Products: SMIQB Vector Signal Generator, AMIQ I/Q Modulation Generator with WinIQSIM™ Software

WCDMA Signal Generator Solutions by Rohde & Schwarz

Application Note

The SMIQB Vector Signal Generator and the AMIQ I/Q Modulation Generator with the WinIQSIM™ software are outstanding signal sources for 3rd generation communication systems. This paper describes how to apply R&S signal generators for 3GPP WCDMA measurements, and introduces 3GPP WCDMA and related measurement applications.

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1 WCDMA Evolution Overview

The movement towards a worldwide 3G wireless communication standard started in Japan in 1997. Because the capacities of the existing networks were nearly exhausted, the demand for new systems was urgent. NTT DoCoMo developed an experimental WCDMA system for network field tests. This experimental system was the basis of the Japanese ARIB standard released in 1998. NTTDoCoMo and ARIB standards are based on Frequency Division Duplex (FDD) architecture and 4.096 Mcps chip rate [1]. In Europe the ETSI developed a 4.096 Mcps chip rate standard in parallel.

In the U.S. a different approach was used. Based upon the established IS-95 standard, the CDMA2000 system was developed. CDMA2000 has several different operation modes. Some work with multi carrier signals, using three IS-95 carriers at the same time. Other modes use direct spreading, i.e. a single carrier with 3.6864 Mcps chip rate, which differs from the chip rate used by the Europeans and the Japanese.

In the last two years efforts were made to merge these different approaches into one world wide standard. The aim was to harmonize step-by-step the different techniques and obtain common solutions for all three possible modes of a 3G system: FDD, Time Division Duplex (TDD) and Multi Carrier (MC). MC is demanded by U.S. institutions, as it is backwards-compatible with the current IS-95 frequency band architecture. The European and Japanese focus on the FDD mode, with TDD to be realized later. TDD is assumed to be the best solution for data transfer, as it easily enables different data rates in both directions of a connection. European and Japanese institutions met in the 3GPP group, U.S. and Japanese contributors formed the 3GPP2 group. The two paths are to meet in a core network covering the three different modes with a common pilot architecture for all modes. In the end a worldwide IMT 2000 standard will be derived from the core network. Fig. 1 shows the evolution process of 3G communication systems in total.

The FDD mode developed by 3GPP is the most settled one at the moment. It uses a chip rate of 3.84 Mcps. Therefore this application note focuses on the 3GPP standard (FDD mode). Rohde & Schwarz provides several solutions for 3GPP signal generation, depending on the application, which are outlined in sections 5 and 6. The sections 2-4 contain a 3GPP WCDMA overview and describe the key properties of WCDMA systems.

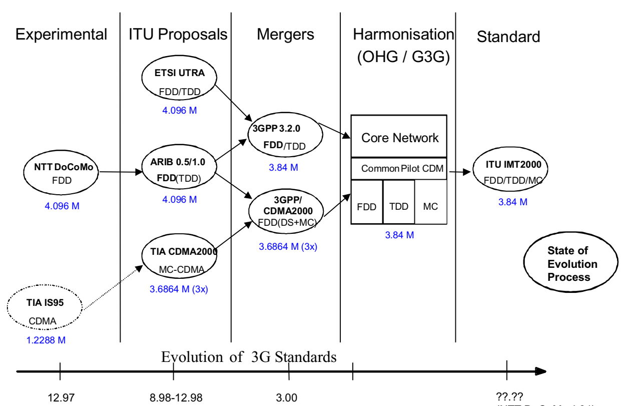


Fig. 1 Evolution map for 3rd generation communication standards.

1 To be in agreement with the 3GPP standard, chip rates are denoted in Mcps, which is an abbreviation for “Million chips per second” and means 106 s-1. Bit and symbol rates are written in kbps (“thousand bits per second”, i.e. 103 s-1) and ksps (“thousand symbols per second”, i.e. 103 s-1). Mcps, kbps and ksps are no SI units.

2 Key Properties of WCDMA Signals

The principle of orthogonal codes

The basic idea of code division multiple access systems is orthogonal coding. Instead of assigning specific frequencies or time slots to each user, the system's users are distinguished by assigning codes. The codes fulfill the same role as frequency or time "portions" in frequency or time division systems: the signals from different users must not interfere. The related procedure is called *orthogonal spreading*.

Spreading means that a symbol[2] is XOR multiplied[3] by a defined bit sequence called code. If the code length is n bits, the single symbol is transformed to n so-called chips. The resulting chip rate is n times the original symbol rate. To give an example: a spreading code 1111 has a length - normally called spreading factor - of four. A single one will be spread to the sequence 0000 (1 XOR'ed with 1 gives 0), a single zero results in 1111.

In general, codes are not arbitrarily chosen, but selected according to certain mathematical rules. These rules provide sets of codes that are *orthogonal* to each other. Orthogonal codes have no correlation, so they do not interfere. Consequently, signals spread with different codes that are orthogonal to each other also do not interfere.

For a single connection, input data is spread with a particular code in the transmitter part. To recover the data in the receiver, the same orthogonal code must be used at the receive end. Using a different code will produce noise without any useful information.

The best way to outline this is to give an example. Let's regard a simple base station with three transmitting users A, B, C as shown in Fig. 2. User A's data will be spread with the code 0101, B's data with 0011, C's data with 0000. The three resulting spread signals are added and transmitted via the air interface.

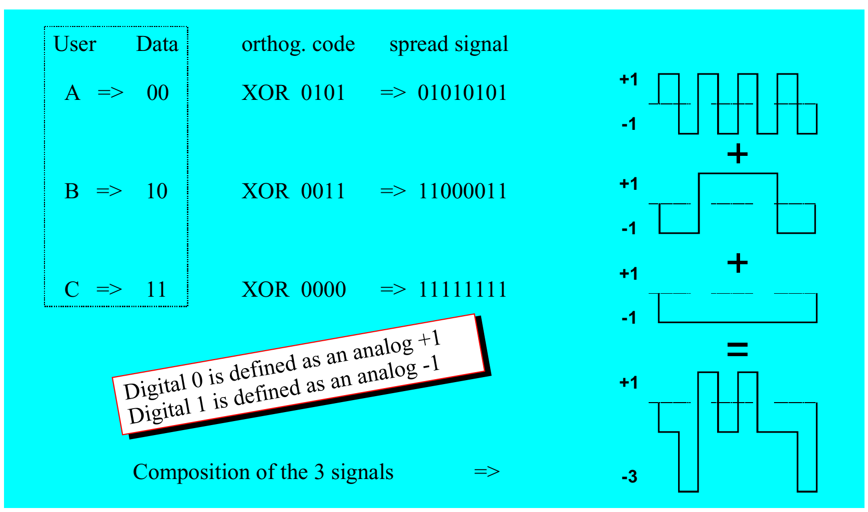


Fig. 2 Superposition of three signals with orthogonal codes.

A mobile that communicates with user A will use the same code as A to despread the received sum signal. Applying code 0101 will "filter" the A data

[2] In WCDMA systems the data bits are called "symbols" before spreading, but after channel coding and frame building.

3 XOR multiplication means modulo 2 addition

out of the entire received signal (seeFig. 3). The B and C connections will work in a similar way. On the other hand, a mobile using code 1010 will despread only noise because no data spread with 1010 is transmitted.

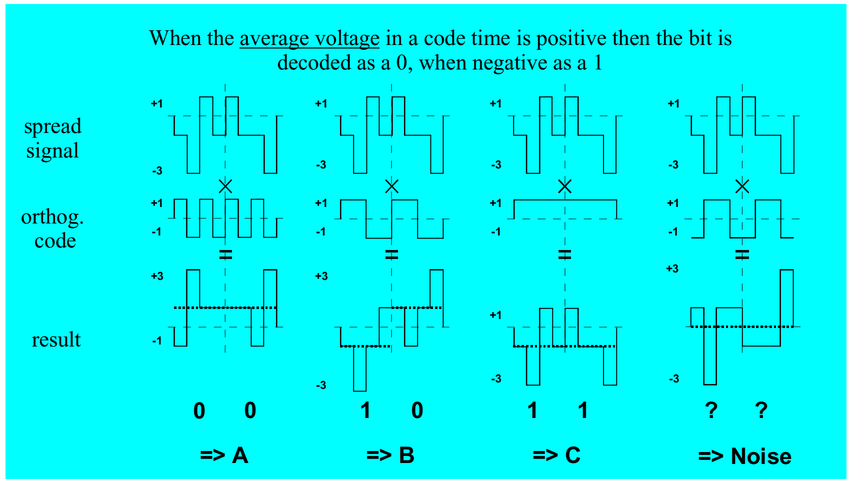


Fig. 3 Decoding of the signal contributions from Fig. 2. If the average voltage over 4 chips is positive, the bit is decoded as zero. A negative average voltage gives a one. In real life the receiver uses correlation methods to extract the appropriate signal part.

One important conclusion is that the signals from all other participants in the system appear as noise in a receiver. This has some consequences on the systems architecture. For example, a general rule in any CDMA system is that every device has to send with the least possible power to reduce the inherent noise floor.

Statistical properties, CCDF and crest factor

Communication systems based on the CDMA principle in some ways behave differently from the established TDMA systems like GSM. First of all, the code division principle leads to superposition of many single channel signals and therefore to much higher crest factors[4]. So the crest factor is the first key parameter of a WCDMA signal. The second is the statistical behaviour of the signal, especially how often the peak values occur.

The Complementary Cumulative Distribution Function (CCDF) describes the statistical behaviour of a signal. It indicates how often a particular power level is exceeded. The measurement procedure is in principle (see also Fig. 4):

i. Divide the entire power level range of the signal into small intervals.

ii. Measure the signal power in time domain with good time resolution often enough to get a statistically relevant result (for example 1 million values).

iii. Check how many values fall into or above the first power interval – which will be all, so for zero power the CCDF is always equal to 100%.

iv. Go on with the next higher power interval - and so on…

Plot the probability of being *above* a certain interval as a function of the power level. This gives the CCDF function. Usually the CCDF is

4 Crest factor = ratio of peak power to average power; in this paper we shall talk about powers, not voltages, throughout.

represented in units of the average power and given in the region between the average and the peak power.

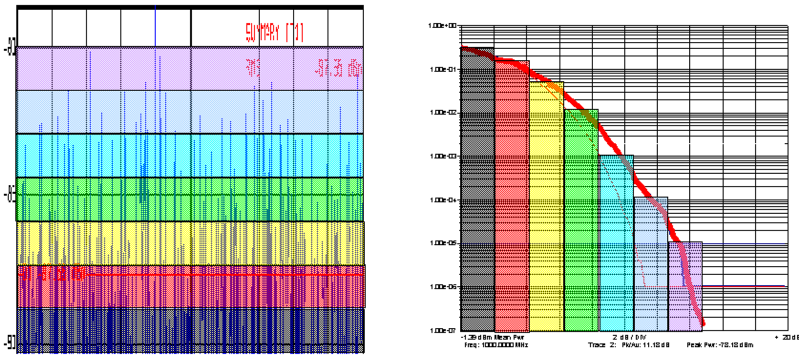


Fig. 4 Calculation of the CCDF function.

Even if two signals have the same peak to average ratio, they can significantly differ in statistical properties. If the peak values appear very rarely, the signal is easier to handle than in cases when peak power is reached for significant time intervals.

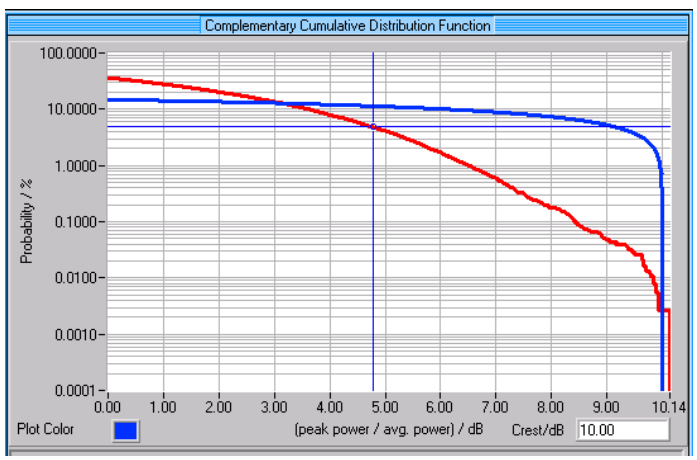


Fig. 5 Two signals with the same crest factor can have different CCDF functions and therefore stress an amplifier in different ways.

Fig. 5 shows two different CCDF curves with roughly the same crest factor, but different shape. A steep CCDF means that the peak value, or near-peak values are reached often. For a given crest factor, a signal with a steep CCDF leads to more stress on an amplifier.

With rare peaks the signal can be clipped in principle without significantly increasing the bit error rate of the communication line. With clipping, the bits related to the peak values might be corrupted. But if the probability of such peak values is small, only a few bits are affected, and this can easily be compensated with intelligent error protection algorithms. Clipping is used in base stations to reduce stress on amplifiers.

The CCDF and crest factor of a WCDMA signal depend on the number of active code channels as well as the spreading code configuration and data contents of the channels.

3 Introduction to WCDMA Measurements

Signal generator requirements

As the key parameters of the WCDMA signal differ depending on the measurement application, so do the requirements for signal sources. The user only interested in spectral measurements needs an easily configurable setup with the (few) most important parameters. On the other hand, bit error rate measurements require at least one channel with complete data operation capabilities, together with a realistic "background" signal from other code channels, mobile or base stations. The challenge for a signal source is to cover all measurement applications with one solution.

Physical performance

The physical performance requirements on measurement equipment are derived from the requirements on the devices under test. There is a general rule that the measurement equipment shall have 10 dB better performance than the device to be tested. This can be explained as follows.

Regard a typical setup consisting of signal source, device under test (DUT) and signal analyzer. All three devices are non-ideal, i.e. they give rise to signal disturbances and noise. If, for example, the phase noise of the DUT is measured, and signal source and DUT have the same performance, the analyzer measures the combined phase noise of both devices. This leads to a result 3 dB higher than the "true" value. (We have implicitly assumed that the phase noise contribution from the analyzer is negligible.)

The conclusion is: all measurement instruments need significantly better performance than the device under test, so that their contributions to signal disturbances can be neglected. Fig. 6 shows that 10 dB is a practical margin.

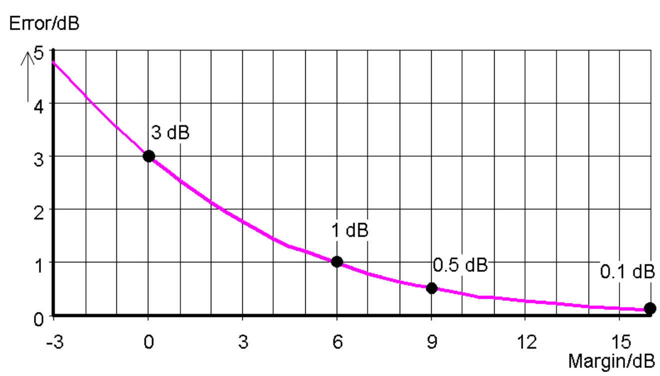


Fig. 6 Measurement error due to measurement equipment (one measuring device and the DUT taken into account).

In a similar way, all components in a device contribute to disturbances. Therefore, to obtain a defined performance for the entire device, the components have to be significantly better.

In mobile communication, the requirements on base stations are stricter than for mobiles. This is because a base station has to serve many connections at the same time. Furthermore, a mobile is a mass-produced article, and a base station is not. Thus, it makes sense to design sophisticated base stations, in order to keep mobiles cheaper. For base and mobile stations the mandatory performance is defined in the specifications of the communication standards.

Spectral measurements

For many component tests the data content is not analyzed. So it is sufficient to generate signals with a defined spectrum and CCDF without specifying the data or the code channel configuration in all details. This is suitable for measuring RF or baseband amplifiers and for basic tests on components like I/Q modulators or D/A converters.

