Multi-Channel Signal Generation Applications with R&S®SMW200A – Overview

Application Note

Products:

- R&S®SMW200A
- R&S®SGT100A
- R&S®SGS100A
- R&S®SGU100A

The R&S®SMW200A vector signal generator has the outstanding ability to simultaneously generate up to eight independent signals from a single instrument. The advanced multi-channel architecture allows realizing even complex applications like MSR, carrier aggregation, MIMO or enhanced interference scenarios with a minimum of effort.

This application note gives an overview of common multi-channel application examples and how to equip the Rohde & Schwarz signal generator R&S®SMW200A appropriately.

Application Note

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ROHDE&SCHWARZ

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The following abbreviations are used in this application note for Rohde & Schwarz products:

- The R&S®SMW200A vector signal generator is referred to as SMW
- The R&S®SGT100A vector RF source is referred to as SGT
- The R&S®SGS100A vector RF source is referred to as SGS
- The R&S®SGU100A vector RF source is referred to as SGU
- The R&S®WinIQSIM2™ signal generation software is referred to as WinIQSIM2
- The R&S®Pulse Sequencer software is referred to as Pulse Sequencer
- The R&S®ARB Toolbox Plus software is referred to as ARB Toolbox Plus.

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1 Introduction

This application note gives an overview of common multi-channel applications and how to equip the Rohde & Schwarz signal generator SMW appropriately.

Please note that this document covers only the standard SMW equipped with B10 baseband generator (maximum bandwidth is 160 MHz). The wideband SMW equipped with B9 wideband baseband generator (maximum bandwidth is 2000 MHz) is not subject of this application note.

Chapter 2 includes important definitions which are used throughout this document.

Chapter 3 gives an introduction to typical use cases where multiple test signals are needed. Additionally, the main technical parameters are outlined that are to be taken into account when deciding on a signal generation solution.

Chapter 4 briefly describes the multi-channel signal generation capabilities of the SMW and gives general guidance about needed options.

Chapter 5 gives an overview of typical multi-channel/multi-carrier applications and informs about the recommended instrument configuration.

Chapter 6 gives an overview of typical MIMO applications and informs about the required instrument configuration.

2 Definitions

Throughout this document the following definitions are used.

SISO

A SISO system is a transmission system with a single Tx and a single Rx antenna. There is no cross-talk between multiple SISO channels. Each SISO system generally transmits its own data.
Ideal multi-carrier scenarios – where the signals are transmitted at different frequencies – are considered as multiple independent SISO systems.

MIMO

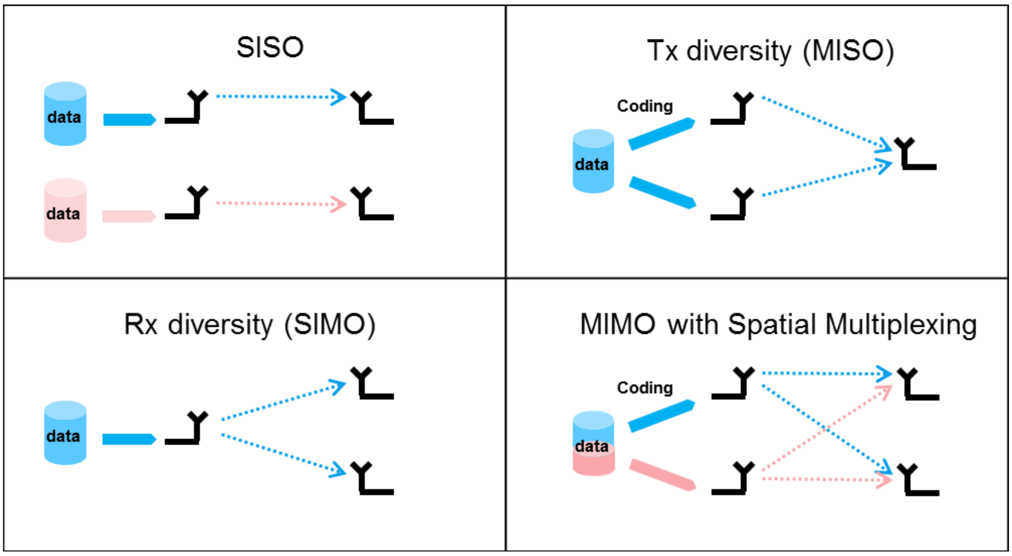
A MIMO system is a transmission system which uses multiple Tx and RX antennas.
MIMO systems are divided into *spatial diversity* systems and *spatial multiplexing* systems.

Spatial diversity

Spatial diversity means transferring the same data stream simultaneously on the same frequency, such that the receive antennas obtain replicas of the signal.
Transmit diversity (multiple input, single output – MISO) and receive diversity systems (single input, multiple output – SIMO) are both special types of spatial diversity systems.

Spatial multiplexing

Spatial multiplexing means transferring different data streams simultaneously on the same frequency by using multiple transmit and receive antennas.



3 Multi-Channel Test Requirements

3.1 Typical Use Cases

There are manifold requirements for multi-channel signal generation.

Modern mobile communication standards make use of sophisticated transmission principles. Diversity, MIMO or beam forming are only a few to name that are used for increasing the overall robustness and throughput while maintaining efficient resource usage. These three techniques have in common that multiple antennas are used for signal transmission. This also increases the complexity of a test setup.

Standards like LTE-Advanced combine multiple carriers for a coordinated transmission with effectively higher bandwidth for the users. This feature is called carrier aggregation. Testing a carrier aggregation capable multi-band receiver of a mobile phone or components like filters or PAs hence means to generate all the carriers at the same time in the different frequency bands. And for assessing the receiver performance all the carriers need to be created in a coordinated way like a real base station would do it. If carrier aggregation is additionally combined with MIMO the complexity of the test scenarios can further increase.

Another very important test case is to test the robustness of a communication system against interference. This interference can occur due to imperfections in the receiver or transmitter (e.g. crosstalk), it can be caused by multipath propagation effects in the channel, it might originate from neighboring cells (same or different standard) or from other RF systems that are competing for the same RF resource. The latter is especially the case in unlicensed bands. For testing these kinds of effects, a signal generation solution needs to be capable to generate not only the wanted signal, but also all the interferers – no matter how many interferers are to be generated and how different these interferers might be in terms of frequency, level, bandwidth or data content. Also channel simulation for all these interferers might be needed for realistic test of a receiver.

Multiple signal sources are also required for testing aerospace and defense equipment. In a typical radar scenario (e.g. air traffic control radar) a multitude of objects (e.g. planes) are to be distinguished. Therefore the complete evaluation of the radar receiver's resolution and tracking capabilities typically requires multiple separate test sources. Testing phased array antennas also necessitates a multi-channel signal source that allows generation of multiple phase coherent RF signals.

