Requirements

The software runs on a PC with

CPU	Pentium 330MHz or better
RAM	128 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 98SE/NT/2000/XP	Microsoft operating system
NI-488.2 V1.7 (or above)	IEC/IEEE – bus driver from National Instruments. See http://www.natinst.com for latest revision.
NI-VISA V3.0 (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. Not required for Windows 2000/XP.

Note: *In case only the NI-488.2 GPIB driver is installed but no VISA driver the program will react as if there were no device connected to the GPIB bus.*

4   UTRA-FDD Fading on Baseband Level (IQ) with CMU and ABFS

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 the cable no. 1100.6993.00 which is included in the CMU-B17 option. The UE (user equipment) or BS (base station) is connected to the RF2 connector of the CMU, which is set to bidirectional operating mode (input/output).
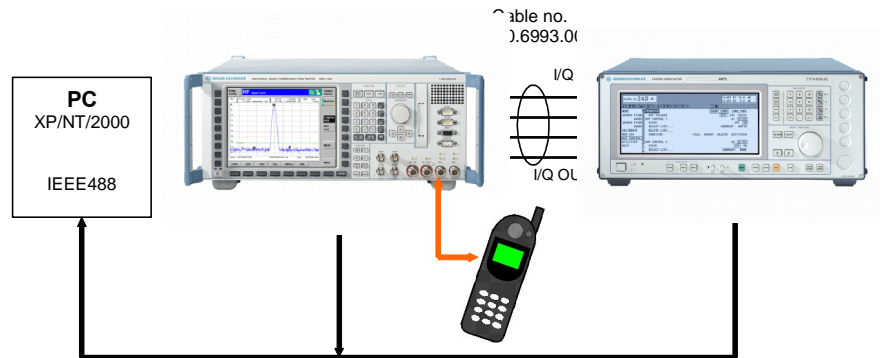

Fig. 1   CMU and ABFS Connection

Basics of Fading Tests with IQ IF Loop

The ABFS adds fading and noise effects to the CMU signal on the IQ level (baseband). When an ABFS is inserted into the CMU IQ loop by switching on the CMU-B17 option, the signal power decreases due to the losses on the switched path. The ABFS 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 UE the CMU generator level setting must compensate this insertion loss. This is achieved by setting the EXTERNAL ATTENUATION parameter of the CMU generator to the value of this insertion loss.

The ABFS fading simulator supports several UTRA-FDD fading standards (3GPP_BS_4.1.0_Case1...Case4, 3GPP_UE_4.1.0_Case1...Case6, 3GPP_3.0_MOVING, 3GPP_3.0_BIRTH-DEATH) with multiple paths and profiles (Rayleigh, Pure Doppler, etc.).

A power component (Fading Gain) resulting from the sum of the power of each path must be added to the Insertion Loss in order to obtain the correct total loss of the ABFS IQ path.

Additive white Gaussian noise (AWGN) is added to simulate the presence of communication traffic at the input of the receiver under test.

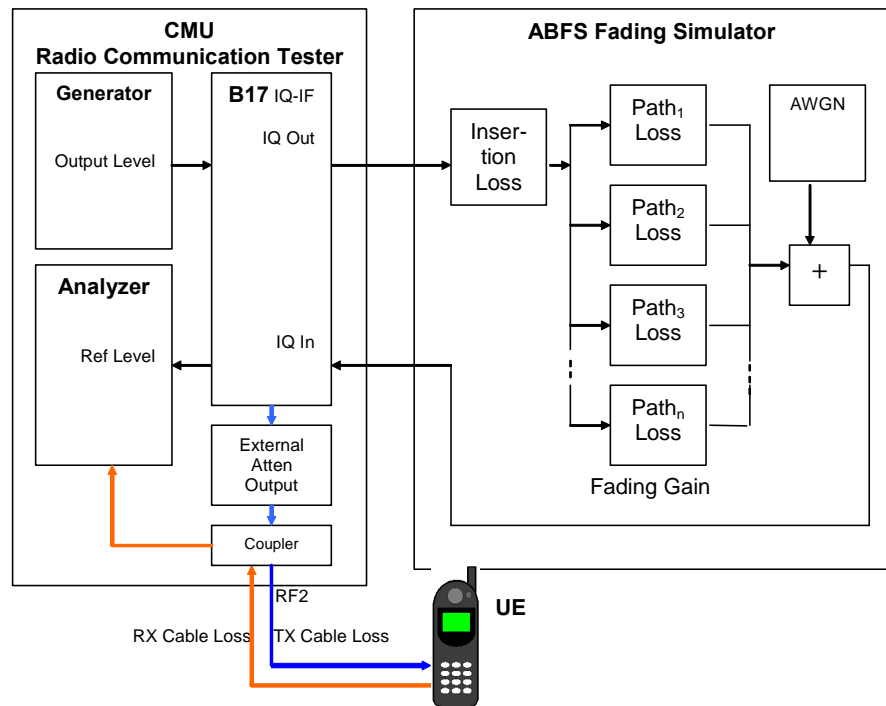The following schematic shows the signal paths and their calculation.

Fig. 2 Fading with IQ IF Loop

Insertion Loss

The **INSERTION LOSS** is defined in the program **UTRAFDDFADCAL.EXE** as the ABFS insertion loss plus of the loss of the IQ cable to and from the CMU. It must be measured only once for each hardware configuration.

Note: *The ABFS insertion loss is 12dB with **INSERTION LOSS SETTING MODE -> AUTO** and can be varied from 6 to 24dB with **INSERTION LOSS SETTING MODE -> MANual**.*

Fading Gain

The **FADING GAIN** is the gain caused by the sum of various fading paths power components. This value is usually positive for standard fading pro-files with at least one path with 0dB loss. The **FADING GAIN** must be updated each time the fading profile is changed and is calculated as follows:

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

P_nLOSS = Loss of n-th path (appears as negative gain in the formula). The maximum number of paths is N = 12 for the ABFS.

Since the paths are switched together in parallel, the sum of the power am-plification factors (linear path losses) must be added and the resulting sum logarithmized.

Note: *The formula above applies to fading profiles consisting of non cor-related signal paths (usually Raleigh for all standards). The calcu-lated 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.*

AWGN Level

The AWGN Level is the additional amount of power applied to the UE by adding White Gaussian Noise with a specified signal to noise ratio to the faded signal. The following schematic and formulas show the functional layout of the IQ path and its calculation.
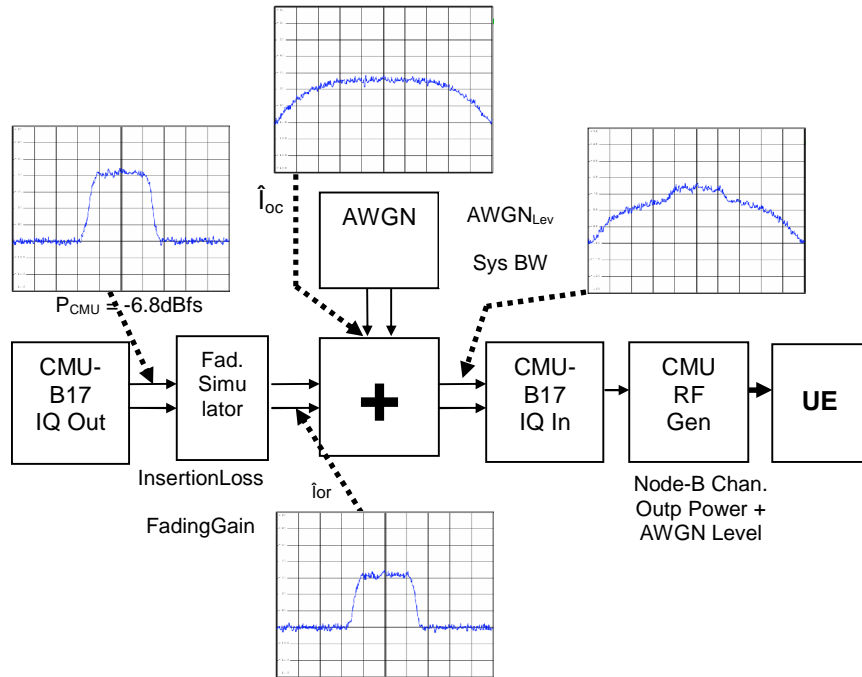

Fig. 3 IQ Path

The CMU I or Q output supplies a peak voltage of:

$$Upp \qquad = 0.5V$$

The corresponding level P_{MAX} at a 50 Ohm terminated lead is:

$$P\max \qquad = 10 * \log\left(\frac{Upp^2}{50\Omega * 1mW}\right)$$

$$= 10 * \log\left(\frac{0.25W}{0.05W}\right)$$

$$\approx +7dBm = 0dBfs$$

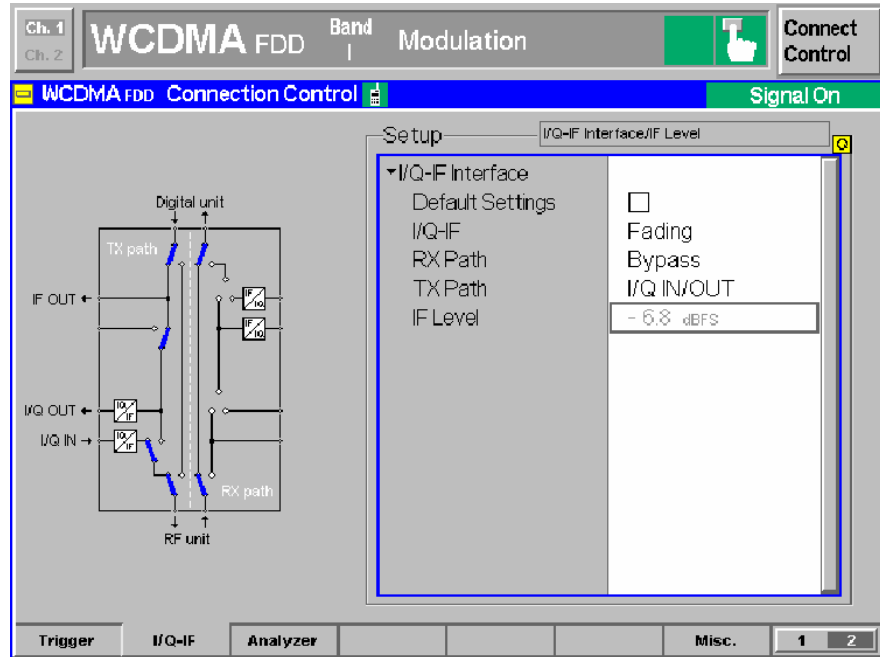The dynamic margin for UTRA-FDD signals is factory set to

$$DynMar \qquad = -6.8dBfs$$

Fig. 4 IF Level

The UTRA-FDD IQ baseband power level P_{CMU} at the CMU-B17 outputs is factory adjusted to:

$$Pcmu = P\max - DynMar$$

$$= 7dBm - 6.80dB$$

$$= +0.20dBm$$

The output power of the fading simulator is:

$$\hat{I}or/dB = Pcmu - InsertionLoss - FadingGain$$

$$= 0.2dBm - 12.72dB + 4.77dB = -7.75dBm$$

The power supplied by the noise and distortion simulator NDSIM ($\hat{I}oc =$ AWGNLevel) is referenced to 0.5Vpp = +7dBm. The maximal AWGNLevel possible on the ABFS is -17dBfs = -10dBm. The ABFS sets the AWGN bandwidth to 1.4 times the chip rate so the noise level is constant in the measured 3GPP channel.