In some cases a signal source is also required for transmitter tests of base stations or mobiles, if the device under test operates in loopback mode. Then the DUT receives the signal from the source and in turn transmits it to the measuring unit, for example a spectrum or code domain analyzer. Part of these transmitter tests (e.g. modulation accuracy, adjacent channel power ratio [5]) only require a statistically correct signal.

A typical test setup for spectral measurements is shown in Fig. 7.

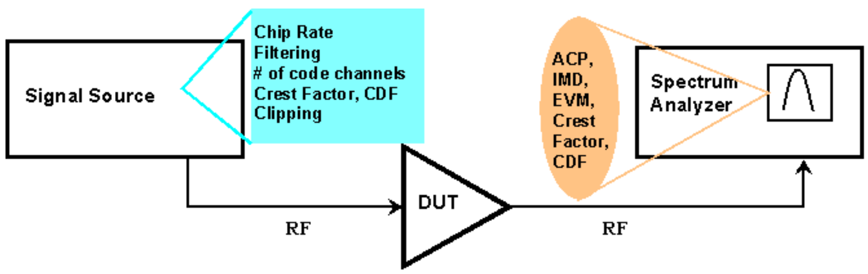


Fig. 7 Basic test setup for spectral measurements with the key parameters for signalling and the measurement quantities.

The important parameters to be varied are the crest factor and the shape of the signal's CCDF. Besides the general system parameters such as system chip rate or link direction, the application usually requires setting the number of code channels and varying the CCDF for a given number of channels. A clipping functionality is also useful for clipping can be selectively applied to reduce demands on amplifier linearity and therefore costs in production.

For testing I/Q modulators the signal source has to provide the WCDMA signal as analog I/Q baseband signal. In many cases I/Q modulators have differential inputs so the signal source needs differential outputs, including adjustable offset voltages.

For D/A converter tests, the signal has to be output in digital format, either as I/Q or IF signal.

[5] Some authors write Adjacent Channel Leakage Ratio (ACLR) instead of Adjacent Channel Power Ratio (ACPR), which has the same meaning.

Data level measurements, receiver tests

The data itself in the code channels is only important for testing on data level. For example, for testing components manipulating data as coding devices, or spreading units, or measurements on a complete transceiver or receiver unit; or on the complete communication line.

The receiver tests described in the 3GPP specification TS 25.141 “Base station conformance testing (FDD)” are measurements on data level.

The basic data level test is bit error rate measurement, mostly used for the receiver part of the signal chain. The signal source has to generate at least one code channel with “useful” data to be received by the device under test and analyzed. Furthermore a realistic “signal background” has to be provided to simulate real-world conditions. If, for example, a mobile receiver has to be tested, the signal generator has to simulate more or less a complete base station. Depending on the test conditions, additional noise generation or fading capabilities may be necessary.

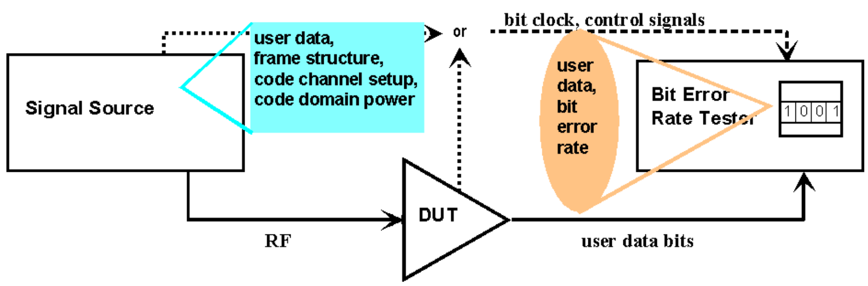


Fig. 8 Basic setup for data level tests, here for measuring bit error rates.

Response tests

The next higher test level covers situations where the device under test “communicates” with the signal source. This must not be mixed up with a real BS – MS connection including signalling. What is meant in this case, is that the DUT reacts to the received signal and “responds” to the signal generator by sending specific commands. These commands can, for example, change the output power of defined channels. Therefore we will call such measurements *response tests*. For example, simulating closed loop power control, a typical power control method for WCDMA systems. The main feature is that one part of the signal chain (for example the mobile) controls the output power of its counterpart (in our example the power of the code channel that the base station transmits to this mobile).

If the signal generator plays the role of the base station, it must generate a code channel with useful contents for the communication with the mobile to be tested, and also a realistic signal background. This can be a set of code channels generated as with spectral test scenarios or a signal that has a similar CCDF function. Such background signals look like noise with a special CCDF due to the code channel orthogonality and are therefore called Orthogonal Channel Noise Simulation (OCNS). The power level in the communication channel must be controllable by an external device, here the mobile.

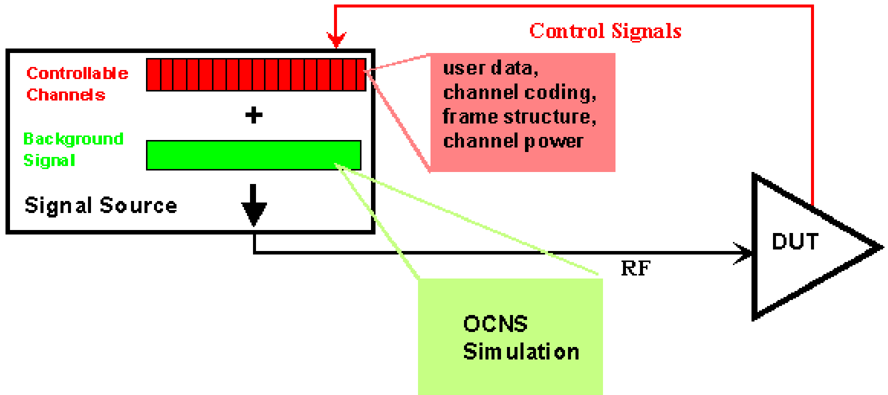


Fig. 9 Typical test setup for response tests.

Another typical scenario would be, for example, the access procedure of a mobile to a base station. In this case the signal generator simulates the mobile to test the base station.

4 Description of 3GPP WCDMA

Block diagram

The following figure shows the essential block diagram of 3GPP WCDMA.

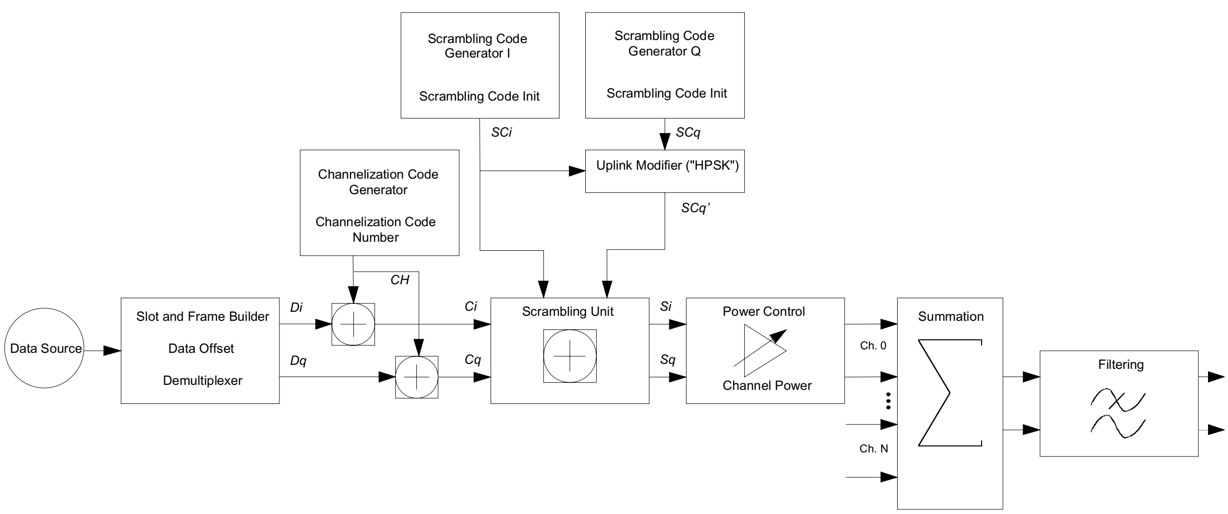


Fig. 10 Block diagram of 3GPP WCDMA

The signal chain starts with the data generation. In a real-world situation this would include voice coding and some channel coding parts to improve the error resistance of the system. The bits from the data source are embedded in a frame structure. The structure depends on the channel type and data rate to be used. The general frame structure is that one frame is 10 ms long and contains 15 slots of 0.667 ms duration. Different structures are used for access procedures, control messages and data transfer.

The structured data (called symbols at this stage of the signal chain) are then spread with appropriate spreading codes, called channelization codes. The spreading factor to be used depends on the symbol rate before the spreading. Higher symbol rates need smaller spreading factors for the chip rate (the rate after spreading) is fixed.

The channelization code is a signature for the single communication line where the scrambling code identifies the base or mobile station. The generation law of the scrambling code is fixed in the standard, but it is possible to get different scrambling code „realizations“ by using different initial values (the so-called scrambling code inits). A base or mobile station uses a specific initial value as signature. For example a base station communicates with several mobiles at the same time. It will use the same scrambling code inits, but different channelization codes for every communication line. The structure of the scrambling code differs depending on the link direction, in uplink there are also different scrambling modes possible. (See Ref. 1 for details.) Scrambling does not change the chip rate.

To give an example: let the data rate (symbol rate) from the data source be 30 ksps. The frame builder does not change this rate. The chip rate of the system shall be 3.84 Mcps. Then the symbols are spread by the factor 3840000 / 30000 = 128, that means a channelization code of length (=spreading factor) 128 is used. This gives chips with a rate of 3.84 Mcps. The chips are scrambled with the scrambing code by XOR operation without further spreading, so the final chip rate is still 3.84 Mcps.

Finally the chips are mapped to states in the I/Q plane. In most cases the resulting mapping is QPSK-like.

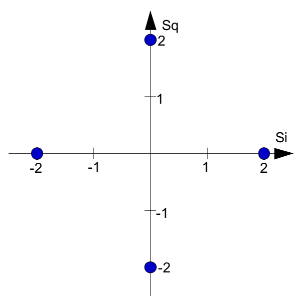


Fig. 11 Constellation diagram of a channel with 0 dB power

Up to now we described one single code channel. All the channels are then added to a sum signal (weighted with their relative channel power) by vector addition in the I/Q representation. For example, if the signal consists of two Dedicated Physical Channels (DPCH) with a power of -6 dB and -12 dB and each channel contains independent source data, the following constellation diagram is obtained:

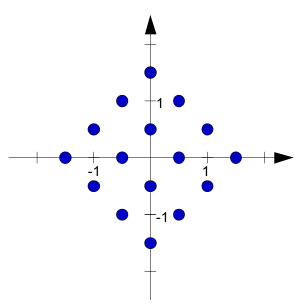


Fig. 12 Constellation diagram of a 3GPP WCDMA signal with two DPCH channels

The sum signal is then filtered using a root cosine filter with a rolloff factor α = 0.22 according to the standard. The resulting baseband signal with limited bandwidth can be converted to an analog I/Q signal to drive an I/Q modulator.

The **frequency bands** assigned to 3GPP (FDD mode) are currently:

1920 MHz to 1980 MHz	Uplink (mobile transmit, base receive)
2110 MHz to 2170 MHz	Downlink (base transmit, mobile receive)

Organization of Uplink and Downlink Channels

Physical channels

The basic physical resource of the system is the code/frequency plane. In addition, on the uplink, different information streams may be transmitted on the I and Q branch. Consequently, a physical channel corresponds to a specific carrier frequency, code, and, on the uplink, relative phase (0 or $\pi/2$).

Transport channels and their mapping to physical channels

Transport channels are the services offered by Layer 1 to the higher layers. A transport channel is defined by how and with what characteristics data is transferred over the air interface. There are dedicated channels, transmitting information related to a specific connection (e.g. speech), and common channels with system-inherent information. The only dedicated transport channel in 3GPP is the Dedicated Channel (DCH). On the other hand there are six types of common transport channels. Broadcast Channel (BCH), Forward Access Channel (FACH), Paging Channel (PCH) and Downlink Shared Channel (DSCH) are downlink transport channels, Random Access Channel (RACH) and Common Packet Channel (CPCH) are uplink transport channels. Every transport channel is mapped to a physical channel. Furthermore, there are physical channels that do not carry a transport channel, but are used for system specific messages. These are the Synchronization Channels (SCH) and the Indicator Channels AICH, AP-AICH, CD/CA-AICH, PICH and CSICH.

Transport Channels	Physical Channels
DCH	Dedicated Physical Data Channel (DPDCH)
	Dedicated Physical Control Channel (DPCCH)
RACH	Physical Random Access Channel (PRACH)
CPCH	Physical Common Packet Channel (PCPCH)
	Common Pilot Channel (CPICH)
BCH	Primary Common Control Physical Channel (P-CCPCH)
FACH, PCH	Secondary Common Control Physical Channel (S-CCPCH)
DSCH	Physical Downlink Shared Channel (PDSCH)
	Synchronisation Channel (SCH)
	Acquisition Indicator Channel (AICH)
	Access Preamble Acquisition Indicator Channel (AP-AICH)
	Paging Indicator Channel (PICH)
	CPCH Status Indicator Channel (CSICH)
	Collision-Detection/Channel-Assignment Indicator Channel (CD/CA-ICH)

Fig. 13 Mapping of transport channels to physical channels.

Dedicated and common physical channels

In general, physical channels can be divided in dedicated and common channels. Dedicated channels are associated with a certain connection while common channels have more general, system-related functionality.

In **uplink**, there are two types of dedicated channels, the DPDCH and the DPCCH. DPDCHs carry the user data while the DPCCH is used for related information like Transmit Power Control bits.

The uplink common channels are: PRACH for setting up a call and PCPCH for packet-oriented services.

In **downlink** there is one type of dedicated channel, the DPCH which carries both the user data and the related control informations.

The downlink common channels are:

P-CPICH and S-CPICH	Common Pilot Channels
P-CCPCH and S-CCPCH	Common Control Physical Channels
P-SCH and S-SCH	Synchronization Channels
PDSCH	Physical Downlink Shared Channel
AICH, AP-AICH, CD/CA-ICH, PICH and CSICH	Indicator Channels

Mobile Station Modes

A 3GPP mobile station can operate in three different modes.

- PRACH only: The MS generates a single PRACH. This mode is used when a call is set up from the mobile to the base station.
- PCPCH only: The MS generates a single PCPCH. This channel is used for the transmission of packet-oriented services, e.g. SMS.
- DPCCH + DPDCH: This is the standard mode for speech and data transmission. The MS generates a control channel (DPCCH) and up to 6 data channels (DPDCH), depending on the required data rate.

Physical channels in uplink

In the **uplink** direction the following channels are used.

PRACH Physical Random Access Channel

The PRACH is sent by a mobile station to set up a connection. The base station assigns an access slot and a signature to the mobile station. The signature is used to derive the spreading code for the PRACH. A PRACH consists of one or several preambles of length 4096 chips and a message of length 10 ms or 20 ms. If the base station is ready for connection, it sends an P-AICH (Physical Acquisition Indication Channel). The mobile station only sends the message part after the base station has sent the P-AICH. The preamble part is repeated with constant power until the base station acknowledges by sending the AICH.

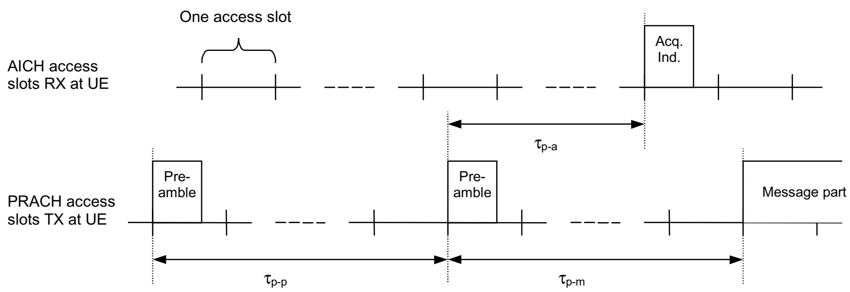


Fig. 14 Timing relation between the PRACH and the AICH as seen at the MS.