All in all there is a multitude of test scenarios where multi-channel signal generation is necessary. However, realizing these tests with separate signal generators is often unnecessarily complicated. Usability, synchronization accuracy, test system size and instrument cost can be optimized by using the SMW vector signal generator platform.

3.2 Technical Challenges

Depending on the desired test scenario some influencing factors have to be taken into consideration for selecting the best suitable signal generation solution. In the following the most important test scenario parameters are described.

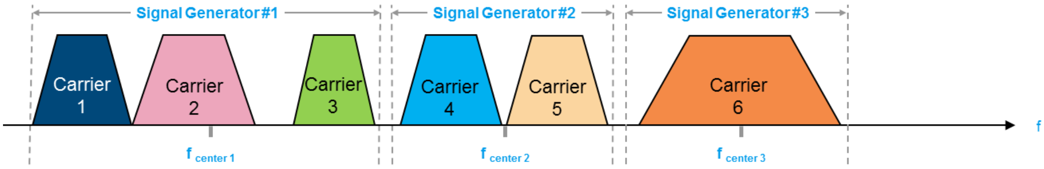
3.2.1 Carrier Frequency

In the first place, the maximum carrier frequency determines the needed frequency variant of the test instrument to be used. E.g. for the SMW vector signal generator there are frequency variants of 3 GHz, 6 GHz, 12.75 GHz, 20 GHz and 40 GHz available. Also dual-RF configurations (3+3 GHz, 6+6 GHz, 20+20 GHz) are possible as well as adding more RF paths via external instruments (SGS, SGT, SGU).

Test Scenario Parameter	Impact on signal generation solution
Carrier frequency	Frequency variant of the signal generator

3.2.2 Signal Bandwidth and RF Channels

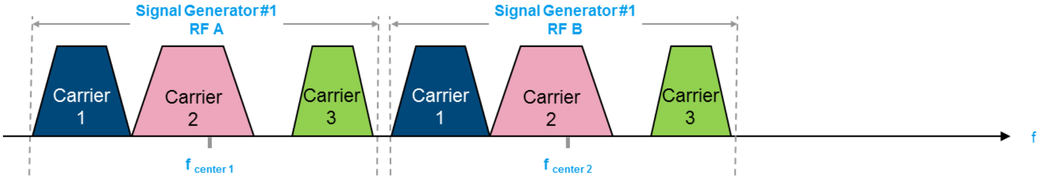
A vector signal generator has a certain baseband and RF bandwidth. Within this bandwidth also different carriers or signals can generally be created. Depending on the number of carriers, their bandwidth and the spacing between the carriers one or multiple signal generators are required for complex test scenarios.



Generation of a wideband signal scenario via multiple signal generators

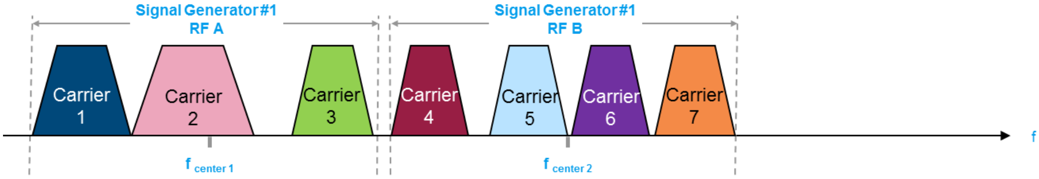
With a multi-channel signal generator like the SMW multiple different RF center frequencies can be generated at the same time via individual RF paths. Depending on the instrument configuration either the same baseband signal (a) or completely different signals scenarios (b) can be output via the different RF paths. Latter operation mode is similar to the use of separate signal generators, but with advantages for a multi-channel signal generator in terms of time synchronization, usability, test system size and instrument cost.

(a) Multi-channel output signal of an SMW with one baseband section and two RF channels.



Generation of a wideband signal scenario via a multi-channel signal generator like the SMW. Instrument with one baseband and two RF sections. The same baseband signal scenario is output twice via two different RF

(b) Multi-channel output signal of an SMW with two baseband sections and two RF channels.



Generation of a wideband signal scenario via a multi-channel signal generator like the SMW. Instrument with two baseband and two RF sections. Each RF section is outputing its own baseband signal scenario.

Generally, the higher the number of separate basebands and RF channels that are available in a multi-channel signal generator the more flexibly can such an instrument be used. With a single SMW there is a possibility to have up to eight signal generation paths.

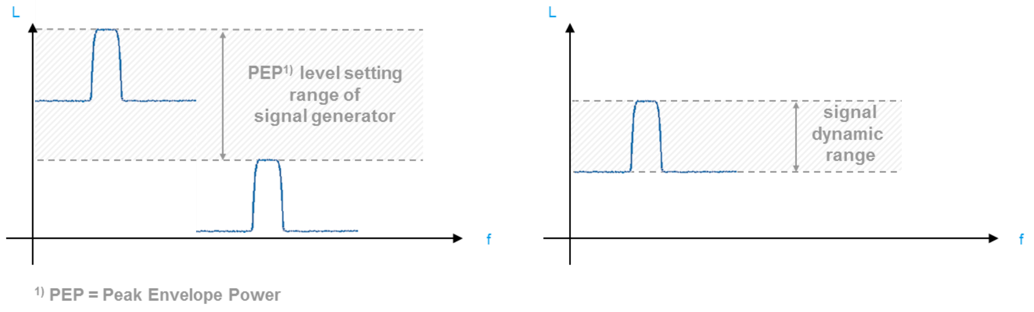
Test Scenario Parameter	Impact on signal generation solution
Bandwidth of a single carrier	Bandwidth option of the signal generator
Number of carriers, bandwidth of each carrier and carrier spacing	Determines number of signal generators or signal generation paths of a multi-path instrument like the SMW

3.2.3 Level and Dynamic Range

When generating multi-channel signals, the needed dynamic range of the whole signal scenario with all signal components is very important.

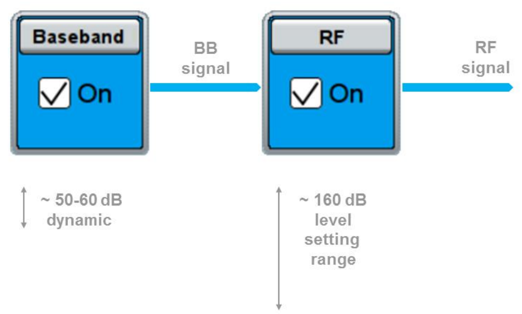
It has to be distinguished between absolute level (a) and the dynamic range (b) of a signal:

(a) Absolute level of a signal (b) Dynamic range of a signal



Modern vector signal generators like the SMW have an RF level setting range of more than 160 dB which is achieved via wideband amplifiers in combination with electronic or mechanical attenuators in the RF path. Hence, generation of signals with very high or very low power is easily possible.