$$\hat{I}oc/dB = P\max + AWGNlev - 10*\log\left(\frac{SysBw}{3.84MHz}\right) = -4.75dBm$$

The signal to noise ratio Îor/Ioc defined in the test specification (e.g. -3dB) and depends on following formula:

$$\frac{\hat{I}or}{Ioc} / dB = Pcmu - InsertionLoss - FadingGain - P\max$$

$$- AWGNlev + 10 * \log\left(\frac{SysBw}{3.84MHz}\right)$$

Note: *The noise spectral density of ABFS is flat within 1.4 times the set system bandwidth. This means, with a system bandwidth of 3.84MHz you obtain flat noise within 5.376 MHz. The 3GPP specification however requires 3.84 MHz * 1.5 = 5.76 MHz noise bandwidth. In our opinion, 5.376 MHz is sufficient for all hardware tests. For all cases, where a noise bandwidth of 5.76 MHz is mandatory, we suggest to set the system bandwidth of the ABFS to 3.84 MHz * 1.5 / 1.4 = 4.114 MHz. In UtraFddFadCal AWGNLev is compensated depending on the System Bandwidth.*

The ABFS accepts only the (absolute) AWGN level so the formula above needs to be solved accordingly (e.g. InsertionLoss determined by calibration=12.72dB, FadingGain for Fine Delay 3GPP_UE_4.1.0_Case2 fading profile with 3 paths, 0dB = 4.77dB).

$$AWGNLvl = Pcmu - InsertionLoss - FadingGain - P\max - \hat{I}or\big/Ioc$$

$$= 0.20dBm - 12.72dB + 4.77dB - 7dB + 3dB$$

$$= -11.75dBm$$

After adding AWGN to the signal the output power is:

$$OutputPower = 10 * \log\left(10^{\frac{\hat{I}or}{10}} + 10^{\frac{Ioc}{10}}\right)$$

$$= 10 * \log\left(10^{-0.775} + 10^{-0.475}\right)$$

$$= -2.98dBm$$

Example: Fading profile (FSIM -> FINE DELAY -> STANDARD -> 3GPP_UE_4.1.0_Case3) and Îor/Ioc -1dB. The **INSERTION LOSS** has been measured according to the calibration routine (e.g. 12.72dB) described in the section "Calibrating the Insertion Loss". The **FADING GAIN** is calculated as shown on p.7 and the **RX/TX CABLE LOSS** has been measured (e.g. 1dB).

Fig. 5 3GPP_UE_4.1.0_Case3

The **EXT**ernal **ATTEN**uation **OUTPUT** is calculated as:

$$ExtAttenOutput = InsertionL\,oss - FadingGain + RxCableLos\,s$$

$$= InsertionLoss -$$

$$\left(10 * \log\left(10^{\frac{-Path1Loss}{10}} + 10^{\frac{-Path2Loss}{10}} + 10^{\frac{-Path3Loss}{10}}\right) + 1.0\right) dB$$

$$= \left(12.72 - 10 * \log\left(10^{\frac{-0}{10}} + 10^{\frac{-0}{10}} + 10^{\frac{-0}{10}}\right) + 1.5\right) dB$$

$$= (12.72 - 4.77 + 1.5) dB$$

$$= 9.45 dB$$

This precise calculation method makes an additional power measurement at the UE input obsolete after changing the fading profile.

Note: *The calculated AWGN level may be checked with a R&S®FSP, R&S®FSU or R&S®FSQ spectrum analyzer.*

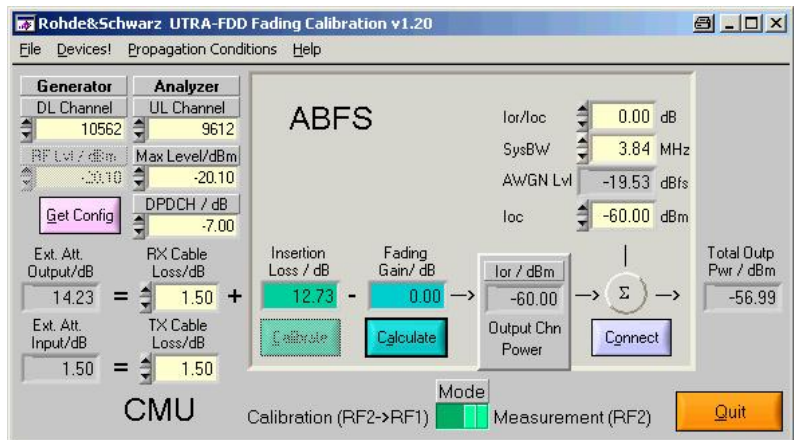1. Set Îor/Ioc to 0.00 dB in **UTRAFDDFADCAL**. (see section 6 for operating instructions).

Fig. 6 Îor/Ioc = 0 dB

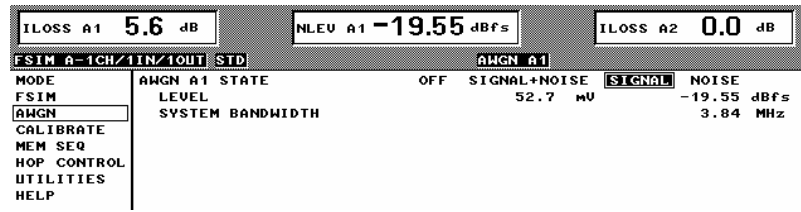2. *Set the ABFS to SIGNAL in the AWGN menu*

Fig. 7 Select Îor only

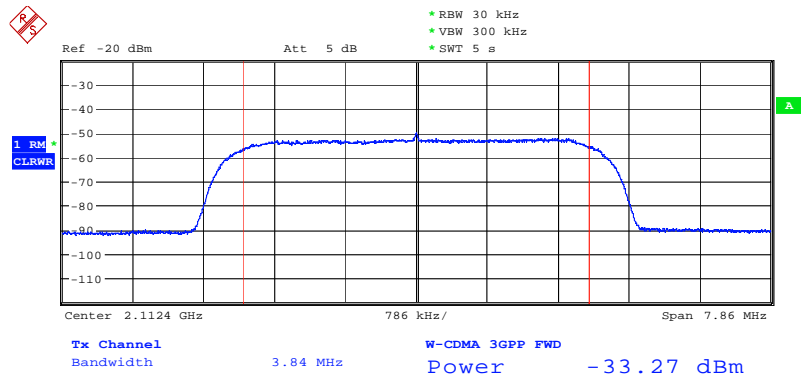3. *Measure the 3GPP channel power with the FSx spectrum analyzer.*

Fig. 8 Measured Îor Power

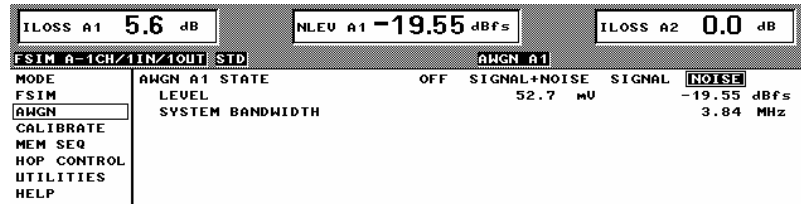4. *Select NOISE in the ABFS AWGN menu.*

Fig. 9 Select Ioc only

5. *Measure the channel power again. Both levels should coincide according to the measurement accuracy.*
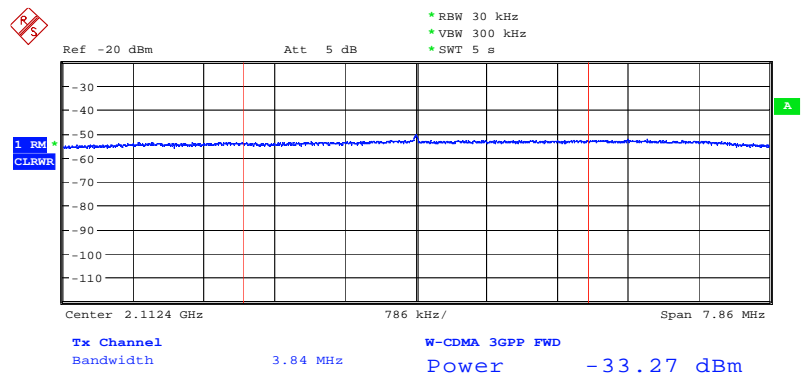

Fig. 10 Measured Ioc power

Rx and Tx Cable Loss

The **RX CABLE LOSS** is the attenuation of the cable from CMU RF2 output connector to the UE and must be specified or measured separately. The same applies for the **TX CABLE LOSS** which, is the attenuation from the UE to the CMU RF2 input. When the combined CMU input/output RF2 is used with one cable connected to the UE, the **RX** and **TX CABLE LOSS** are equal. When using a custom UE adaptor with directional coupler they will differ.

