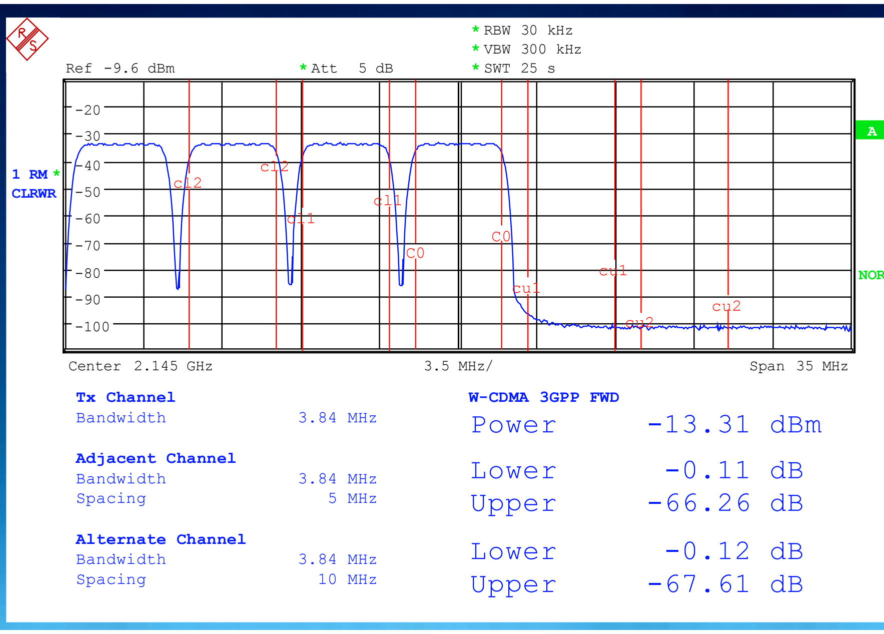


SMIQ03HD, FSU

Generating and Analyzing 3GPP Multicarrier Signals with High Dynamic Range

Application Note

This application note describes three ways of generating multicarrier signals with high dynamic range for testing power amplifiers of 3GPP radio base stations. It also gives tips for optimizing spectrum analyzer settings in order to measure the Adjacent Channel Leakage Ratio (ACLR).

Subject to change – D. Picken/R. Minihold 03/2002– 1MA48_1E

Contents

1 Summary

This application note describes three ways of generating multicarrier signals for testing power amplifiers of 3GPP radio base stations.

The corresponding sets of waveform (*.wv) files are delivered with this application note. The WinIQSIM™ software is used to download these files to the signal generator(s).

The application note also gives tips for optimizing spectrum analyzer settings in order to measure the Adjacent Channel Leakage Ratio (ACLR)

It is assumed that you are familiar with 3GPP testing requirements and know the Rohde & Schwarz program of Signal Generators and Signal Analyzers. Readers seeking background information are referred to the literature sources in section 5. Specifically:

- Technical Specification 3GPP TS 25.141 [1] describes the base-station measurements in detail.
- W-CDMA Signal Generator Solutions, R&S Application Note 1GP39_1E [2] provides a tutorial on W-CDMA signal properties and introduces the R&S signal generator families SMIQ and AMIQ.
- 3GPP FDD Base Station Tests with Vector Signal Generator SMIQ, R&S Application Note 1GP41_0E [3], describes the setting up of signal generators for 3GPP tests on base stations.

Rohde & Schwarz Application Notes and product data sheets are available for download on the internet at http://www.rohde-schwarz.com

2 Why Multicarrier Test Signals?

To keep costs down, modern base station transmitters apply several W-CDMA carriers simultaneously to the power amplifier stage. To handle such signals, the amplifier must be extremely linear. The test equipment also has to meet high requirements in order to measure amplifier performance correctly.

For the measurement of Adjacent Channel Leakage Ratio (ACLR), the 3GPP specification TS25.141 [1] calls for a multicarrier signal in accordance with Test Model 1 containing 64 DPCHs.

A typical test setup for this measurement is shown in Fig. 1.

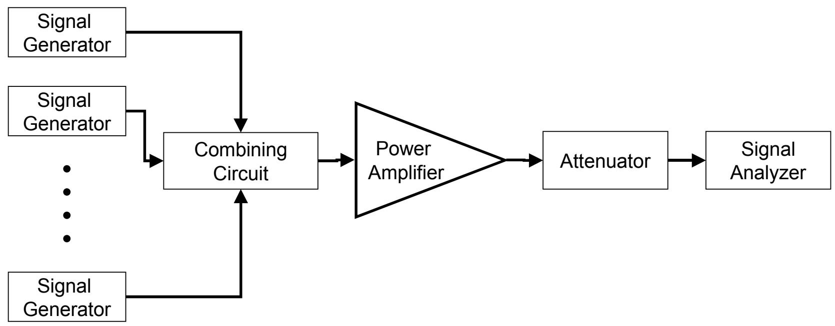


Fig. 1: Basic setup for ACLR measurements on a base station power amplifier stage.

