3GPP FDD and LTE Multicell and Multi-UE Scenarios with the R&S®SMU200A Signal Generator
Application Note

Products:

| R&S®SMU200A

The R&S®SMU200A from Rohde & Schwarz is a vector signal generator with a unique two-path architecture. Both paths can be equipped with realtime SISO and MIMO fading simulators and AWGN generators. In addition, the two paths can be internally combined and/or split, resulting in a number of routing variants.

This application note describes how to set up 3GPP FDD and LTE multicell and multi-UE scenarios with the R&S®SMU200A with a focus on routing and leveling of the baseband signals. Furthermore, it describes in detail how to determine the correct AWGN settings, i.e. how to calculate the required signal-to-noise ratio for the various scenarios.

Application Note

C. Tröster

08.2011-1GP80_0E

ROHDE&SCHWARZ

Table of Contents

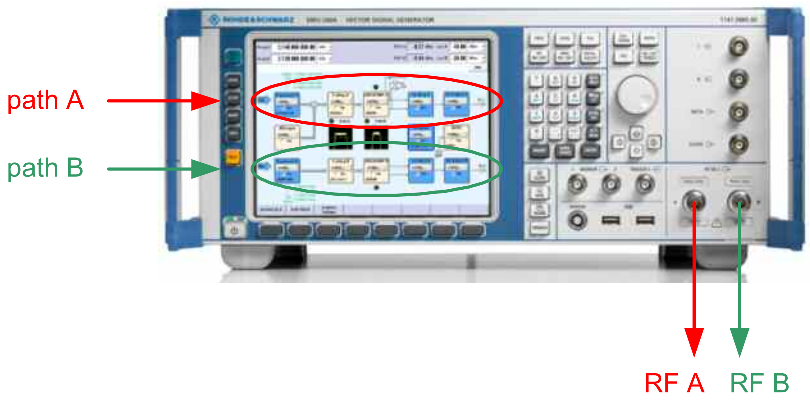
1 Note

The abbreviation "SMU" is used in this application note for the Rohde & Schwarz product R&S®SMU200A.

The word "level" always relates to power, i.e. all levels in this application note are power levels, not voltage levels.

2 Overview

The SMU is a vector signal generator with a unique two-path architecture effectively combining two complete signal generators in a single instrument.



The SMU provides internal realtime fading simulation and additive white Gaussian noise (AWGN) generation. Furthermore, the user can take advantage of the various routing possibilities. For example, the two baseband signals can be combined and routed to one RF port, e.g. for transmit diversity tests. Or one baseband signal can be split and routed to both RF ports, e.g. for receive diversity tests. Even more complex signal routings required for MIMO tests are possible.

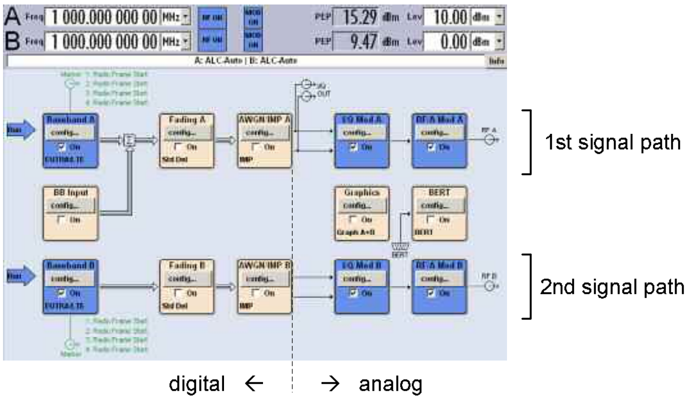
Due to its outstanding capabilities, the SMU is perfectly suited for generating multicell or multi-UE scenarios requiring only a minimum of test equipment. This greatly simplifies the test setup and eases leveling.

This application note describes how to set up multicell or multi-UE scenarios with the SMU and, more precisely, how to route and level the signals and how to determine the correct AWGN settings. It begins with a summary of the related basic knowledge and then lists several illustrative examples starting with a simple and ending with an advanced example.

3 Basics

3.1 Signal Routing

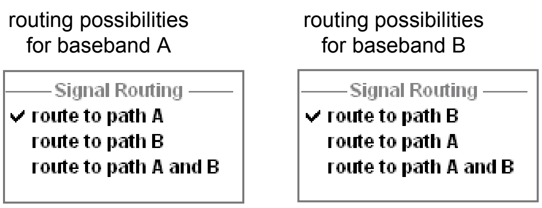
The SMU can be equipped with two signal paths. With the respective options, each signal path forms a complete vector signal generator on its own including a baseband generator, fading simulator, AWGN generator and I/Q modulator with RF output. Each path can be leveled individually by setting different RF output levels.



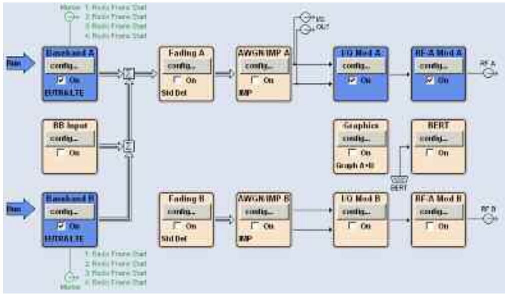
The two-path concept makes it possible to combine the two baseband signals internally. The SMU offers different routing possibilities that can be set via the “Baseband” block and/or the “Fading” block. The routing is done in the digital domain of the SMU, which enables lossless signal addition with highest precision.

3.1.1 Signal Routing via “Baseband” Block

The SMU provides various routing possibilities for each baseband signal that can be selected in the “Baseband” block.



For example, the two baseband signals can be added and routed to RF output A by selecting “route to path A” for basebands A and B. If the SMU is equipped with fading simulators, the two baseband signals are added *prior to* the fading simulators.



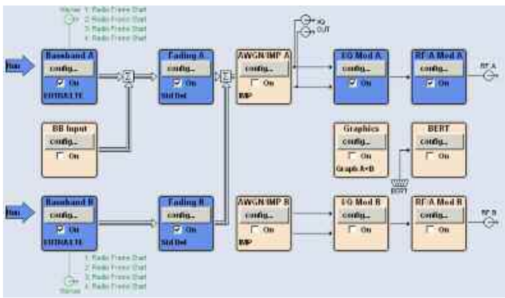
3.1.2 Signal Routing via "Fading" Block

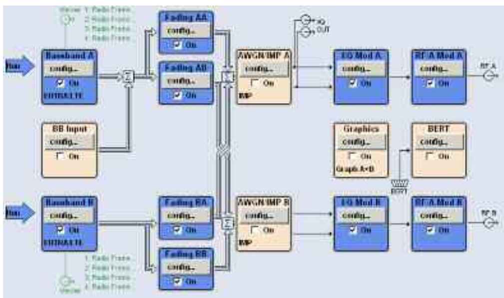
If the SMU is equipped with fading simulators, it offers various additional routing possibilities for the baseband signals that can be selected in the "Fading" block. Even complex routing scenarios for MIMO are available.

routing possibilities for the fading simulators A and B

Signal Routing	
✔ A —► A	|| B —► B
A —► A(unfaded)	|| B —► B (max paths)
A —► A(max paths)	|| B —► B (unfaded)
A —► A	|| B —► A
A —► B	|| B —► B
A —► A and B	|| B —► A and B
A —► A and B	|| B —► (open)
A —► (open)	|| B —► A and B
MIMO	
1x2 MIMO + Addition Baseband B	
2x2 MIMO	
2x4 MIMO	
4x2 MIMO	
2x3 MIMO	
3x2 MIMO	

For example, the two baseband signals can be added *after* the fading simulators and routed to RF output A by selecting "A → A, B → A" routing. If, for example, "2x2 MIMO" routing is selected, the baseband signals are faded and added as required for 2x2 MIMO testing.





3.2 Baseband Leveling

When two identical baseband signals are added, they will appear at the RF output by default with *equal* average levels. If the two baseband signals should appear with *different* average levels at the RF output, a relative "baseband level" needs to be set. The addition of the two baseband signals A and B is performed in the digital domain of the instrument, i.e. before I/Q modulation and RF up-conversion. In this digital domain, real RF levels do not exist yet. For this reason, the SMU uses the concept of baseband leveling, which basically is a relative leveling of the two signals A and B in the digital domain. A relative baseband level translates into real different RF levels for the RF signal components A and B after I/Q modulation and RF up-conversion.

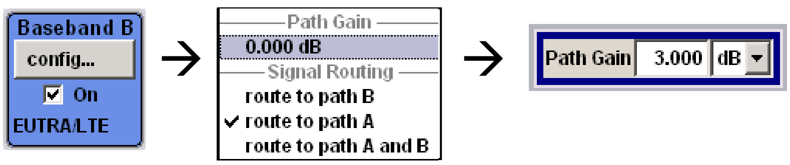
There are different possibilities for setting a relative level between the two basebands:

- Parameter "Path Gain" in the "Baseband" block
- Parameter "Summation Ratio A/B" in the "Fading" block
- MIMO correlation matrix in the "Fading" block
- Parameter "Power Offset Relative to Level Display" in the LTE option

Note that which of these possibilities can be used depends on the signal routing. The different possibilities are explained in detail in the following sections. The relative level set via the mentioned possibilities always relates to the average levels of the two baseband signals.

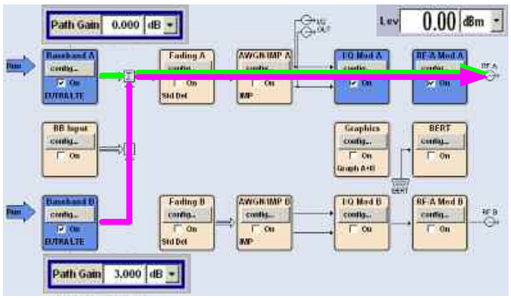
3.2.1 Path Gain

The parameter "Path Gain" can be set for each baseband separately in the "Baseband" block.



The "Path Gain" setting defines the gain for the baseband signal of the selected path relative to the baseband signal of the other path. The entered gain affects the signal level at the output of the "Baseband" block. Positive and negative gain values can be entered for the selected path (i.e. path A and/or path B), resulting in a higher or a lower level of this path relative to the other. The setting range is –50 dB to 50 dB.

Note that the entered path gain is only effective when the signals from the two basebands are *added* (before the "Fading" block). The parameter "Path Gain" is ignored if the baseband signals are not added.

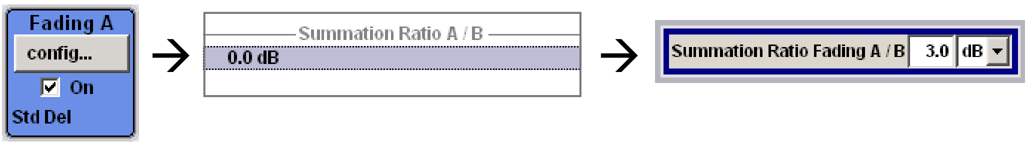


For example, if a path gain of 3 dB is set for path B, then the level of baseband B is 3 dB higher, i.e. twice as high as the level of baseband A.

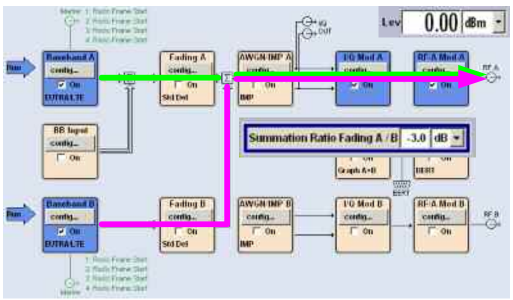
Note that the relative gain set with the parameter "Path Gain" is ignored if the baseband signals are summed after the “Fading” block (i.e. at the output of the “Fading” block). In this case the relative level between the basebands is set with the parameter "Summation Ratio A/B" (see next section).