Note: *When the CMU reaches its calibration deadline it may occur that the RF generator level is close to the specified limits. An offset of 0.5dB, for instance, enormously affects all types of error rate measurements (BLER, FER). In case the actual CMU RF output power is less than the nominal level, this may be compensated by increasing the **RX CABLE LOSS** by the difference. In case the measured power is higher than the nominal value the **RX CABLE LOSS** must be decreased by the difference.*

5 Installing the Level Correction Software

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

UTRAFDDFADCAL V1.XX.MSI

DISTFILE.CAB

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

UTRAFDDFADCAL.EXE   Executable

UTRAFDDFADCAL.CFG   Configuration file

UTRAFDDFADCAL.CHM   Online help manual

Before running **UTRAFDDFADCAL** assign at least one of the desired WCDMA $_{FDD}$-UE **SIGNALING** and **NON-SIGNALING** function groups to one or more of the 29 possible GPIB secondary addresses (1..29) on the CMU.
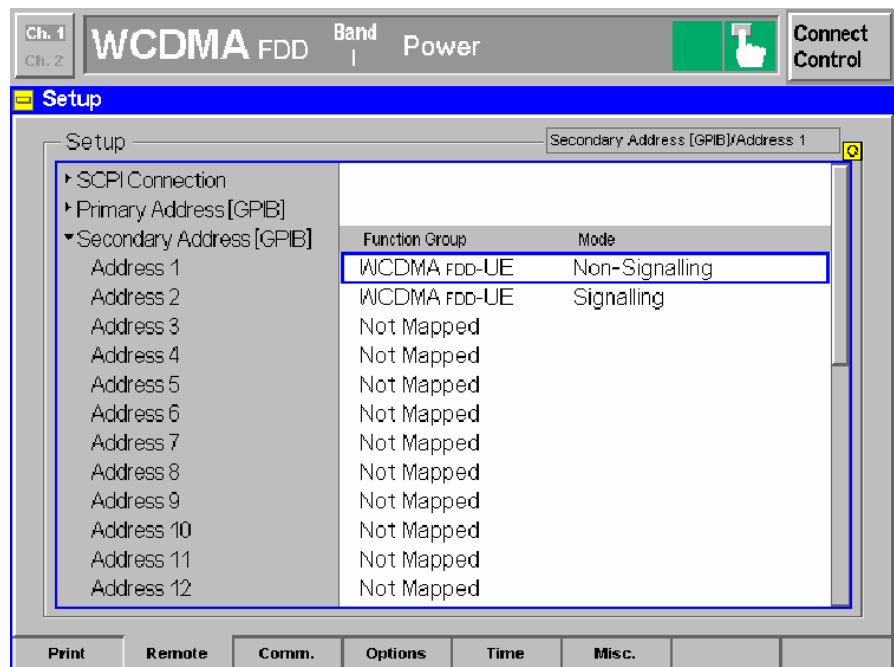

Fig. 11 CMU GPIB secondary address setup

6 Running the Level Correction Software

This section describes the program's menu items and controls. Start **UTRAFDDFADCAL.EXE** on the PC. The program's purpose is to set the CMU external generator attenuation to the calculated ExtAtten value so the CMU generator output level display shows the signal power actually applied to the UE.

Menu

File

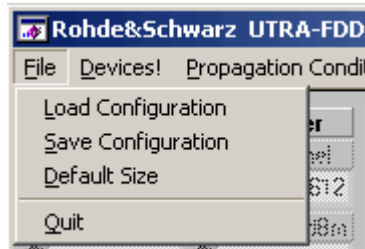All program and device specific data can be saved and loaded from a configuration file.

Fig. 12 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 sec. address of UTRA-FDD PCS non-signaling module
    CMU GPIB sec. address of UTRA-FDD PCS signaling module
    ABFS GPIB primary address
    Cable Loss
    Insertion Loss
    Calibration / Measurement Mode flag (0=Cal, 1=Meas)
    Signal / Noise Ratio
    Width and Height of main window

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

- **DEFAULT SIZE** – Resets program window to original size.

Devices

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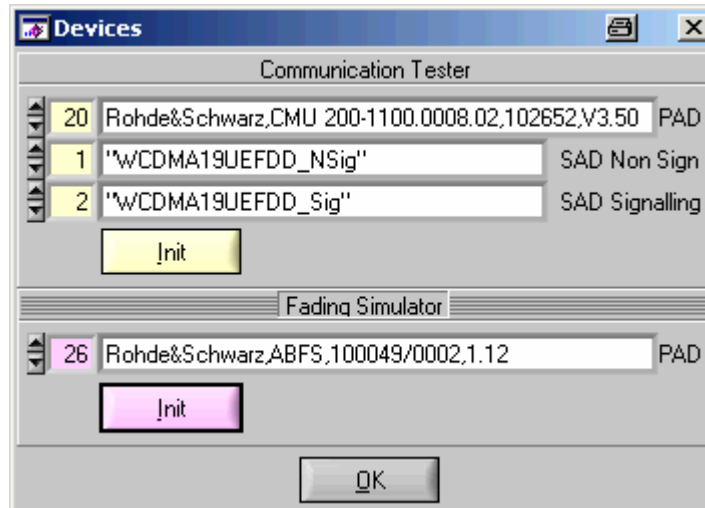

Fig. 13 Select Devices

- CT (communication tester) **PAD** – GPIB primary address of the CMU. <u>Range:</u> 0 to 30.

- CT **SAD Non Sign** – GPIB secondary address of the CMU option to be used for Calibration Mode. <u>Range:</u> 1 to 29.

- CT **SAD Signaling** – GPIB secondary address of the CMU option to be used for Measurement Mode. <u>Range:</u> 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. <u>Range:</u> 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. It also turns the fading and AWGN option ON and sets AWGN system bandwidth (SysBw) to 5.8MHz.

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 RF frequency to the same frequency the CMU generator has in signaling mode.

Propagation Conditions

The menu **PROPAGATION CONDITIONS** allows selection of static propagation (AWGN), multi-path fading propagation (**FINE DELAY**), moving propagation (**MOVING DELAY**) and Birth Death according to UTRA-FDD test specification *3GPP2 C.S0011-B*.
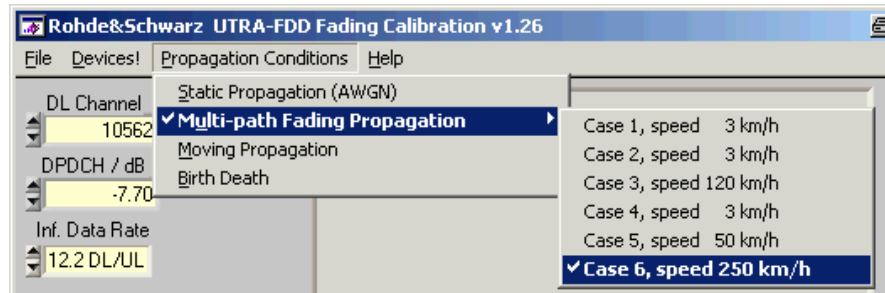

Fig. 14 Propagation Conditions

Please remember to update the **FADING GAIN** and **EXT. ATTEN.** display by pressing the **CALCULATE** button in the main program window after changing the fading profile in the menu or on the ABFS.

Help

- **HELP** – displays online help

- **ABOUT** – displays revision and copyright information

Controls and Indicators

UtraFddFadCal has two different operating modes, the **CALIBRATION MODE** which is used obtain the **INSERTION LOSS** and the **MEASUREMENT MODE, WHICH** allows calculation of the **FADING GAIN**.

Calibration Mode

The **CALIBRATION MODE** is used to measure the hardware dependant **INSERTION LOSS** resulting from the nominal ABFS ILOSS (insertion loss) setting and the loss of the IQ connection cables. The **INSERTION LOSS** is usually ILOSS ± 0.05dB depending on the hardware configuration. In **CALIBRATION MODE** the **INSERTION LOSS** and **CALIBRATE** controls are highlighted and the CMU **EXT**ernal **ATTEN**uation is turned **OFF**.

Note: *Allow sufficient warm-up time for the CMU and ABFS in order to obtain correct measurement results.*
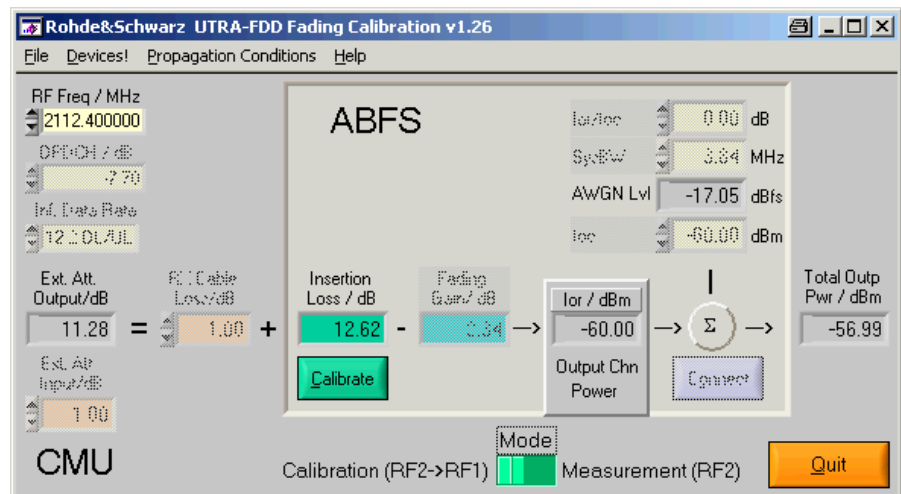

Fig. 15 Main Window Calibration Mode

- Generator **RF FREQ** – Control for CMU generator frequency. The analyzer **RF FREQ**uency indicator is automatically set to the same value. Range 10MHz to 2700MHz.

- Analyzer **RF FREQ** – Indicator for the CMU analyzer frequency. Is automatically set to generator frequency in CALIBRATION MODE.

- **GET CONFIG** reads the following CMU generator and analyzer settings.

  o Generator **RF FREQUENCY** (non signaling) or **CHANNEL** (signaling). The ABFS is automatically set to the RF frequency corresponding to the CMU generator CHANNEL in signaling mode.

  o Analyzer **RF FREQ**UENCY

Note: *The generator and analyzer frequency and level controls/indicator are mainly designated for monitoring purposes. The frequency, for instance is not relevant in calibration mode, since it is a comparative measurement compensating the RF frequency response. In calibration mode the generator level is automatically set to the maximum (-20.1 dBm) and in measurement mode (see p.18-20) this control is dimmed, since **I**OC and **Î**OR/**I**OC determine the level (**OUTPUT CHN POWER**).*

- **MODE** – chooses between **CALIBRATION** and **MEASUREMENT** Mode. The ABFS is automatically set to the RF frequency corresponding to the CMU generator CHANNEL in signaling mode.

- **INSERTION LOSS** – Attenuation of the IQ path as determined manually or by pressing the **Calibrate** button (see section 'INSERTION LOSS' on page 6 for further details).

- **CALIBRATE** – Performs full automatic calibration and updates the **INSERTION LOSS** indicator.