3 Three Ways to Generate Multicarrier Signals

In this section we describe three ways of generating 3GPP multicarrier test signals. Each solution has its specific features and advantages as shown in the table below.

Solution	**Features**	**Applications**
Single SMIQ03HD Signal Generator with Option B60	simple and economic test setup	production testing
Two SMIQ03HD Signal Generators in Master-Slave Mode with Option B60	improved spectral purity	R&D
Four SMIQ03HD Signal Generators with coupled output signals	highest spectral purity, maximum dynamic range and accuracy	R&D, type approval

Common to all proposed solutions is the use of the R&S Signal Generator SMIQ03HD with its supperior dynamic range and its Arbitratry Waveform Generator option SMIQ-B60 (ARB). Using digital signal processing in the baseband and a true baseband IQ modulator, the SMIQ03HD offers excellent modulation accuracy, beyond the performance of generators using signal processing at the IF. Special hardware in the HD models of the SMIQ optimizes the adjacent channel performance.

The attached waveform files will be downloaded from a PC into the SMIQ03HD via the WinIQSIM™ Software and the IEEE-488 GPIB interface. The waveform files are provided as file attachments to this application note. The WinIQSIM™ Software is part of the option "Arbitrary Waveform Generator" SMIQ-B60.

The generated signals follow the specifications of the 3rd Generation Partnership Project (3GPP) and simulate closely the real-life conditions to be expected at a base station. The 3GPP Technical Specification

TS 25.141 [2] describes a number of signal combinations, known as Test Models, for use in measurements.

At the output of the base station or amplifier, measurements are made using a Rohde & Schwarz Signal Analyzer FSU. The requirements on the analyzer are demanding, so that accurate results can only be obtained if the analyzer is properly set up, making use of special functions to optimize its linearity and noise performance in the presence of complex, wideband signals of high dynamic range. Please refer to section 4 of this Application Note for tips to achieve optimized settings on the FSU Spectrum Analyzer. These settings are used to obtain the example results shown in the following sections.

In each case, the measured results should be compared with the Test Requirement specified in 3GPP TS 25.141 (V.3.6.0), subclause 6.5.2.2.5:

BS channel offset below the first or above the last carrier frequency	ACLR limit
5 MHz (adjacent channel)	44.2 dB
10 MHz (1st alternate channel)	49.2 dB

The screen shots provide evidence that all three generator solutions using SMIQ(s) in combination with the FSU are capable of performing these measurements to the required standard. The setup using four SMIQ03HD Signal Generators offers the widest measurement margin and is therefore best suited for laboratory work.

Single Signal Generator SMIQ03HD with ARB Option SMIQ-B60

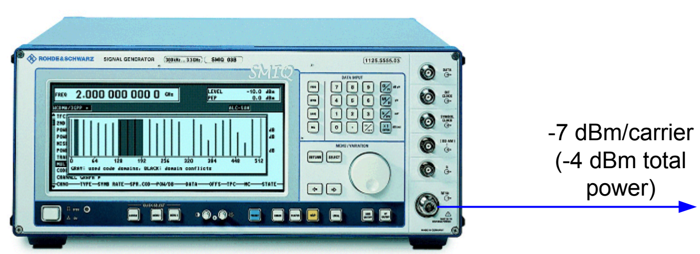


Fig. 2: Generating a 4-carrier 3GPP signal with a single SMIQ03HD

The simplest way to obtain a 3GPP test signal with four modulated physical carriers is to use a single SMIQ03HD with ARB. The baseband signal is generated in the ARB Option SMIQ-B60 and used to modulated the RF output of the Signal Generator SMIQ.

A waveform using a multicarrier setup (4 x 3GPP Test Model 1 with 64 DPCH logical carriers with 5 MHz spacing, file: *4x3GPPMulticarrier_OS1_SCV.wv*) is downloaded into the Signal Generator SMIQ. The carriers are de-correlated using different scrambling codes (0, 1, 2 and 3). Each carrier is given an offset of 1/5 of a W-CDMA/3GPP slot. The crest factor of the four-carrier signal is calculated using the R&S Simulation Software WinIQSIM to 11.32 dB. The SMIQ sets according to the calculation the correct PEP automatically. The 10 MHz IQ filter is switched on within the Vector Mode menu (option SMIQB47 is required) to suppress baseband noise outside the wanted spectrum. Further the SMIQ should be set to LOW-NOISE within the Level menu. This function suppresses further existing broadband noise in the generator. The overall peak power of the SMIQ should not exceed +8 dBm to avoid excessive generation of ACP due to intermodulation in the SMIQ signal path. This limits the available overall power to about –4 dBm and the channel power per channel to about –10 dBm.