3.2.2 Summation Ratio A/B

The parameter “Summation Ratio A/B” can be set in the “Fading” block.



The “Summation Ratio A/B” setting defines the relative level of the baseband signals if the signals are *added* after the “Fading” block. The entered ratio affects the signal level at the output of the “Fading” block. Positive and negative ratio values can be entered. A positive value results in a higher level of baseband A relative to B and a negative value in a higher level of baseband B relative to A. The setting range is –80 dB to 80 dB.



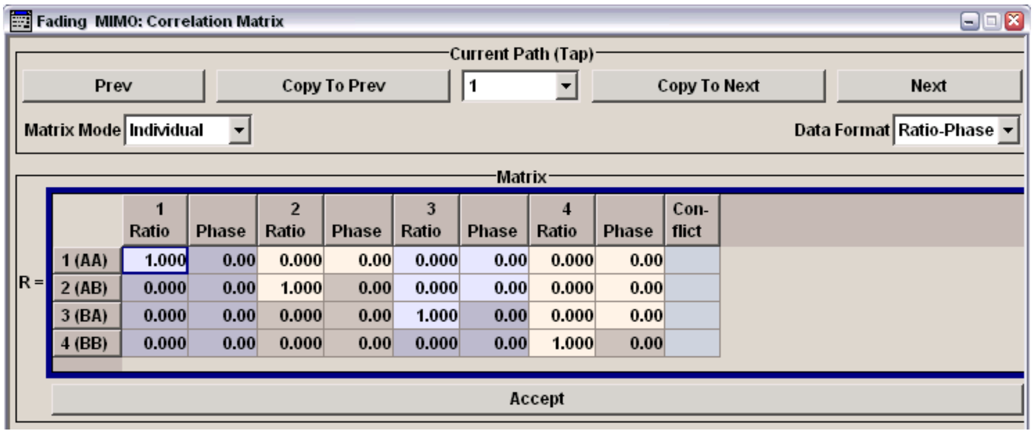
For example, if a summation ratio of –3 dB is set, then the level of baseband B is 3 dB higher, i.e. twice as high as the level of baseband A.

Note that the relative level set with the parameter "Summation Ratio A/B" is effective even if the fading simulators are turned off.

If MIMO routing is used, the parameter "Summation Ratio A/B" is disabled and the MIMO matrix is used instead for leveling (see next section).

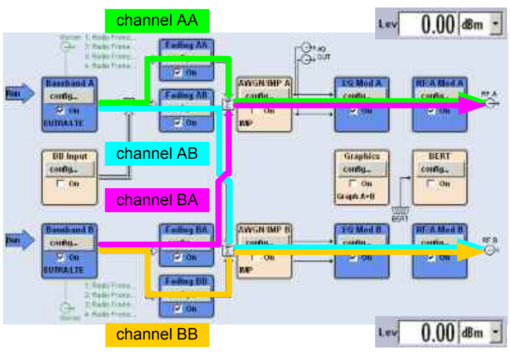
3.2.3 MIMO Matrix

The MIMO correlation matrix can be called from the “Fading” block if MIMO routing is applied.



The matrix can be used to set different baseband levels if the baseband signals are added using one of the MIMO routings.

In MIMO applications, the matrix is primarily used to set correlations between the individual fading channels via the off-diagonal elements. (Please see reference [6] for a detailed description of the correlation matrix.) The diagonal elements of the matrix can be used to set the levels of the fading channels relative to each other.



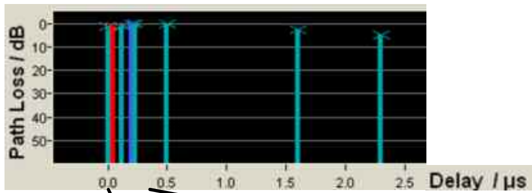
	1 Ratio	Phase	2 Ratio	Phase	3 Ratio	Phase	4 Ratio	Phase
1 (AA)	0.500	0.00	0.000	0.00	0.000	0.00	0.000	0.00
2 (AB)	0.000	0.00	0.500	0.00	0.000	0.00	0.000	0.00
3 (BA)	0.000	0.00	0.000	0.00	1.000	0.00	0.000	0.00
4 (BB)	0.000	0.00	0.000	0.00	0.000	0.00	1.000	0.00

For example, for the 2x2 MIMO routing there are four fading channels (AA, AB, BA, BB). Each fading channel can be leveled individually by adjusting the corresponding diagonal element in the matrix. By default, the diagonal elements are set to "Ratio" = 1.0, i.e. all channels have equal levels. By setting a "Ratio" value smaller than 1.0, it is possible to attenuate the level of the respective fading channel. Linear values ranging from 0.0 to 1.0 can be entered if the matrix mode is set to "Individual".

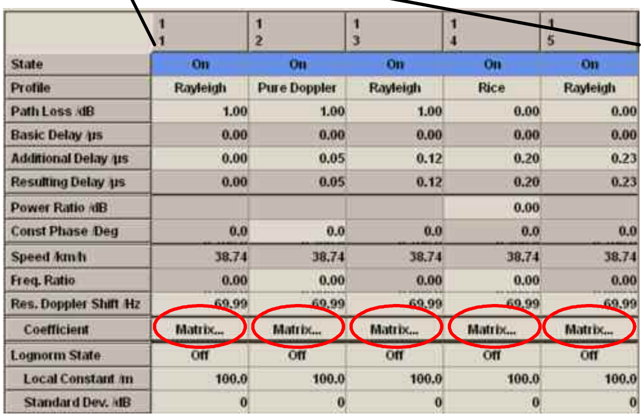
In the above example, we attenuated fading channels AA and AB by a factor of two (3 dB) relative to channels BA and BB by setting 0.5 for AA and AB. As a consequence, the level of baseband B is 3 dB higher, i.e. twice as high as the level of baseband A.

Note that a fading scenario can include several fading paths (taps). In this case, the matrix of *each* path needs to be adjusted (as indicated in the following figure). The diagonal elements of the matrixes are set to the same values.

Path Graph



Path Table



	1 1	1 2	1 3	1 4	1 5
State	On	On	On	On	On
Profile	Rayleigh	Pure Doppler	Rayleigh	Rice	Rayleigh
Path Loss /dB	1.00	1.00	1.00	0.00	0.00
Basic Delay /µs	0.00	0.00	0.00	0.00	0.00
Additional Delay /µs	0.00	0.05	0.12	0.20	0.23
Resulting Delay /µs	0.00	0.05	0.12	0.20	0.23
Power Ratio /dB				0.00	
Const Phase /Deg	0.0	0.0	0.0	0.0	0.0
Speed /km/h	38.74	38.74	38.74	38.74	38.74
Freq. Ratio	0.00	0.00	0.00	0.00	0.00
Res. Doppler Shift /Hz	69.99	69.99	69.99	69.99	69.99
Coefficient	Matrix...	Matrix...	Matrix...	Matrix...	Matrix...
Lognorm State	Off	Off	Off	Off	Off
Local Constant /m	100.0	100.0	100.0	100.0	100.0
Standard Dev. /dB	0	0	0	0	0

Note that the relative levels set with the matrix are only effective if the fading simulators are turned on. Nevertheless, the MIMO routing can also be used without fading simulation[1]. If fading is unwanted, a single fading path with a static fading profile can be selected. This setting effectively means no fading.

[1] with firmware version 2.20.230.26 beta or later.

Path Table

	1 1	1 2	1 3
State	On	Off	Off
Profile	Static Path	Rayleigh	Rayleigh
Path Loss /dB	0.00	10.00	10.00
Basic Delay /µs	0.00	0.00	0.00
Additional Delay /µs	0.00	0.00	0.00
Resulting Delay /µs	0.00	0.00	0.00
Power Ratio /dB			
Const Phase /Deg	0.0	0.0	0.0
Speed /km/h	3.000	3.000	3.000
Freq. Ratio	0.00	0.00	0.00
Res. Doppler Shift /Hz	0.00	0.02	0.02
Coefficient	Vector...	Matrix...	Matrix...
Lognorm State	Off	Off	Off
Local Constant /m	200.0	200.0	200.0

For the fading profiles “Static Path”, “Pure Doppler” and “Const. Phase” the matrix reduces to a vector – basically the off-diagonal elements of the MIMO matrix disappear and the diagonal elements form now a vector. The attenuation is entered in dB. For example, fading channels AA and AB can be attenuated by a factor of two relative to channels BA and BB by setting –3.0 for AA and AB. The vector elements BA and BB are set to 0.0 (no attenuation).

Vector

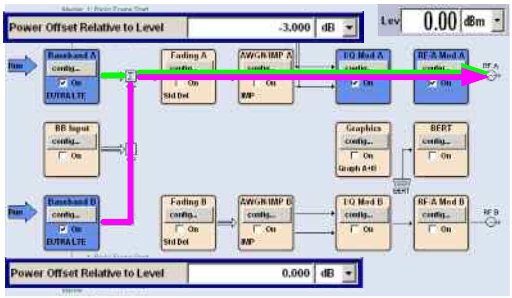
	Gain	Phase
1 (AA)	-3.00	0.00
2 (AB)	-3.00	0.00
3 (BA)	0.00	0.00
4 (BB)	0.00	0.00

3.2.4 Power Offset Relative to Level Display

The parameter “Power Offset Relative to Level Display” is a special parameter available in the LTE option. This parameter can be set for each baseband separately.

The “Power Offset Relative to Level Display” setting defines the level of the baseband signals of the selected path relative to the level display in the header of the instrument. The entered power offset affects the signal level at the output of the “Baseband” block as well as the signal level at the RF output. Negative offset values can be entered for the selected path (i.e. path A and/or path B), resulting in a lower level of this path relative to the corresponding level display.

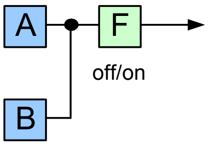
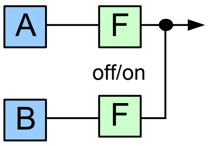
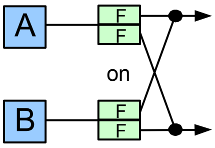
The parameter “Power Offset Relative to Level Display” can be used to set different levels for the two basebands. The setting range is –20 dB to 0 dB. A relative baseband level can be set for any signal routing. In contrast to the other leveling methods, this parameter can also be used if no baseband addition is applied (routing as shown in section 3.1). However, in this case it is preferable to level the two instrument paths directly via the RF level display settings. The parameter “Power Offset Relative to Level Display” should be used primarily when the two baseband signals are added.



For example, if a power offset of –3 dB is set for path A, then the level of baseband B is 3 dB higher, i.e. twice as high as the level of baseband A.

In contrast to the other leveling methods, the parameter “Power Offset Relative to Level Display” has an impact on the RF output level. For example, the RF level is set to 0.00 dBm in the level display. Due to signal addition, the level of each baseband is 3.01 dB lower than the set RF level. In addition, the power offset of –3 dB for path A lowers the level of baseband A by another 3 dB. At the RF output, baseband signal A has a level of –6.01 dBm and baseband signal B has a level of –3.01 dBm. The actual RF output level is thus only –1.25 dBm, not 0.00 dBm.