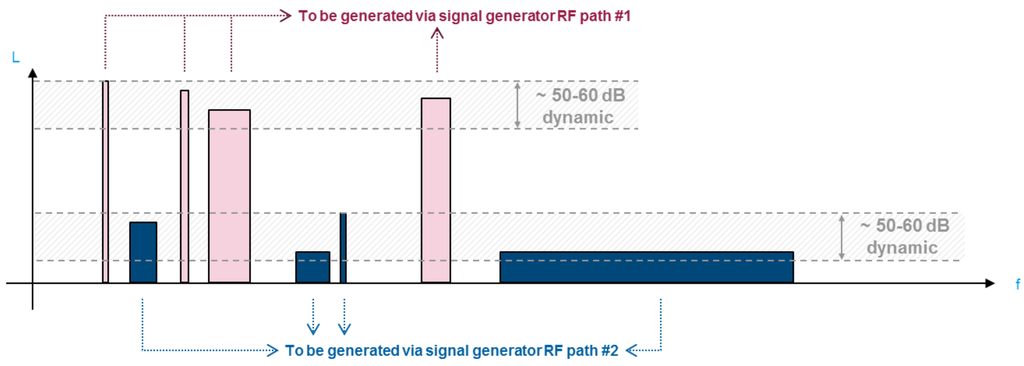
The dynamic range of the digital baseband section of a high-end vector signal generator is typically less. If multiple different carriers/signals are generated by the baseband section and added up digitally – either in real-time or via computing a waveform file that contains all signal components – then the effective dynamic range of the baseband section is relevant. Although the digital signal processing is done at high bit resolutions (e.g. 16 bit for I and Q) the effectively available dynamic range when adding up baseband signals is typically in the range of 50 to 60 dB (mainly due to carrier leakage).



In consequence this means as a rule of thumb that for the generation of multi-channel signals it has to be distinguished whether the needed total dynamic rage is more or less than 50 dB. If all signal components fit within 50 dB dynamic range, then adding the signals in the baseband is possible. Otherwise separate RF signal generation paths should be used and the signal components need to be added at RF via RF combiners to meet the dynamic range requirements.

Test Scenario Parameter	Impact on signal generation solution
Total dynamic range <50 dB	Creation and addition of all signal components in a single baseband section of a signal generator
Total dynamic range >50 dB	Creation of signal components via separate RF paths and addition of signal components at the RF

In order to minimize the number of required separate RF paths for complex scenarios with many carriers and large dynamic range requirements it is advised to generate all carriers with low levels via one RF and all carriers with high levels via a second RF path.



3.2.4 Signal Duration

For throughput assessment or BER/BLER/PER/FER[1] evaluation of a receiver, sufficient signal duration and data content is required when generating a test signal. Otherwise the statistical significance of the measurement is not ensured. It is very common to use pseudo-random bit sequences (PN sequences) with a certain periodicity. Here, it is desired to use non-truncated sequences to ensure that all bit combinations are tested. Furthermore there is often a certain signal duration needed for a receiver under test to synchronize onto the test signal.

The baseband ARB memory size of a vector signal generator is generally sufficient for creation of single carrier signals, even with long signal durations. However, if multiple carriers are to be generated – each with its own long data sequence and periodicity – the ARB memory might not be sufficient for generating all the signal components with the desired length via a single ARB waveform.

Even if the ARB length is sufficient, the computation time for creation of a multi-carrier waveform will still be very long. A long calculation time generally causes problems and has to be avoided; especially if waveform parameters need to be changed frequently it would enforce re-calculation of the complete multi-carrier waveform every time.

The traditional solution in these cases is to use multiple separate vector signal generators, each for generation of one of the signal components. This unnecessarily increases test instrument costs. With true multi-channel signal generators like the SMW, all signal components are generated via their own baseband sources and the signal addition happens in real-time. This not only reduces cost, but also minimizes overall test system complexity and test time.

Test Scenario Parameter	Impact on signal generation solution
Signal duration	Multi-carrier signals where each carrier requires a long signal sequence are best created by a dedicated baseband for each carrier

[1] BER = Bit Error Rate, BLER = Block Error Rate, PER = Packet Error Rate, FER = Frame Error Rate

3.2.5 Signal Timing

Time synchronization between different signals can be essential. E.g. multiple carriers of an LTE-Advanced carrier aggregation scenario all need to be generated in a time-aligned manner. Otherwise a receiver might not be able to demodulate the signals. Same applies for different antenna signals that are to be generated for beam forming applications. Hence, it is important to know the desired absolute time synchronization accuracy in order to decide for a signal generation solution.

Test Scenario Parameter	Impact on signal generation solution
Timing accuracy between carriers/signals	Common baseband clock needed for all baseband sources; Common trigger needed for all baseband sources; Time alignment needed to compensate for different cable lengths when using multiple separate signal generators.

Multi-channel signal generators, where all signals are originating from a single instrument, inherently generate the signals in a time-aligned manner.

3.2.6 Number of Physical RF Connectors at a multi-channel DUT

For conducted tests, each RF connector of a multi-channel DUT needs to be fed with a test signal. Depending on the tests either a switch matrix (for sequential testing) is needed or a signal generator with separate RF outputs (for simultaneous stimulation) is required to mate 1:1 with the input connectors of the DUT. The latter is e.g. required for diversity, MIMO or beam forming tests where multiple antennas are in use simultaneously. This requirement has an impact on the number of separate RF paths that are to be available with the selected signal generation solution.

Test Scenario Parameter	Impact on signal generation solution
Number of physical RF connectors/antennas at the DUT	Generally, a separate RF output is needed for each physical connector at the DUT.

3.2.7 Phase Coherence

Applications like beam forming, beam steering, direction finding or differential RF all require a defined phase between the generated RF signals. Multiple signal generators generally need a common LO that is used for all RF paths to achieve phase stable conditions. The capability to offer LO distribution/coupling functionality is an important criterion when selecting a signal generator for these kinds of applications.

Test Scenario Parameter	Impact on signal generation solution
Accuracy of the relative phase between carriers/signals/antennas	LO and/or reference frequency distribution might be needed for all RF paths in order to meet the desired phase accuracy. Time alignment of all baseband signals is a mandatory pre-requisite for phase-coherent modulated signals.

4 SMW Features

The SMW is a powerful and flexible multi-channel signal generator which can be tailored to the application at hand.

The following chapters give an overview of the configuration possibilities of the SMW with focus on multi-channel applications.