Note: The warning in the SMIQ display that occurs when switching on the 10 MHz IQ filter may be ignored. The 4 carrier spectrum fits well to the filter bandwidth.

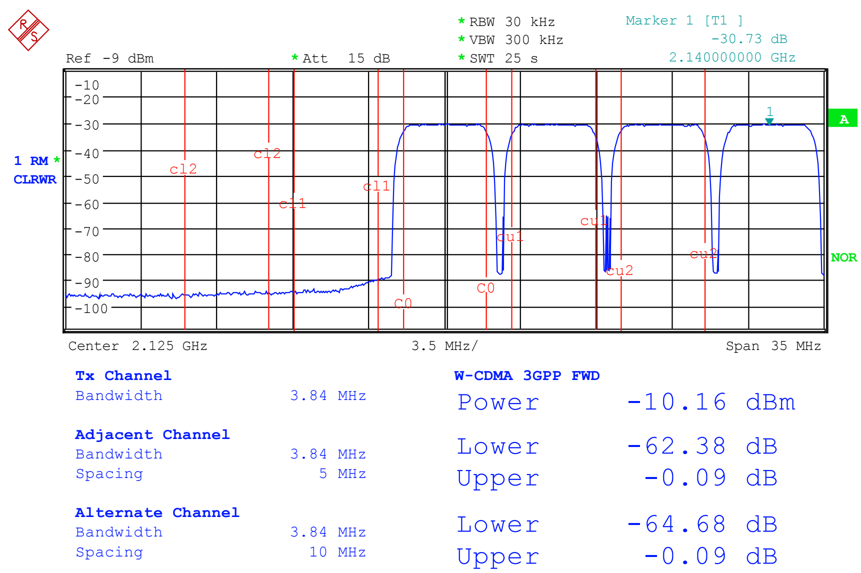


Fig. 3: ACLR measurement results, lower adjacent channel and 1st alternate channel

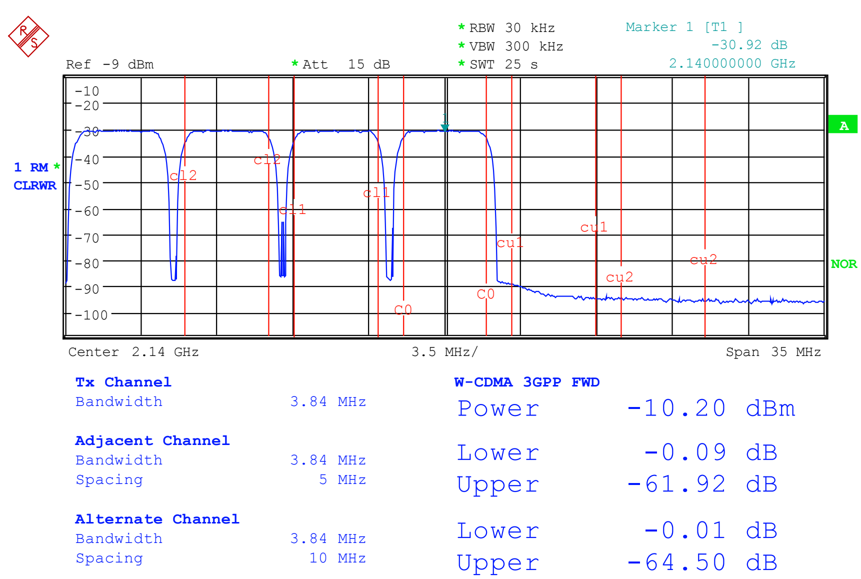


Fig. 4: ACLR measurement results, upper adjacent channel and 1st alternate channel

Two Signal Generators SMIQ03HD with ARB Option SMIQ-B60

A four-carrier signal can also be obtained using a combination of two Signal Generators SMIQ03HD in master-slave configuration. Each Signal Generator is fitted with an ARB Option SMIQ-B60. A two-carrier signal is generated by each set of generators and their output signals are then combined. This more complex setup achieves a performance improvement of some 2.5 dB.