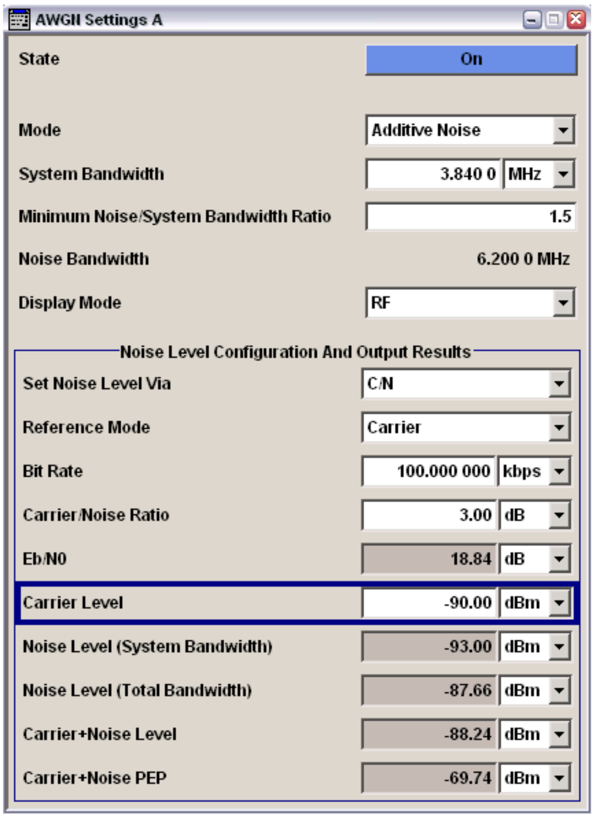
3.2.5 Summary

Overview				
Routing (Example)	**Path gain**	**Summation ratio A/B**	**MIMO matrix**	**Power offset** (LTE)
	✓	✗	✗	✓
	✗	✓	✗	✓
	✗	✗	✓	✓

- If the baseband signals are added before the fading simulator, the parameter “Path Gain” determines the relative baseband level.
- If the baseband signals are added after the fading simulator, the parameter “Summation Ratio A/B” determines the relative baseband level.
- If MIMO routing is applied, the MIMO matrix determines the relative baseband level.
- The parameter “Power Offset Relative to Level Display” (LTE) can be used with any signal routing and in principle also in combination with the parameters “Path Gain”, “Summation Ratio A/B” and the MIMO matrix.
- The parameters “Path Gain”, “Summation Ratio A/B” and the MIMO matrix determine a relative baseband level without impact on the RF output level. If a level of e.g. 0.0 dBm is set in the level display, the RF level of the output signal is 0.0 dBm.
- The parameter “Power Offset Relative to Level Display” (LTE) determines a relative baseband level *with* impact on the RF output level. If a level of e.g. 0.0 dBm is set in the level display, the RF level of the output signal is lower than 0.0 dBm if a non-zero power offset is applied.

3.3 AWGN

3.3.1 Important GUI Parameters

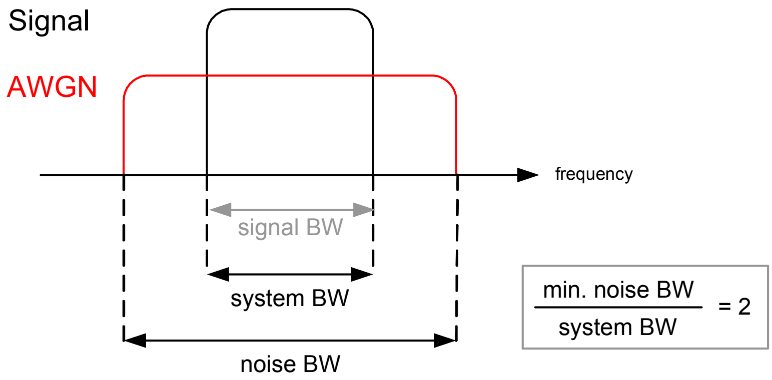


System Bandwidth:
The noise level within this RF frequency range (bandwidth) is calculated based on the set signal-to-noise ratio (i.e. parameter "Carrier/Noise Ratio").

Normally, the system bandwidth is set to the occupied bandwidth of the wanted signal. For example, for 3GPP FDD signals the system bandwidth should be set to 3.84 MHz.

Noise Bandwidth:
Noise can also occur outside the set system bandwidth. The actual noise bandwidth can be increased beyond the system bandwidth by using the parameter "Minimum Noise/System Bandwidth Ratio". This way, the noise inside the system bandwidth is flat. Note that the noise level is always calculated in relation to the system bandwidth from the set signal-to-noise ratio (SNR).

The noise bandwidth is calculated as follows:
Noise Bandwidth = System Bandwidth · Minimum Noise/System Bandwidth Ratio



Carrier/Noise Ratio:
The entered value determines the SNR that is used to calculate the noise level within the system bandwidth.

Carrier Level:
The displayed value is the level of the signal *without* the noise contribution and corresponds to the value in the header of the instrument.

Noise Level:
The displayed value is the noise level within either the system bandwidth or the total noise bandwidth.

Carrier+Noise Level:
The displayed value is the level of the RF output signal and corresponds to the signal *with* the noise contribution.

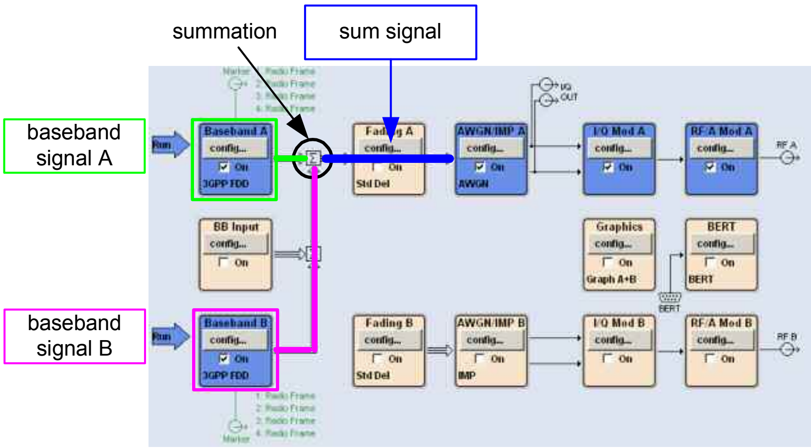
Please refer to reference [1] for more details.

If the parameter “Reference Mode” is set to “Carrier” (default), the noise level within the system bandwidth is determined by the following parameters:

- Carrier/Noise Ratio
- Carrier Level

3.3.2 SNR Calculation

If the baseband signals are added, then the SNR set in the “AWGN” block affects the *sum* signal.



For example, the SNR is set to 7 dB. As a result, the SNR for each baseband is 4 dB (i.e. 3 dB lower) if the two basebands have equal levels. However, if the basebands have unequal levels, the calculation is not that easy.

3.3.2.1 Path Gain

For example, the SNR is set to 7 dB and a relative level of 3 dB is set by applying a path gain of –3 dB for baseband B. As a result, the SNR for baseband A is 5.24 dB and the SNR for baseband B is 2.24 dB, as can be calculated using the following formulas:

$$SNR\ A = SNR_{set} + 10\,dB \cdot \log_{10}\left(\frac{10^{\frac{gain\ A}{10\,dB}}}{10^{\frac{gain\ A}{10\,dB}} + 10^{\frac{gain\ B}{10\,dB}}}\right) \qquad (1a)$$

$$SNR\ B = SNR_{set} + 10\,dB \cdot \log_{10}\left(\frac{10^{\frac{gain\ B}{10\,dB}}}{10^{\frac{gain\ A}{10\,dB}} + 10^{\frac{gain\ B}{10\,dB}}}\right) \qquad (1b)$$

If the SNRs of the two basebands are given and the resulting SNR setting in the “AWGN” block needs to be calculated, then the following formula can be used:

$$SNR_{set} = 10\,dB \cdot \log_{10}\left(10^{\frac{SNR\ A}{10\,dB}} + 10^{\frac{SNR\ B}{10\,dB}}\right) \qquad (2)$$

3.3.2.2 Summation Ratio A/B

If a relative baseband level is set by applying a summation ratio, then the formulas given in section 3.3.2.1 can be used with *gain A* = summation ratio and *gain B* = 0.

3.3.2.3 MIMO Matrix

If a relative baseband level is set via the MIMO matrix, then the SNR for baseband A and baseband B at RF output A can be calculated using the following formulas:

$$SNR\ A = SNR_{set} + 10\,dB \cdot \log_{10}\left(\frac{M_{AA}}{M_{AA} + M_{BA}}\right) \qquad \text{(3a)}$$

$$SNR\ B = SNR_{set} + 10\,dB \cdot \log_{10}\left(\frac{M_{BA}}{M_{AA} + M_{BA}}\right) \qquad \text{(3b)}$$

where SNR_{set} is the SNR set in “AWGN” block A and *M* is the (linear) value of the diagonal matrix element for the fading channels AA and BA.

The SNR for baseband A and baseband B at RF output B can be calculated using the same formulas[2] but with SNR_{set} corresponding to the SNR set in “AWGN” block B.

If the SNRs of the two basebands are given and the resulting SNR setting in the “AWGN” blocks A and B need to be calculated, then one of the following formulas[2] can be used:

$$SNR_{set} = SNR\ A - 10\,dB \cdot \log_{10}\left(\frac{M_{AA}}{M_{AA} + M_{BA}}\right) \qquad \text{(4a)}$$

or alternatively

$$SNR_{set} = SNR\ B - 10\,dB \cdot \log_{10}\left(\frac{M_{BA}}{M_{AA} + M_{BA}}\right) \qquad \text{(4b)}$$

3.3.2.4 Power Offset Relative to Level Display

If a relative baseband level is set via the LTE parameter "Power Offset Relative to Level Display", then the SNR for baseband A and baseband B can be calculated using the following formulas[3]:

[2] since $M_{AA} = M_{AB}$ and $M_{BA} = M_{BB}$

[3] provided no other leveling method is used in parallel such as “Path Gain“, “Summation Ratio A/B“ or MIMO matrix

$$SNR\ A = SNR_{set} - 3.01\,dB + Power\ Offset\ A \qquad (5a)$$

$$SNR\ B = SNR_{set} - 3.01\,dB + Power\ Offset\ B \qquad (5b)$$

where *Power Offset* is the value of the parameter "Power Offset Relative to Level Display" set for basebands A and B, respectively.

If the SNRs of the two basebands are given and the resulting SNR setting in the “AWGN” block needs to be calculated, then the following formula can be used:

$$SNR_{set} = SNR\ A + 3.01\,dB - Power\ Offset\ A \qquad (6a)$$

or alternatively

$$SNR_{set} = SNR\ B + 3.01\,dB - Power\ Offset\ B \qquad (6b)$$

Note that formulas 5 and 6 differ from formulas 1 and 2 for the parameter “Path Gain” and must not be used in exchange. The parameter "Power Offset Relative to Level Display" sets the baseband level relative to the level display and basically independent from the second baseband. Therefore, in formulas 5a and 5b only the 3 dB attenuation due to the signal addition and the set power offset must be taken into account. (In contrast, the parameter “Path Gain” sets the baseband level relative to the second baseband, i.e. relative to the sum level of signals A and B.)