Measurement Mode

The **MEASURMENT MODE** is used to calculate the **FADING GAIN**, switch the CMU to signaling mode and turn on the CMU-B17 fading path. In **MEASUREMENT MODE** the **CALCULATE** button and **FADING GAIN** indicator are highlighted and the CMU **EXT**ernal **ATTEN**uation is turned **ON**.
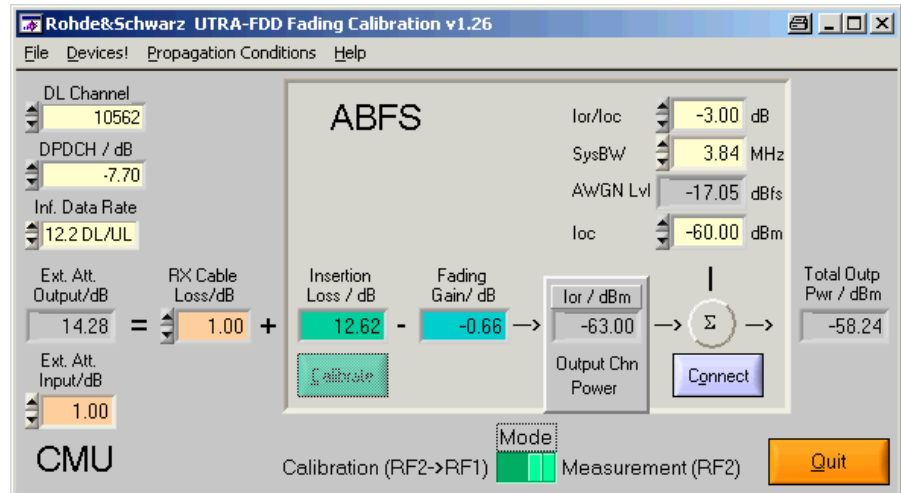

Fig. 16 Main Window Measurement Mode

- Generator **DL CHANNEL** – Control for the CMU generator **D**own**L**ink Channel.

- Analyzer **UL CHANNEL** – Control for the CMU analyzer **U**p**L**ink Channel.

- **DPDCH** – Ratio of the Dedicated Physical Data Channel DPDCH power to the Physical Common Pilot Channel P-CPICH power. Range -35 to +15 dB.

- **INF.DATA RATE** – Bit / symbol rate for test channel. Range 12.2, 64, 144, 384 kbps.

- **FADING GAIN** – Gain resulting from sum of various fading paths. It is calculated by pressing the **CALCULATE** button 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. **FADING GAIN** is updated with the calculated value.

- **Î**OR**/I**OC – Signal / AWGN ratio control prescribed by test specification.

- **S**YS**BW** – ABFS AWGN system bandwidth control. The default setting for 3GPP is 3.84 MHz. Range 10 kHz to 10 MHz.

Note: *The noise spectral density of ABFS is flat within 1.4 times the set system bandwidth. This means, with a system bandwidth of 3.84MHz you obtain flat noise within 5.376 MHz. The 3GPP specification however requires 3.84 MHz * 1.5 = 5.76 MHz noise bandwidth. In our opinion, 5.376 MHz is sufficient for all hardware tests. For all cases, where a noise bandwidth of 5.76 MHz is mandatory, we suggest to set the system bandwidth of the ABFS to 3.84 MHz * 1.5 / 1.4 = 4.114 MHz.*

- **AWGN LvL** – AWGN level in relation to IQ full-scale (= $0.5V_p$). If the calculated value (by pressing **CALCULATE** or changing **Îor/Ioc** or **SYSBW**) is out of range (-50dBm <= AWGN level <= -17dBm) active ABFS path losses are increased accordingly.

Note: The ABFS path losses are reset as soon as you choose a fading profile from the **PROPAGATIONS CONDITIONS** menu in UtraFadCal or manually on the ABFS.

- **IOC** – Control for the AWGN power at 3.84 MHz system bandwidth as defined in the UTRA-FDD specification.

- **RX CABLE LOSS** – the user specified attenuation for the cable from the RF2 connector to the UE including the coupling loss for test adaptors. The **RX CABLE LOSS** is added to the level offset **EXT ATTEN**. This control may be used to compensate CMU RF level offsets (see p.10).

- **EXT ATTEN OUTPUT** – Indicator for level offset which is applied to the output power to compensate for **INSERTION LOSS**, **FADING GAIN**, and **RX CABLE LOSS**.

$$ExtAttenOutput = InsertionLoss - FadingGain + CableLoss$$

UTRAFDDFADCAL displays the following error message in case the CMU generator exceeds its maximum output level due to the **EXT ATTEN OUTPUT** value. If this error occurs press **OK** and enter the correct parameters.

Fig. 18 Level Warning

- **EXT ATTEN INPUT** – Control for TX CABLE LOSS.

Note: *The EXT ATTEN OUTPUT and INPUT displays are automatically updated when the CALIBRATE or CALCULATE buttons are pressed or the RX CABLE LOSS and EXT.ATT.INPUT values are changed manually. In MEASUREMENT Mode the EXT ATTEN OUTPUT and INPUT values are immediately transferred to the CMU.*

- **CONNECT** – Turns ABFS fading and AWGN OFF in order to ease UE registering and connection (When fading and AWGN is turned ON during this procedure the mobile may lose synchronization and drop the connection).

Note: *For a safe registration and connection of your mobile press the* **CONNECT** *button first. Then register your mobile phone into the CMU provided WCDMA network by turning it OFF and ON. The CMU shows that the registration has been successful by displaying a different window requesting you to press the* **CONNECT UE** *button for connection build-up. After the connection has been established press OK in the* MOBILE AND REGISTRATION *window which turns ABFS fading and AWGN ON again. Now all conditions are met to perform a BER or BLER measurement.*
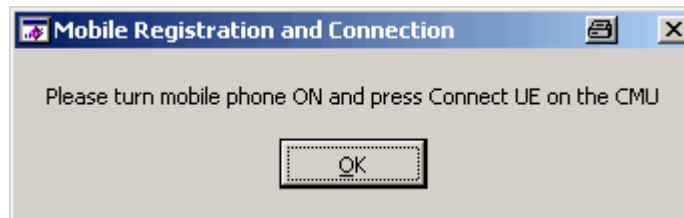
Fig. 19 Mobile Registration and Connection

Calibrating the Insertion Loss

The program **UTRAFDDFADCAL** performs an automatic calibration of the **INSERTION LOSS** after pressing the **CALIBRATE** button. This section describes how this procedure may be done manually.

The **INSERTION LOSS** is device dependant and must be determined only once for an individual setup (CMU + ABFS + IQ connection cables, see fig. 2).

Fig. 20 Calibration Configuration

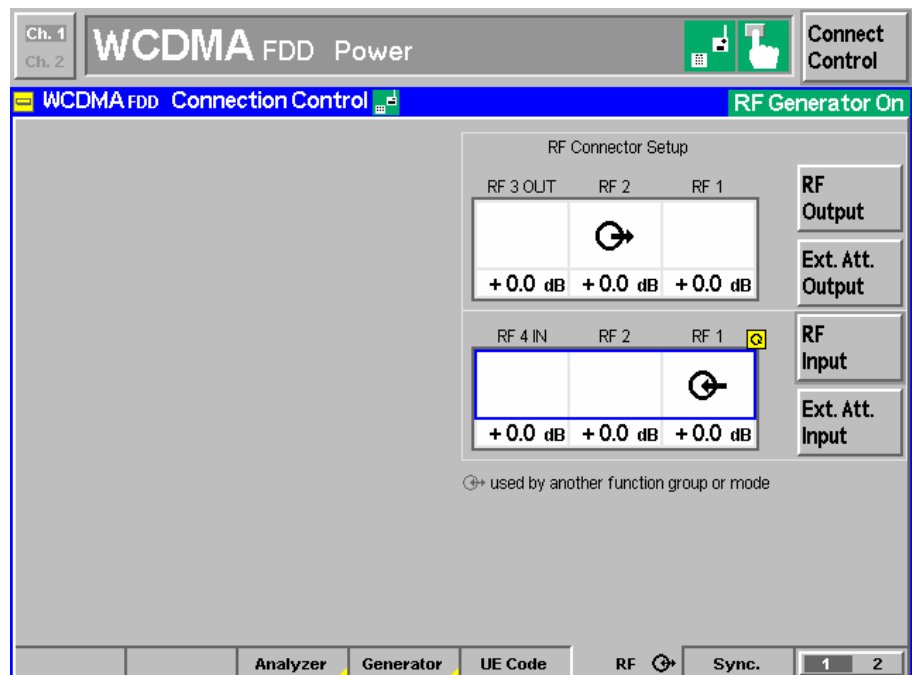1.   Define RF1 as output and RF2 as input on the CMU.

Fig. 21 CMU RF Setup

2. Disable the AWGN generator in the ABFS with **AWGN** -> **AWGN A1 STATE** -> **OFF**.

3. Turn the ABFS fading simulator ON with **FSIM** -> **STANDARD FAD** -> **STATE** -> **RUN**.

4. Switch the ABFS to **FSIM** -> **STANDARD FAD** -> **STANDARD...** -> **CALIBRATION MODE** (1 path, CPHAS profile, 0.0dB path loss). This sets the **FADING GAIN** to zero and the measured value will only reflect the **INSERTION LOSS**.