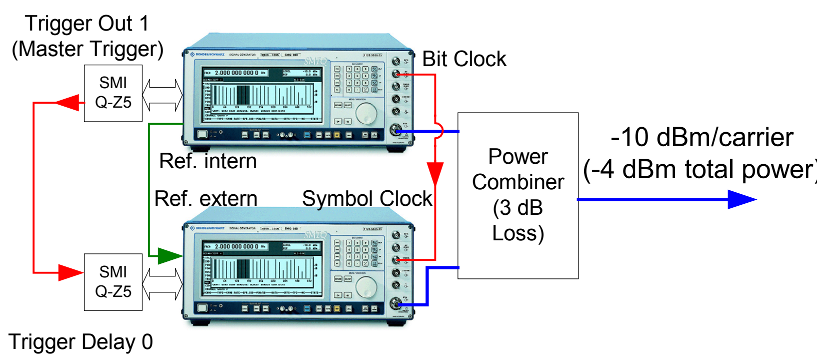


Fig. 5: Signal generation using 2 SMIQ03HDs (strictly according to ETSI 3GPP TS 25.141, Chapter 6.1.1.6.3)

Waveforms using a multicarrier setup of WINIQSIM (files *2x3GPPMulticarrierOS1_1.wv* and *2x3GPPMulticarrierOS1_2.wv*) containing two carriers of Test Model 1 with 64 DPCH and a spacing of 5 MHz are downloaded into each SMIQ03HD. Again the carriers are de-correlated using different scrambling codes 0, 1 and 2, 3 Each carrier is given an offset of 1/5 of a W-CDMA/3GPP slot. Triggering between the two SMIQ is established by sending one master trigger to the slave. The two instruments are operated via the same 10-MHz reference. The bit clock output of the upper SMIQ feds the symbol clock input of the lower one.

It has been proven that in practice a simplified configuration according to Fig. 6 (without any synchronization and triggering) shows exactly the same results and is therefore recommended.

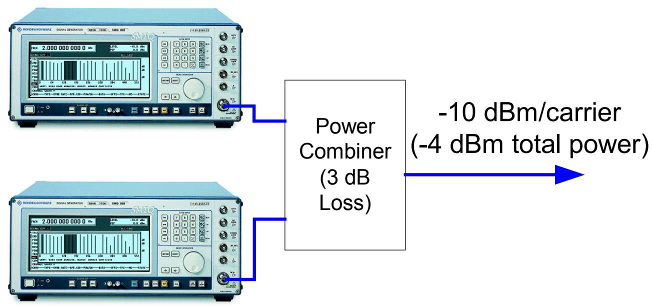


Fig. 6: Recommended simplified configuration using 2 SMIQs

The crest factor of the four-carrier signal could not be measured but for each set of the two carriers WinIQSIM computed the crest factor used for the ARB in order to set the correct PEP in the SMIQ. A two-path power combiner from MiniCircuits (ZAPD-4) has been chosen for its good decoupling characteristics. In order to improve the measurement conditions, the 5 MHz LOW ACP Filter SMIQ-B47 has been selected. The SMIQ whose spectrum is adjacent to the adjacent channel to measure is set to Low Distortion, the other one to Low Noise to give optimum performance.

The maximum available output power is about the same as before. The 2 SMIQ deliver a 3 dB higher output level (only 2 carriers) but the power combiner adds 3 dB attenuation.

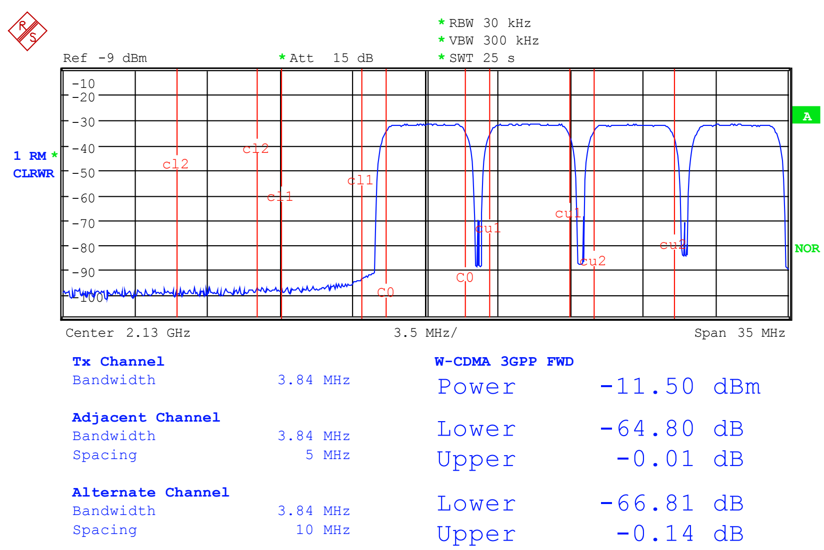


Fig. 7: ACLR measurement results, lower adjacent channel and 1st alternate channel