4 Simple Baseband Addition and AWGN

Test requirement:

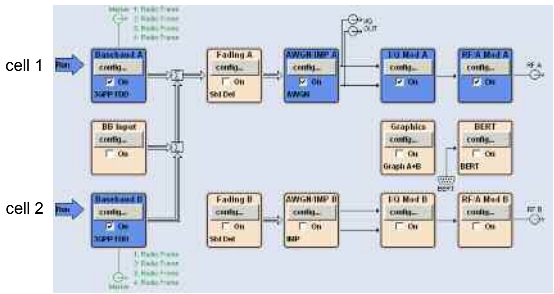
- Two cells with different SNRs shall be simulated
  - Cell 1 shall have an SNR of 2 dB
  - Cell 2 shall have an SNR of 8 dB
- One RF test signal is required for testing
  - The level is user-defined, e.g. –50 dBm

Test solution:

Signal routing:

Both basebands are routed to RF output A:

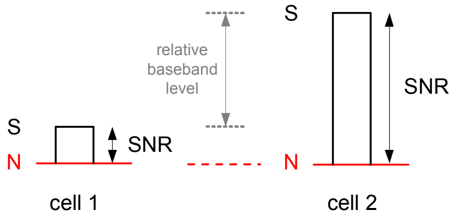
“Baseband” block A: route to path A
“Baseband” block B: route to path A



Cell 1 is simulated by baseband A, and cell 2 by baseband B.

Leveling:

The relative baseband level can be deduced from the SNRs of the two cells:
8 dB – 2 dB = 6 dB
Cell 2 is 6 dB higher in level than cell 1.



The relative baseband level is set by means of the parameter “Path Gain”:

“Baseband” block A: path gain = 0 dB
“Baseband” block B: path gain = 6 dB

The RF output level for path A is set to –50 dBm.

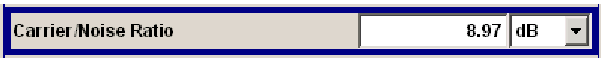
AWGN:

In the “AWGN” block, the system bandwidth needs to be set to the occupied signal bandwidth, e.g. for a 3GPP FDD signal, the system bandwidth is set to 3.84 MHz. Otherwise, the calculated SNR will not yield the wanted noise level.

The SNR set in the “AWGN” block relates to the sum signal.

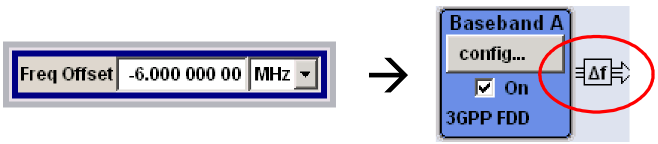
The carrier/noise ratio that needs to be set can be calculated from formula (2) as follows:

$$SNR = 10\,dB \cdot \log_{10}\left(10^{\frac{2\,dB}{10\,dB}} + 10^{\frac{8\,dB}{10\,dB}}\right) = 8.97\,dB$$

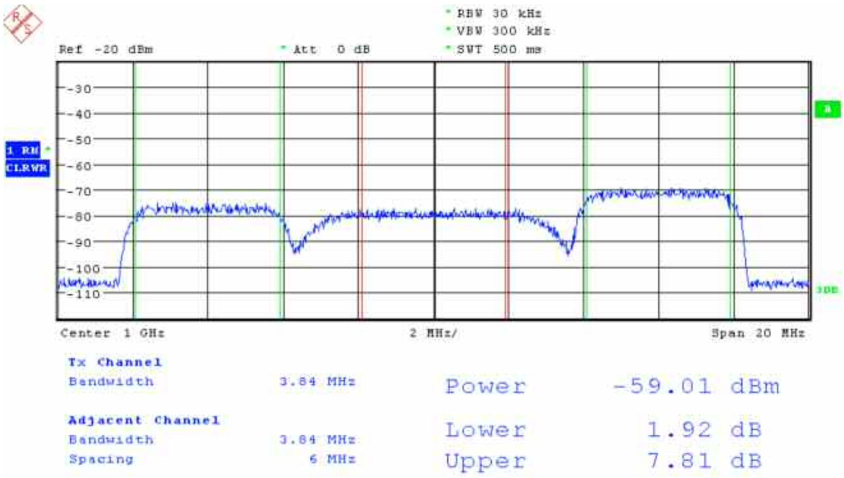


Setup verification:

For test purposes, a frequency offset is used for both basebands to separate the two signals in the spectrum from each other and from the AWGN signal. For baseband A an offset of –6 MHz is set and for baseband B +6 MHz.



A channel power measurement performed with a spectrum analyzer shows the two baseband signals (3GPP FDD signals) and the generated AWGN signal (with 3.84 MHz system bandwidth). The set channel bandwidth is 3.84 MHz, the set channel spacing is 6 MHz. The measured level of the lower channel (baseband A) is 2 dB higher than the noise level, and the level of the upper channel (baseband B) is 8 dB higher in accordance with the test requirement.


RBW 30 kHz
VBW 300 kHz
SWT 500 ms
Ref -20 dBm
Att 0 dB
1 RM
CLRWR
-30
-40
-50
-60
-70
-80
-90
-100
-110
A
3DB
Center 1 GHz
2 MHz/
Span 20 MHz
Tx Channel
Bandwidth
3.84 MHz
Power
-59.01 dBm
Adjacent Channel
Bandwidth
3.84 MHz
Spacing
6 MHz
Lower
1.92 dB
Upper
7.81 dB

5 Two 3GPP FDD Cells with Specified Signal and Noise Levels

5.1 Without Fading Simulation

Test requirement:

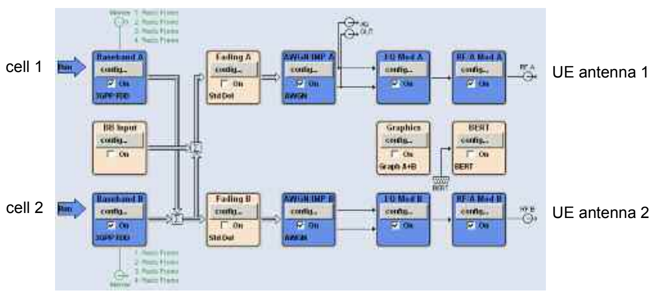
- Two 3GPP FDD cells with different levels shall be simulated
  - Cell 1 shall have a level of –94 dBm
  - Cell 2 shall have a level of –98 dBm
- The noise level shall be –100 dBm / 3.84 MHz
- The SMU shall be used for receive diversity testing, i.e. the signals of cell 1 and cell 2 shall be received by two UE antennas → Two RF test signals are required for testing

Test solution:

Signal routing:

Both basebands are routed to RF outputs A and B:

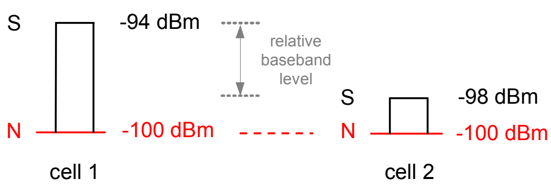
“Baseband” block A: route to paths A and B
“Baseband” block B: route to paths A and B



Cell 1 is simulated by baseband A, and cell 2 by baseband B.

Leveling:

Cell 1 is 4 dB higher in level than cell 2.



The relative baseband level is set by means of the parameter “Path Gain”:

“Baseband” block A: path gain = 0 dB
“Baseband” block B: path gain = –4 dB

The sum level of the two cell signals is –92.54 dBm.

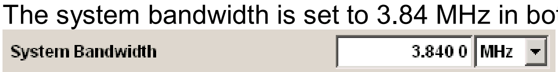
$$sum\,level = 10\,dBm \cdot \log_{10}\left(10^{\frac{-94\,dBm}{10\,dBm}} + 10^{\frac{-98\,dBm}{10\,dBm}}\right) = -92.54\,dBm$$

This calculation can be done in a simple way by using the R&S dBCalculator software tool [2]:

The RF output level of both paths is set to the calculated sum level:

AWGN:

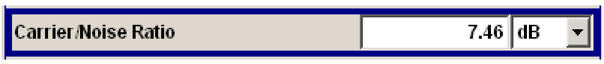
The system bandwidth is set to 3.84 MHz in both “AWGN” blocks:



The carrier/noise ratio that needs to be set in both “AWGN” blocks can be determined as follows:

Carrier level: –92.54 dBm
Noise level: –100.0 dBm

SNR = –92.54 dBm – (–100.0 dBm) = 7.46 dB



5.2 With Fading Simulation

Test requirement:

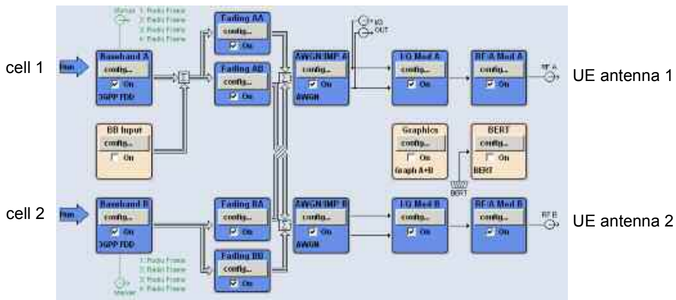
- Two 3GPP FDD cells with different levels
  - Cell 1: –94 dBm
  - Cell 2: –98 dBm
- Noise level: –100 dBm / 3.84 MHz
- Receive diversity → two RF test signals
- Fading simulation

Test solution:

Signal routing:

Both basebands are routed to RF outputs A and B using the MIMO routing. Actually, this signal routing is intended for MIMO testing but can also be (mis)used for other scenarios like this one.

“Fading” block: 2x2 MIMO

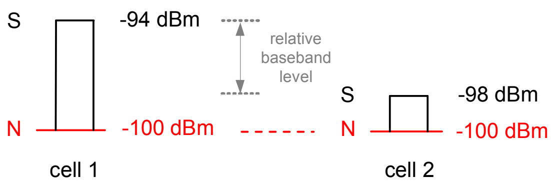


Cell 1 is simulated by baseband A, and cell 2 by baseband B.

Note:
In case fading is temporarily unwanted, a single fading path with a static fading profile can be selected. This setting effectively means no fading. See section 3.2.3 for details.

Leveling:

Cell 1 is 4 dB higher in level than cell 2.



The relative baseband level is set via the MIMO matrix:

The level of cell 2, i.e. the level of baseband B, has to be lowered by 4 dB. This means that the fading channels BA and BB need to be attenuated.

The linear matrix values can be calculated as follows:

The formula $10^{\frac{4\,dB}{10\,dB}} = 2.512$ is used to convert the logarithmic power ratio (4 dB) into a linear power ratio:

$$\frac{level\ A}{level\ B} = 2.512$$

In the formula above, the higher baseband level is set to 1. The formula is then solved for the lower baseband level. In this example,

$$\frac{1}{level\ B} = 2.512 \ ; \qquad level\ B = \frac{1}{2.512} = 0.398$$

When using the R&S dBCalculator software tool [2] to do the matrix value calculation, enter “4” into the “dB ratio” field, then enter “1” into the “P1” field. The level “P2” is calculated: 0.398.

The matrix elements for the fading channels BA and BB need to be set to 0.398 in order to attenuate baseband B by 4 dB relative to baseband A.

	1 Ratio	Phase	2 Ratio	Phase	3 Ratio	Phase	4 Ratio	Phase	Con-flict
1 (AA)	1.000 0	0.00	0.000 0	0.00	0.000 0	0.00	0.000 0	0.00	
2 (AB)	0.000 0	0.00	1.000 0	0.00	0.000 0	0.00	0.000 0	0.00	
3 (BA)	0.000 0	0.00	0.000 0	0.00	0.398 0	0.00	0.000 0	0.00	
4 (BB)	0.000 0	0.00	0.000 0	0.00	0.000 0	0.00	0.398 0	0.00	

If the used fading scenario includes several fading paths, the matrix of each path needs to be adjusted, i.e. the diagonal elements need to be set as shown above.