Fig. 14 shows the structure of the message part. The 10 ms message part radio frame is split into 15 slots, each of length T_{slot} = 2560 chips. Each slot consists of two parts, a data part to which the RACH transport channel is mapped and a control part that carries Layer 1 control information. The data and control parts are transmitted in parallel. A 10 ms message part consists of one message part radio frame, while a 20 ms message part consists of two consecutive 10 ms message part radio frames. The message part length can be determined from the used signature and/or access slot, as configured by higher layers.

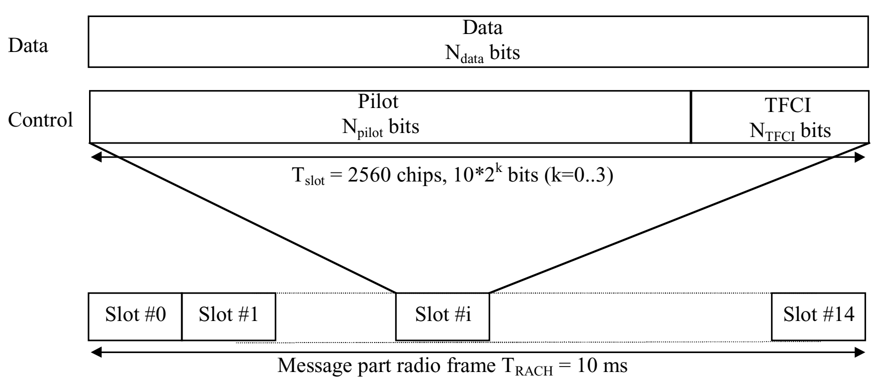


Fig. 15 Structure of the PRACH message part.

PCPCH Physical Common Packet Channel

The PCPCH is used for packet-oriented services like SMS. The transmission procedure is similar to the PRACH mode. The mobile starts transmission at the beginning of a number of well-defined time intervals, relative to the timebase given by the base station. The access slot timing and structure is identical to the RACH. The PCPCH consists of one or several Access Preambles, one Collision Detection Preamble, a DPCCH Power Control Preamble and the message part of variable length.

The PCPCH access procedure is shown in Fig. 16. The MS sends Access Preambles until it receives an AP-AICH from the BS. Unlike with the PRACH, the Access Preambles are transmitted with increasing power here. After sending the Collision Detection Preamble and in turn receiving the CD-ICH, the mobile starts transmitting the PCPCH message part. The power of the PCPCH message is controlled by a DPCCH sent by the BS.

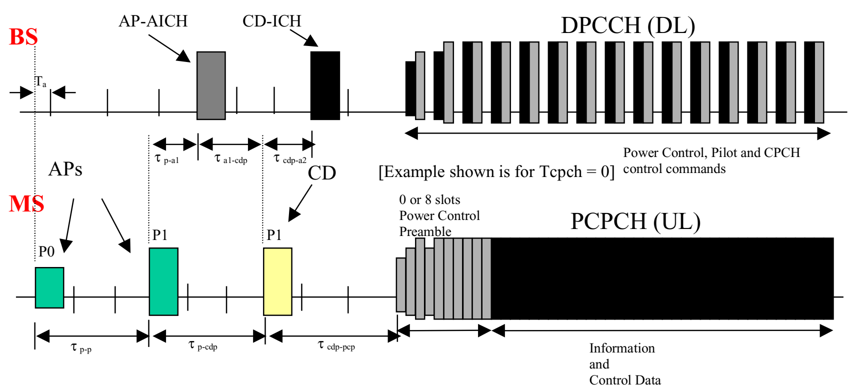


Fig. 16 Time relation between the PCPCH and the AICH.

DPCCH Dedicated Physical Control Channel

A DPCCH slot consists of four parts: Pilot, Transport Format indicator (TFCI), Feedback Information (FBI), and Transmit Power Control (TPC). The pilot is used to synchronize the receiver and contains frame timing information. The TFCI bits inform the BS receiver about the current DPCCH / DPDCH configuration of the mobile and the code channel scenario. The FBI bits are used to support techniques requiring feedback from the mobile to the BS or the BS controller. The TPC tells the counterpart (in this case the base station) to increase or decrease channel power (closed loop power control). The DPCCH has its own spreading code and is not channel coded.

DPDCH Dedicated Physical Data Channel(s)

The DPDCH contains the user data and is channel coded.

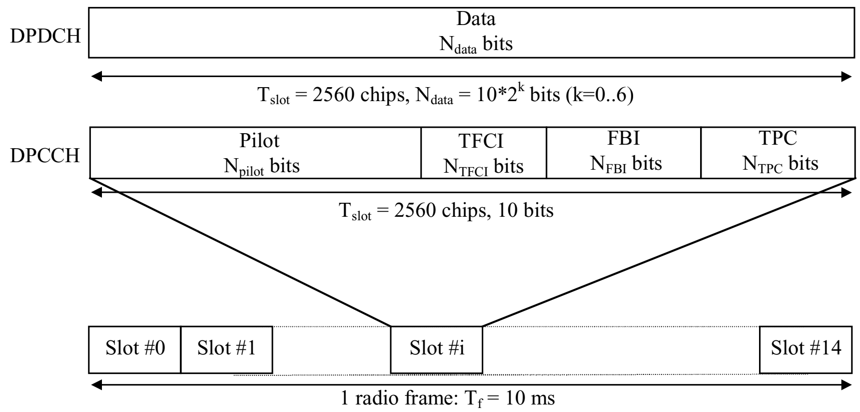


Fig. 17 Frame structure for uplink DPDCH and DPCCH.

In uplink Hybrid Phase Shift Keying (HPSK) is used to reduce the demands on the mobile transmitters. HPSK is a coding method to reduce the probability of zero crossings of the transmitted signal. By modifying the scrambling code, simultaneous changes of I(t) and Q(t) are cut down by 50%. This reduces the crest factor by roughly 1.5 dB. (Remark: use of O-QPSK in the IS-95 uplink has a comparable effect.)

Base station configurations

Naturally, base station configurations are more complex than mobile station modes. However, not all downlink channels are essential, and typical configurations can be described.

The following control channels are necessary for synchronization of the mobile and always present:

Primary Common Pilot Channel (P-CPICH), Primary Common Control Physical Channel (P-CCPCH), Primary and Secondary Synchronization Channel (P-SCH, S-SCH), and Paging Indicator Channel (PICH).

Thus, a basic BS signal contains these control channels and a varying number of Dedicated Physical Channels (DPCHs). The number of DPCHs and their symbol rates depend on the number of connections and the required data rates. In case of high data rates required, several DPCHs can be linked together and transmitted to one and the same mobile (multicode state).

Physical channels in downlink

In **downlink** the connection is managed via several control channels which shall be described briefly:

P-CPICH, S-CPICH Primary and Secondary Common Pilot Channels

The Primary CPICH is the default phase reference for all downlink channels and is transmitted over the entire cell. There is one and only one P-CPICH per cell. One or several Secondary CPICH can be used as phase reference for the Secondary CCPCH and the downlink DPCH. S-CPICH can be transmitted over the entire cell or only over a part of the cell.

P-CCPCH, S-CCPCH
Primary and Secondary Common Control Physical Channels

The P-CCPCH carries the Broadcast Channel with system- and cell-specific information. It is always transmitted over the entire cell. The P-CCPCH has no TPC, TFCI or pilot parts and is not transmitted during the first 256 chips of each slot. Instead, primary and secondary SCH are transmitted during this period.

In addition to the P-CCPCH one or more S-CCPCHs can be established. The Secondary CCPCH is used to carry the Forward Access Channel (FACH) and the Paging Channel (PCH). The FACH is used for setting up a connection by the BS. The PCH is associated with physical-layer generated Paging Indicators to support efficient sleep-mode procedures. The S-CCPCH has a data and a pilot part. It can also have a TFCI part at the beginning of the slot. The basestation maps data for different mobile stations (or groups of mobile stations) to the SCCPCH using multiplex techniques. A single mobile station then has to filter its relevant information out of the SCCPCH signal.

P-SCH, S-SCH Primary and Secondary Synchronization Channels

The P-SCH is the same for all base stations, where the S-SCH sends a sequence of 16 different spreading codes to indicate the slot position inside a 10 ms frame. P-SCH and S-SCH transmit identical data on I and Q, leading to a constellation diagram rotated by 45 degrees. The superposition of P-CCPCH, P-SCH and S-SCH generates a typical signal shape in the time domain. This allows the receiver to detect the slot timing approximately.

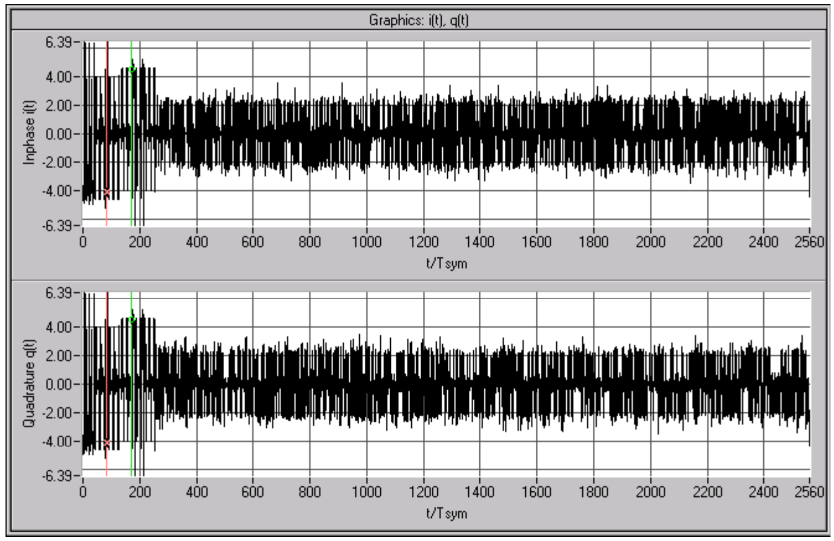


Fig. 18 Superposition of P-CCPCH, P-SCH and S-SCH in time domain.

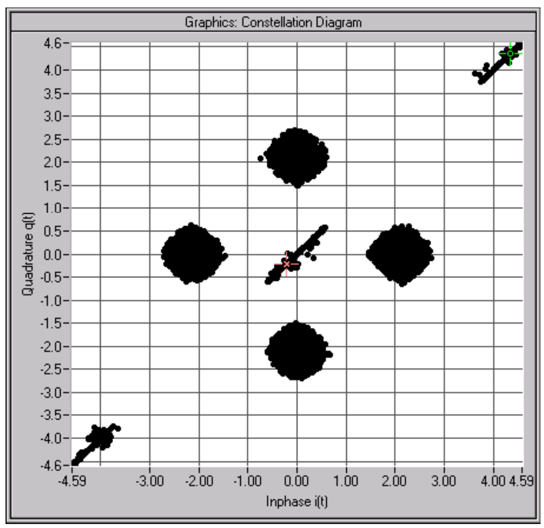


Fig. 19 Constellation diagram of a signal consisting of P-CCPCH, P-SCH and S-SCH. The four circular areas come from the P-CCPCH, the linear areas (diagonals) from P-SCH and S-SCH.

PDSCH Physical Downlink Shared Channel

The PDSCH is shared by users based on code multiplexing. It is always associated with one or several downlink DPCHs (each PDSCH radio frame with one DPCH). The PDSCH and DPCH do not have necessary the same spreading factors, the PDSCH spreading factor may vary from frame to frame.

AICH Acquisition Indicator Channel

The AICH corresponds to the uplink PRACH and is used during the mobile's access to the system. The procedure is described above in the PRACH section.

AP-AICH, CD/CA-ICH
Access Preamble Acquisition Indicator Channel
Collision Detection/Channel Assignment Indicator Channel

Similar to the AICH / PRACH pair, these channels correspond to the uplink PCPCH channel. The access procedure for the PCPCH is described above.

PICH Paging Indicator Channel

The PICH is a fixed rate physical channel (spreading factor 256) to carry the Paging Indicators. The PICH is always associated with an S-CCPCH to which a paging transport channel is mapped.

CSICH CPCH Status Indicator Channel

The CSICH is a fixed rate physical channel (spreading factor 256) to carry CPCH status information. A CSICH is always associated with an AP-AICH and uses the same channelization and scrambling codes.

DPCH Dedicated Physical Channels

There is only one type of downlink dedicated physical channels, the DPCH. However, within one DPCH data is transmitted in time-multiplex with control information (known pilot bits, TPC commands, optional TFCI). The downlink DPCH can thus be seen as a time multiplex of a downlink DPCCH and a downlink DPDCH.

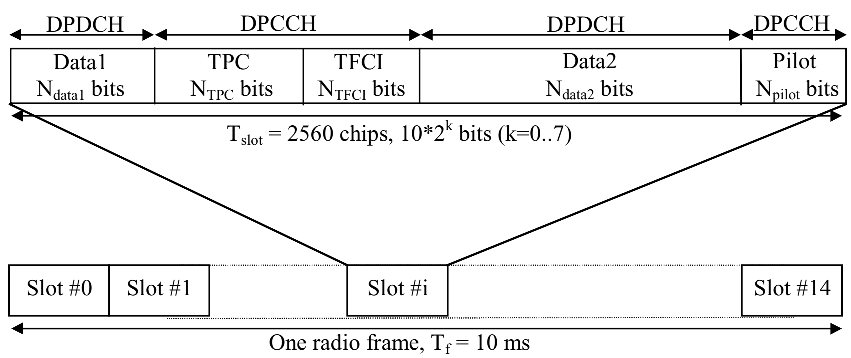


Fig. 20 Frame structure for downlink DPCH.

Synchronization of a mobile station

Synchronization of a mobile station to a base station is a three step process.

1. **Slot synchronization**
   The mobile station receiver searches for the P-SCH which provides the Primary Synchronization Code. This code is the same for all base stations. The mobile station receiver uses correlation methods for the search. As the P-SCH is always transmitted at the beginning of a slot, the mobile station gets the slot timing by detecting the P-SCH.
2. **Frame Synchronization and Code Group Identification**
   After the slot timing is detected, the mobile station can synchronize to the frame by correlating with all possible Secondary Synchronization Codes. As the sequence of the codes is fixed, frame timing and the so-called code group can be obtained.
3. **Scrambling Code Identification**
   If the Code Group is known, the number of possible Primary Scrambling Codes is limited. The actual code is again detected with a correlation method. With a known PSC, the P-CCPCH can be decoded and the mobile station can synchronize to a super frame (1 super frame = 72 frames). Then the Broadcast Channel Information containing the system and cell parameters can be analyzed.

Code Domain in 3GPP

One significant difference between 3GPP WCDMA and the “classical” IS-95 is the use of spreading factors. While the spreading factor in IS-95 is always 64, it can vary between 4 and 512 in 3GPP. This means that, for example, a base station can transmit code channels with different spreading factors at the same time [6] - which has some impact on the required system’s intelligence. The use of varying spreading factors leads to complications that do not appear at IS-95: While spreading codes of the same length (“order”) are orthogonal to each other, this is not true in general for codes of different orders.

The spreading codes in 3GPP follow a hierarchical principle, codes of higher order are derived from codes of lower order (see Fig. 21).

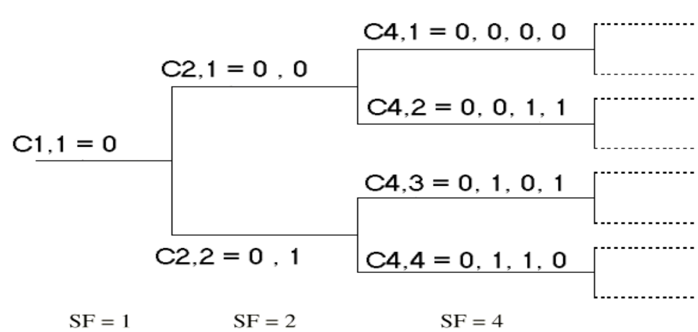


Fig. 21 Derivation of spreading codes in 3GPP (“hierarchy tree”).