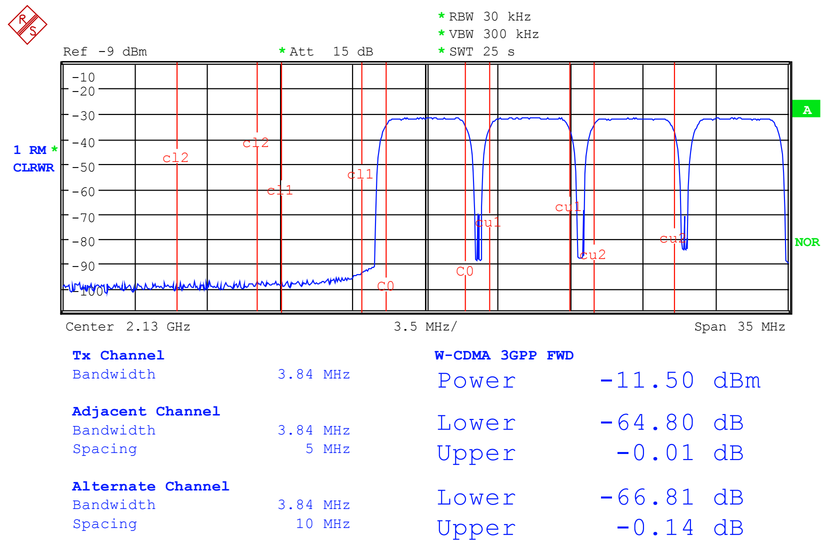


Fig. 8: ACLR measurement results, upper adjacent channel and 1st alternate channel

Four Signal Generators SMIQ with ARB Option SMIQB60 or 3GPP Option SMIQB45

The highest spectral purity - and with it the highest measurement dynamic range - is obtained by using 4 Signal Generators SMIQ03HD and adding their output signals using a suitable combining network .

A single 3 GPP carrier can be produced either by the 3 GPP option SMIQB45 or with ARB Option SMIQB60.

Using SMIQB45 Testmodel 1_64 DPCH is chosen in every SMIQ. but different (0,1,2,3) spreading codes are set. Further decorrelation is managed by the trigger setup shown in Fig. 9.

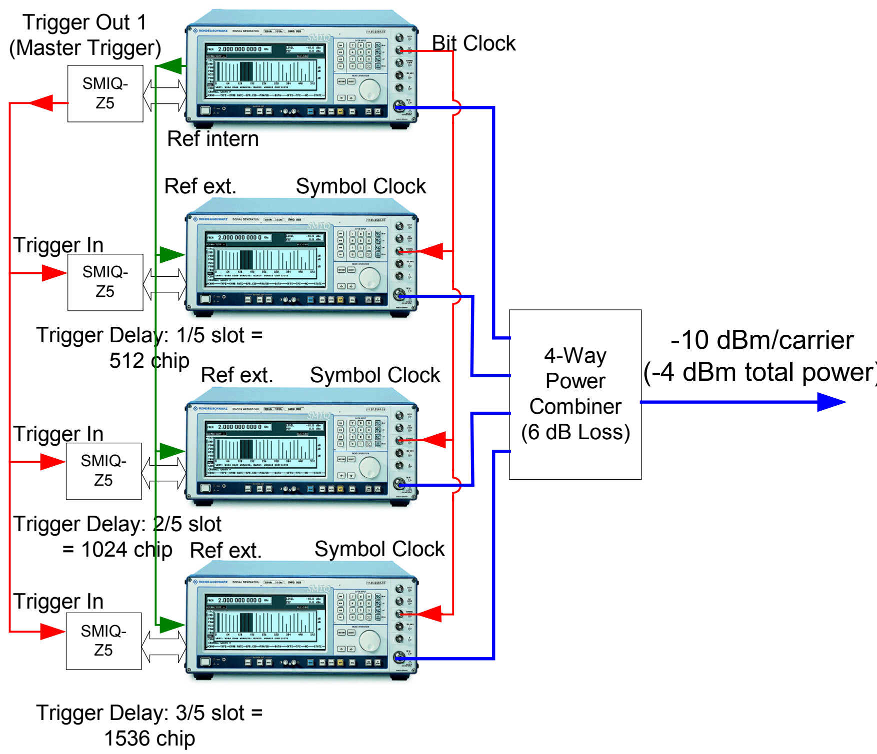


Fig. 9: Signal generation using 4 SMIQ03HD's (strictly according to ETSI 3GPP TS 25.141, Chapter 6.1.1.6.3)

Using alternatively the ARB function waveforms containing Test Model 1 with 64 DPCH and different spreading codes (0, 1, 2 and 3) files: *1x3GPPT1_64S1.wv*, *1x3GPPT1_64S2.wv*, *1x3GPPT1_64S3.wv*, *1x3GPPT1_64OS2S4.wv* are downloaded into each SMIQ. Each Test Model has the same PRBS 9 sequence. In order to de-correlate the carriers effectively, the 2nd to 4th carriers have a timing offset of 1/5 slot per carrier, by using the trigger setup shown in Fig. 9. The bit clock output of the top SMIQ feds the symbol clock inputs of the other SMIQ's.