For full detail regarding the instrument configuration please refer to the online configurator which can be found on the instrument web page at:

http://www.rohde-schwarz.com/en/product/smw200a

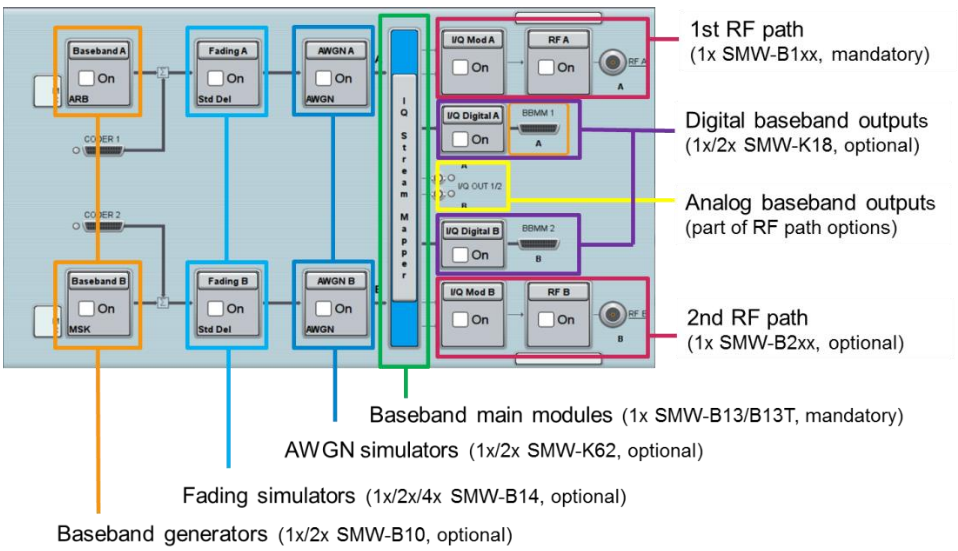
Configure your product

For binding instrument data please refer to the “R&S SMW200A Vector Signal Generator – Data Sheet”, which can also be downloaded from the instrument web page.

For a detailed description of all instrument functions, please refer to the instrument manuals, which are also available from the instrument web page.

4.1 SMW Introduction

The SMW vector signal generator can be flexibly configured – from a single channel RF generator up to a multi-channel signal generator with MIMO fading. The instrument features a graphical user interface with a block diagram as central control element. Depending on the installed hardware and software options the functional blocks of the block diagram change. The general signal flow is from left to right. The following picture shows the block diagram of an SMW that is configured as dual baseband and dual RF vector signal generator.



The main functional blocks are:

Baseband generators (SMW-B10)

This is the hardware providing one or multiple baseband sources. Up to two baseband generator hardware modules can be installed. By means of these baseband generators, digitally modulated physical layer signals can be created. Options for various cellular and wireless communication standards are available and allow standard compliant testing. Additionally, the baseband generators can play back arbitrary waveform files. The waveform files may originate from Rohde & Schwarz waveform tools like WinIQSIM2, Pulse Sequencer Software, ARB Toolbox Plus or from third-party tools such as Matlab. The number of available baseband sources depends on the installed options and is described in chapter 3.2. Also ARB memory depth and baseband bandwidth can be configured flexibly via additional options.

Fading simulators (SMW-B14)

These are the hardware modules for real-time channel emulation. Depending on the installed options SISO fading, MIMO channel simulation (with or without correlation) and standard compliant fading scenarios for all important cellular and wireless communication standards are supported. Up to 4 fading hardware modules can be installed. Together with additional software licenses the functionality can be scaled up to 8x SISO fading, up to 4x8 or 8x4 MIMO or even to support multi-cell/multi-carrier scenarios with e.g. 4x 2x2 MIMO. Details are explained in chapter 4.4. Fading simulators are optional.

AWGN simulators (SMW-K62)

Optionally, the SMW can be equipped with AWGN generation capabilities for receiver noise simulation as it is e.g. required for receiver dynamic range tests. Independent and uncorrelated AWGN simulation is available for up to 8 baseband signal streams.

Baseband main module (SMW-B13/B13T)

The baseband main module provides signal routing capabilities. Furthermore, it supplies the hardware for the digital baseband outputs. Via the IQ stream mapper the baseband signal streams are assigned to the various signal generator outputs (RF, analog baseband or digital baseband). There are two variants of the baseband main module – a single channel version (SMW-B13) as well as a multi-channel version (SMW-B13T). A baseband main module is mandatory.

RF (SMW-B1xx/B2xx)

The RF options supply essential signal generator hardware like the RF synthesizer, the IQ modulator (with analog IQ inputs) the RF attenuator or the Automatic Level Control (ALC) circuits. Further functions such as analog modulations or RF phase coherence and LO distribution can be added via additional options. One RF path SMW-B1xx is mandatory.

Analog baseband outputs

The analog baseband I/Q outputs are part of the baseband main module. With SMW-B13, one analog I/Q output is available. With SMW-B13T two analog I/Q outputs are available.

Digital baseband outputs (SMW-K18)

In total there can be 6 digital baseband outputs per instrument. Up to two outputs are part of the baseband main module hardware (one for SMW-B13, two for SMW-B13T) and additional four are part of the fading simulator hardware (one per fading simulator module). The digital baseband outputs are enabled by software license SMW-K18 (1x or 2x). One SMW-K18 plus SMW-B13/-B13T enables one digital baseband output, for multiple digital IQ outputs two SMW-K18 options plus SMW-B13T are required. The number of used digital baseband outputs depends on the general system configuration which determines the number of input and output channels of the SMW.

For multi-channel signal generation there are important enhancement options:

MIMO Fading/Routing (SMW-K74)

This software license enhances the fading section of the SMW to enable MIMO fading. With two installed fading modules SMW-B14, it allows up to 2x2 MIMO fading including settable correlations between all four fading channels (2 direct paths, 2 cross-paths) and summing of the signals. With four installed fading modules, MIMO fading up to 2x8, 8x2 or 4x4 is supported including settable correlations, emulation of direct paths and cross-paths as well as summing of the signals. In total up to 16 fading channels (incl. cross-paths) can be emulated[2]. The option SMW-K74 can be installed once and requires two or four faders SMW-B14 as prerequisite.

Higher-Order MIMO (SMW-K75)

This software license extents the SMW-K74 option by enabling additional higher order MIMO fading modes. With four installed fading modules, MIMO fading up to 4x8 and 8x4 is supported including settable correlations, emulation of direct paths and cross-paths as well as summing of the signals. In total up to 32 fading channels (incl. cross-paths) can be emulated[2]. The option SMW-K75 can be installed once and requires four faders SMW-B14 and the SMW-K74 option as prerequisite.

Multiple Entities (SMW-K76)

In non-MIMO configurations (2xSMW-B10 installed) the SMW has up to two baseband sources: baseband A and baseband B. By means of the Multiple Entities software option SMW-K76 the maximum number of available baseband sources is increased from two to a maximum of eight. The SMW-K76 can be installed once and requires SMW-B13T and 2x SMW-B10.

Together with additional four fading modules SMW-B14, each of these up to eight baseband signals can individually be SISO faded. SISO fading means that each channel is configured and faded separately; there is no crosstalk between the fading channels.