[6] This is especially used for DPCHs while most of the common channels have a fixed spreading factor.

Naturally, there is only one code with spreading factor one, consisting of a single zero. It leaves the incoming data unchanged (1 XOR 0 = 1 and 0 XOR 0 = 0). From this code, called $c_{1,1}$, two codes of order 2 (spreading factor = 2) can be derived. From the two codes of order 2, one gets four codes of order 4, and so on. Every code subsystem with spreading factor N has N different codes. Codes in the same column are orthogonal to each other while codes in the same branch of the hierarchy tree depend on each other.

The idea of **code domain** display is to represent the various spreading factors and code subsystems in a graphical, easy-to-handle manner.

The spreading factor of codes is indicated by the width of the code bars. Codes with small spreading factors are represented by broad bars. For example, there are only two different orthogonal codes with spreading factor 2, consequently two bars will cover the entire code domain. With spreading factor 512 one needs 512 codes to cover the whole domain. Occupation of the same code domain region is indicated with bars laying over each other. Such a case is called domain conflict. Codes that are occupying the same code domain are not orthogonal and should not be used at the same time.

The following figures show some examples for the relation between the code tree diagram and the code domain representation.

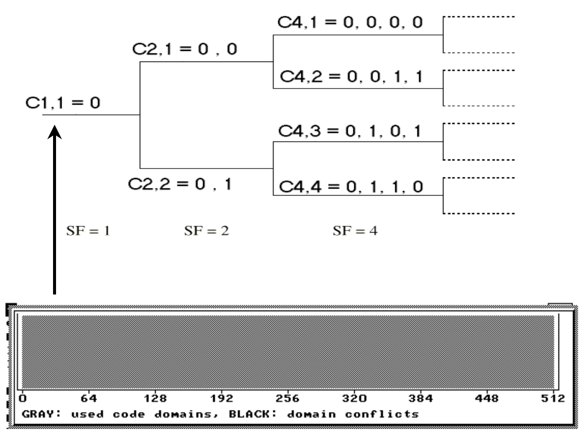


Fig. 22 The code $c_{1,1}$ has spreading factor 1 and therefore covers the entire code domain.

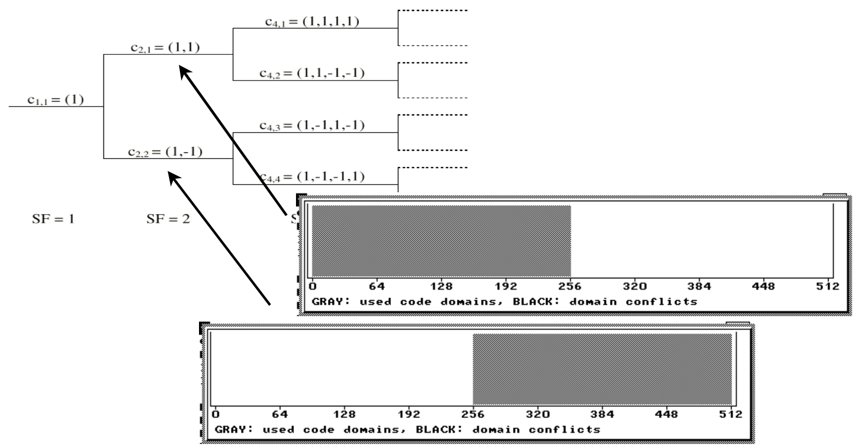


Fig. 23 There are two different codes with spreading factor 2, $c_{2,1}$ and $c_{2,2}$. Each of them covers half of the code domain.

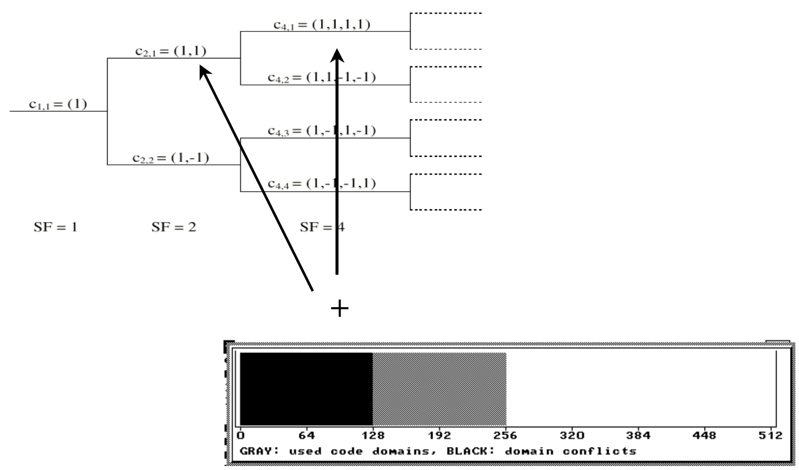


Fig. 24 Code $c_{4,1}$ covers the first quarter of the code domain. Using codes $c_{2,1}$ and $c_{4,1}$ uses part of the code domain twice and results in a domain conflict (indicated by the black bar).

Statistical properties of 3GPP signals

As mentioned above, the superposition of many code channels may lead to very high crest factors in the WCDMA sum signal. Therefore, the signal's statistical properties – expressed in the Complementary Cumulative Distribution Function CCDF – play an important role.

The statistical behaviour of a 3GPP signal mostly depends on four parameters:

- the number of code channels (which is obvious)
- the selection of channelization codes
- the correlation of the user data
- the timing offsets between code channels

Selection of channelization codes

Channelization codes of the same order are orthogonal to each other. However, there are codes in this subset that resemble each other more than others, any code has “near and far relatives” among the codes of the same order. Thus, code selection affects the statistical properties of the sum signal. The probability of constructive interference is higher if “similar” codes are chosen [7].

Let’s regard a simple 3GPP example: a downlink signal with P-CPICH, P-SCH, S-SCH, P-CCPCH and 8 DPCH (all with 15 ksps, i.e. spreading factor 256). The scenario with worst (highest) crest factor has neighbouring code numbers, as can be seen in the upper code domain display of Fig. 25. For lowest crest factor the codes have to be selected “equidistantly” in the code domain – see the lower display of Fig. 25.

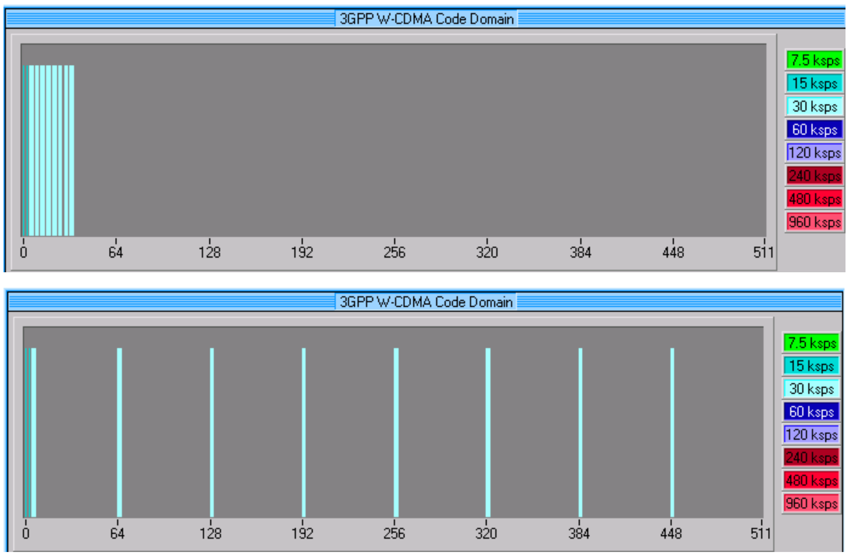


Fig. 25 Code selection for worst (upper) and best (lower) crest factor for a BS with P-CPICH, P-SCH, S-SCH, P-CCPCH and 8 DPCH (15 ksps) active.

[7] This is well-known in IS-95. The IS-97 test model defines a Walsh code scenario with number of code channels and relative power. However, the Walsh codes to be used are not specified. This has lead to ambiguous measurement results for the “IS-97 test model” because the model is not clearly defined. A selection where almost all code numbers are multiples of 8 leads to maximum crest factor, and therefore would be the most sensible choice.The Walsh codes are chosen to be 0 (Pilot), 4, 8, 16, 24, 32 (Sync), 40, 48 and 56.

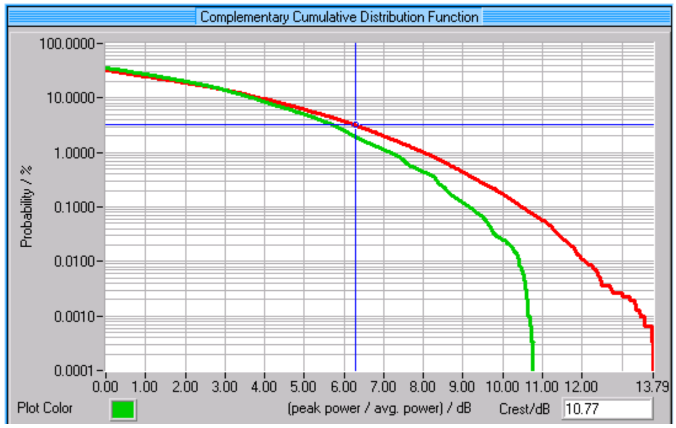


Fig. 26 CCDF results for the two code selections in Fig. 25. The worst case scenario leads to 13.8 dB crest factor, the best case to 10.8 dB.

The crest factors of both scenarios differ about 3 dB (see Fig. 26). The effect increases with increasing number of codes.

Data correlation

Sending the same data on all channels may increase the probability of constructive interference, especially for code selections with high crest factor. However, this is not a realistic situation, therefore we do not further investigate this effect here.

Timing offset

For a given selection of channelization codes, the crest factor can be reduced by assigning different timing offsets to different channels.

As the pilot symbol part of DPCHs is not coded, all DPCH contain the same pilot bits. This leads to constructive interference if the pilot parts are transmitted at the same time. Therefore, it is possible in 3GPP to use timing offsets for the channels. Taking the best case code selection from above, a timing offset of 3 times 256 chips from channel to channel leads to a further crest factor decrease of 1.4 dB (see Fig. 27). Again the effect increases with increasing number of channels.

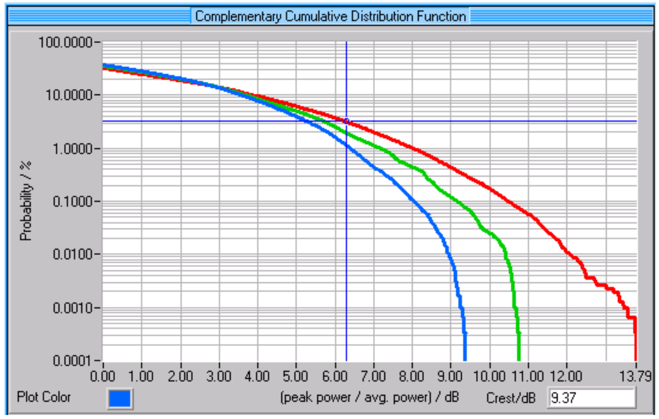


Fig. 27 Using timing offsets further reduces the crest factor of the 3GPP signal. Here the CCDF curves of the worst case code selection without offsets (right curve), the best case code selection without offsets (middle curve) and the best case code selection with timing offsets (left curve) are compared.

More information on the properties of 3GPP signals can be found in [5] section 2.14.3, or [7] section 8.3.

Fading in 3GPP

3GPP defines performance tests for base stations as well as for mobiles. In these tests, the DUT has to demodulate a DPCH (or another channel) under defined propagation conditions. The Bit Error Rate (BER) or Block Error Rate (BLER)[8] of the demodulated channel is measured.

There are four different propagation conditions defined in 3GPP:

Static propagation condition

White Gaussian Noise is added to the test signal.

Multi-path fading propagation conditions

The signal is split into up to four paths, all with classical Doppler spectrum. The relative delay and average power of the paths in different scenarios is shown in the table below.

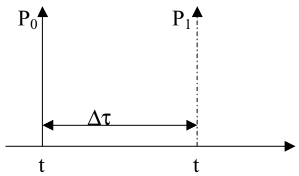
Table 1 Cases for multi-path fading propagation conditions.

Case 1, speed 3 km/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

[8] In the BER test, the error rate for the user data bits is measured, in the BLER test, CRC bits obtained from forward error correction are checked.

Moving propagation conditions

In the moving propagation condition, the signal is split into two (non-fading) paths, one static, Path 0, and one moving, Path 1. The time difference between the two paths is according to the equation in Fig. 28. The paths have equal strengths and equal phases.



$$\Delta\tau = 1 + \frac{A}{2}\left(1 + \sin(\Delta\omega \cdot t)\right)$$

$$A = 5\ \mu s$$

$$\Delta\omega = 40 \cdot 10^{-3}\, s^{-1}$$

Fig. 28 Moving propagation conditions

Birth-Death propagation conditions

In this scenario the signal is split into two (non-fading) paths, Path 1 and Path 2 which alternate between ‘birth’ and ’death’. The positions the paths appear are randomly selected with an equal probability rate and are shown in Fig. 29.

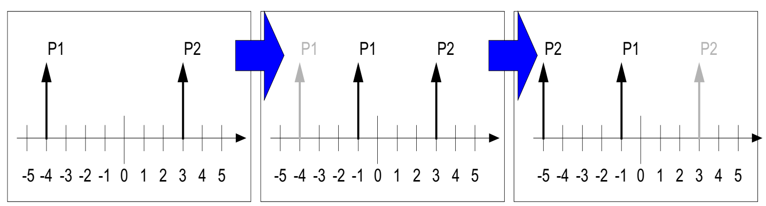


Fig. 29 Birth-Death propagation sequence

1. Two paths, Path 1 and Path 2 are randomly selected from the group [-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5] µs. The paths have equal strengths and equal phases.
2. After 191 ms, Path 1 vanishes and reappears immediately at a new location randomly selected from the group [-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5] µs but excludes the point Path 2.
3. After an additional 191 ms, Path 2 vanishes and reappears immediately at a new location randomly selected from the group [-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5] µs but excludes the point Path 1.
4. The sequence in 2) and 3) is repeated.

5 R&S Signal Generator Solutions for 3GPP WCDMA

Overview

In general, R&S offers different signal generator configurations capable of 3GPP WCDMA. A big part of applications is covered by all of them. But as the different solutions are based on different technical approaches, for a specific application one configuration may be more suitable than others. This section describes the different configurations and their application range.

Generation of a 3GPP RF signal can be divided into three functional parts: generating the I/Q baseband signal, baseband signal processing (AWGN, fading simulation) and generating the modulated RF signal.

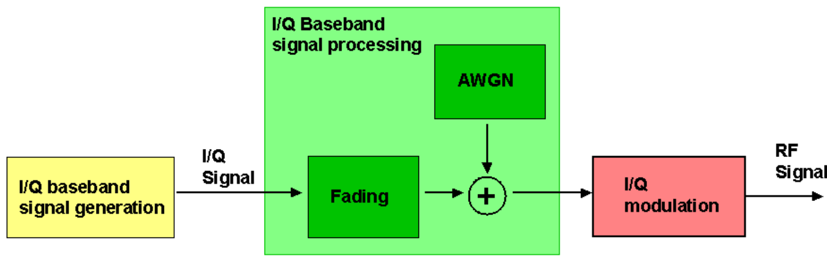


Fig. 30 Generating a 3GPP RF signal.

For all RF applications the SMIQ Vector Signal Generator is used for baseband signal processing and RF signal generation. However, there are two different approaches to generate the baseband signal that drives the SMIQ's I/Q modulator. One is to use SMIQ's 3GPP personality (options SMIQB45 and SMIQB48). The other possibility is to generate 3GPP signals with the WinIQSIM™ software (which runs on an external PC) and download them to an arbitrary waveform generator (ARB). This can either be the I/Q Modulation Generator AMIQ, which is a separate box, or the SMIQ-internal ARB SMIQB60.