It has been proven that a more convenient and simpler setup (without any triggering and synchronization) shows exactly the same results, see Fig. 10. Using 4 different signal generators there is no measureable effect of correlation. Therefore the setup according to Fig. 10 is recommended.

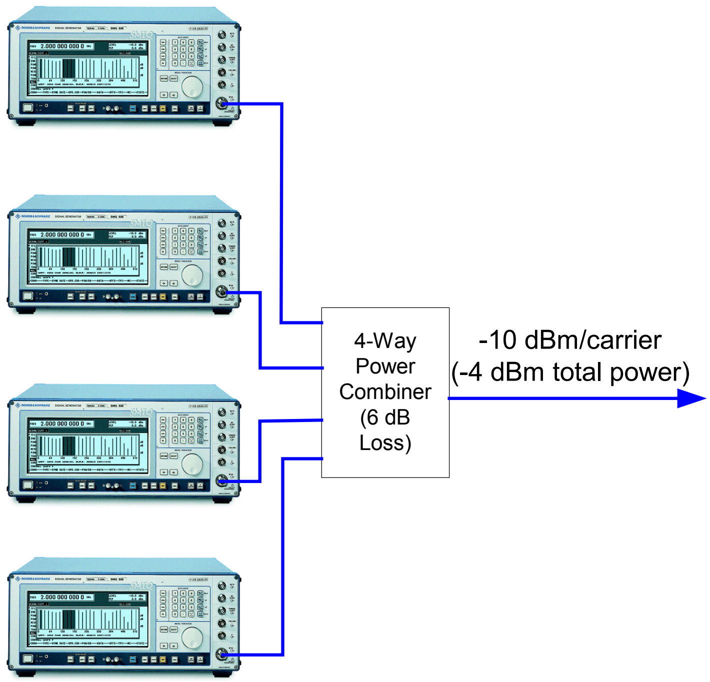


Fig. 10: Recommended simplified configuration which shows in practice exactly the same behaviour as the setup in Fig. 9

The screen shots show measurements taken for the upper adjacent and alternate channel as well as for the lower adjacent and alternate channel. The SMIQ nearest to the channel to measure is using the LOW-DIST function in the LEVEL menu. The more distant SMIQs are using the LOW-NOISE function. In all SMIQs the IQ filter 2.5 MHz is switched on (Vector Modulation Menu, SMIQ-B47 needed).

A four-path power combiner ZB4PD-42 from Mini-Circuits has been chosen.

Note:
In the frequency range 2110 to 2170 MHz a further significant improvement in dynamic range to about –74 dB in the adjacent channel can be achieved using four SMIQ03HD with option SMIQB57 (SMIQB57 does not alow to generate more than one single 3 GPP carrier with one SMIQ03HD).

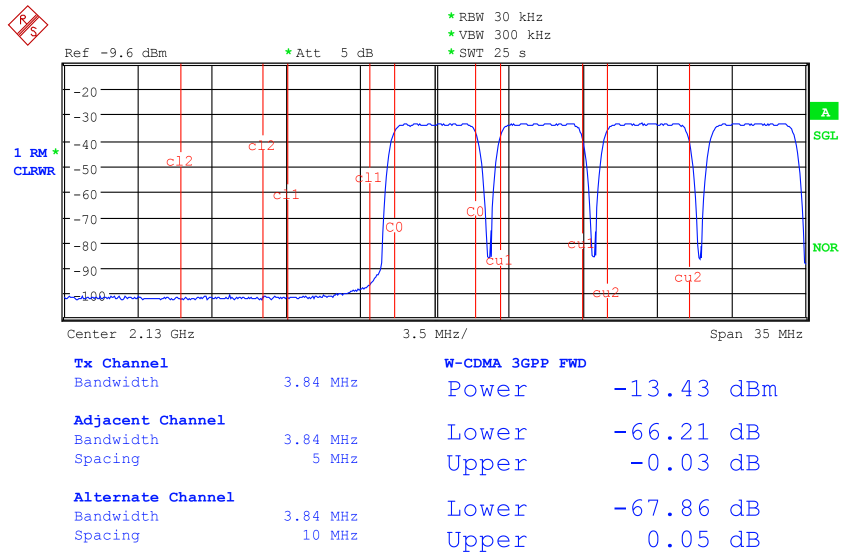


Fig. 11: ACLR measurement results, lower adjacent channel and 1st alternate channel