Together with four fading modules SMW-B14 plus SMW-K74 MIMO fading/routing option multiple separate MIMO systems can be simulated. The number of MIMO systems depends on the order of the MIMO systems that are emulated. In total up to 32 fading channels (incl. cross-paths) can be emulated[2]. This allows e.g. simulation of 4 LTE-A carriers with 2x2 MIMO (4x 2x2) or 2 cells with 4x2 MIMO each (2x 4x2).

[2] 2x2 = 4 fading channels, 3x3 = 9 fading channels, 4x2 = 8 fading channels, 4x4 = 16 fading channels, 8x2 = 16 fading channels, 2x8 = 16 fading channels, 8x4 = 32 fading channels, 4x8 = 32 fading channels

Stream Extender (SMW-K550)

This software license enables the SMW to duplicate generated baseband signals (streams) for SISO configurations with 3 or 4 entities.
The duplicated baseband streams have identical content but can be separately shifted in frequency in the I/Q stream mapper. The option SMW-K550 can be installed once and requires SMW-B13T, 2x SMW-B10 and the SMW-K76 option as prerequisite.

MIMO Subsets for Higher Order MIMO Scenarios (SMW-K821)

This software license extents the SMW-K75 option by enabling 8x8 MIMO channel emulation with two SMWs. Each SMW emulates a subset of 32 fading channels. In total, 64 fading channels are emulated in realtime. The option SMW-K821 can be installed once per instrument and requires four faders SMW-B14, the SMW-K74 option and the SMW-K75 as prerequisite.

In the following chapters the multiple entities functionality as well as the fading capabilities (for SISO as well as MIMO) are described in more detail.

4.2 Multiple Entities Functionality

The SMW allows simultaneous playback of up to eight different signals from its baseband section. These signals can be generated individually/independently or in a coupled way (e.g. for MIMO applications).

Each individual signal or each group of coupled signals is referred to as a “baseband entity” or “entity”.

The minimum configuration to enable a certain number of entities can be found in the following table.

Entities	Max. BW	Required instrument options		Supported signal type
1	160 MHz	1x SMW-B10 1x SMW-B13	*Baseband generator* *Baseband main module, 1path*	“any”
2	160 MHz	2x SMW-B10 1x SMW-B13T	*Baseband generator* *Baseband main module, 2path*	“any”
3-4	160 MHz	2x SMW-B10 1x SMW-B13T 1x SMW-K76	*Baseband generator* *Baseband main module, 2path* *Multiple Entities*	“any”
5-8	80 MHz	2x SMW-B10 1x SMW-B13T 1x SMW-K76	*Baseband generator* *Baseband main module, 2path* *Multiple Entities*	“coupled entities” only

Notes:

- the full bandwidth of 160 MHz is only available with option SMW-K522
- “any” = all available digital standards and systems as listed in the SMW200A data sheet

- "coupled entities" = currently supported by LTE, WLAN, ARB [3]
- Each digital standard or system requires a software license. If a digital standard or system is used more than once at the same time, a second software license is required. More than 2 licenses are not required.
- Waveform files for the SMW ARB are generated via WinIQSIM2 options, via one of the Pulse Sequencer software options, via the "generate waveform" feature of the SMW internal digital standard options or via third-party tools (e.g. MATLAB®).

Optionally, each baseband signal can individually be SISO faded. At a minimum the following number of fading modules needs to be installed.

Number of entities	**Max. BW**	**Required instrument options**
1	160 MHz	1x SMW-B14 *Fading simulator*
2	160 MHz	2x SMW-B14 *Fading simulator*
3-4	160 MHz	4x SMW-B14 *Fading simulator*
5-8	80 MHz	4x SMW-B14 *Fading simulator*

Optionally, individual AWGN can be added to each baseband signal. At a minimum the following options need to be installed.

Number of entities	**Max. BW**	**Required instrument options**
1	160 MHz	1x SMW-B13 *Baseband main module, 1 path* 1x SMW-K62 *AWGN*
2	160 MHz	1x SMW-B13T *Baseband main module, 2 path* 2x SMW-K62 *AWGN*
3-4	160 MHz	1x SMW-B13T *Baseband main module, 2 path* 2x SMW-K62 *AWGN simulator*
5-8	80 MHz	1x SMW-B13 *Baseband main module, 2 path* 2x SMW-K62 *AWGN*

The SMW features up to two RF outputs, up to six digital baseband IQ outputs and up to two analog baseband IQ outputs. The eight baseband signals can be flexibly routed via the SMW internal "IQ stream mapper" to one of these outputs. If desired, the signals can be added up in real-time with individual frequency, level and phase offsets.

By that it is very easy to generate multi-carrier signals for interference simulation or multi-standard radio tests. Furthermore, changing a single parameter of one baseband signal is possible independently from the parameters of the other signals. Time-consuming recalculation of a big multi-signal/multi-carrier waveform is avoided.

[3] for updated information about supported systems and standards see SMW200A data sheet

4.3 Stream Extender Functionality

For SISO configurations with 3 or 4 entities (i.e. 3x1x1 or 4x1x1), the SMW offers the stream extender feature. By enabling this feature, the SMW duplicates the signal of each baseband. At maximum four real-time basebands signals can be duplicated to yield eight baseband streams. All streams arrive at the IQ stream mapper and can freely be added and routed to the outputs. An individual frequency offset can also be applied to each stream.

Stream duplication via SMW-K550 is available even without fader hardware SMW-B14.

Entities	**Max. BW**	**Required instrument options**	**Supported signal type**
3-4	80 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module, 2path* 1x SMW-K76 *Multiple Entities* 1x SMW-K550 *Stream Extender*	“any”

Note: “any” = all available digital standards and systems as listed in the SMW200A data sheet

Baseband signal generation, duplication and signal routing – all in real-time – allows for very long signal sequences and eliminates the need of creating multi-carrier ARB waveforms.

4.4 MIMO Fading Capabilities

The SMW can be configured as versatile and powerful MIMO fading simulator. Depending on the installed options the SMW supports different orders of MIMO systems. The following table lists the minimum number of required options for different MIMO configurations. Additional frequency options (mandatory) as well as baseband options (optional) need to be added depending on the application that shall be covered.