Fig. 22 ABFS Calibration Mode

5. Select the CMU mode **3G UMTS USER EQUIPMENT** -> **WCDMA FDD** -> **NON SIGNALING** -> **MAXIMUM POWER**.
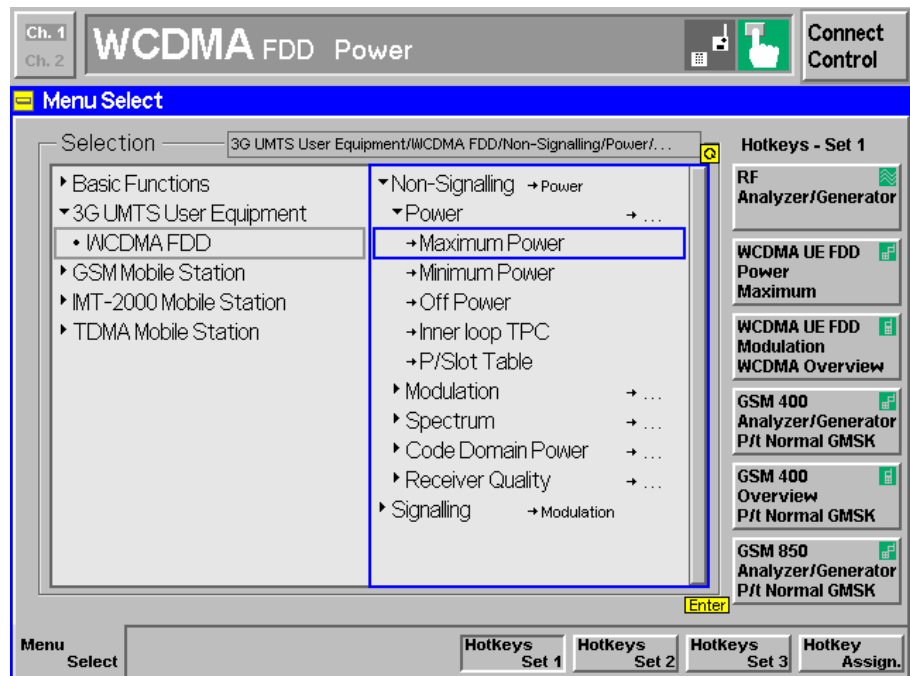

Fig. 23 CMU Mode
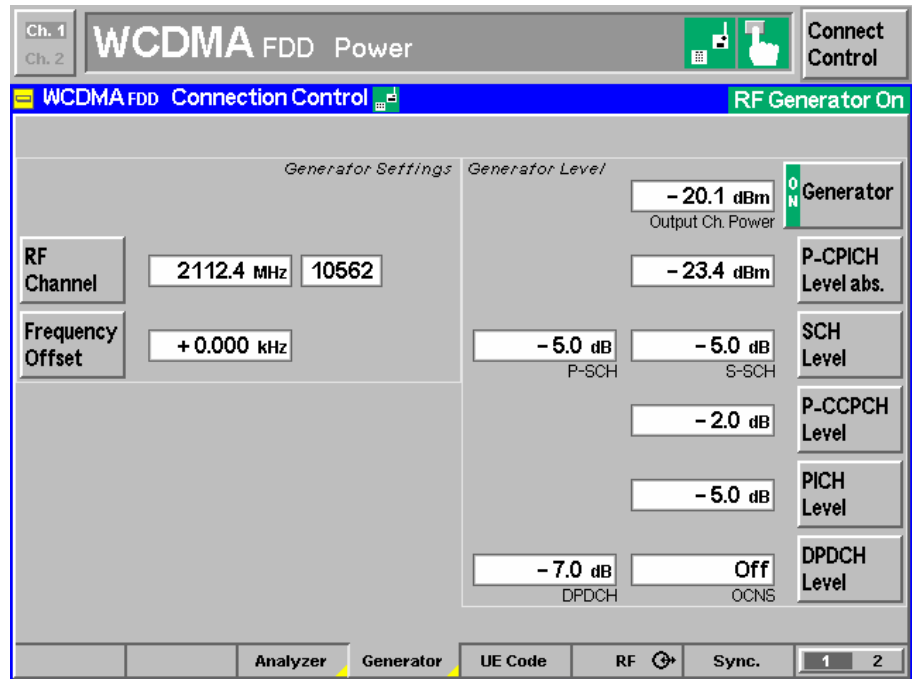
6. Use the following CMU generator settings.

Fig. 24 CMU Generator Setup

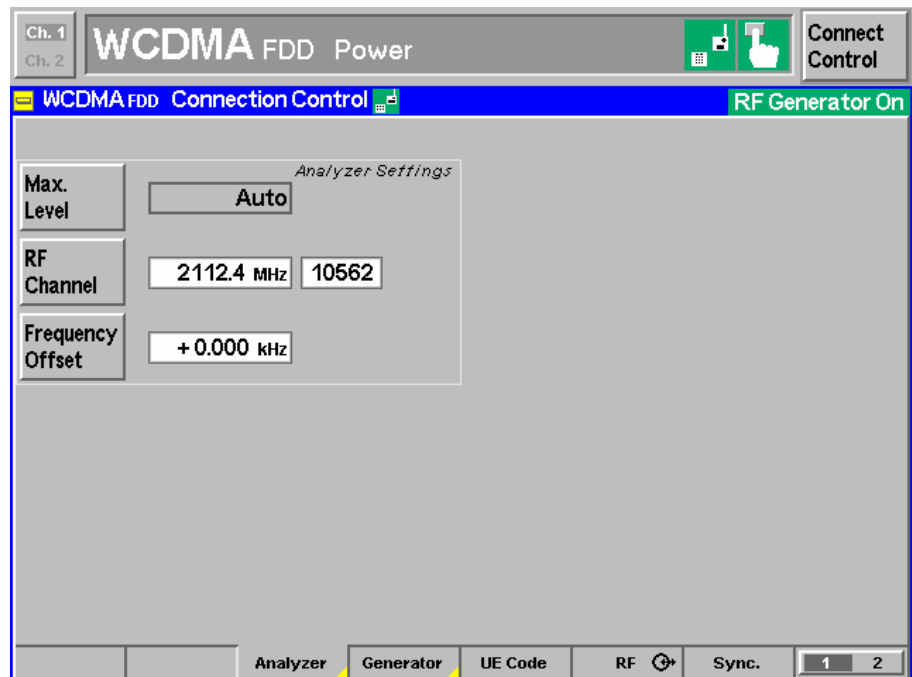7. Set the CMU analyzer to the same frequency or channel as the genera-tor.

Fig. 25 CMU Analyzer Setup

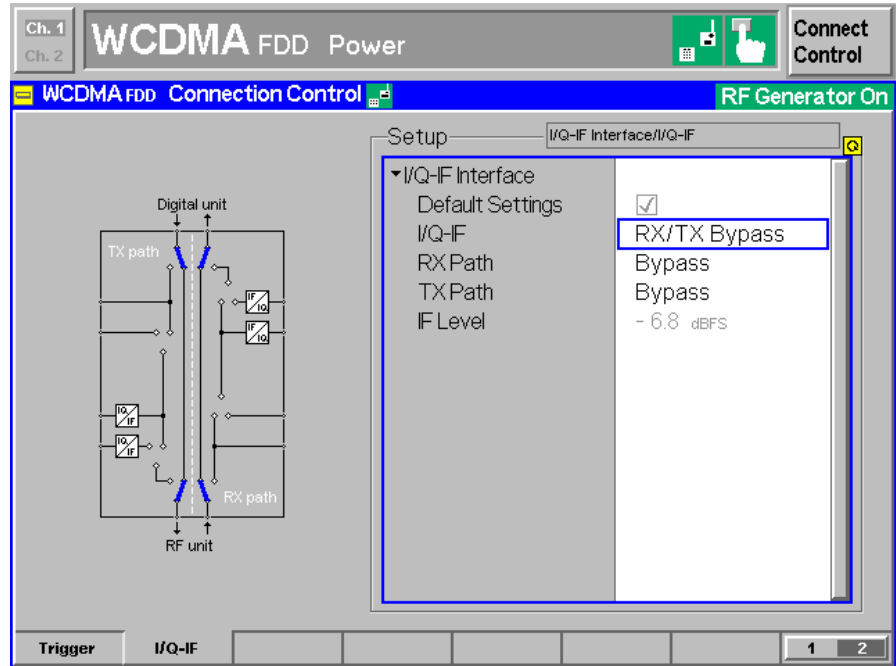8. Set the IQ/IF board to Bypass mode

Fig. 26 IQ/IF Bypass Configuration

in order to obtain the reference Average MS Power **PREF**.
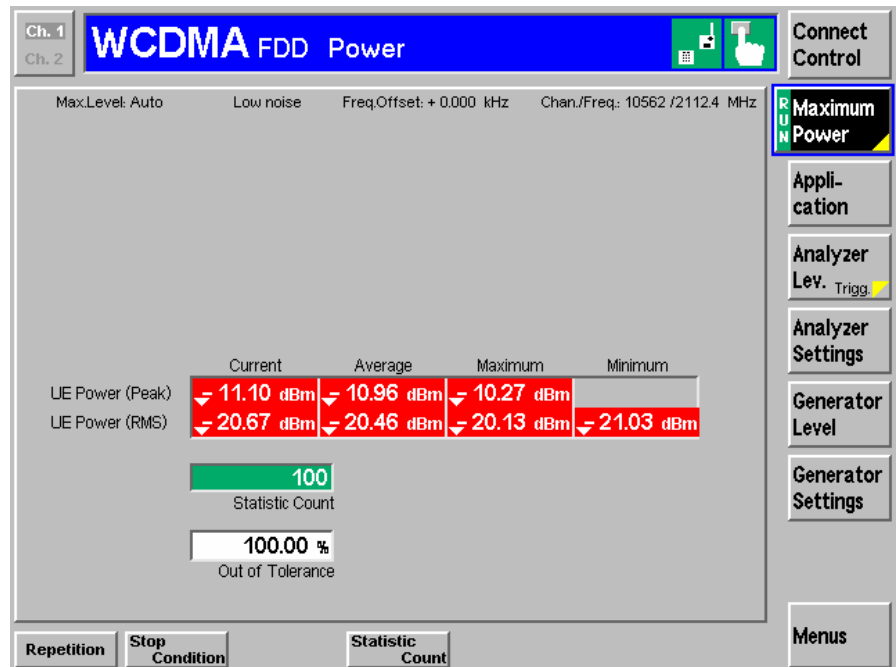
Fig. 27 Power in Bypass Mode

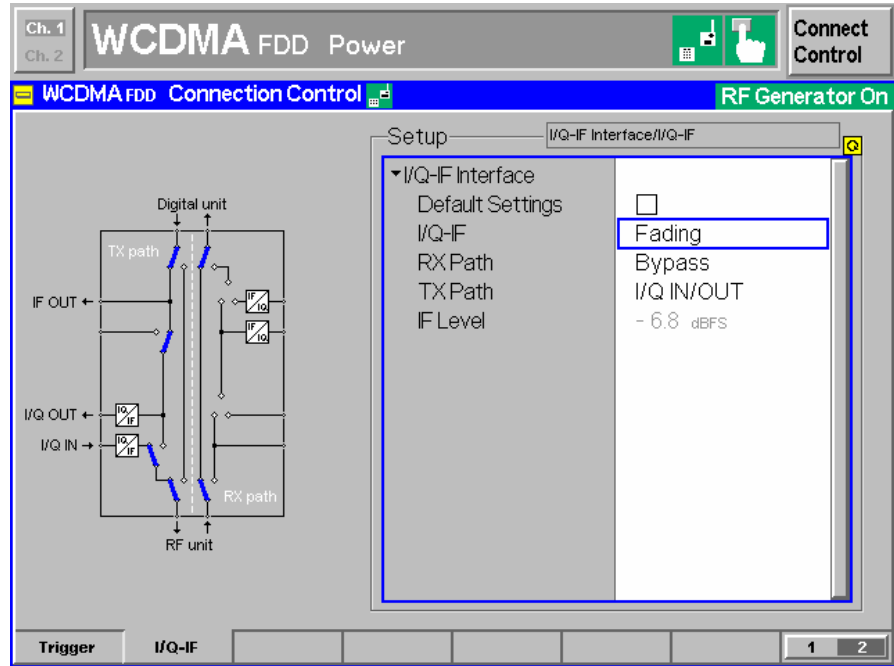9. Activate the IQ loop and send the signal through the fading simulator.