Generating the I/Q Signal

SMIQ + SMIQ 3GPP personality or SMIQ + WinIQSIM™ with Arbitrary Waveform Generator?

Both approaches cover most basic WCDMA applications, including spectral measurements with single carriers. For some measurements, either the SMIQB45/48 or the WinIQSIM™ approach might be more suitable.

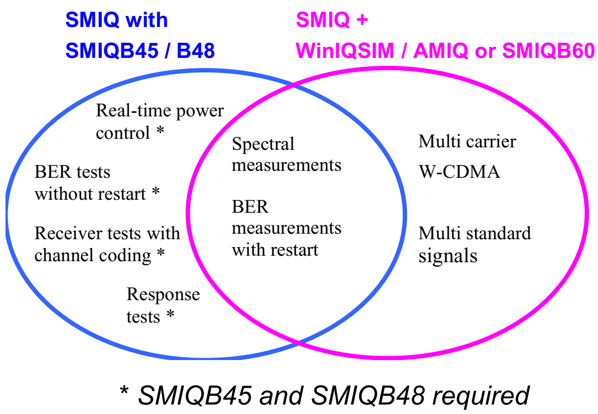


Fig. 31 Rough applications map of R&S 3GPP WCDMA signal generator solutions. “Spectral Measurements” covers all applications where the data content of the signal is not important (see 3.3). “Response Tests” are measurements where the signal source and the DUT interact, see 3.5 for an explanation.

SMIQB45/48 provides channel coding, very long sequences and real-time power control of up to four channels. These features are not provided by the WinIQSIM™/ARB solutions. Receiver and performance tests on base stations and mobiles require some of these features, thus SMIQB45/48 is the suitable solution for such tests, as well as for response measurements such as power control tests.

On the other hand, the WinIQSIM™/ARB solution can generate multi carrier 3GPP signals, SMIQB45/48 cannot. Therefore, the WinIQSIM™/ARB approach is the appropriate one for tests on amplifiers and other components with multi carrier signals.

As WinIQSIM™ runs on an external PC, it generally has more graphics features making signal analysis more comfortable, by also providing signal representations as spectrum (FFT magnitude), I(t) and Q(t), vector or eye diagram.

The applications in the intersection in Fig. 31 are covered by both solutions, the 3GPP personality as well as WinIQSIM™. Concerning the 3GPP personality, only SMIQB45 is required for these applications, SMIQB48 is not needed.

Spectral Measurements and BER tests with restart: Common features of SMIQB45 and WinIQSIM™

The basic features of SMIQB45 and WinIQSIM™ are the same, as listed below.

- Downlink: Simulation of up to 512 data channels distributed to a maximum of 4 base stations with 128 code channels each.
- Uplink: Simulation of up to 4 mobile stations, each operating in one of the modes PRACH only, PCPCH only, DPCCH + DPDCH
- Chip rate 3.84 Mcps (15 slots per frame)
- Physical channels in downlink: P-CPICH, S-CPICH, P-CCPCH, S-CCPCH, P-SCH, S-SCH, PDSCH, PICH, AICH, AP-AICH, Downlink DPCCH and DPCH
- Physical channels in uplink: PRACH, PCPCH, DPCCH, DPDCH

The variable parameters and the functionality are described in detail in the related datasheets and user manuals of SMIQ and WinIQSIM™.

A built-in *clipping* function allows simulating signal clipping, as performed by base stations.

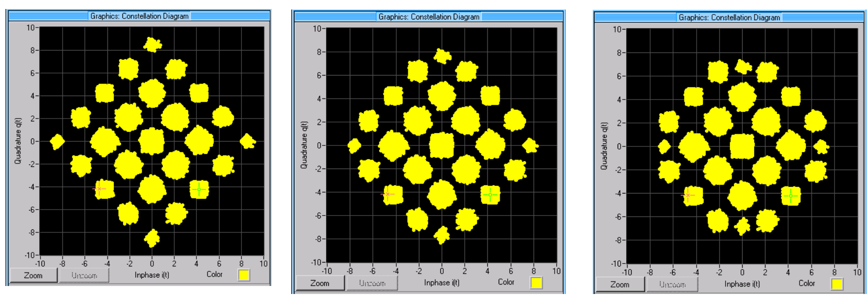


Fig. 32 Effect of the clipping function on the signal's constellation, as displayed in WinIQSIM™. From left to right: 100% level (no clipping), clipping at 90%, clipping at 80%

Assistant and graphic functions make the user interface easy to handle. The *parametrizable predefined settings* function can generate a WCDMA downlink signal by setting just a few important parameters: number of channels, spreading factor, high, medium or low crest factor. This "easy edit" function is especially useful for spectral measurements where the details of the base station configuration are less important.

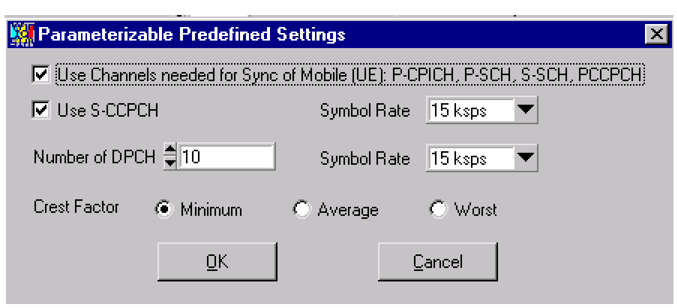


Fig. 33 Parametrizable predefined settings in WinIQSIM™

All important graphical representations of the WCDMA setup can be displayed: the *code domain* and *channel graph* of a base station as well as the *constellation diagram* and *CCDF* of the entire signal.

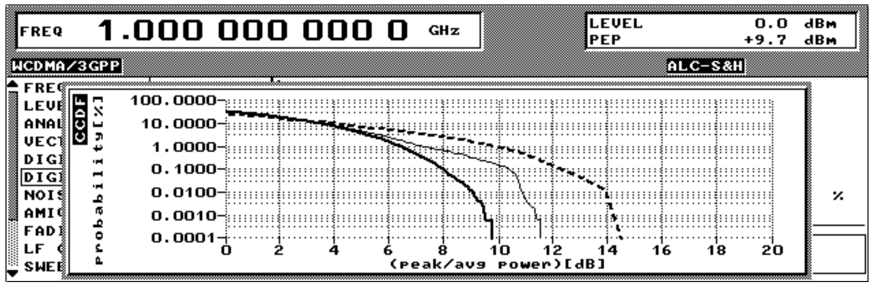


Fig. 34 CCDF display in SMIQB45

The *resolve domain conflicts* function can eliminate code channel overlapping automatically in the code domain of a base station.

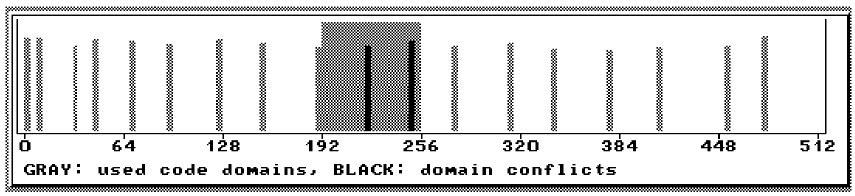


Fig. 35 Code domain display in SMIQB45. The black bars indicate a code domain conflict.

As a conclusion, both WinIQSIM™ and SMIQB45 cover spectral measurements.

Data level tests: Extended functions with SMIQB45 and SMIQB48

Option SMIQB48 extends SMIQB45 to measure on the data level, and for response tests as described in section 3.5, where the device under test (at least partly) controls the transmitted WCDMA signal.

This is possible due to the implementation of "enhanced" channels in the WCDMA setup. This function can be used in downlink for up to four DPCHs, in uplink for one DPCCH and up to 6 DPDCHs. With four enhanced channels active, WCDMA sequences of up to 255 frames can be generated. With one enhanced channel active, a sequence of 1022 frames is possible, to test, for example, a bit error rate without restart with PRBS 9 as user data, including channel coding. To embed continuous PRBS 9 sequences into the WCDMA frame structure without truncating, 1022 frames are required [9].

Furthermore, the power of the enhanced channels can be externally controlled in real time to simulate closed loop power control.

[9] Without channel coding 511 frames would be sufficient, but a factor of two is required due to the interleaver depth.

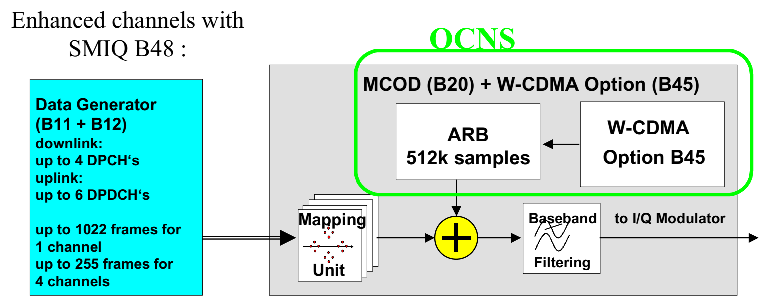


Fig. 36 Functionality of the SMIQB45 and SMIQB48 3GPP WCDMA options.

The enhanced channels can be combined with the standard base or mobile station setups to build a realistic entire WCDMA scenario. The "wanted" WCDMA channel to be demodulated by the DUT is generated by one (or more) enhanced channels, while the correct "background" signal is taken by the standard channels. In downlink, up to 508 standard channels can be used to generate such a background, which is called Orthogonal Channel Noise Simulation (OCNS). In uplink, a background scenario of up to 64 additional mobile stations is possible. To approximate a real-world situation, the periods of the wanted channels and the background are chosen to be different. The combined signal will then have the same statistical properties as a true real-time signal.

Data level tests: Channel coding with SMIQB45 and SMIQB48

Up to four enhanced channels can be coded in accordance with the definition of the reference measurement channels [1]. In both uplink and downlink, the reference measurement channels for 12.2 kbps, 64 kbps, 144 kbps and 384 kbps are implemented. In addition, AMR speech 12.2 kbps to TS 25.944 is supported.

As an example, Fig. 37 shows the structure of the 12.2 kbps uplink reference measurement channel.

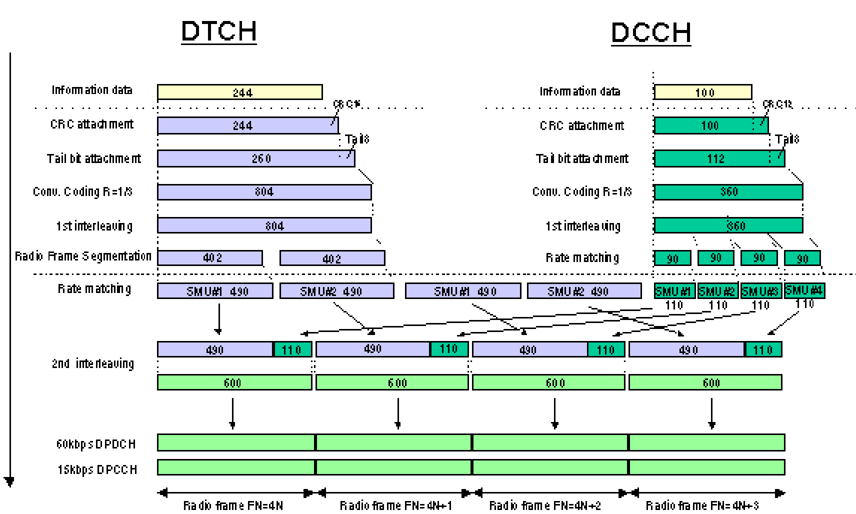


Fig. 37 Structure of the 12.2 kbps uplink reference measurement channel

The coding process starts at the top of the figure. Without going into details of the different coding steps, it can be seen that for a DTCH one information data block is distributed to two radio frames. This data is relevant for bit error rate and block error rate tests. The DCCH part contains higher layer information and is not important here.

Multi carrier WCDMA and multi standard signals with WinIQSIM™

WinIQSIM™ also has outstanding multi carrier capabilities. Multiple WCDMA carriers are generated with the *Multi Carrier Mixed Signal* system of WinIQSIM™. The single WCDMA carriers are generated separately with the 3GPP WCDMA system and then mixed in the Multi Carrier Mixed Signal system. This function is not limited to multi carrier WCDMA. Mixed systems, for example WCDMA carriers combined with GSM or other systems, are also possible.

These features can be used to simulate transmitters of multi system base stations. Such units become more and more important as they provide integration of new WCDMA technologies in existing networks.

Which arbitrary waveform generator, AMIQ or SMIQB60?

The main difference between these two ARBs is not the quality of the signal, but the ARB's "capacity". AMIQ has more memory and higher sample rates than SMIQB60. AMIQ03 provides 4 MSamples memory [10], the model AMIQ04 16 MSamples.

For SMIQB60, the nominal memory size is 512 kSamples. However, this value cannot be compared directly to the corresponding values of normal ARBs like AMIQ. SMIQB60 performs the oversampling required to suppress the aliasing effects automatically in realtime by means of hardware interpolation, i.e., the wave to be stored does not lengthen by the oversampling factor. For example, an oversampling factor of 1.62 is sufficient for a WCDMA signal. Compared to an AMIQ signal with an oversampling of 4, the output memory of SMIQB60 corresponds to a 1.25 MSamples memory.

The oversampling factor also affects the maximum possible bandwidth of the signal to be generated. As SMIQB60 has a maximum clock rate of 40 MHz, the maximum I/Q bandwidth is 40 MHz / 1.62, which gives roughly 24 MHz. For AMIQ, the maximum clock rate is 100 MHz. With an oversampling of 4, the maximum I/Q bandwidth would be 25 MHz. However, the oversampling factor can be reduced without decreasing the signal quality significantly. (Only the aliasing products are shifted towards the wanted signal.) The theoretical limit is an oversampling of 2; however, the baseband filters for signal shaping have to be taken into account. This leads to a maximum I/Q bandwidth of about 40 MHz for AMIQ.

This means, that AMIQ in general provides longer sequences and higher bandwidths than SMIQB60.

A comparison of the possible sequence lengths of 3GPP WCDMA signals for the different solutions is given in the table below.

[10] This denotes the RAM capacity. "4 MSamples" means that AMIQ03 can play waveforms with up to 4 million samples length.

Table 2 Maximum possible sequence length (in numbers of frames) for typical signals with different solutions.

Number of 3GPP carriers	Max. length in frames with SMIQB45	Max. length in frames with SMIQB45+B48	Max. length in frames with WinIQSIM™ + SMIQB60	Max. length in frames with WinIQSIM™ + AMIQ03/04
1	13	13 for standard channels 1022 for 1 enhanced channel, 256 for 4 enhanced channels	6	26 / 104
3	-	-	1	15 / 63
5	-	-	1	11 / 45

As can be seen, SMIQB60 has limited capacity for (modulated) multi carrier signals. Due to its higher bandwidth and clock rate, AMIQ is the most suitable source for such kinds of signals [11].

Besides long sequence lengths and clock rates, AMIQ, as a separate box, has some additional unique features. In addition to the I/Q baseband signal, AMIQ provides up to four marker channels that can be programmed for many different applications, for example trigger signals, bit or symbol clock, pulses or data bit sequences. The built-in harddisk can store hundreds of waveforms, so that different test scenarios can be loaded without the need of recalculation. SMIQB60 can store up to 22 waveforms.

Pure Baseband Applications: AMIQ special options

Although SMIQ also provides analog I/Q signals, for many baseband applications AMIQ will be the most suitable solution. AMIQ is the only instrument that can be equipped with differential (option AMIQ-B2) and digital outputs (option AMIQ-B3, up to 16 bits resolution). Thus, AMIQ is the best tool to test boards with such kinds of interfaces. For example, I/Q modulator boards are usually driven with differential I/Q signals, while D/A converters need a digital input signal rather than an analog one.

[11] It has to be mentioned that short ARB sequences may falsify the statistical properties of a signal. A peak value that would occur with a real-time signal is not captured because the sequence is not long enough. Thus, a bigger ARB memory is a benefit for generating realistic signal scenarios. However, a detailed investigation of this topic is beyond the scope of this paper.