Number of entities	**MIMO system per entity**	**Max. BW**	**Required instrument options**
1	1x2 2x1 2x2	160 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 2x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing*
1	1x3 1x4 2x3 2x4 3x1 3x2 4x1 4x2	160 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing*
1	1x8 2x8 3x1	80 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator*

	3x3 3x4 4x3 4x4 8x1 8x2		1x SMW-K74 *MIMO fading/routing*
1	4x8 8x4	40 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing* 1x SMW-K75 *Higher-order MIMO*
1	8x8	40 MHz	Two SMWs, each with 2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing* 1x SMW-K75 *Higher-order MIMO* 1x SMW-K821 *MIMO Subsets*
2	1x2	160 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 2x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing*
2	2x1 2x2	160 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing*
2	1x3 1x4 2x3 2x4 3x1 3x2 4x1 4x2	80 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing* 1x SMW-K75 *Higher-order MIMO*
2	3x3 3x4 4x3 4x4	40 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing* 1x SMW-K75 *Higher-order MIMO*
3	1x2 2x1 2x2	80 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing* 1x SMW-K76 *Multiple Entities*
4	1x2 2x1 2x2	80 MHz	2x SMW-B10 *Baseband generator* 1x SMW-B13T *Baseband main module* 4x SMW-B14 *Fading simulator* 1x SMW-K74 *MIMO fading/routing* 1x SMW-K76 *Multiple Entities*

4.5 RF Extensions

The SMW features up to two internal RF paths. Via up to two analog baseband outputs and up to six digital baseband outputs, the SMW can be supplemented by additional RF sources.

Together with additional digitally connected SGT vector RF sources, the SMW is turned into a versatile eight channel vector signal generator for frequencies up to 6 GHz. Together with two analog SGS RF sources applications up to 12.75 GHz are covered. Together with two SGS RF sources with attached SGU up-converters applications in the microwave range up to 40 GHz are supported. In all cases the RF extension units can be controlled by the SMW, so that the multi-instrument setup behaves like a single T&M instrument.

The following table lists the recommended configuration of the RF section for setups <u>where all RF paths have the same maximum frequency</u>. Options for the baseband section of the SMW are only included in the list if mandatory for connecting external RF extension units. Depending on the desired baseband functionality, further baseband options (baseband generators, fading simulator modules, AWGN, digital standards, etc.) are to be added to the SMW configuration.

RF paths	Max. frequency	Required instrument options		
1	3 GHz	1x SMW200A	*Vector signal generator, base unit*	
		1x SMW-B13	*Baseband main module, 1 path*	
		1x SMW-B103	*Frequency 3 GHz,1^{st} path*	
	6 GHz	1x SMW200A	*Vector signal generator, base unit*	
		1x SMW-B13	*Baseband main module, 1 path*	
		1x SMW-B106	*Frequency 6 GHz,1^{st} path*	
	12.75 GHz	1x SMW200A	*Vector signal generator, base unit*	
		1x SMW-B13	*Baseband main module, 1 path*	
		1x SMW-B112	*Frequency 12.75 GHz,1^{st} path*	
	20 GHz	1x SMW200A	*Vector signal generator, base unit*	
		1x SMW-B13	*Baseband main module, 1 path*	
		1x SMW-B120	*Frequency 20 GHz,1^{st} path*	
	40 GHz	1x SMW200A	*Vector signal generator, base unit*	
		1x SMW-B13	*Baseband main module, 1 path*	
		1x SMW-B140	*Frequency 40 GHz,1^{st} path*	
2	3 GHz	1x SMW200A	*Vector signal generator, base unit*	
		1x SMW-B13T	*Baseband main module, 2 path*	
		1x SMW-B103	*Frequency 3 GHz,1^{st} path*	
		1x SMW-B203	*Frequency 3 GHz,2^{nd} path*	
	6 GHz	1x SMW200A	*Vector signal generator, base unit*	
		1x SMW-B13T	*Baseband main module, 2 path*	
		1x SMW-B106	*Frequency 6 GHz,1^{st} path*	
		1x SMW-B206	*Frequency 6 GHz,2^{nd} path*	
	12.75 GHz	1x SMW200A	*Vector signal generator, base unit*	MAIN UNIT
		1x SMW-B13T	*Baseband main module, 2 path*	
		1x SMW-B112	*Frequency 12.75 GHz,1^{st} path*	
		1x SGS100A	*RF Source, Base unit*	EXTENSION UNIT
		1x SGS-B106V	*Frequency 6 GHz*	
		1x SGS-B112V	*Frequency extension 12.75 GHz*	
		1x SGS-B26	*Step attenuator*	

RF paths	Max. frequency	Required instrument options	
2	20 GHz	1x SMW200A *Vector signal generator, base unit* 1x SMW-B13T *Baseband main module, 2 path* 1x SMW-B120 *Frequency 20 GHz,1st path* 1x SMW-B220 *Frequency 20 GHz,2nd path*	
	40 GHz	1x SMW200A *Vector signal generator, base unit* 1x SMW-B13T *Baseband main module, 2 path* 1x SMW-B140 *Frequency 40 GHz,1st path*	MAIN UNIT
		1x SGS100A *RF Source, Base unit* 1x SGS-B106V *Frequency 6 GHz* 1x SGS-B112V *Frequency extension 12.75 GHz* 1x SGU100A *RF Up-converter, Base unit* 1x SGU-B120V *Frequency 20 GHz* 1x SGU-B140V *Frequency extension 40 GHz* 1x SGU-B26 *Step attenuator* 1x SGU-Z4 *Connection Kit SGU to SGS*	EXTENSION UNITS
3	3 GHz	1x SMW200A *Vector signal generator, base unit* 1x SMW-B13T *Baseband main module, 2 path* 1x SMW-B103 *Frequency 3 GHz,1st path* 1x SMW-B203 *Frequency 3 GHz,2nd path* 1x SMW-K18 *Digital baseband output*	MAIN UNIT
		1x SGT100A *RF Source 3 GHz, Base unit* 1x SGT-K18 *Digital baseband connectivity* 1x SMU-Z6 *R&S Digital IQ interface cable*	EXTENSION UNITS
	6 GHz	1x SMW200A *Vector signal generator, base unit* 1x SMW-B13T *Baseband main module, 2 path* 1x SMW-B106 *Frequency 6 GHz,1st path* 1x SMW-B206 *Frequency 6 GHz,2nd path* 1x SMW-K18 *Digital baseband output*	MAIN UNIT
		1x SGT100A *RF Source 3 GHz, Base unit* 1x SGT-KB106 *Frequency extension 6 GHz* 1x SGT-K18 *Digital baseband connectivity* 1x SMU-Z6 *R&S Digital IQ interface cable*	EXTENSION UNITS
	12.75 GHz	1x SMW200A *Vector signal generator, base unit* 1x SMW-B13T *Baseband main module, 2 path* 1x SMW-B112 *Frequency 12.75 GHz,1st path*	MAIN UNIT
		2x SGS100A *RF Source, Base unit* 2x SGS-B106V *Frequency 6 GHz* 2x SGS-B112V *Frequency extension 12.75 GHz* 2x SGS-B26 *Step attenuator*	EXTENSION UNITS
	20 GHz	1x SMW200A *Vector signal generator, base unit* 1x SMW-B13T *Baseband main module, 2 path* 1x SMW-B120 *Frequency 20 GHz,1st path* 1x SMW-B220 *Frequency 20 GHz,2nd path*	MAIN UNIT
		1x SGS100A *RF Source, Base unit* 1x SGS-B106V *Frequency 6 GHz* 1x SGS-B112V *Frequency extension 12.75 GHz*	EXTENSION UNITS
		1x SGU100A *RF Up-converter, Base unit* 1x SGU-B120V *Frequency 20 GHz* 1x SGU-B26 *Step attenuator* 1x SGU-Z4 *Connection Kit SGU to SGS*	