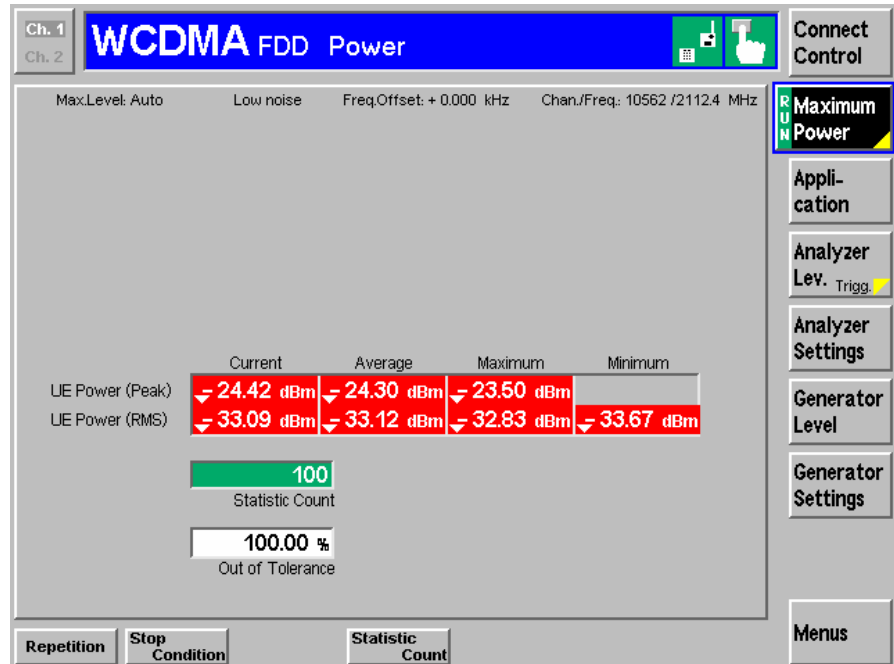Fig. 28 IQ/IF Fading Configuration

Fig. 29 Power with Calibration Mode Standard Fading

10. The resulting Average MS Power **P$_{MEAS}$** (Fig. 23) must be subtracted from the reference power **P$_{REF}$** (Fig. 21) to obtain the **INSERTION LOSS** of the IQ path.

$$InsertionLoss = P_{REF} - P_{MEAS} = -20.46 dBm + 33.12 dBm = 12.66 dB$$

7 Testing UE Receiver Quality with BLER Measurements Under Fading Conditions and AWGN

The receive characteristics of the Dedicated Channel (DCH) in different multi-path fading environments are determined by the **BL**ock **E**rror **R**atio (BLER) values.

How To Use the Test Specification

The following example describes the relevant parameters for performing the test **7.3 DEMODULATION OF DCH IN MULTI-PATH FADING PROPAGATION CONDITIONS** with **CASE 2** and **TEST 5** (see table below taken from the test specification 3GPP TS 34.121).

Table 7.3.1.3: DCH parameters in multi-path fading propagation conditions (Case 2)

Parameter	Test 5	Test 6	Test 7	Test 8	Unit
Phase reference		P-CPICH			
$\hat{I}_{or}/I_{oc}$	−3	−3	3	6	dB
I_{oc}		−60			dBm / 3,84 MHz
Information Data Rate	12,2	64	144	384	kbps

PHASE (or **LEVEL**) **REFERENCE** is the P-CPICH physical layer of the WCDMA signal.

Îor/Ioc is the S/N Ratio between the WCDMA Output Channel Power **Î**$_{or}$ and the AWGN signal level **I**$_{oc}$. This value (e.g. Test 5 = -3dB) must be entered in the **UTRAFDDFADCAL** program which automatically calculates the **AWGN LEVEL** (see p.8 for details on its derival) and sends it to the ABFS. Since the ABFS AWGN level allows only 0.05 dB steps there may be a small difference between the nominal and actual value.
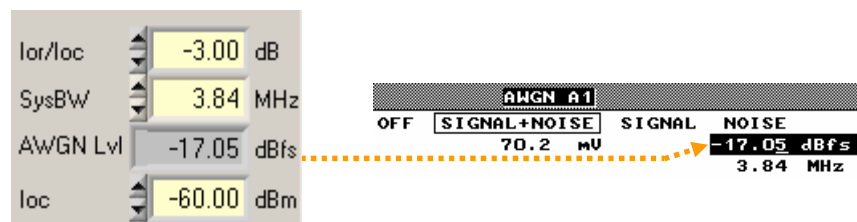

Fig. 30 AWGN Level

The source code for remote ABFS AWGN level setting is shown in appendix A-1.

Ioc is the absolute AWGN level (e.g. -60dBm for Case 2, Test 5) at 3,84 MHz system bandwidth.

INFORMATION DATA RATE is the data rate of the signal e.g. 12.2 kbps for Case 2, Test 5, CMU default value.

Table 7.3.1.4: DCH requirements in multi-path fading propagation conditions (Case 2)

Test Number	$\dfrac{DPCH\_E_c}{I_{or}}$	BLER
5	–7,7 dB	10^{-2}
6	–6,4 dB	10^{-1}
	–2,7 dB	10^{-2}
7	–8,1 dB	10^{-1}
	–5,1 dB	10^{-2}
8	–5,5 dB	10^{-1}
	–3,2 dB	10^{-2}

$\dfrac{DPCH\_Ec}{Ior}$ is the ratio of the Dedicated Pilot Channel to the Output Channel Power (e.g. -7.7dB for Case 2, Test 5).
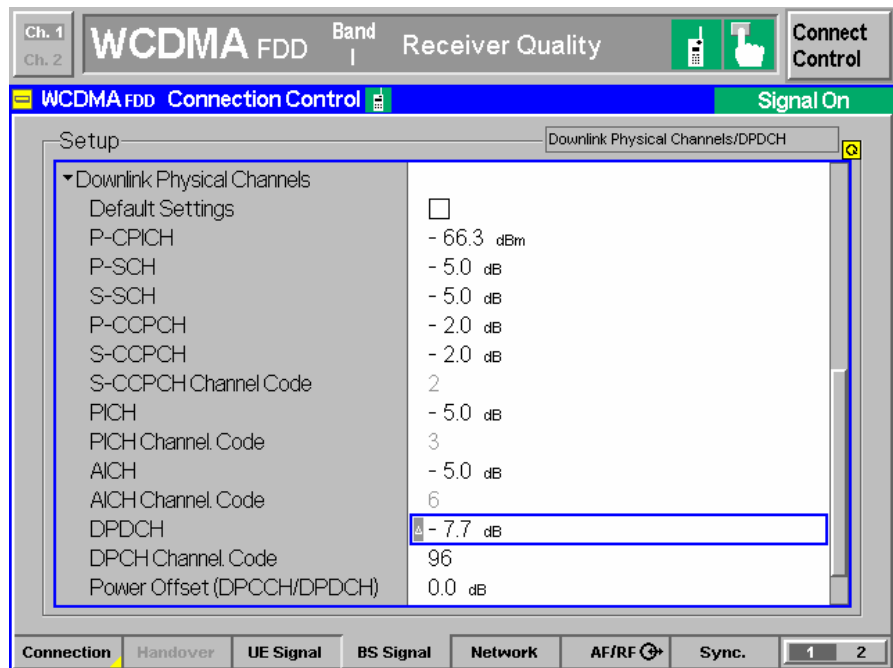

Fig. 31 DPDCH Level

BLER is the specified maximum measured Block Error Rate (e.g 10^{-2}=1%).

Table D.2.2.1: Propagation conditions for multi-path fading environments

Case 1, speed 3km/h		Case 2, speed 3 km/h		Case 3, speed 120 km/h	
Relative Delay [ns]	Average Power [dB]	Relative Delay [ns]	Average Power [dB]	Relative Delay [ns]	Average Power [dB]
0	0	0	0	0	0
976	-10	976	0	260	-3
		20000	0	521	-6
				781	-9

The required fading profile can be set with **UTRAFDDFADCAL** in the menu **PROPAGATION CONDITIONS**.

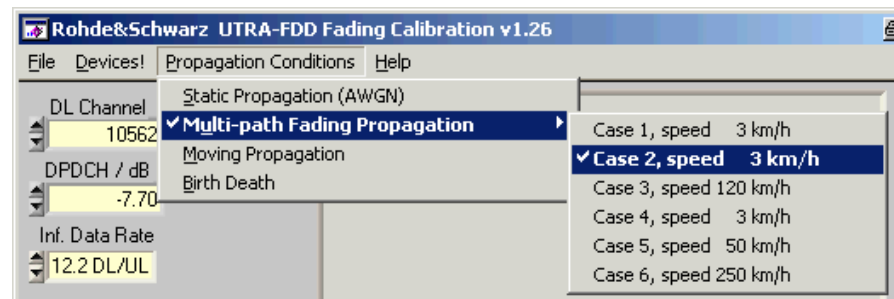Fig. 32 Select Fading Profile

This sets up the ABFS Fine Delay fading profile in the following manner.

Fig. 33 ABFS Fading Profile

Note: *The minimum possible delay on the ABFS is 25ns.*

The source code on appendix A-2 shows how to set the Multi-path Fading Propagation Case 2 in an own test application.

Keep in mind that the **FADING GAIN** may change when the fading profile is varied and needs to be updated in **UTRAFDDFADCAL** (see p.7 for details on the **FADING GAIN** calculation). Appendix A-3 shows the remote command sequence for the automatic **FADING GAIN** calculation.

Calibration and Test Procedure

This section contains a step by step guide that shows how to calibrate the **INSERTION LOSS**, prepare and perform a BLER measurement under condition of fading as prescribed in the UTRA-FDD test specifications for user equipment (3GPP TS 34.121).