Processing I/Q baseband signals: fading and noise

To complete the real-world environment, AWGN and fading capabilities can be added. With option SMIQB49 - Fading Functions for WCDMA (3GPP) - an SMIQ, equipped with Fading Simulators SMIQB14 (mandatory) and SMIQB15 (recommended), can generate the signals required to simulate all three fading scenarios defined in the standard (multipath propagation, moving propagation and birth-death propagation).

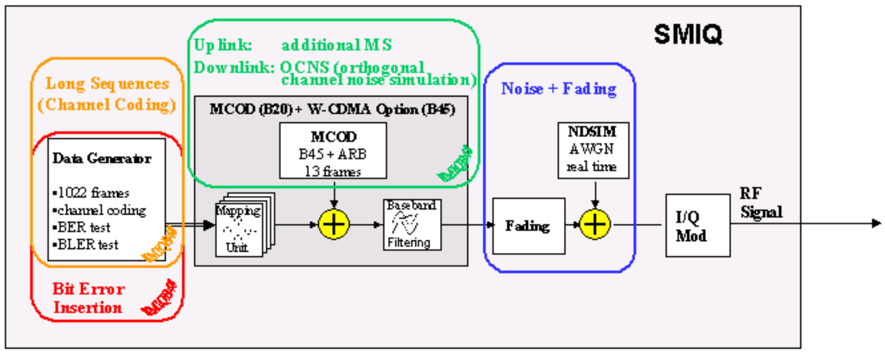


Fig. 38 Baseband signal processing for 3GPP WCDMA, including noise generation and fading simulation, here with SMIQB45/48 for generating the I/Q signal.

Option SMIQB17 adds Gaussian noise to the signal to take the influence of neighbouring cells into consideration, for example. SMIQB17 also provides distortion to simulate amplifier nonlinearities. This function can be used in amplifier tests, either to simulate certain amplifier characteristics, or to generate predistorted signals for nonlinearity compensation.

Generating the RF signal: I/Q Modulation and ACPR Performance

No matter which configuration is used for creating the I/Q baseband signal, this signal is fed into SMIQ's I/Q modulator to generate the modulated RF signal. The I/Q modulator is also the most important factor for ACPR performance. Thus, there are no significant differences in ACPR performance between the SMIQB45/48 personality and the arbitrary waveform generators SMIQB60 and AMIQ.

SMIQB47 is a special option to improve the ACPR performance for all configurations. The following table shows typical ACPR values with SMIQB47 for some 3GPP signals.

Table 3 Typical ACPR values obtained with SMIQB47 option

3GPP signal	ACPR, 5 MHz offset, typ. values	ACPR, 10 MHz offset, typ. values
1 DPCH	-67 dBc	-71 dBc
test model 1, 16 DPCH	-65 dBc	-68 dBc

Measuring bit error rates

Besides signal generation, both AMIQ or SMIQ can be extended for bit error rate testing with option AMIQ-B1 for AMIQ or option SMIQB21 for SMIQ. For installing SMIQB21, the SMIQB20 Modulation Coder is a prerequisite. The BER test options can analyze data of PRBS type. Therefore the user data of the code channel to be evaluated has to be PRBS. The device under test has to demodulate the WCDMA signal and return the user data as a serial bit stream. If the transmitted data was encoded, the DUT must also decode the data. If the DUT returns not only the user data but the whole frame including headers and other functional parts, the data has to be masked, so that only the user data part is counted. This mask signal also has to be provided by the DUT.

Generally, the generated WCDMA signals are precalculated and therefore have a limited sequence length. On the other hand, many frames are required to embed PRBS sequences into the WCDMA data structure so that the PRBS is not truncated at the end of the sequence. The reason for this is that a WCDMA slot contains a number of user data bits which differs from the cycle length of a PRBS. As PRBS lengths are always a prime number or a product of two prime numbers, they will never fit into a small number of frames. To ensure a signal with complete, non-truncated PRBS 9 user data, a sequence length of 511 frames is required. If one frame contains n data bits, then 511 frames can be filled with $n \cdot 511$ data bits, which is n times a complete PRBS 9.

Except for the enhanced channel functionality in SMIQB48, the possible signals are too short for non-truncated PRBS generation in WCDMA. In such a situation the BER tester has to be informed when the PRBS is truncated. This happens at the end of every cycle of the generated sequence. SMIQB45 can generate this restart signal if the DUT lacks such a function. WinIQSIM™ can program a similar restart signal for AMIQ or SMIQB60 [12].

General Remarks

The following sections shall demonstrate the wide variety of 3GPP applications that can be covered with Rohde & Schwarz signal generators. As with every overview publication it cannot describe all the different scenarios in detail. But we will publish additional application notes dealing with specific 3GPP measurements in the near future.

To indicate the appropriate instruments for the specific applications, an application guide table is shown in section 9 of this paper.

[12] With AMIQ, one of the four marker outputs can be used for the restart signal. With SMIQB60, it is possible to program one of the two trigger outputs of SMIQ.

6 3 GPP Application Examples: Spectral Measurements

Amplifier tests with single carrier signals

All signal generator configurations for 3GPP (SMIQ with SMIQB45, SMIQ with AMIQ/ WinIQSIM™, SMIQ with SMIQB60/ WinIQSIM™) provide 3GPP single carrier signals for spectral measurements, including the 3GPP test models defined in 3GPP TS 25.141. These models are defined for BS transmitter measurements. To test BS amplifiers, however, a signal generator must provide the appropriate signals.

The test model 1, for example, defines downlink signals for tests on spectrum emission mask, Adjacent Channel Power Ratio (ACPR), spurious emissions, transmit intermodulation and maximum output power. The signal consists of P-CPICH, PICH, P-CCPCH, P-SCH, S-SCH and n DPCHs, where n = 16, 32 or 64, with a defined channel power and code configuration.

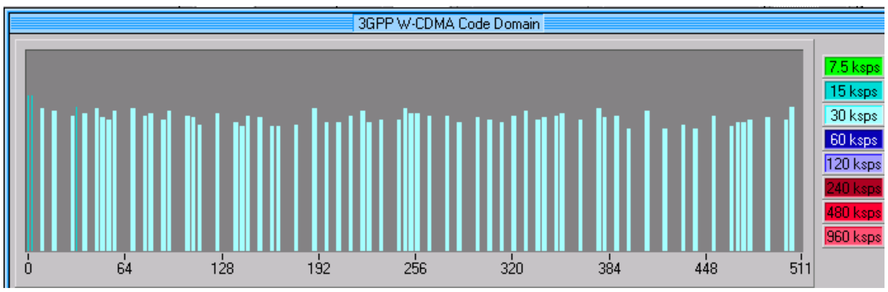


Fig. 39 Code domain display of the 3GPP test model 1 with 64 DPCHs.

The 3GPP test models are implemented as presets in SMIQB45 and can be activated with a few simple settings. In WinIQSIM™ the test models are available as example files, delivered with the software.

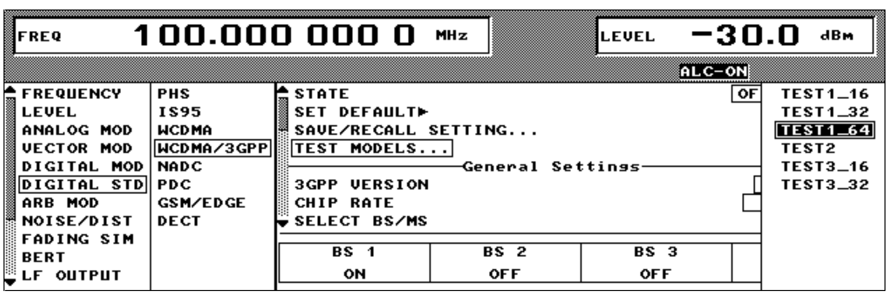


Fig. 40 Selecting 3GPP test models in SMIQB45

The signal output from the device under test can be measured with an FSIQ or FSP spectrum analyzer to determine the ACP, CCDF, crest factor and Error Vector Magnitude (EVM) of the output signal.

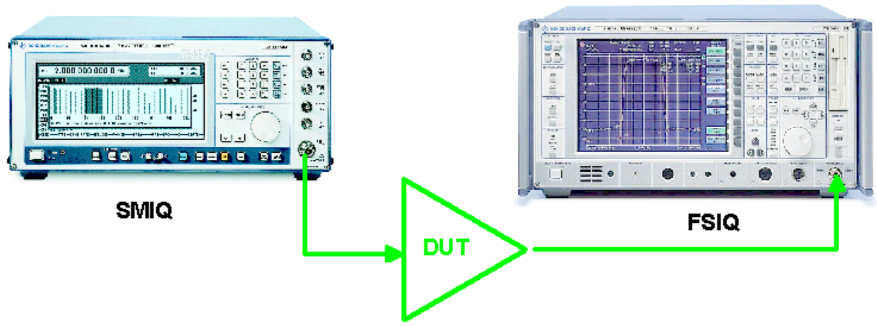


Fig. 41 Principle test setup for amplifier tests

Using the clipping function for amplifier tests

WCDMA signals may have very high crest factors - especially if the number of channels is high and the timing offset is unfavourable. High crest factors entail two basic problems:

1. The nonlinearity of a power amplifier (compression) causes intermodulation which expands the spectrum (spectral regrowth).
2. Since the level in a D/A converter is relative to the maximum value, the average value is converted with a relatively low resolution. This results in a high quantization noise.

Both effects increase the adjacent-channel leakage ratio.

From all the possibilities listed in section 4.9 for influencing the crest factor, changing the **clipping level** is the simplest and most effective. In this case a limit value is defined which is a percentage of the highest peak value.

All current values exceeding this limit will be clipped to this value. Since clipping is done prior to filtering, the procedure does not influence the spectrum. The EVM however increases.

Since clipping the signal not only changes the peak value but also the average value, the effect on the crest factor is unpredictable.

The following figures and table show the effect of clipping on the test model signal from above.

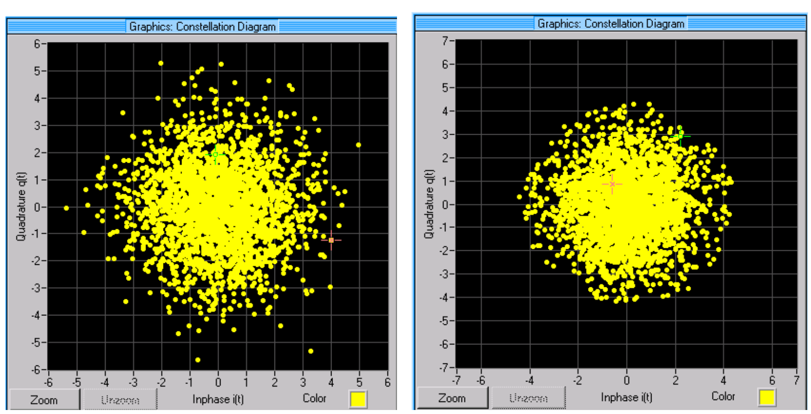


Fig. 42 From left to right: the test model signal of Fig. 39 (a) not clipped, (b) clipped to 50% of the original peak level.

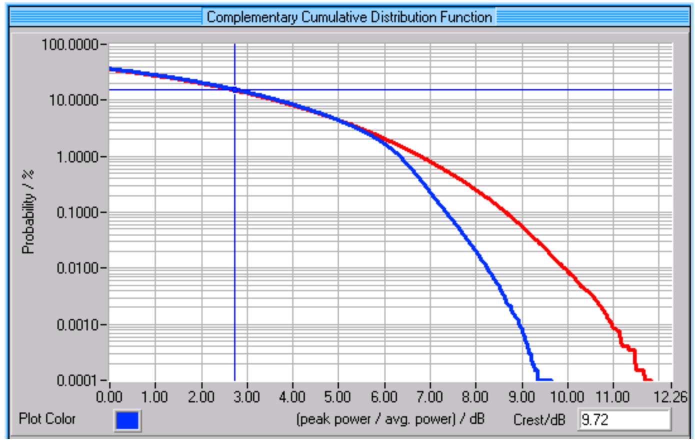


Fig. 43 CCDF for the test model signal of Fig. 39, (a) not clipped, (b) clipped to 50% of the original peak level.

The procedure is now to measure the modulation accuracy of the signal (EVM) and the ACPR as a function of the clipping level, for various signal scenarios. Stronger clipping increases EVM while weaker clipping causes high crest factors and therefore worse ACPR performance. The purpose of the test is to find the best compromise between EVM and ACPR.

Amplifier tests with multi carrier signals

AMIQ/ WinIQSIM™ and SMIQ provide multi carrier signals that can be used, for example, to test amplifier performance. The multi carrier signal can be calculated with the WinIQSIM™ software. WinIQSIM™ can also calculate the theoretical CCDF and other parameters of the signal.

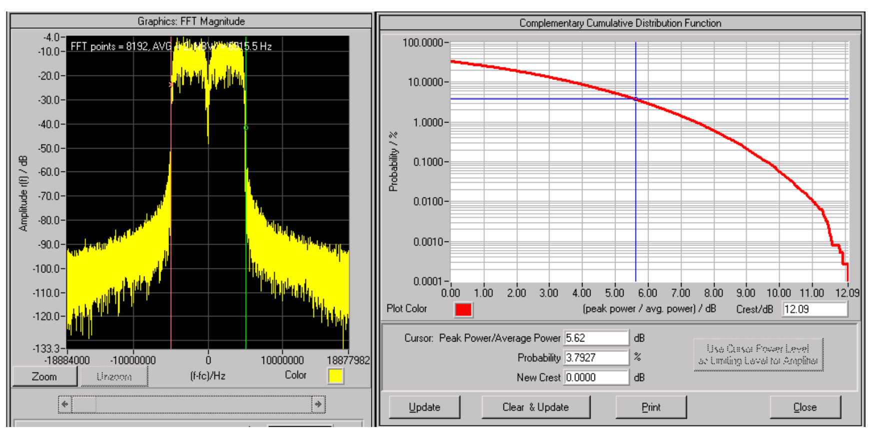


Fig. 44 Two 3GPP carriers and the related CCDF, calculated with WinIQSIM™

The signal output from the device under test can be measured with an FSIQ signal analyzer to determine the ACP, CCDF and crest factor of the output signal.

In addition, the distortion simulator of the option SMIQB17 could be used to compensate distortions of the amplifier under test.

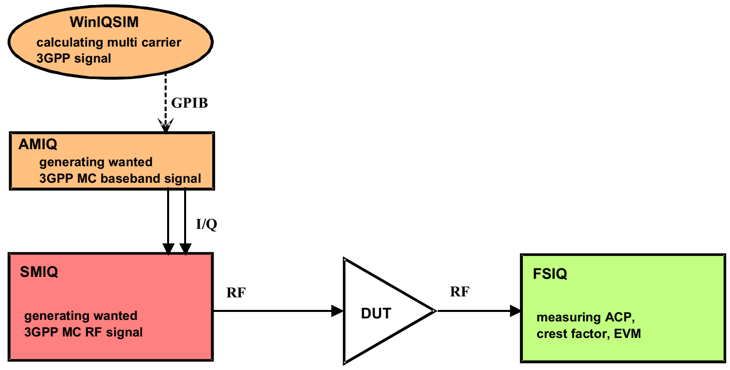


Fig. 45 Test setup for amplifier tests with multi carrier signals, using AMIQ/ WinIQSIM™ and SMIQ

More information on multi carrier signal generation can be found in [8].

I/Q modulator tests with AMIQ/ WinIQSIM™

Usually I/Q modulators have balanced differential amplifiers at their inputs to reduce or avoid the coupling in of unwanted signals or to compensate the offset drift of their input transistors. AMIQ with option Differential Outputs (AMIQ-B2) is ideal for examining devices of this kind because it provides highly accurate and highly stable I/Q signals and DC bias voltages for setting operating points.

The wanted 3GPP signal is calculated by WinIQSIM™ and transferred to AMIQ via GPIB or RS232 connection. The AMIQ hardware, including Differential Outputs, can be set from WinIQSIM™ via GPIB or RS232 [13].