RF paths	Max. frequency	Required instrument options		
3	40 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B140	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 40 GHz,1^{st} path*	MAIN UNIT
		2x SGS100A 2x SGS-B106V 2x SGS-B112V	*RF Source, Base unit* *Frequency 6 GHz* *Frequency extension 12.75 GHz*	EXTENSION UNITS
		2x SGU100A 2x SGU-B120V 2x SGU-B140V 2x SGU-B26 2x SGU-Z4	*RF Up-converter, Base unit* *Frequency 20 GHz* *Frequency extension 40 GHz* *Step attenuator* *Connection Kit SGU to SGS*	
4	3 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B103 1x SMW-B203 2x SMW-K18	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 3 GHz,1^{st} path* *Frequency 3 GHz,2^{nd} path* *Digital baseband output*	MAIN UNIT
		2x SGT100A 2x SGT-K18 2x SMU-Z6	*RF Source 3 GHz, Base unit* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS
	6 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B106 1x SMW-B206 2x SMW-K18	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 6 GHz,1^{st} path* *Frequency 6 GHz,2^{nd} path* *Digital baseband output*	MAIN UNIT
		2x SGT100A 2x SGT-KB106 2x SGT-K18 2x SMU-Z6	*RF Source 3 GHz, Base unit* *Frequency extension 6 GHz* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS
	20 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B120 1x SMW-B220	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 20 GHz,1^{st} path* *Frequency 20 GHz,2^{nd} path*	MAIN UNIT
		2x SGS100A 2x SGS-B106V 2x SGS-B112V	*RF Source, Base unit* *Frequency 6 GHz* *Frequency extension 12.75 GHz*	EXTENSION UNITS
		2x SGU100A 2x SGU-B120V 2x SGU-B26 2x SGU-Z4	*RF Up-converter, Base unit* *Frequency 20 GHz* *Step attenuator* *Connection Kit SGU to SGS*	
5	3 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B103 1x SMW-B203 2x SMW-K18 2x SMW-B10 4x SMW-B14	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 3 GHz,1^{st} path* *Frequency 3 GHz,2^{nd} path* *Digital baseband output* *Baseband Generator* *Fading modules*	MAIN UNIT
		1x SMW-K74 *or* 1x SMW-K76	*MIMO/Routing* *Multiple Entities*	
		3x SGT100A 3x SGT-K18 3x SMU-Z6	*RF Source 3 GHz, Base unit* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS

RF paths	Max. frequency	Required instrument options		
5	6 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B106 1x SMW-B206 2x SMW-K18 2x SMW-B10 4x SMW-B14	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 6 GHz,1st path* *Frequency 6 GHz,2nd path* *Digital baseband output* *Baseband Generator* *Fading modules*	MAIN UNIT
		1x SMW-K74 *or* 1x SMW-K76	*MIMO/Routing* *Multiple Entities*	
		3x SGT100A 3x SGT-KB106 3x SGT-K18 3x SMU-Z6	*RF Source 3 GHz, Base unit* *Frequency extension 6 GHz* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS
6	3 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B103 1x SMW-B203 2x SMW-K18 2x SMW-B10 4x SMW-B14	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 3 GHz,1st path* *Frequency 3 GHz,2nd path* *Digital baseband output* *Baseband Generator* *Fading modules*	MAIN UNIT
		1x SMW-K74 *or* 1x SMW-K76	*MIMO/Routing* *Multiple Entities*	
		4x SGT100A 4x SGT-K18 4x SMU-Z6	*RF Source 3 GHz, Base unit* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS
	6 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B106 1x SMW-B206 2x SMW-K18 2x SMW-B10 4x SMW-B14	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 6 GHz,1st path* *Frequency 6 GHz,2nd path* *Digital baseband output* *Baseband Generator* *Fading modules*	MAIN UNIT
		1x SMW-K74 *or* 1x SMW-K76	*MIMO/Routing* *Multiple Entities*	
		4x SGT100A 4x SGT-KB106 4x SGT-K18 4x SMU-Z6	*RF Source 3 GHz, Base unit* *Frequency extension 6 GHz* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS

RF paths	Max. frequency	Required instrument options		
7	3 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B103 1x SMW-B203 2x SMW-K18 2x SMW-B10 4x SMW-B14	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 3 GHz,1st path* *Frequency 3 GHz,2nd path* *Digital baseband output* *Baseband Generator* *Fading modules*	MAIN UNIT
		1x SMW-K74 *or* 1x SMW-K76	*MIMO/Routing* *Multiple Entities*	
		5x SGT100A 5x SGT-K18 5x SMU-Z6	*RF Source 3 GHz, Base unit* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS
7	6 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B106 1x SMW-B206 2x SMW-K18 2x SMW-B10 4x SMW-B14	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 6 GHz,1st path* *Frequency 6 GHz,2nd path* *Digital baseband output* *Baseband Generator* *Fading modules*	MAIN UNIT
		1x SMW-K74 *or* 1x SMW-K76	*MIMO/Routing* *Multiple Entities*	
		5x SGT100A 5x SGT-KB106 5x SGT-K18 5x SMU-Z6	*RF Source 3 GHz, Base unit* *Frequency extension 6 GHz* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS
8	3 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B103 1x SMW-B203 2x SMW-K18 2x SMW-B10 4x SMW-B14	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 3 GHz,1st path* *Frequency 3 GHz,2nd path* *Digital baseband output* *Baseband Generator* *Fading modules*	MAIN UNIT
		1x SMW-K74 *or* 1x SMW-K76	*MIMO/Routing* *Multiple Entities*	
		6x SGT100A 6x SGT-K18 6x SMU-Z6	*RF Source 3 GHz, Base unit* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS

RF paths	Max. frequency	Required instrument options		
	6 GHz	1x SMW200A 1x SMW-B13T 1x SMW-B106 1x SMW-B206 2x SMW-K18 2x SMW-B10 4x SMW-B14	*Vector signal generator, base unit* *Baseband main module, 2 path* *Frequency 6 GHz,1st path* *Frequency 6 GHz,2nd path* *Digital baseband output* *Baseband Generator* *Fading modules*	MAIN UNIT
		1x SMW-K74 *or* 1x SMW-K76	*MIMO/Routing* *Multiple Entities*	
		6x SGT100A 6x SGT-KB106 6x SGT-K18 6x SMU-Z6	*RF Source 3 GHz, Base unit* *Frequency extension 6 GHz* *Digital baseband connectivity* *R&S Digital IQ interface cable*	EXTENSION UNITS

Note:

- The SMW with 1 or 2 SMW-K18 options enables 1 or 2 digital baseband outputs for connection of up to 2 SGT RF sources. 4x SMW-B14, 2x SMW-K18, 2x SMW-B10 as well as either SMW-K74 or SMW-K76 are mandatory to enable connection of up to six SGT.
- For physical connection of each SGT to SMW, one R&S Digital IQ interface cable SMU-Z6 is required.