1. For the calibration procedure connect **RF2** (defined as output) with **RF1** (defined as input) on the CMU. The RF1 input signal is not attenuated by a directional 20dB coupler as it would be in RF2 and is therefore more sensitive.

2. Start **UTRAFDDFADCAL.EXE** and press the **INIT** buttons in the **DEVICES** menu (see section DEVICES, p.14).

3. Switch to **CALIBRATION MODE** in **UTRAFDDFADCAL**. This will set the CMU **OUTPUT CHANNEL POWER** to the max. CMU level of -20.1 dBm during the calibration process.
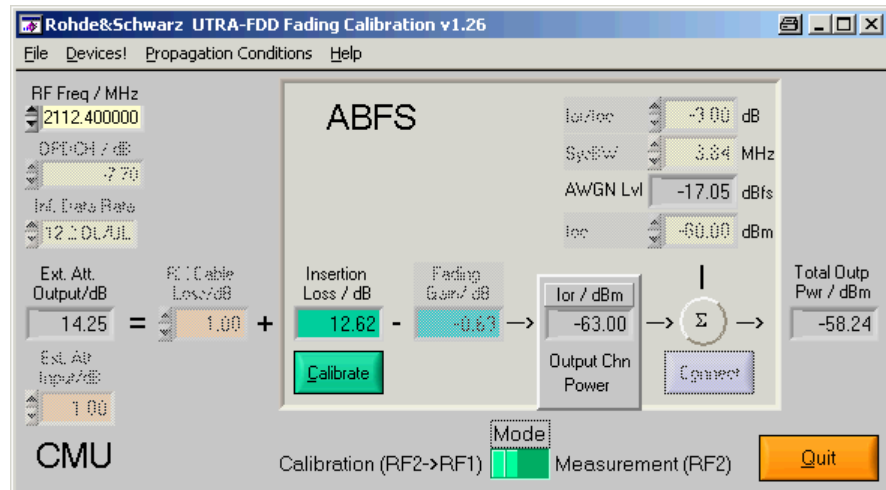
Fig. 34 UtraFddFadCal Calibration Setup

4. Enter desired values for **GENERATOR RF FREQ**uency (e.g. 2112.4 MHz), **RF LEVEL** (Output Channel Power, e.g. 20.10 dBm = max. output level) and **ANALYZER MAX LEVEL**. The **ANALYZER RF FREQ**uency is automatically set to the same value. This may be checked by pressing the **GET CONFIG** button.

5. Determine the **INSERTION LOSS** by pressing the **CALIBRATE** button. The calibration takes approx. 10s and is ready when the **CALIBRATE** button is no longer dimmed.

6. Switch to **MEASUREMENT MODE, WHICH** switches the CMU-B17 Fading path ON.
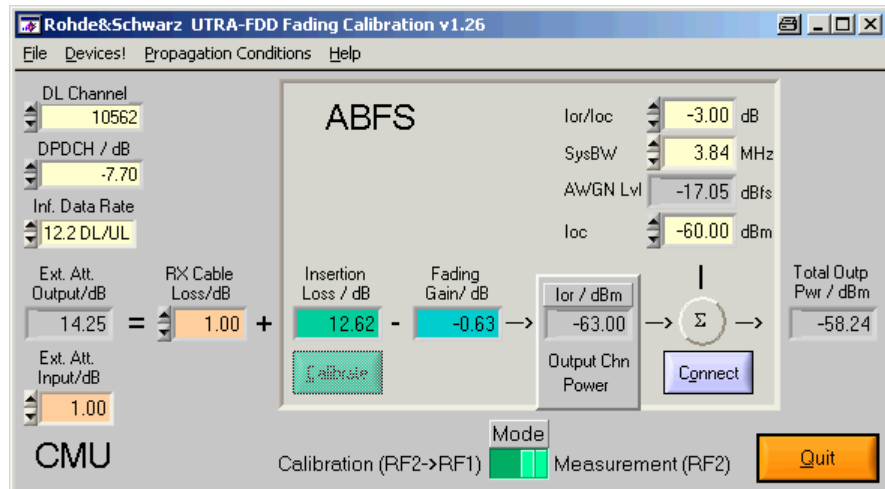
Fig. 35 UtraFddFadCal Measurement Setup
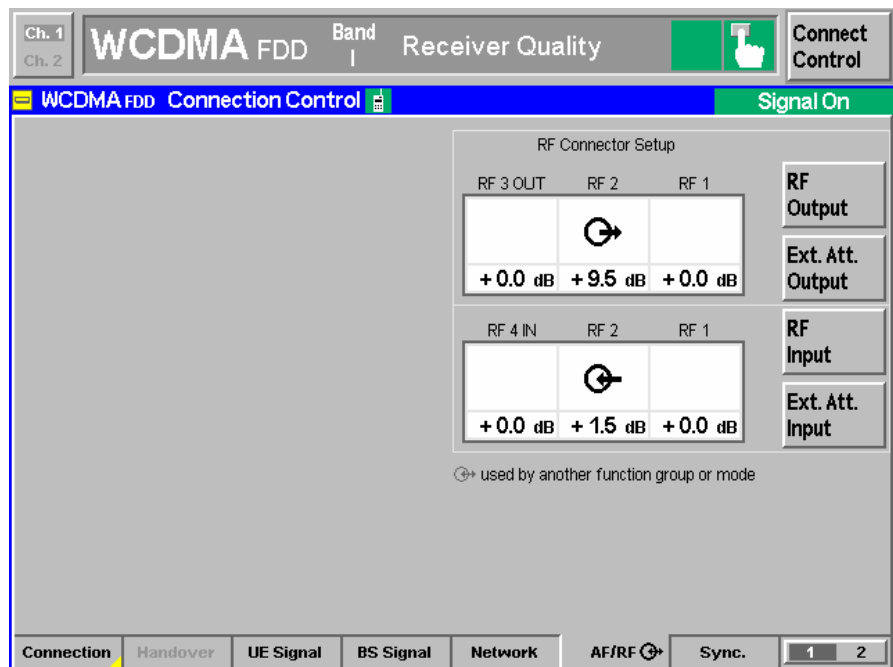
Fig. 36 RF Connector Setup

By switching to **MEASUREMENT MODE** the ABFS **RF FREQUENCY** is also automatically set to the CMU generator (BS) RF frequency. This corresponds to the following manual procedure on the ABFS, e.g.

FSIM -> **FINE DELAY** -> **RF FREQUENCY CH1** -> **2114.2 MHZ**

7. Select the desired fading profile, e.g. **PROPAGATION CONDITIONS -> MULTI-PATH FADING PROPAGATION** -> **CASE 2, SPEED 3 KM/H**.

8. Calculate the **FADING GAIN** by pressing the **CALCULATE** button (= 4.77dB for Case 2, 3 Paths with 0dB attenuation). This also updates the **AWGNLVL** display. Make sure that **SYSBW** ≥ 1.5 * chip rate, e.g. chip rate = 3.84Mcps -> **SYSBW** = 5.86 MHz.

9. Optionally edit **RX** and **TX CABLE LOSS**, e.g. 1.00dB. It can be determined as described in section *Controls and Indicators -> Measurement Mode*, page 19.

10. Disconnect the cable from **RF1** (in) and connect it to the UE.

11. On the CMU select the BLER test by choosing **MENU SELECT** -> **3G UMTS USER EQUIPMENT** - > **WCDMA FDD-UE** -> **SIGNALING** -> **RECEIVER QUALITY** -> **BER**. Press **ENTER** to confirm the selection.
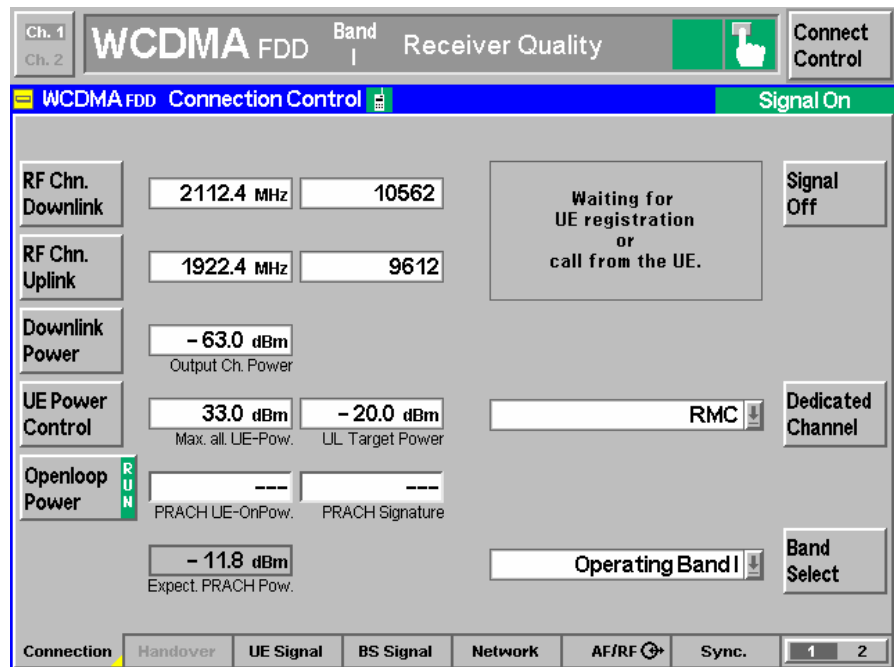
Fig. 37 Connection Control

12. Set **GENERATOR DL** (Downlink) **CHANNEL** in **UTRAFDDFADCAL** to desired value, e.g. 10562 (= 2112.4 MHz).

13. In **UTRAFDDFADCAL** enter desired value for **ANALYZER UL** (Uplink) **CHANNEL**, e.g. 9612 (= 1922.4 MHz).

14. Set **ANALYZER MAX LEVEL** in **UTRAFDDFADCAL** to desired value, e.g. 0.00 dBm.

15. Press the **CONNECT** button in **UTRAFDDFADCAL** to ease mobile registration and call establishment (turns ABFS fading and AWGN OFF).
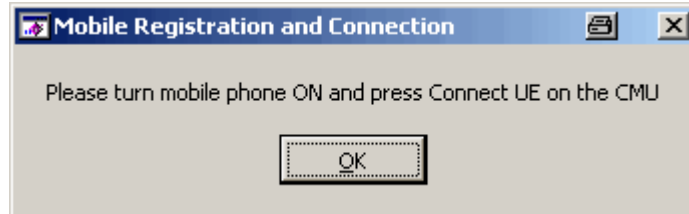
Fig. 38 Mobile Registration and Connection

16. Register the mobile by switching the power on.

17. Establish a UTRA-FDD connection by pressing **CONNECT UE** on the CMU.

18. In the **MOBILE REGISTRATION AND CONNECTION** window of **UTRAFDDFADCAL** press **Ok** to continue (turns ABFS fading and AWGN ON).