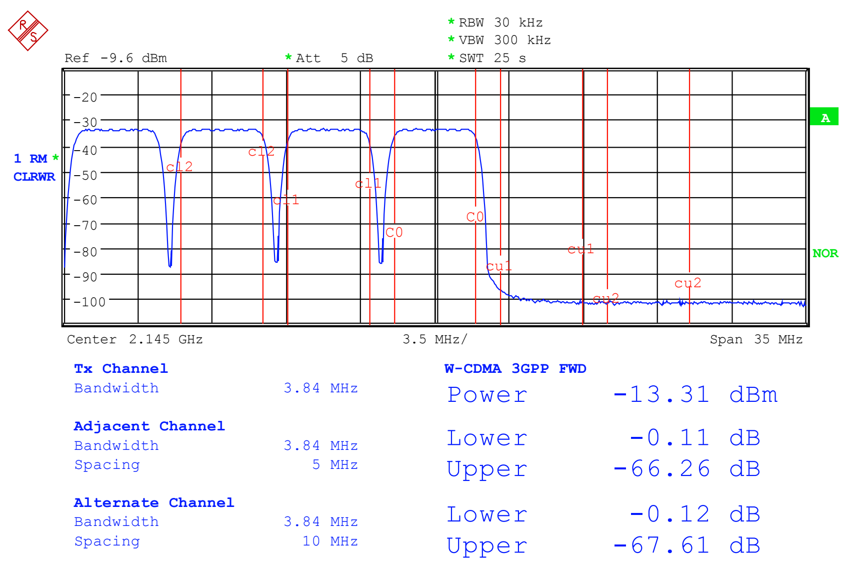


Fig. 12: ACLR measurement results, upper adjacent channel and 1st alternate channel

4 Optimized Settings on the FSU for Multicarrier Analysis

The measurement of very low adjacent-channel power levels on a multicarrier CDMA signal requires extremely high performance from the spectrum analyzer.

At a first glance the signal within the transmit channels looks like white noise, but in terms of signal statistics it differs from white noise. The crest factor (= ratio of peak power to RMS power) of the signal depends on the number of coded channels transmitted.

In the test signal commonly used for ACLR measurements (model 1 with 64 code channels) it is approximately 10.5 dB. Adding more RF channels increases the crest factor further to about 11.5 dB for four RF channels (assuming there is no correlation between the signals in the different RF channels). The spectrum analyzer must cope with these high peak amplitudes.

Several parameters of the spectrum analyzer influence its inherent dynamic range:

- the load capability of the signal path without distorting the CDMA signal
- the thermal noise floor of the spectrum analyzer and
- the phase noise of the internal local oscillators.

As these requirements go to the limit of the dynamic capabilities of a spectrum analyzer, it has to be set up very carefully in order to attain optimum dynamic range.

New Firmware Function: Noise Compensation. Starting from Firmware Version 1.41 the FSU has a new firmware function called Noise Correction (*NOISE CORR ON*) which compensates for the thermal noise floor by switching off the input signal and making a sweep to calculate the inherent power. This information is then later used in signal processing stages for noise compensation. A remarkable increase in dynamic range by about 7 dB is thus achieved.

The reference level of the analyzer and the attenuator should be set independently for best matching (select the function RF ATTEN MANUAL).

Attenuator settings

The FSU allows the attenuator to be set in steps of 5 dB. When working with a 4-carrier 3GPP signal, the best compromise between signal-to-noise ratio on the one hand and the internally generated intermodulation products and spectrum regrowth on the other is obtained when the signal level at the mixer (the FSU input signal level – the attenuation setting) is in the range -12 dBm to -17 dBm.

Example:

Signal Level: +1 dBm ---> Attenuator setting: 15 dB

Signal Level at input mixer: - 14 dBm

Setting the reference level

To minimize the effects of IF noise, the reference level should be set as low as possible (i.e. the gain in the IF stage of the analyzer should be as high as possible) while taking care to avoid overloading.

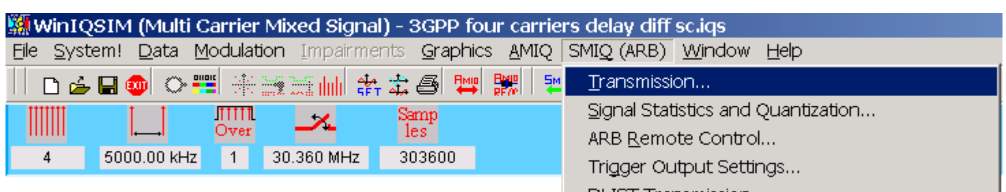
To achieve this, reduce the reference level in 1-dB steps until the overload limit is reached (observe the IFOVL warning at the left-hand side of the screen). Then increase the reference level until the overload warning switches off.