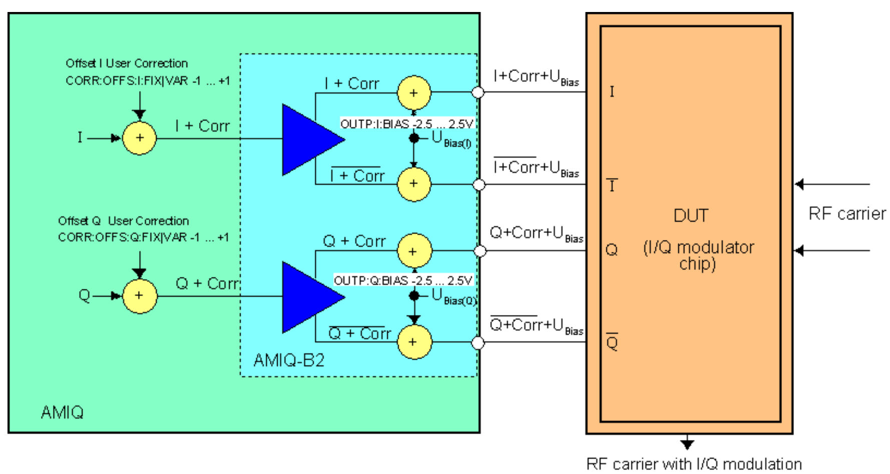


Fig. 46 Test of an I/Q modulator chip with AMIQ

[13] It is also possible to control AMIQ via batch floppy, without using an external device. See [9] for details.

D/A converter tests with AMIQ/ WinIQSIM™

The AMIQ option Digital Output (AMIQ-B3) has a wide range of applications, from measurements on DACs through tests of digital mobile-radio interfaces to the use of Low-Voltage Differential Signalling (LVDS) links.

A critical aspect of DAC tests is the spectral purity of the clock used. An impure clock signal causes a DAC to generate additional harmonics and nonharmonics, which in turn reduce the spurious-free dynamic range. To eliminate this source of error, the DUT can be supplied with a clock of extremely high spectral purity from an external source. AMIQ is driven by the same clock for the necessary synchronization of clock edges with the digital I/Q (or IF) signal (see Fig. 47)

The wanted 3GPP signal is calculated by WinIQSIM™ and transferred to AMIQ via GPIB or RS232 connection. The AMIQ hardware, including Differential Outputs, can be set from WinIQSIM™ via GPIB or RS232 [13]. A spectrum analyzer can be used to check the impact on spectral purity at the DUT output.

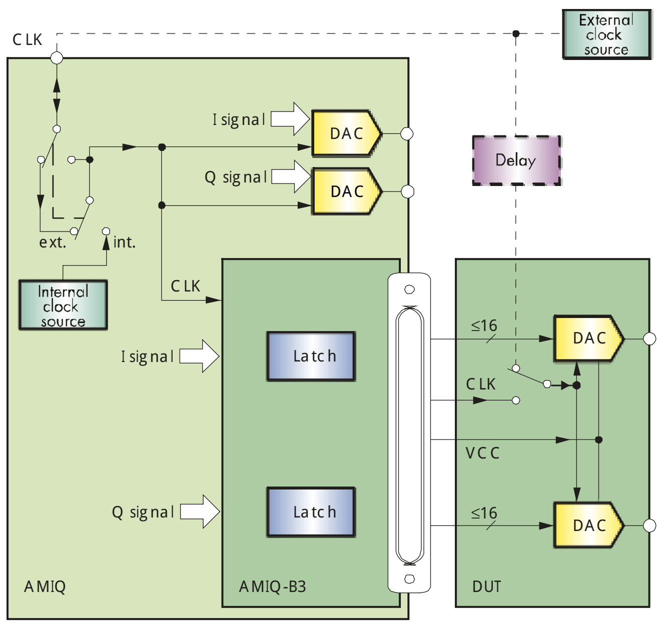


Fig. 47 D/A converter test with AMIQ

7 3GPP Application Examples: Data Level Measurements

Bit Error Rate Measurements with truncated PN Sequences

Besides signal generation, both AMIQ or SMIQ can be extended for bit error rate testing with option AMIQ-B1 for AMIQ or option SMIQB21 for SMIQ. For installing SMIQB21, the SMIQB20 Modulation Coder is a prerequisite. The BER test options can analyze data of PRBS type. Therefore the user data of the code channel to be evaluated has to be PRBS. The device under test has to demodulate the WCDMA signal and return the user data as a serial bit stream. If the transmitted data was encoded, the DUT must also decode the data. If the DUT returns not only the user data but the whole frame including headers and other functional parts, the data has to be masked, so that only the user data part is counted. This mask signal also has to be provided by the DUT.

Generally, the generated WCDMA signals are precalculated and therefore have a limited sequence length. On the other hand, many frames are required to embed PRBS sequences into the WCDMA data structure so that the PRBS is not truncated at the end of the sequence. The reason for this is that a WCDMA slot contains a number of user data bits which differs from the cycle length of a PRBS. (As PRBS lengths are always a prime number or a product of two prime numbers, they will never fit into a small number of frames.) To ensure a signal with complete, non-truncated PRBS 9 user data, a sequence length of 511 frames is required. If one frame contains n data bits, then 511 frames can be filled with $n \cdot 511$ data bits, which is n times a complete PRBS 9.

Except for the enhanced channel functionality in SMIQB48, the possible signals are too short for non-truncated PRBS generation in WCDMA. In such a situation the BER tester has to be informed when the PRBS is truncated. This happens at the end of every cycle of the generated sequence. SMIQB45 can generate this restart signal if the DUT lacks such a function.

Here is an example with PRBS 9 data and a 4 frame downlink signal using a DPCH channel with a symbol rate of 30 ksps. Every slot can take 30 user data bits. The entire 4 frame sequence then contains 1800 user data bits (15 slots per frame in 3.84 Mcps chip rate).

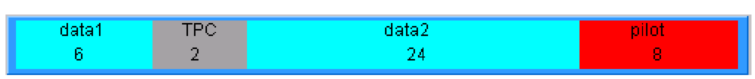


Fig. 48 A DPCH with 30 ksps contains 30 user data bits.

SMIQB45 then will use three full PRBS 9 sequences and the first 267 bits of the fourth PRBS 9 period for these 1800 data bits.

The four frame signal will be precalculated, and continuously repeated during signal output.

Fig. 49 Frames sent in the resulting SMIQ output signal.

The user data in the resulting output signal will be three complete PRBS 9 sequences, then a truncated one, three complete, then a truncated, and so on.

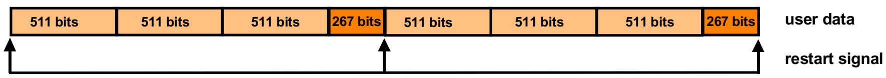


Fig. 50 User data in the resulting SMIQ output signal. This data has to be returned from the DUT to the SMIQB21 BER tester.

At every wraparound of this sequence, SMIQB45 can send a restart signal to indicate the "reset" of the PRBS sequence. This restart signal can be shifted with respect to the data sequence to compensate the delay in the signal path.

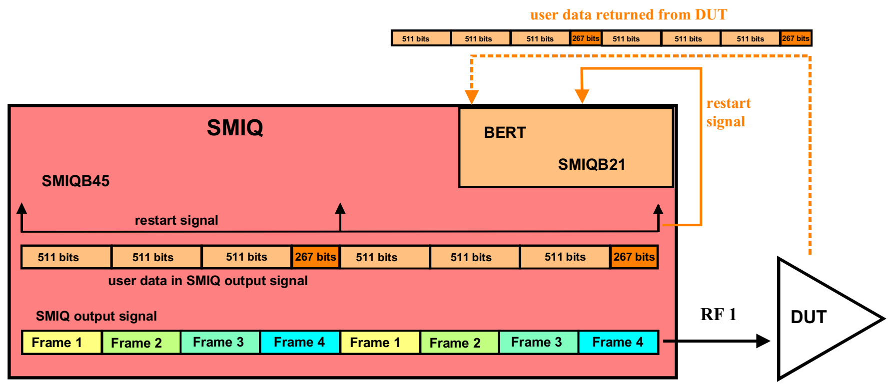


Fig. 51 Setup for BER measurement with truncated PRBS and the restart function.

Bit Error Rate Measurements with Enhanced Channels (SMIQB48)

SMIQB48 (extension to SMIQB45) provides up to four enhanced channels with extended sequence length and additional functions.

As outlined above, for a non-truncated PRBS 9 sequence as user data, a signal of 511 frames length is required. This is valid for data that is not channel coded. Including channel coding leads to an additional factor of 2, resulting in a required sequence length of 1022 - as we have seen for the reference measurement channel described in section 5.2.

Thus, SMIQB48 can generate a fully coded 12.2 kbps reference measurement channel with cyclic, non-truncated PRBS 9 sequences as user data. Therefore, restart signals for the BER tester are not necessary. Besides this, longer sequences have also the advantage that all possible states of the system are taken on – otherwise the measurements may neglect situations that thoroughly occur in real operation.

Base Station Receiver Tests to 3GPP TS 25.141

All receiver tests follow more or less one principle. The signal generator transmits an appropriate signal. This is received, demodulated and despread by the base station, and the bit error rate of the recovered user data bits is measured. In some cases the transmitted signal is only varied in power, in others White Gaussian Noise or an interfering signal is added. The interfering signal can be another 3GPP signal or just a CW carrier. The wanted 3GPP signal (the one to be demodulated) includes one of the reference measurement channels and an additional background signal, if necessary. Details concerning the parameter values can be found in [1].

There are several types of receiver measurements:

Reference sensitivity level

The minimum receiver input power is measured at which the bit error rate does not exceed a defined value. The signal generator transmits a 12.2 kbps uplink reference measurement channel. No interfering signal is present.

Dynamic range

An AWGN signal is added to the wanted 3GPP signal (again a 12.2 kbps uplink reference measurement channel). The bit error rate is measured as a function of signal-to-noise ratio.

Adjacent channel selectivity

The BER of the wanted 3GPP signal is measured in presence of an interfering 3GPP signal in the upper or lower adjacent channel. The wanted signal shall have –115 dBm, the interfering signal –52 dBm, measured at the input of the base station. Due to the level difference between wanted and interfering signal, the latter shall have an ACPR of –63 dBc or better.

The wanted 3GPP signal is again a 12.2 kbps uplink reference measurement channel. For the interfering signal, the specification states "WCDMA signal with one code", which is not very precise. The condition can be fulfilled in a sensible way, for example, with an uplink signal in DPDCH+DPCCH mode, with one DPDCH active.

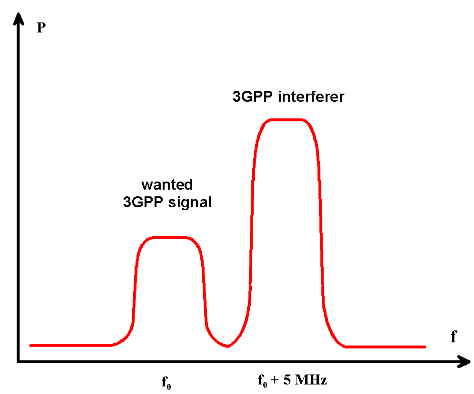


Fig. 52 Signal scenario for ACPR measurement.

Blocking characteristics

This is the same scenario as in adjacent channel selectivity, except that the interfering signal is not in the adjacent channels of the wanted signal, but somewhere else. The interferer's offset from the wanted 3GPP signal varies from 10 MHz to such a value that the center frequency of the interferer covers the range from 1 MHz to 12.75 GHz. If the interferer is located in the 3GPP uplink band (1920 MHz to 1980 MHz, "in-band blocking"), use a WCDMA signal with one code. This is also valid for the 20 MHz regions just below and above the 3GPP band. If the interferer is more than 20 MHz away from the 3GPP uplink band, use a CW signal.

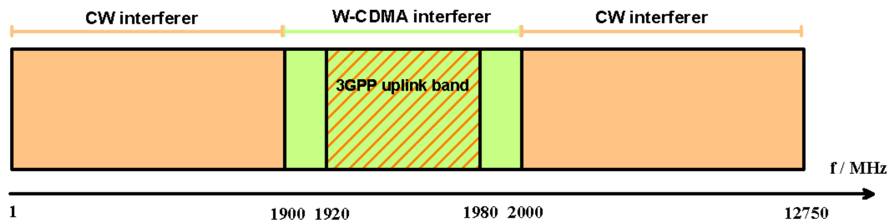


Fig. 53 Interferer type for different center frequencies of the interfering signal. The offset from the wanted signal is always at least 10 MHz.

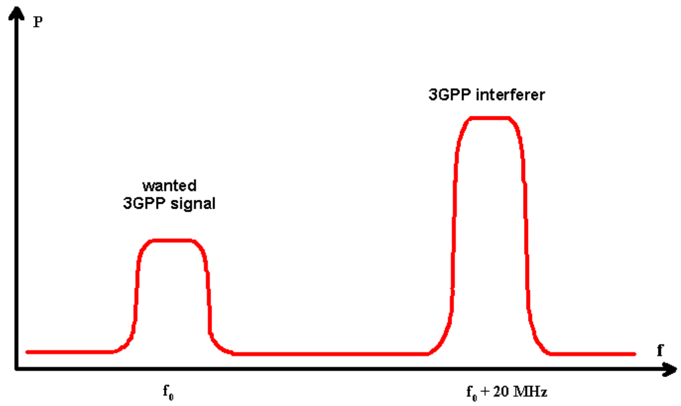


Fig. 54 Signal scenario for blocking characteristics measurement, here with 3GPP interferer

Intermodulation characteristics

This is another variation of testing in presence of interfering signals. Here, two interferers, one CW and one modulated, are placed with 10 MHz and 20 MHz offset to the wanted signal, so that one of their 3rd order intermodulation products falls into the wanted channel, according to

$$f_{IM} = 2(f_0 + 10\,\text{MHz}) - (f_0 + 20\,\text{MHz}) = f_0$$

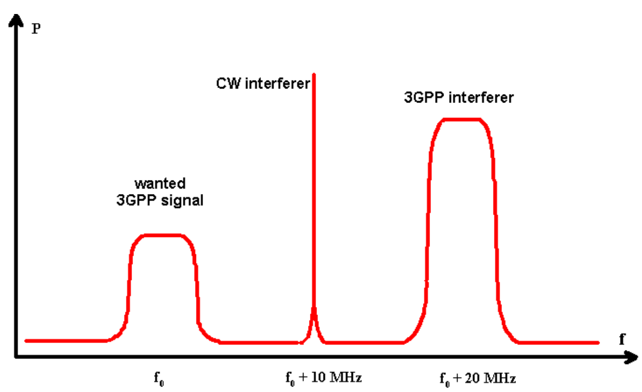


Fig. 55 Signal scenario for intermodulation characteristics measurement. One of the 3rd IM products of the two interfering signals falls into the wanted channel.

Table 4 Signal parameters for intermodulation characteristics measurement.

Type of signal	Offset	Signal level
Wanted signal	-	-115 dBm
CW signal	10 MHz	-48 dBm
WCDMA signal with one code	10 MHz	-48 dBm

Spurious Emissions

This test measures the emissions generated or amplified in the receiver itself that appear at the antenna connector of the BS. Thus, no signal generator is needed for this test.

Test setup

A suitable setup for all the tests consists of three signal generators, two SMIQs and one SMR microwave signal generator. The microwave generator is needed because out-of-band blocking requires CW interferers with up to 12.75 GHz.

The first SMIQ needs the options SMIQB45 and SMIQB48 to generate the (coded) uplink reference measurement channel. Either the base station has a built-in BER tester or the bit error rate test option SMIQB21 can be used to measure the BER. The DUT has to return the demodulated and decoded raw data to the SMIQ BER tester. For the Dynamic Range measurement, the Noise and Distortion option SMIQB17 is required.

The second SMIQ needs the option SMIQB45 and generates the interfering 3GPP signal while SMR provides the CW carrier for out-of-band blocking and intermodulation characteristics.