19. The resulting BER / BLER / DBLER is displayed on the CMU.
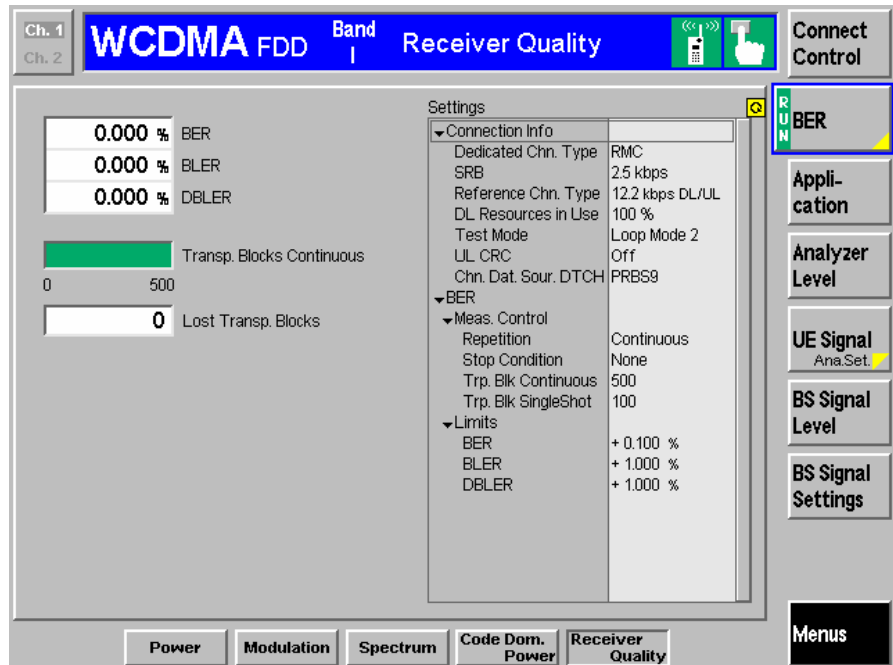
Fig. 39 BLER Measurement

Note: *In order to avoid mobile registration loss when controlling CMU remotely, uncheck the option SETUP -> REMOTE -> LOCAL REMOTE ->TRANSITION -> DISCONNECTION.*

Measuring BLER Characteristic

While the specification mainly applies for production tests, developers may need more information in order to classify devices such as a BLER vs. Output Channel Power characteristic. The example below was performed with a CMU200, ABFS and a CMU-Z10 shielded chamber for mobile stations. If no mobile station RF adapter is available use the CMU-Z11 antenna coupler. Case 2, test 5 of the specification allows max. 10^{-2} = 1% BLER at -63 dBm Outp.Channel Power.

Fig. 40 BLER vs. Output Channel Pwr

The characteristic above shows a sudden increase of the BLER at approx. -95 dBm and demonstrates the importance of precise level measurement and calculation.

8 Appendix A: Remote Control Command Sequences

A-1 Turn AWGN ON (ABFS)

```
viPrintf (hFSim, "AWGN:STAT ON"); // AWGN ON
viPrintf (hFSim, "AWGN:MODE SN"); // Signal+Noise
viPrintf (hFSim, "AWGN:SNR %0.2lf", AwgnLev);
```
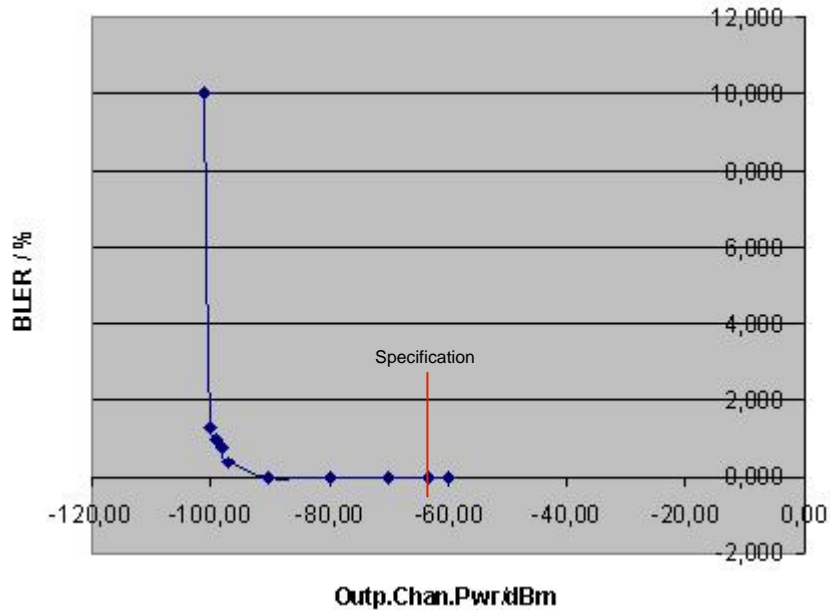
A-2 Fading Profile Configuration (ABFS)

```
SNRatio = -3.0;
viPrintf (hFSim, ":FSIM:FDEL ON");

switch (FPrf)
{
  //--- Static ---
  case 0x0100:
    viPrintf (hFSim, ":FSIM:FDEL OFF");
    viPrintf (hFSim, ":FSIM:MDEL OFF");
    viPrintf (hFSim, ":FSIM:BIRT OFF");
    viPrintf (hFSim, ":AWGN:STAT ON");
    viPrintf (hFSim, ":AWGN:MODE SN");
    viPrintf (hFSim, ":AWGN:SNR %lf", SNRatio);
    break;

  //--- Fine Delay Case 1 ---
  case 0x0080:
    viPrintf (hFSim, ":FSIM:FDEL:STAN G3UEC1");
    viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL  25ns");
    viPrintf (hFSim, ":FSIM:FDEL:PATH2:DEL 976ns");
    break;

  //--- Fine Delay Case 2 ---
  case 0x0040:
    viPrintf (hFSim, ":FSIM:FDEL:STAN G3UEC2");
    viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL 25ns");
    viPrintf (hFSim, ":FSIM:FDEL:PATH2:DEL 976ns");
    viPrintf (hFSim, ":FSIM:FDEL:PATH3:DEL 20000ns");
    break;

  //--- Fine Delay Case 3 ---
  case 0x0020:
    viPrintf (hFSim, ":FSIM:FDEL:STAN G3UEC3");
    viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL 25ns");
    viPrintf (hFSim, ":FSIM:FDEL:PATH2:DEL 260ns");
    viPrintf (hFSim, ":FSIM:FDEL:PATH3:DEL 521ns");
    viPrintf (hFSim, ":FSIM:FDEL:PATH4:DEL 781ns");
    break;

  //--- Fine Delay Case 4 ---
  case 0x0010:
    viPrintf (hFSim, ":FSIM:FDEL:STAN G3UEC4");
    viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL 25ns");
    viPrintf (hFSim, ":FSIM:FDEL:PATH2:DEL 976ns");
    break;
```

```
                //--- Fine Delay Case 5 ---
                case 0x0008:
                  viPrintf (hFSim, ":FSIM:FDEL:STAN G3UEC5");
                  viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL 25ns");
                  viPrintf (hFSim, ":FSIM:FDEL:PATH2:DEL 976ns");
                  break;

                //--- Fine Delay Case 6 ---
                case 0x0004:
                  viPrintf (hFSim, ":FSIM:FDEL ON");
                  viPrintf (hFSim, ":FSIM:FDEL:STAN G3UEC6");
                  viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL 25ns");
                  viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL 260ns");
                  viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL 521ns");
                  viPrintf (hFSim, ":FSIM:FDEL:PATH1:DEL 781ns");
                  break;

                //--- Moving ---
                case 0x0002:
                  viPrintf (hFSim, ":FSIM:MDEL ON");
                  break;

                //--- Birth Death ---
                case 0x0001:
                  viPrintf (hFSim, ":FSIM:BIRT ON");
                  break;
              }
```

A-3 Automatic SWLoss Calculation (ABFS)

```c
switch (typ)
{
  case FSIM:
    viQueryf (hdl, "FSIM:STAN?", "%s", szStd);
    idx = 12;
    for (i=1; i<=idx; i++)
    {
      viQueryf (hdl, "FSIM:PATH%d:STAT?", "%d",i, mod);
      if (mod)
      {
        viQueryf(hdl,"FSIM:PATH%d:LOSS?","%lf",i,&los);
        amp = pow (10.0, -los * 0.1);
        sum += amp;
      }
    } break;

  case FDEL:
    viQueryf (hdl, "FSIM:FDEL:STAN?", "%s", szStd);
    for (i=1; i<=4; i++)
    {
      viQueryf(hdl, "FSIM:FDEL:PATH%d:STAT?", "%d", i,
              &mod);
      if (mod)
      {
        viQueryf (hdl, "FSIM:FDEL:PATH%d:LOSS?", "%lf",
                  i, &los);
        amp = pow (10.0, -los * 0.1);
        sum += amp;
      }
    } break;

  case MDEL:
    sprintf (szStd, "G3MOVE");
    viQueryf (hdl, "FSIM:MDEL:REF:LOSS?", "%lf",
            &los);
    sum += pow (10.0, -los * 0.1);
    viQueryf (hdl, "FSIM:MDEL:MOV:LOSS?", "%lf",
            &los);
    sum += pow (10.0, -los * 0.1);
    break;

  case BIRT:
    sprintf (szStd, "G3BDEA");
    for (i=1; i<=2; i++)
    {
      viQueryf (hdl, "FSIM:BIRT:PATH%d:LOSS?", "%lf",
                i, &los);
      amp = pow (10.0, -los * 0.1);
      sum += amp;
    }
    break;
}
if (!strcmp (buf, "NONE")) return 0.0;
if (sum == 0.0) sum = 1e-199;
FadingGain = 10.0 * log10 (sum);
```

9   Additional Information

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

10 Ordering Information

Communication Tester

CMU 200	Communication Tester	1100.0008.02

Options

CMU-B17	IQ-IF Interface	1100.6906.02
CMU-B69	Option Packet for CMU200	1150.2304.02

Accessories

CMU-Z11	Shielded Cover	1150.1008.02
CMU-Z10	Antenna Coupler	1150.0801.02

Fading Simulator

ABFS	Base Band Fading Simulator	1114.8506.02