Switch on noise correction

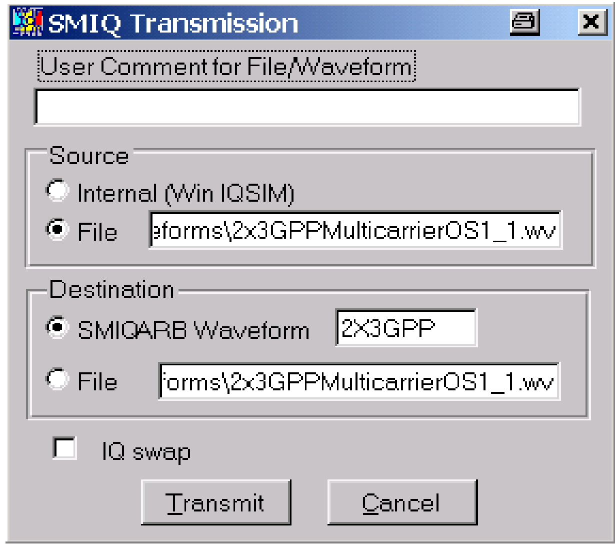
After setting of the attenuation and the reference level switch on the noise correction function (*NOISE CORR ON*) to achieve the maximum dynamic range with the FSU. Note that the best results with noise compensation are achieved with a lower mixer level signal as compared to the normal ACLR measurement. This is because the compensation works only for the input noise but not for the inherent intermodulation products generated by the FSU. The change of the mixer level is done automatically through a 5 dB increase of the input attenuation, when the noise compensation is switched on.

5 Appendix: How to download the waveform files to SMIQ

- Connect computer with GPIB port of SMIQ03HD
- Unpack downloaded zipped waveform files
- Start WINIQSIM Software
- Click on SMIQ(ARB) and select Transmission....



- Click on Source: File, then click to File window and choose appropriate path to wanted waveform file



- Select Destination SMIQ ARB Waveform (if not already selected)
- Click on Transmit (Check SMIQ GPIB address settings if not done before)

For further instructions see Software Manual of WINIQSIM.

6 Literature References

[1] 3GPP Technical Specification TS 25.141 (V3.6.0 – 2001-06)

[2] WCDMA Signal Generator Solutions by Rohde & Schwarz – R&S Application Note 1GP39

[3] 3GPP FDD Base Station Tests with Vector Signal Generator SMIQ – R&S Application Note 1GP41_0E

[4] Measurement of Adjacent Channel Power on Wideband CDMA Signals - R&S Application Note 1EF40_0E

[5] Measurement of Adjacent Channel Leakage Power on 3GPP W-CDMA Signals with the FSP - R&S Application Note 1ES41_0Ee

[6] Signal Generator SMIQ – Fit for 3G with new options, News from Rohde & Schwarz No. 166 (2000/I), page 10

[7] R&S Data Sheet Signal Generator SMIQ03HD *PD 0757.7375.21*

[8] R&S Data Sheet Signal Analyzer FSU *PD 0757.6504.23*

[9] Measurements on 3GPP Base Station Transmitter Signals - R&S Application Note 1EF44_1E

[10] Software Manual WINQSIM

7 Further Information

Please send your comments and suggestions on this Application Note to:
TM-Applications@rsd.rohde-schwarz.com

8 Ordering Codes

Vector Signal Generator		
R&S SMIQ03HD	300 kHz to 3.3 GHz	1125.5555.33
Options:		
R&S SMIQB11	Datengenerator	1085.4502.04
R&S SMIQB20	Modulationscoder	1125.5190.02
R&S SMIQB45	Ditaler Standard 3GPP	1104.8232.02
R&S SMIQ-B57	High ACLR for WCDMA 3GPP (2110 MHz to 2170 MHz)	1105.1831.02
R&S SMIQ-B60	Arbitrary Waveform Generator incl. WinIQSIM™	1136.4390.02
Spectrum Analyzer		
R&S FSU3	20 Hz to 3.6 GHz	1129.9003.03
R&S FSU8	20 Hz to 8 GHz	1129.9003.08
Options:		
R&S FS-K72	WCDMA 3GPP Application Firmware BTS Code Domain Power Measurements for FSU	1154.7000.02
Recommend extras		
R&S RDL 50	High Power Attenuator 20dB, 50 W, 0 to 6 GHz	1035.1700.52

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