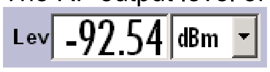
Note that the relative baseband level set via the matrix is *not* effective if the fading simulators are turned off. If fading is temporarily unwanted, a static fading profile can be selected with vector elements set to 0, 0, –4 and –4 for the fading channels AA to BB, respectively.

The sum level of the two cell signals is –92.54 dBm.

$$sum\,level = 10\,dBm \cdot \log_{10}\left(10^{\frac{-94\,dBm}{10\,dBm}} + 10^{\frac{-98\,dBm}{10\,dBm}}\right) = -92.54\,dBm$$

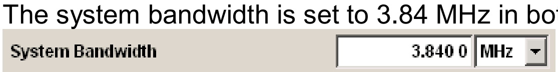
This calculation can also be done using the R&S dBCalculator software tool [2]:

The RF output level of both paths is set to the calculated sum level:



AWGN:

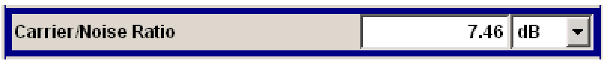
The system bandwidth is set to 3.84 MHz in both “AWGN” blocks:



The carrier/noise ratio that needs to be set in both “AWGN” blocks can be determined as follows:

Carrier level: –92.54 dBm
Noise level: –100.0 dBm

SNR = –92.54 dBm – (–100.0 dBm) = 7.46 dB



Cross check:
Alternatively, the carrier/noise ratio can also be calculated from the matrix diagonal elements using formula (4a):

$$SNR = 6\,dB - 10\,dB \cdot \log_{10}\left(\frac{1}{1+0.4}\right) = 7.46\,dB$$

with *SNR A* = –94 dBm – (–100.0 dBm) = 6 dB

6 Two LTE Cells with Specified Signal and Noise Levels

Test requirement:

- Two LTE cells with different levels shall be simulated
  - Cell 1 shall have a level of –94 dBm
  - Cell 2 shall have a level of –98 dBm
- The noise level shall be –100 dBm within the occupied signal bandwidth
- The SMU shall be used for receive diversity testing, i.e. the signals of cell 1 and cell 2 shall be received by two UE antennas → Two RF test signals are required for testing
- Fading simulation shall be applied

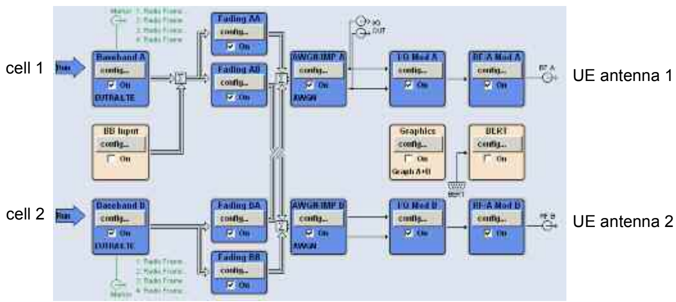
Test solution:

In principle, this scenario can be set up as described in section 5.2, but for LTE scenarios there is an easier way to set up the instrument, as described in the following.

Signal routing:

Both basebands are routed to RF outputs A and B using the MIMO routing.

“Fading” block: 2x2 MIMO

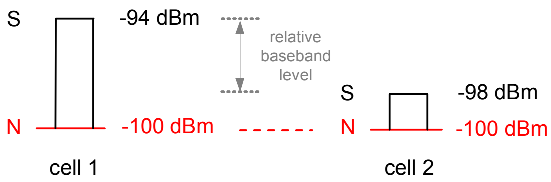


Cell 1 is simulated by baseband A, and cell 2 by baseband B.

Note:
If fading is temporarily unwanted, the fading simulators can simply be switched off. It is not necessary to select a static fading profile, since the MIMO matrix is not used for leveling, as described in the following.

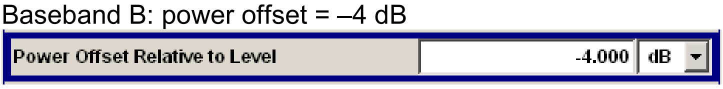
Leveling:

Cell 1 is 4 dB higher in level than cell 2.



The relative baseband level is set via the parameter “Power Offset Relative to Level Display”. The level of cell 2, i.e. the level of baseband B has to be lowered by 4 dB.

Baseband A: power offset = 0 dB
Baseband B: power offset = –4 dB

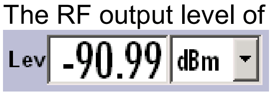


Note that the MIMO matrix is used with default values, i.e. all diagonal elements are set to Ratio = 1.

The level of cell 1 is higher and thus serves as the reference level: –94.0 dBm.
This reference level is valid for both cells, i.e. both instrument paths, since baseband B is already leveled by means of the parameter “Power Offset Relative to Level Display” with respect to this reference level.
Therefore, the theoretical sum level of the two baseband signals is –91.0 dBm.

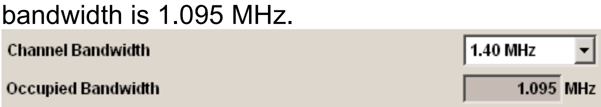
$$sum\,level_{theoretical} = 10\,dBm \cdot \log_{10}\left(10^{\frac{-94\,dBm}{10\,dBm}} + 10^{\frac{-94\,dBm}{10\,dBm}}\right) = -90.99\,dBm$$

The RF output level of both paths is set to the calculated theoretical sum level:

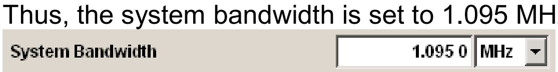


AWGN:

The system bandwidth is set to the occupied signal bandwidth. For example, for an LTE downlink signal with a channel bandwidth of 1.4 MHz, the occupied signal bandwidth is 1.095 MHz.



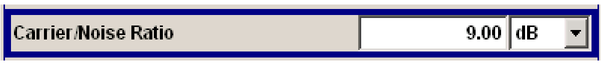
Thus, the system bandwidth is set to 1.095 MHz in both “AWGN” blocks:



The carrier/noise ratio that needs to be set in both “AWGN” blocks can be determined as follows:

Carrier level: –91.0 dBm
Noise level: –100.0 dBm

SNR = –91.0 dBm – (–100.0 dBm) = 9.0 dB



Cross check:
Alternatively, the carrier/noise ratio can also be calculated using formula (6):

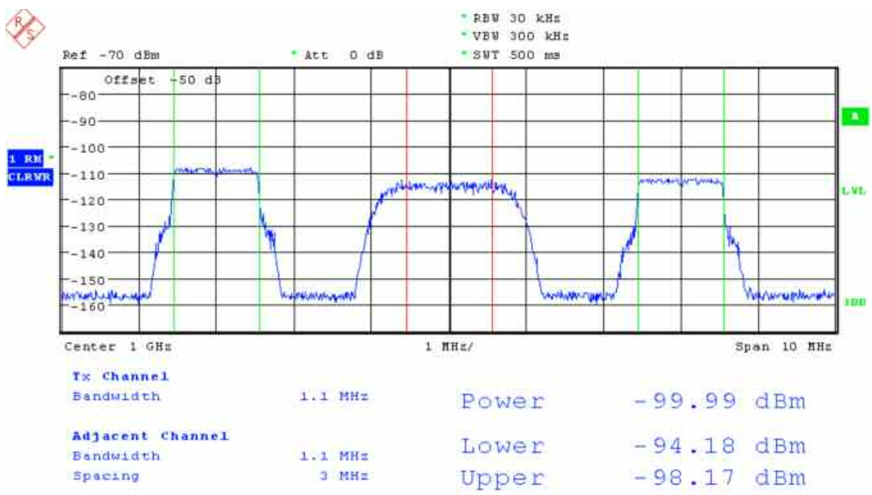
$$SNR = 10\,dB \cdot \log_{10}\left(2 \cdot 10^{\frac{6\,dB}{10\,dB}}\right) = 9.0\,dB$$

with SNR_{max} = *SNR A* = –94 dBm – (–100.0 dBm) = 6 dB

Setup verification:

For test purposes, a frequency offset is used for both basebands to separate the two signals in the spectrum from each other and from the AWGN signal. For baseband A an offset of –3 MHz is set, and for baseband B +3 MHz. The fading simulation is switched off. Since the RF output level is very low, a level offset of –50 dBm is set on the SMU to provide a sufficient signal level for the spectrum analyzer. With an offset of –50 dBm and a level display setting of –91 dBm, the SMU effectively outputs –41 dBm. Accordingly, a reference level offset of –50 dBm is set on the spectrum analyzer.

A channel power measurement shows the two baseband signals (1.4 MHz LTE signals) and the generated AWGN signal (with 1.1 MHz system bandwidth). The set channel bandwidth is 1.1 MHz, which corresponds to the occupied signal bandwidth. The measured level of the lower channel (baseband A) is –94 dBm, the level of the upper channel (baseband B) is –98 dBm and the measured noise level is –100 dBm in accordance with the test requirement.



7 Faded UE and Unfaded Reference UE

Test requirement:

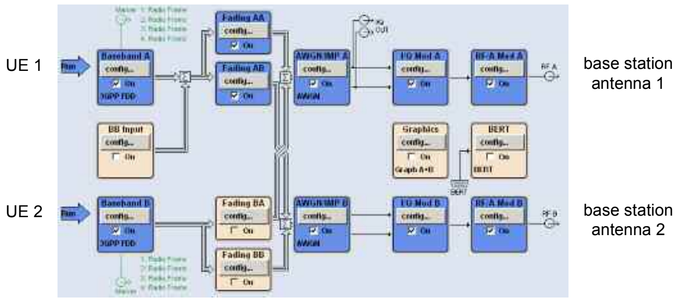
- Two 3GPP FDD UEs with different levels shall be simulated
  - UE 1 shall have a level of –97 dBm
  - UE 2 shall have a level of –95 dBm
- The noise level shall be –100 dBm / 3.84 MHz
- Fading simulation shall be used for UE 1 only
  - UE 1 is dynamically faded
  - UE 2 remains unfaded
- The SMU shall be used for receive diversity testing, i.e. the signals of UE 1 and UE 2 shall be received by two base station antennas → Two RF test signals are required for testing

Test solution:

Signal routing:

Both basebands are routed to RF outputs A and B using the MIMO routing.

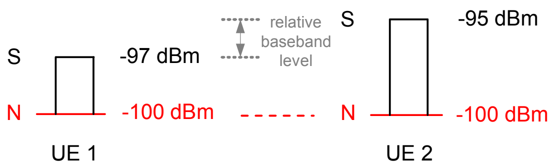
“Fading” block: 1x2 MIMO + Addition Baseband B



UE 1 is simulated by baseband A, and UE 2 by baseband B. UE 1 is faded, UE 2 is unfaded.

Leveling:

UE 2 is 2 dB higher in level than UE 1.



The relative baseband level is set via the MIMO matrix. The matrix contains only the fading channels AA and AB, since channels BA and BB are not faded.

The level of UE 1, i.e. the level of baseband A, has to be lowered by 2 dB. The linear matrix values for the fading channels AA and AB can be calculated as follows:

The formula $10^{\frac{-2\,dB}{10\,dB}} = 0.631$ is used to convert the logarithmic power ratio (–2 dB) into a linear power ratio:

$$\frac{level\ A}{level\ B} = 0.631$$

In the formula above, the level of baseband B is set to 1. The formula is then solved for the level of baseband A. In this example,

$$\frac{level\ A}{1} = 0.631\ ; \qquad level\ A = 0.631$$

When using R&S dBCalculator [2] to do this calculation, enter “–2” into the “dB ratio” field, then enter “1” into the “P2” field. The level “P1” is calculated: 0.631.