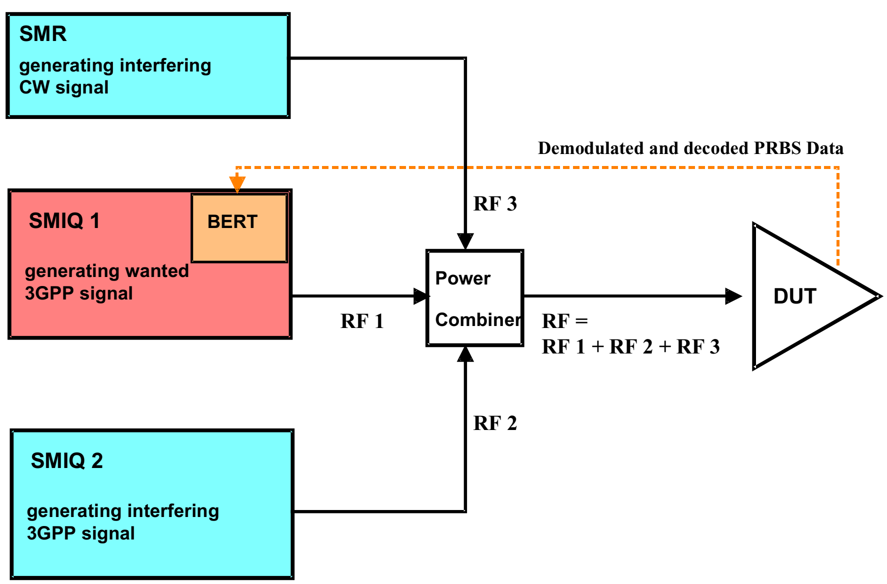


Fig. 56 Test setup suitable for the BS receiver tests according to TS 25.141.

Base Station Performance Tests to 3GPP TS 25.141

The principle of the performance tests is similar to the receiver tests. Here, the BS has to demodulate a Dedicated Channel transmitted by the signal generator in defined conditions. The Block Error Rate (BLER) of the demodulated channel is measured.

For the wanted 3GPP signal, use an uplink reference measurement channel as defined in the standard [1], with bit rate 12.2 kbps, 64 kbps, 144 kbps or 384 kbps. The tests shall be performed for the reference measurement channels that are supported by the base station.

The specification does not define background signal scenarios. However, SMIQ can add a background signal to the wanted signal if necessary, consisting of up to 50 additional mobiles.

As there are no interferers present in these measurements, in principle one SMIQ signal generator is sufficient . Besides SMIQB45 and B48, SMIQB17 (AWGN generation) and SMIQB14, B15, B49 (for the different propagation conditions) are required.

Demodulation in static propagation conditions

White Gaussian Noise is added to the wanted 3GPP signal. The BLER of the demodulated channel is measured as a function of the signal-to-noise ratio.

Other propagation conditions

In the following three scenarios the wanted 3GPP signal undergoes different propagation conditions. These are the conditions described in section 4.10. After fading the signal, White Gaussian Noise is added. The BLER of the demodulated channel is measured as a function of the signal-to-noise ratio.

The three scenarios are:

- Demodulation in multipath fading conditions
- Demodulation in moving propagation conditions
- Demodulation in birth/death propagation conditions

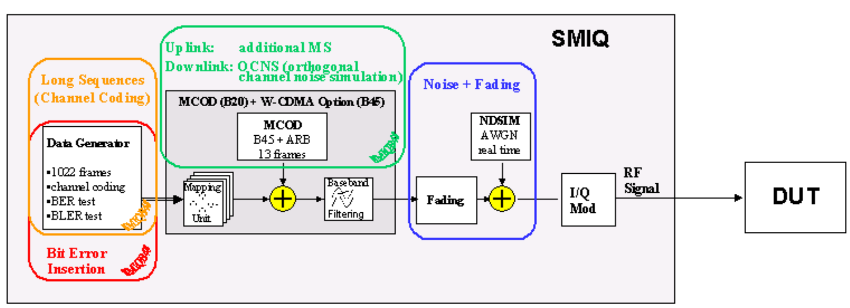


Fig. 57 Test setup for BS performance tests.

Mobile Station Receiver Tests to 3GPP TS 25.101

The receiver tests for mobile are similar to the base station tests, except that the signal parameters are different, and that the tester must now generate downlink signals. For the wanted 3GPP signal, downlink reference measurement channels are defined in the standard [1], similar to the uplink case. In some tests the standard explicitly specifies an OCNS background for the wanted signal [1].

The different tests are:

- Reference Sensitivity Level
- Maximum Input Power
- Adjacent Channel Selectivity
- Blocking Characteristics
- Spurious Response
- Intermodulation Characteristics
- Spurious Emissions

8 3GPP Application Examples: Response Tests

Power control tests (TS 25.104)

SMIQB45 and SMIQB48 can be used to perform power control tests. The ordinary transmit power control is based on the closed loop principle. During an established connection, the mobile measures the received power and the signal to interference ratio (SIR). The SIR has to be kept at a given target value. The mobile transmits power control bits to instruct the base station to increase or decrease the power of the code channel(s) used for the connection. The same procedure is also used in the other link direction.

In a test setup the closed loop power control can be simulated using a SMIQ signal generator with SMIQB45 and SMIQB48 options. SMIQ generates the wanted signal. The code channels to be evaluated for the test have to be simulated by enhanced channels (SMIQB48). The realistic background signal (OCNS) is generated by SMIQB45. The device under test measures the SIR and has to return the power control bits via a TTL line. This line is used to control the output power of the enhanced channels.

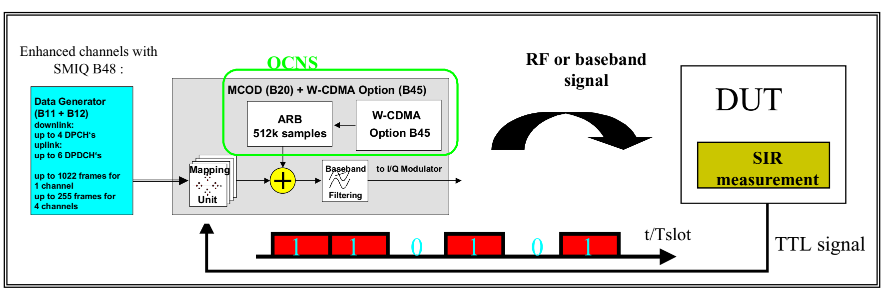


Fig. 58 Basic test setup for power control tests.

9 3GPP Application and Configuration Guides

3GPP Application Guide

The table on the next page gives an overview of which signal generator configuration is suitable for which particular application.

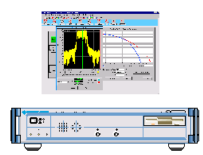
👍 Best choice. There might be more than one best solution for a specific application, especially for more basic ones.

✔ Possible (but not the best choice). Either the solution has some restrictions for the specific application or a part of the setup is not needed.

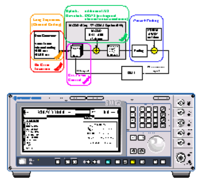
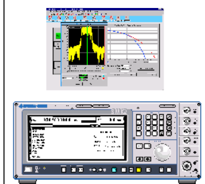
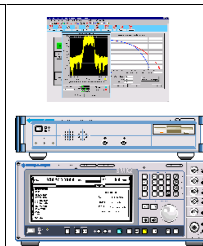
✖ not possible

The necessary options for the configurations are described in section 9.2.

3GPP Application Guide, where I/Q baseband (or IF) signals are required.

Application	 **AMIQ and WinIQSIM™**
Spectral Measurements	
Differential I/Q signals, e.g. for testing I/Q modulator boards	👍
Digital I/Q or IF signals, e.g. for testing D/A converters	👍
Data level measurements (on Baseband)	
BER with short sequences	👍

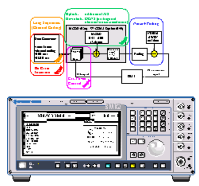
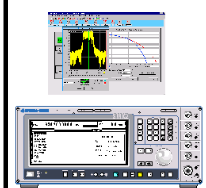
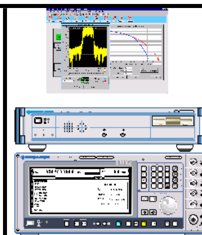
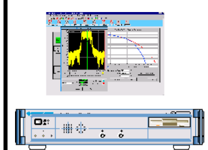
3GPP Application Guide, where RF Signals are required:

Configuration **Application**	 **SMIQ with SMIQB45**	 **SMIQ with SMIQB45/48**	 **SMIQ with SMIQB60 and WinIQSIM™**	 **SMIQ with AMIQ and WinIQSIM™**
Spectral Measurements				
RF Amplifier tests with single carrier	👍	👍	👍	👍
RF Amplifier tests with multi carrier	✖	✖	✔	👍
Data level measurements (on RF)				
BER with short sequences	👍	👍	👍	👍
BER with extended sequences and channel coding	✖	👍	✖	✖
3GPP tests to TS25.141, wanted 3GPP signal	✖	👍	✖	✖
interfering signals for 3GPP tests to TS25.141	👍	✔	✔	✔
Response measurements				
Power control tests to TS25.101	✖	👍	✖	✖

3GPP Configuration Guide

The following table describes which SMIQ and AMIQ options can be used for the different stages of signal generation: I/Q baseband signal generation, baseband signal processing and I/Q modulation. The bit error rate testers are not part of the signal generation chain, but are also built-in to SMIQ or AMIQ. The configurations with SMIQ can generate 3GPP RF signals, the configuration without SMIQ is for creating baseband signals.

Hardware options are written in normal letters. Software and keycode options are written in *italics*. If nothing else is mentioned, the hardware options are prerequisites for the software or keycode options in the same category.

Configuration / **Function**	 **SMIQ with SMIQB45**	 **SMIQ with SMIQB45/48**	 **SMIQ with SMIQB60 and WinIQSIM**	 **SMIQ with AMIQ and WinIQSIM**	 **AMIQ and WinIQSIM (baseband only)**
Basic Units	SMIQ	SMIQ	SMIQ	SMIQ AMIQ	AMIQ
I/Q Baseband Signal Generation	SMIQB20 SMIQB11 *SMIQB45*	SMIQB20 SMIQB11 2 x SMIQB12 (recommended) *SMIQB45* *SMIQB48*	SMIQB20 SMIQB11 *SMIQB60*	*WinIQSIM (free of charge)*	*WinIQSIM (free of charge)* AMIQ-B2 AMIQ-B3
Baseband Signal Processing					
Noise and Distortion	SMIQB17	SMIQB17	SMIQB17	SMIQB17	-
Fading	SMIQB14 (mandatory) SMIQB15 (recommended) *SMIQB49*	SMIQB14 (mandatory) SMIQB15 (recommended) *SMIQB49*	SMIQB14 (mandatory) SMIQB15 (recommended) *SMIQB49*	SMIQB14 (mandatory) SMIQB15 (recommended) *SMIQB49*	-
I/Q Modulation	*SMIQB47 (recommended)*	*SMIQB47 (recommended)*	*SMIQB47 (recommended)*	*SMIQB47 (recommended)*	-
Bit Error Rate Tester	SMIQB20 (prerequisite) *SMIQB21*	SMIQB20 (prerequisite) *SMIQB21*	SMIQB20 (prerequisite) *SMIQB21*	*AMIQ-B1*	*AMIQ-B1*

A short description of the options can be found below:

Option	Short description
I/Q baseband signal generation	
SMIQB11	Data Generator, hardware option, prerequisite for 3GPP options SMIQB45 and B48
SMIQB20	Modulation Coder, hardware option, prerequisite for 3GPP options SMIQB45 and B48 and for the BER test option SMIQB21
SMIQB45	Digital standard WCDMA 3GPP (FDD), software/keycode option, SMIQB11, B20 required
SMIQB48	Enhanced functions for digital standard WCDMA 3GPP (FDD), software/keycode option, SMIQB11, B20, B45 required, 2 x SMIQB12 recommended
I/Q baseband signal processing	
SMIQB14	Fading simulator, hardware option, prerequisite for 3GPP option SMIQB49
SMIQB15	Second fading simulator, hardware option, recommended for 3GPP option SMIQB49
SMIQB49	Enhanced fading functions for WCDMA 3GPP, software/keycode option, SMIQB14 required, SMIQB15 recommended
SMIQB17	Noise generator and distortion simulator, hardware option
I/Q modulation, RF signal generation	
SMIQB47	Improved ACPR for WCDMA and CDMA IS-95, software/keycode option, recommended for all configurations
Bit error rate tests	
SMIQB21	Bit error rate measurements, software/keycode option, SMIQB20 required

For more detailed information on the options see the SMIQ data sheet, available at Rohde & Schwarz, order number PD 757.2438.25 (or download at *http://www.rohde-schwarz.com*).

10 References

[1] 3GPP specifications: TS 25.101 v3.2.2, TS 25.104 v3.2.0, TS 25.211 v3.2.0 and TS 25.141 v3.1.0, 3rd Generation Partnership Project (3GPP) (2000)

[2] W. Kernchen, *Signal Generator SMIQ – Fit for 3G with new options*, News from Rohde & Schwarz **166**, 10 (2000)

[3] B. Küfner, *I/Q Modulation Generator AMIQ – more applications through differential I/Q outputs*, News from Rohde & Schwarz **162**, 20 (1999)

[4] B. Küfner, R. Desquiotz, *I/Q Modulation Generator AMIQ – New models 03 and 04 as well as digital I/Q output option*, News from Rohde & Schwarz **166**, 22 (2000)

[5] Vector Signal Generator SMIQB, Operating Manual, PD 1125.5610.12, Rohde & Schwarz (2000)

[6] I/Q Modulation Generator AMIQ, Operating Manual, PD 1110.3339.12, Rohde & Schwarz (2000)

[7] Software WinIQSIM™ for Calculating I/Q Signals for I/Q Modulation Generator AMIQ, Software Manual, PD 1110.3645.42, Rohde & Schwarz, (2000)

[8] Software WinIQSIM™ for Calculating I/Q Signals for I/Q Modulation Generator AMIQ, Application Manual, PD 1007.9245.42, Rohde & Schwarz, (2000)

[9] M. Banerjee, B. Byrom, *Floppy Disk Control of the I/Q Modulation Generator AMIQ*, Application Note 1GP40_0E, Rohde & Schwarz (2000)

11 Ordering information

I/Q Modulation Generator		
AMIQ03 incl. WinIQSIM™	4 MSamples Memory	1110.2003.03
AMIQ04 incl. WinIQSIM™	16 MSamples Memory	1110.2003.04
Vector Signal Generator:		
SMIQ02B	300 kHz to 2.2 GHz	1125.5555.02
SMIQ03B	300 kHz to 3.3 GHz	1125.5555.03
SMIQ04B	300 kHz to 4.4 GHz	1125.5555.04
SMIQ06B	300 kHz to 6.4 GHz	1125.5555.06
Options:		
SMIQB11	Data Generator	1085.4502.04
SMIQB12	Memory Extension	1085.2800.04
SMIQB14	Fading Simulator	1085.4002.02
SMIQB15	Second Fading Simulator for two channel or 12 path fading	1085.4402.02
SMIQB17	Noise Generator and Distortion Simulator	1104.9000.02
SMIQB20	Modulation Coder	1125.5190.02
SMIQB21	BER Measurement	1125.5490.02
SMIQB45	Digital Standard WCDMA (3GPP)	1104.8232.02
SMIQB47	Low ACP for CDMA and WCDMA	1125.5090.02
SMIQB48	Extended Functions for WCDMA (3GPP)	1105.0587.02
SMIQB49	Extended Fading Functions for WCDMA (3GPP)	1105.1083.02
Signal Generator		
SMR20	2 to 20 GHz	1104.0002.20
SMR27	2 to 27 GHz	1104.0002.27
SMR30	2 to 30 GHz	1104.0002.30
SMR40	2 to 40 GHz	1104.0002.40
Option		
SMR-B11	Frequency Extension 10 MHz to 1 GHz	1104.4250.02

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