The matrix elements for the fading channels AA and AB need to be set to 0.63 in order to attenuate baseband A by 2 dB relative to baseband B.

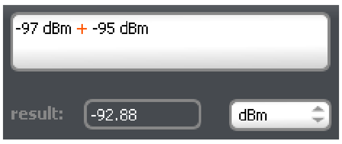
	1 Ratio	Phase	2 Ratio	Phase
1 (AA)	0.630	0.00	0.000	0.00
2 (AB)	0.000	0.00	0.630	0.00

If the used fading scenario includes several fading paths, the matrix of each path needs to be adjusted, i.e. the diagonal elements need to be set as shown above. Note that the relative baseband level set via the matrix is *not* effective if the fading simulators are turned off.

The sum level of the two UE signals is –92.88 dBm.

$$sum\ level = 10\,dBm \cdot \log_{10}\left(10^{\frac{-97\,dBm}{10\,dBm}} + 10^{\frac{-95\,dBm}{10\,dBm}}\right) = -92.88\,dBm$$

This calculation can also be done using R&S dBCalculator [2]:



The RF output level of both paths is set to the calculated sum level:

AWGN:

The system bandwidth is set to 3.84 MHz in both “AWGN” blocks:

The carrier/noise ratio that needs to be set in both “AWGN” blocks can be determined as follows:

Carrier level: –92.88 dBm
Noise level: –100.0 dBm

SNR = –92.88 dBm – (–100.0 dBm) = 7.12 dB

Cross check:
Alternatively, the carrier/noise ratio can also be calculated from the matrix diagonal elements using formula (4a):

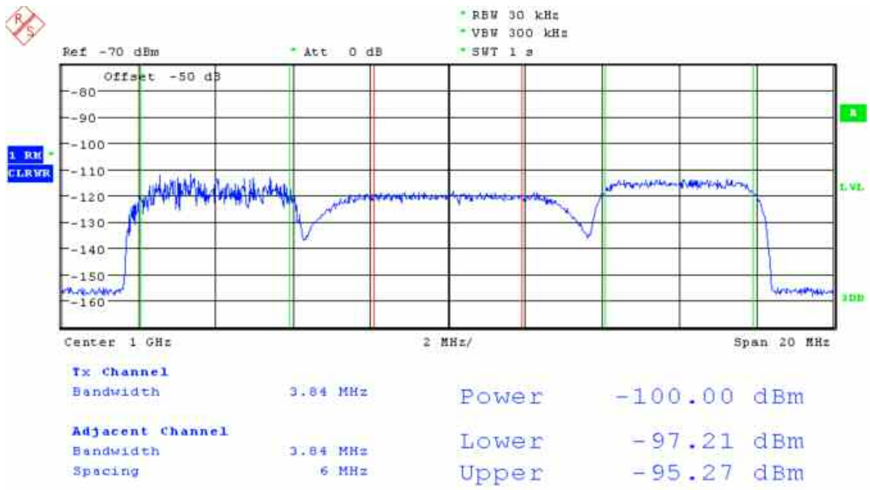
$$SNR = 3\,dB - 10\,dB \cdot \log_{10}\left(\frac{0.631}{0.631+1}\right) = 7.12\,dB$$

with *SNR A* = –97 dBm – (–100.0 dBm) = 3 dB

Setup verification:

For test purposes, a frequency offset is used for both basebands to separate the two signals in the spectrum from each other and from the AWGN signal. For baseband A an offset of –6 MHz is set, and for baseband B +6 MHz. Since the RF output level is very low, a level offset of –50 dBm is set on the SMU to provide a sufficient signal level for the spectrum analyzer. With an offset of –50 dBm and a level display setting of -92.88 dBm, the SMU effectively outputs –42.88 dBm. Accordingly, a reference level offset of –50 dBm is set on the spectrum analyzer. For the measurement, the fading speed is (temporarily) set to its maximum value in order to reduce the necessary measurement time. The sweep time of the analyzer is set to 1 s to sufficiently average over the level fluctuations of baseband A. (The lower the fading speed is, the longer the measurement time has to be.)

A channel power measurement shows the two baseband signals (3GPP FDD signals) and the generated AWGN signal (with 3.84 MHz system bandwidth). The set channel bandwidth is 3.84 MHz. The measured level of the lower channel (baseband A) is -97 dBm, the level of the upper channel (baseband B) is –95 dBm and the measured noise level is –100 dBm in accordance with the test requirement.

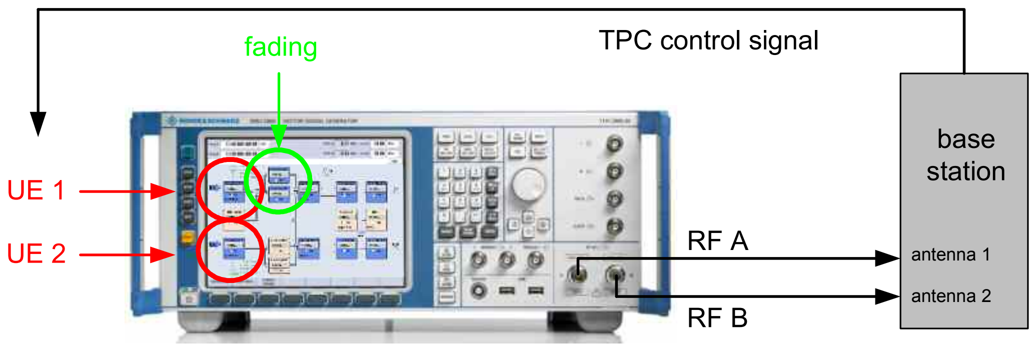


Dynamic power control:

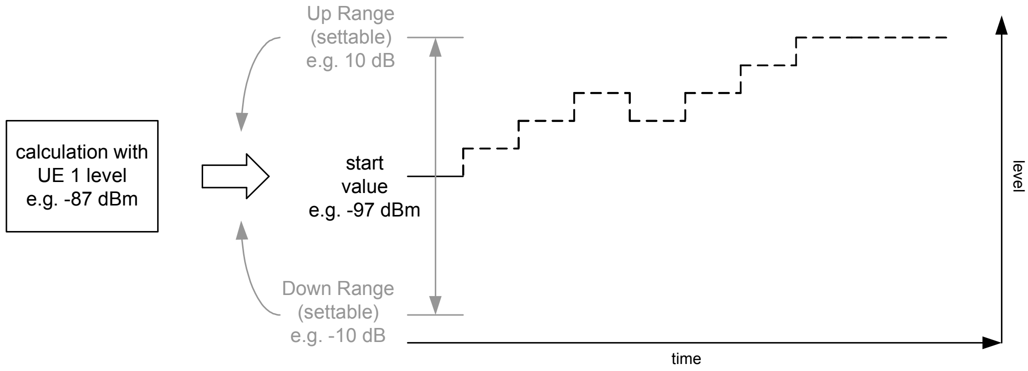
In 3GPP FDD networks, fast closed-loop power control (also called inner-loop power control) is used in the uplink to keep inter-UE interference to a minimum. The transmit power of a UE is adjusted via one or more transmit power control (TPC) commands received in the downlink.
Another benefit of fast power control is that it can be used to combat fading. The UE output power is constantly adjusted such that the fading is compensated and the received power at the base station is maintained constant.

The SMU supports testing of fast closed-loop power control with its SMU-K43 option offering the "dynamic power control" function [3]. With dynamic power control enabled, the level of the selected UE can be increased or decreased within a predefined dynamic range and with a predefined step size. The TPC control information is provided by an external, internal or manual control signal.

In a typical test scenario that uses the test setup described in this section, the level of the unfaded UE serves as the reference level and the level of the faded UE is adjusted in realtime by means of an external TPC control signal coming from the base station.



The level of the faded UE can be adjusted in a settable range, e.g. +/–10 dB, around the start value. The maximum level of UE 1 results from the start value plus the value entered for the parameter “Up Range”. For example, if the start value is –97 dBm and the parameter “Up Range” is set to 10 dB, then the maximum level of UE 1 is -87 dBm. This maximum level is the reference level for the calculation of the leveling and AWGN parameters explained above. Thus, if a start value of –97 dBm is wanted for UE 1, the calculation needs to be done with a level of –87 dBm in this example.



8 Two LTE UEs with Specified SNRs

Test requirement:

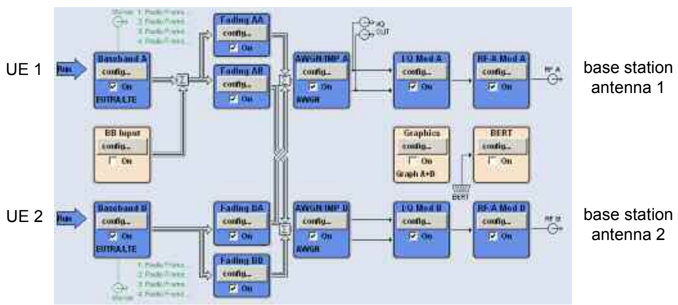
- Two LTE UEs with different SNRs shall be simulated
  - UE 1 shall have an SNR of 6 dB
  - UE 2 shall have an SNR of 2 dB
- The LTE channel bandwidth shall be 3 MHz
- Six resource blocks shall be occupied in each UE
- The noise level shall be –80 dBm / 2.7 MHz
- The SMU shall be used for receive diversity testing, i.e. the signals of UE 1 and UE 2 shall be received by two base station antennas → Two RF test signals are required for testing

Test solution:

Signal routing:

Both basebands are routed to RF outputs A and B using the MIMO routing.

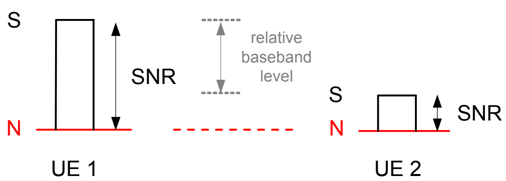
"Fading" block: 2x2 MIMO



UE 1 is simulated by baseband A, and UE 2 by baseband B.

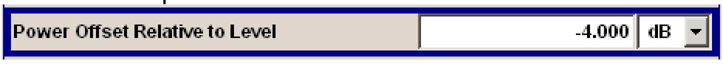
Leveling:

The relative baseband level can be deduced from the SNRs of the two UEs:
6 dB – 2 dB = 4 dB
UE 1 is 4 dB higher in level than UE 2.



The relative baseband level is set via the parameter "Power Offset Relative to Level Display". The level of UE 2, i.e. the level of baseband B has to be lowered by 4 dB.

Baseband A: power offset = 0 dB
Baseband B: power offset = –4 dB



Note that the MIMO matrix is used with default values, i.e. all diagonal elements are set to Ratio = 1.

The RF output level that needs to be set for both paths can be calculated as follows:

In this example, the UE signals occupy six out of 15 possible resource blocks. For a channel bandwidth of 3 MHz, the maximum occupied signal bandwidth is 2.7 MHz. The actual occupied signal bandwidth is thus 6/15 · 2.7 MHz = 1.08 MHz. In the LTE test specification, the SNR is related to average power per (allocated) resource element. For this reason, the relevant noise level is the noise level within the occupied signal bandwidth. The specified noise level is –80 dBm within a bandwidth of 2.7 MHz. The noise level within a bandwidth of 1.08 MHz is –83.98 dBm.

$$\frac{noise\,level_{2.7\,MHz}}{2.7\,MHz} = \frac{noise\,level_{1.08\,MHz}}{1.08\,MHz}$$

$$noise\,level_{1.08\,MHz} = 10\,dBm \cdot \log_{10}\left(\frac{10^{\frac{-80\,dBm}{10\,dBm}}}{2.7} \cdot 1.08\right) = -83.98\,dBm$$

The level of UE 1 can be calculated from the corresponding noise level and the SNR:
Level UE 1 = 6 dB + (–83.98 dBm) = –77.98 dBm

UE 2 has the following level:
Level UE 2 = 2 dB + (–83.98 dBm) = –81.98 dBm

The level of UE 1 is the higher level and thus serves as the reference level:
–77.98 dBm.
This reference level is valid for both UEs, i.e. both instrument paths, since baseband B is already leveled by means of the parameter “Power Offset Relative to Level Display” with respect to this reference level.
Therefore, the theoretical sum level of the two baseband signals is –74.97 dBm.

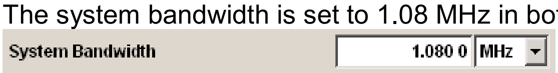
$$sum\,level_{theoretical} = 10\,dBm \cdot \log_{10}\left(10^{\frac{-77.98\,dBm}{10\,dBm}} + 10^{\frac{-77.98\,dBm}{10\,dBm}}\right) = -74.97\,dBm$$

The RF output level of both paths is set to the calculated theoretical sum level:

AWGN:

The carrier/noise ratio that needs to be set in both “AWGN” blocks depends on the set system bandwidth. Normally, the system bandwidth is set to the occupied signal bandwidth, 1.08 MHz in this example. The noise level is, however, specified for a different bandwidth, namely 2.7 MHz. Thus, it makes sense to set the system bandwidth to 2.7 MHz. The required carrier/noise ratio setting will naturally differ in both cases.

Case 1:
The system bandwidth is set to 1.08 MHz in both “AWGN” blocks:



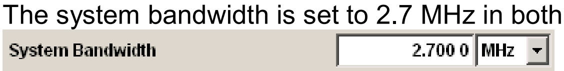
The parameter “Minimum Noise/ System Bandwidth Ratio” should be set to 2.5 to achieve a noise bandwidth of 2.7 MHz minimum.

The carrier/noise ratio that needs to be set in both “AWGN” blocks can be determined as follows:

Carrier level: –74.97 dBm
Noise level (within system bandwidth): –83.98 dBm

SNR = –74.97 dBm – (–83.98 dBm) = 9.01 dB

Case 2:
The system bandwidth is set to 2.7 MHz in both “AWGN” blocks:

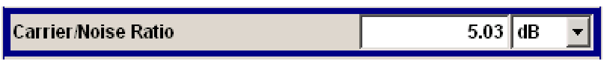


The parameter “Minimum Noise/ System Bandwidth Ratio” should be set to 1.

The carrier/noise ratio that needs to be set in both “AWGN” blocks can be determined as follows:

Carrier level: –74.97 dBm
Noise level (within system bandwidth): –80 dBm

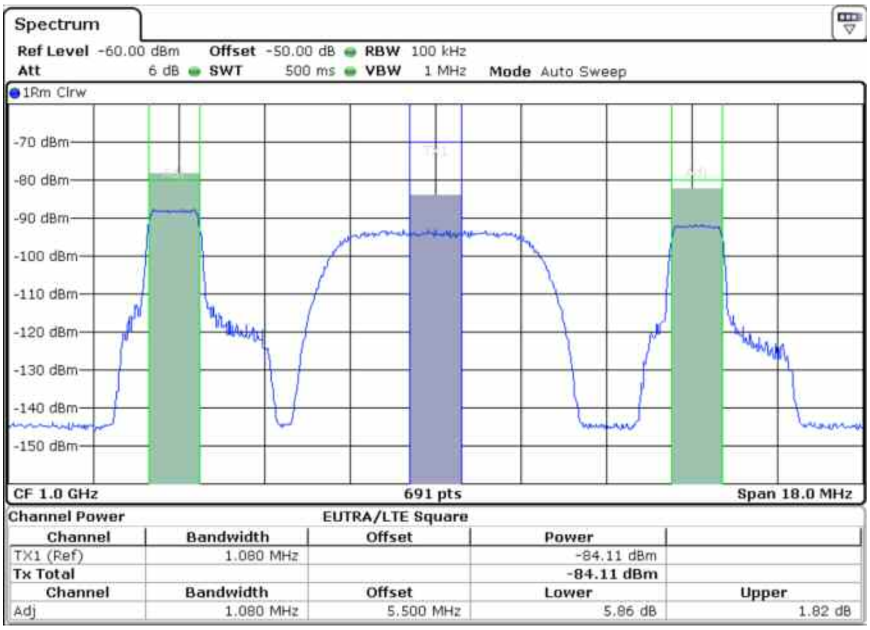
SNR = –74.97 dBm – (–80 dBm) = 5.03 dB



Setup verification:

For test purposes, a frequency offset is used for both basebands to separate the two signals in the spectrum from each other and from the AWGN signal. For baseband A an offset of –5.05 MHz is set, and for baseband B +5.94 MHz. The fading simulation is switched off. Since the RF output level is very low, a level offset of –50 dBm is set on the SMU to provide a sufficient signal level for the spectrum analyzer. Accordingly, a reference level offset of –50 dBm is set on the spectrum analyzer.

A channel power measurement shows the two baseband signals (3 MHz LTE signals) and the generated AWGN signal (with 2.7 MHz system bandwidth). The set channel bandwidth is 1.08 MHz, which corresponds to the occupied signal bandwidth. The measured level of the lower channel (baseband A) is 6 dB higher than the noise level, and the level of the upper channel (baseband B) is 2 dB higher in accordance with the test requirement.



9 LTE Performance Test TS 36.141, 8.3.3 (Multi-User Scenario)

The performance test 8.3.3 “ACK missed detection for multi-user PUCCH format 1a” defined in the 3GPP technical specification 36.141 (Release 8) shall verify the receiver’s ability to detect ACK on the wanted signal in the presence of three interfering signals under multipath fading propagation conditions for a given SNR [5].

Test requirement:

- Wanted signal: LTE uplink
- Three interferers: LTE uplink
- Relative levels:

	Relative power [dB]
Tested signal	-
Interferer 1	0
Interferer 2	-3
Interferer 3	3

from Annex A.9 of [5]

- Fading simulation: ETU70 propagation conditions for all four signals
- Noise level:

Channel bandwidth [MHz]	AWGN power level
1.4	-89.7 dBm / 1.08MHz

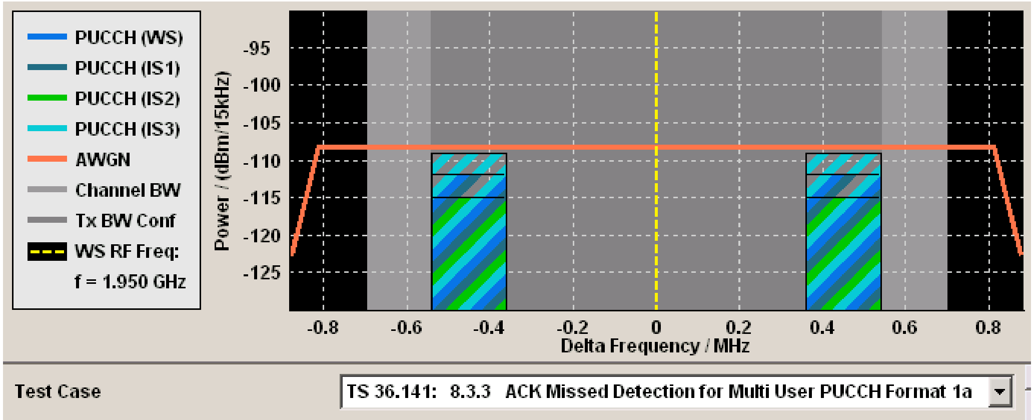
from Table 8.3.3.4.2-1 of [5]

- SNR: –3.5 dB for the wanted signal
  for 1.4 MHz channel bandwidth (from Table 8.3.3.5-1 of [5])
- Receive diversity → Two RF test signals for base station antennas 1 and 2

Test solution:

This test is performed using just two SMUs. The configuration of the SMUs is fast and easy with the **LTE test case wizard** [4], which is included in the R&S®SMU-K55 LTE option.
The test case wizard configures the instrument in line with all test cases in TS 36.141 (Release 8) that require a signal generator. The user simply selects the desired test case, and the SMU sets the LTE test signal, fading simulation and interfering signals such as AWGN, CW and LTE interferers − automatically and standard-compliantly.

When the test case 8.3.3 is selected in both SMUs, the instruments generate the wanted signal and the three interfering signals with the specified relative power settings. In addition, fading simulation and AWGN is applied in line with the technical specification.



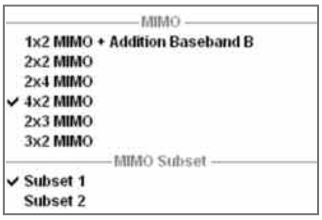
The test case wizard is the most easy-to-use solution for conformance testing of LTE base stations. Nevertheless, we use the test case 8.3.3 of TS 36.141as an advanced example to explain how to perform the signal routing, baseband leveling and AWGN setting manually for this practical test.

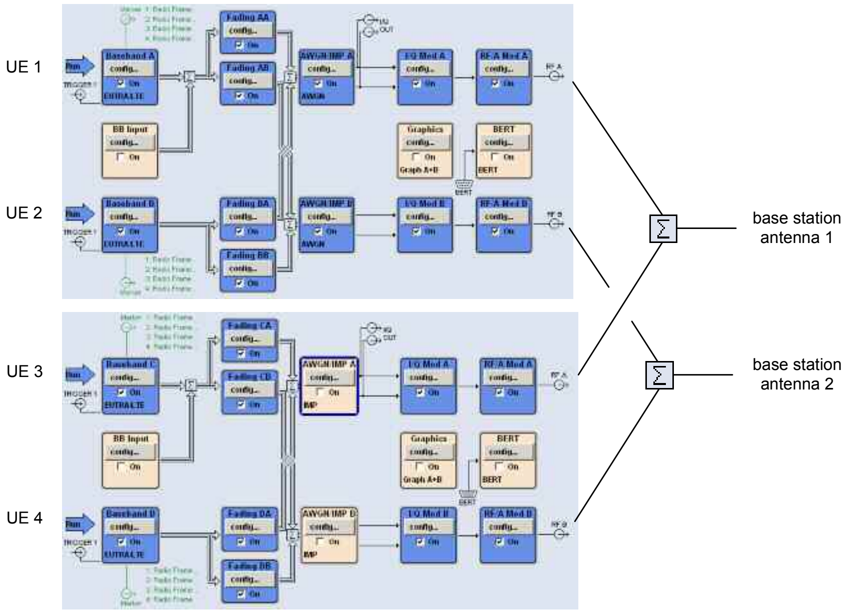
Signal routing:

For each SMU, both basebands are routed to RF outputs A and B using the MIMO routing.

“Fading” block: 4x2 MIMO

- SMU 1: MIMO Subset 1
- SMU 2: MIMO Subset 2

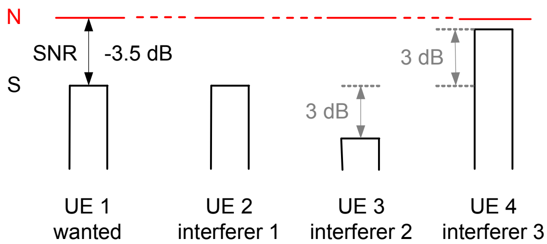




UE 1 is the wanted signal and is simulated by baseband A of SMU 1. UE 2, UE 3 and UE 4 are the interferers and are simulated by baseband B of SMU 1, baseband A of SMU 2 and baseband B of SMU 2, respectively. All four basebands are triggered externally by the base station. The RF outputs A of both instruments are combined externally and connected to antenna 1 of the base station. The RF outputs B of both instruments are also combined externally and connected to antenna 2.

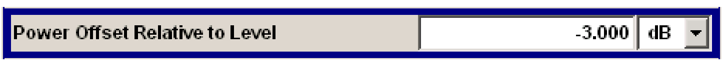
Leveling:

According to the specification, UE 2 has the same level as UE 1. UE 3 is 3 dB lower in level than UE 1, and UE 4 is 3 dB higher.



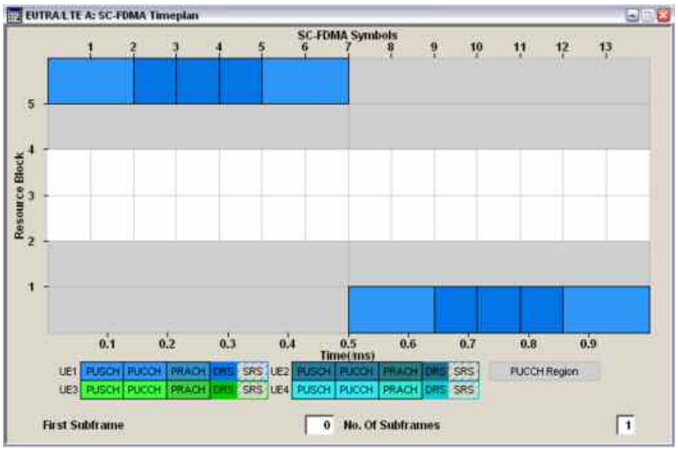
The relative baseband levels are set via the parameter “Power Offset Relative to Level Display”. The level of UE 4 is the highest level and thus serves as the reference level for the power offsets. The levels of UE 1, UE 2 and UE3 have to be attenuated accordingly.

Baseband A of SMU 1: power offset = –3 dB
Baseband B of SMU 1: power offset = –3 dB
Baseband A of SMU 2: power offset = –6 dB
Baseband B of SMU 2: power offset = 0 dB (reference)



The level of UE 1 can be calculated from the specified noise level and the SNR:

The specified noise level is –89.7 dBm within a bandwidth of 1.08 MHz. The UE signal only occupies one out of six possible resource blocks at a point in time as can be seen in the time plan.



The occupied signal bandwidth is thus not 1.08 MHz but only 1.08 MHz / 6 = 180 MHz. In the LTE standard, the SNR is related to average power per (allocated) resource element. For this reason, the relevant noise level is the noise level within the occupied signal bandwidth. The noise level within a bandwidth of 180 kHz is –97.48 dBm.

$$\frac{noise\,level_{1.08\,MHz}}{1.08\,MHz} = \frac{noise\,level_{180\,kHz}}{180\,kHz}$$

$$noise\,level_{180\,kHz} = 10\,dBm \cdot \log_{10}\left(\frac{10^{\frac{-89.7\,dBm}{10\,dBm}}}{1.08\,MHz} \cdot 180\,kHz\right) = -97.48\,dBm$$

The level of UE 1 can be calculated from this noise level and the specified SNR:
Level UE 1 = –97.48 dBm + (–3.5 dB) = –100.98 dBm

The interfering UEs have the following levels:

Level UE 2 = –100.98 dBm + 0 dB = –100.98 dBm
Level UE 3 = –100.98 dBm + (–3 dB) = –103.98 dBm
Level UE 4 = –100.98 dBm + 3 dB = –97.98 dBm

The RF output level that needs to be set for both paths of both SMUs can be determined as follows:

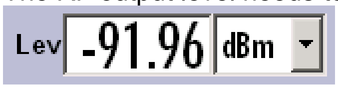
The level of UE 4 is the highest level and thus the reference level: –97.98 dBm. This reference level is valid for all UEs, i.e. instrument paths, since the basebands are already leveled individually by means of the parameter "Power Offset Relative to Level Display" with respect to this reference level.

Therefore, the theoretical sum level of two baseband signals is –94.97 dBm.

$$sum\,level_{theoretical} = 10\,dBm \cdot \log_{10}\left(10^{\frac{-97.98\,dBm}{10\,dBm}} + 10^{\frac{-97.98\,dBm}{10\,dBm}}\right) = -94.97\,dBm$$

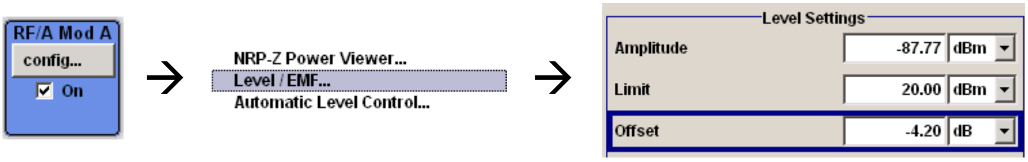
For 4x2 MIMO signal routing, the fading simulator lowers the signal level by 3.01 dB [6]. These 3.01 dB have to be compensated. Thus, the theoretical sum level needs to be increased by 3.01 dB: –94.97 dBm + 3.01 dB = –91.96 dBm

The RF output level needs to be set for both paths of both SMUs to –91.96 dBm:



for all four RF outputs.

The RF outputs A as well as the RF outputs B are summed by an external combiner. The combiner loss (typically 3 dB related to power or 6 dB related to voltage) as well as cable losses also need be considered. For example, assuming the used combiner has a loss of 3.2 dB and the cables attenuate by an additional 1 dB, then the total loss is 3.2 dB + 1 dB = 4.2 dB. To compensate this loss, a level offset of –4.2 dB is set for all four RF outputs in this example.



Note that the test case wizard does not configure the level offset, since this is a setup-specific parameter.

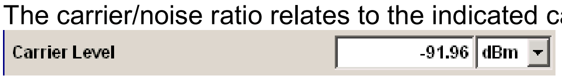
AWGN:

For noise generation the “AWGN” blocks of SMU 1 are used. “AWGN” block A generates the noise for base station antenna 1, while “AWGN” block B generates the noise for antenna 2.

The specified noise level is –89.7 dBm / 1.08 MHz. The system bandwidth is thus set to 1.08 MHz in both “AWGN” blocks of SMU 1:

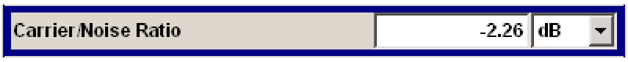
The carrier/noise ratio that needs to be set in both “AWGN” blocks of SMU 1 can be determined as follows:

The carrier/noise ratio relates to the indicated carrier level, which is –91.96 dBm.

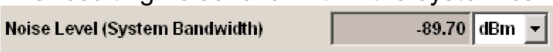


Carrier level: –91.96 dBm
Noise level: –89.7 dBm

SNR = –91.96 dBm – (–89.7 dBm) = –2.26 dB



The resulting noise level within the system bandwidth (1.08 MHz) is indicated:



10 References

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

[2] Rohde & Schwarz, "R&S dBCalculator" Application Note (1GP77)

[3] Rohde & Schwarz, 3GPP FDD incl. enhanced MS/BS tests, HSDPA, HSUPA, HSPA+ Digital Standard for R&S®Signal Generators Operating Manual

[4] Rohde & Schwarz, EUTRA/LTE Digital Standard for R&S®Signal Generators Operating Manual

[5] 3GPP Technical Specification EUTRA/LTE Base Station Conformance Testing (TS 36.141, Release 8)

[6] Rohde & Schwarz, "Guidelines for MIMO Test Setups – Part 2" Application Note (1GP51)

11 Ordering Information

R&S®SMU200A	**Vector Signal Generator**	1141.2005.02
R&S®SMU-B102	100 kHz to 2.2 GHz, (RF path A)	1141.8503.02
R&S®SMU-B103	100 kHz to 3 GHz, (RF path A)	1141.8603.02
R&S®SMU-B104	100 kHz to 4 GHz, (RF path A)	1141.8603.02
R&S®SMU-B106	100 kHz to 6 GHz, (RF path A)	1141.8803.02
R&S®SMU-B202	100 kHz to 2.2 GHz, (RF path A)	1141.9400.02
R&S®SMU-B203	100 kHz to 3 GHz, (RF path B)	1141.9500.02
R&S®SMU-B90	Phase Coherence	1409.8604.02
R&S®SMU-B13	Baseband Main Module	1141.8003.04
R&S®SMU-B9	Baseband Generator with ARB (128 Msample)	1161.0866.02
R&S®SMU-B10	Baseband Generator with ARB (64 Msample)	1141.7007.02
R&S®SMU-B11	Baseband Generator with ARB (16 Msample)	1159.8411.02
R&S®SMU-B16	Differential I/Q Output	1161.0066.02
R&S®SMU-B17	Baseband Input (analog/digital)	1142.2880.02
R&S®SMU-B18	Digital Baseband Output	1159.6954.02
R&S®SMU-B14	Fading Simulator	1160.1800.02
R&S®SMU-B15	Fading Simulator Extension	1160.2288.02
R&S®SMU-K62	Additive White Gaussian Noise (AWGN)	1159.8511.02
R&S®SMU-K71	Dynamic Fading and Enhanced Resolution	1160.9201.02
R&S®SMU-K72	Extended Statistic Functions	1408.7062.02
R&S®SMU-K74	MIMO Fading	1408.7762.02
R&S®SMU-K40	Digital Standard GSM/EDGE	1160.7609.02
R&S®SMU-K41	Digital Standard EDGE Evolution	1408.7810.02
R&S®SMU-K42	Digital Standard 3GPP FDD	1160.7909.02
R&S®SMU-K43	Digital Standard 3GPP Enhanced BS/MS Tests incl. HSDPA	1160.9660.02
R&S®SMU-K45	Digital Standard 3GPP FDD HSUPA	1161.0666.02
R&S®SMU-K46	Digital Standard CDMA2000®	1160.9876.02
R&S®SMU-K47	Digital Standard 1xEV-DO	1408.7410.02
R&S®SMU-K48	Digital Standard IEEE 802.11 (a/b/g)	1161.0266.02
R&S®SMU-K49	Digital Standard IEEE 802.16	1161.0366.02
R&S®SMU-K50	Digital Standard TD-SCDMA	1161.0966.02
R&S®SMU-K51	Digital Standard TD-SCDMA Enhanced BS/MS Tests	1161.1062.02
R&S®SMU-K54	Digital Standard IEEE 802.11n	1408.7562.02
R&S®SMU-K55	Digital Standard EUTRA/LTE	1408.7310.02
R&S®SMU-K59	Digital Standard 3GPP FDD HSPA+	1415.0053.02
R&S®SMU-K69	EUTRA/LTE Closed-Loop BS Test	1408.8117.02
R&S®SMU-K84	LTE Rel.9, Enhanced Features	1408.8475.02

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established more than 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Environmental commitment

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

Certified Quality System
ISO 9001

Regional contact

Europe, Africa, Middle East
+49 89 4129 123 45
customersupport@rohde-schwarz.com

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

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

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

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

www.rohde-schwarz.com