5 Multi-Carrier Applications without MIMO

5.1 General Coexistence/Multi-RAT/Interference Tests

5.1.1 Application Description

Modern devices (e.g. mobile phones, laptops, tablets) support a multitude of different RF signals. E.g.:

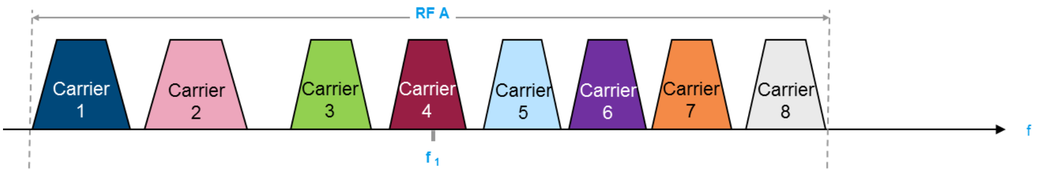
- Cellular Standards
  (e.g. GSM, EDGE, WCDMA, HSPA+, LTE, LTE-A, CDMA200A, 1xEVDO,…)
- Wireless Standards
  (e.g. 802.11a/b/g/n, 802.11ac,…)
- Multimedia / Broadcast
  (DVB-T/H, T-DMB, …)
- Short-range communication
  (e.g. Bluetooth, NFC, EMVCo, ZigBee,…)

By means of interference and co-existence tests the robustness of a device under test (=DUT) is evaluated when multiple of these signals are present at the same time. This can mean to generate interfering signals at the same carrier frequency as the wanted signal as well as simulation of adjacent channel signals.

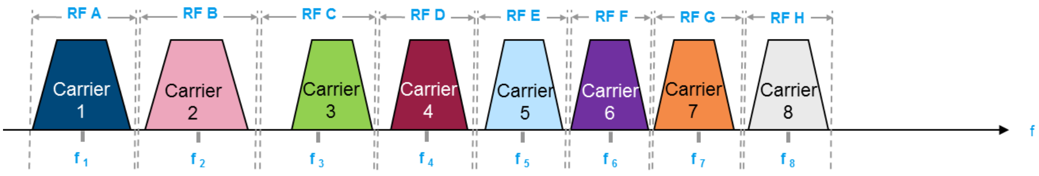
The SMW can generate a multitude of different signals with or without frequency/level offsets from a single instrument. With the SMW-K76 Multiple Entities option up to 8 baseband sources are available which can individually be loaded with single-carrier or multi-carrier waveforms. This offers the required flexibility for even complex interference scenarios and predestinates the SMW for these kinds of tests.

In the following it is distinguished between setups with and without fading simulation as well as in-band (up to four carriers within 160 MHz BW or up to eight carriers within 80 MHz BW) and multi-band applications (multiple carriers with spacing > 160 MHz). In "pure" in-band scenarios all carriers are within one band whereas in "pure" multi-band scenarios all carriers are assumed to be in their own frequency band and are generated via separate signal generation paths.

"Pure" in-band – all carriers in one band:

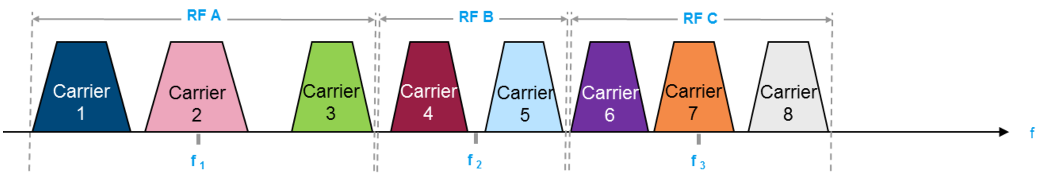


"Pure" multi-band – all carriers in their own band:



"Realistic" multi-band – multiple carriers per band:

In praxis, a real multi-band scenario is generally a mixture of the two described extremes – all carriers of similar amplitude that fit into the baseband bandwidth of a single baseband will be combined into one RF (see also chapters 3.2.3 and 3.2.3). This reduces the number of required RF paths.

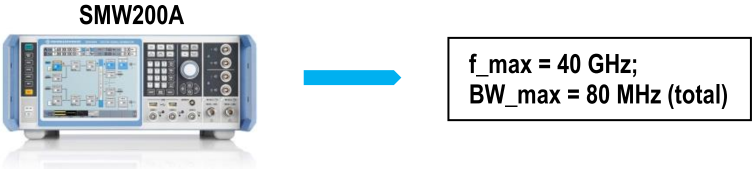


For simplicity, the examples in the following sections present always the "pure" in-band and multi-band scenarios.

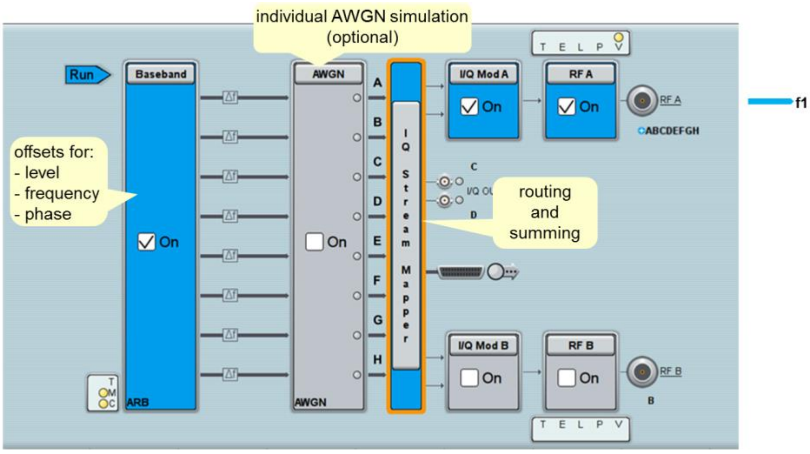
5.1.2 In-band w/o fading

This example explains the needed configuration for a setup with 8 signals. All signals are generated within 80 MHz total bandwidth.

5.1.2.1 Instrument setup



5.1.2.2 SMW System Configuration



System configuration settings:	8 x 1 x 1 coupled sources
IQ stream mapper:	all streams summed into RF A

5.1.2.3 Recommended instruments and options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106/-B112/-B120/-B131/-B140	*Frequency option for 1st path, 3, 6, 12.75, 20, 31.8 or 40 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
optional add-on options:		
2x	SMW-K62	*AWGN*
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1 GS*
	SMW-Kxx	*Internal digital standards options or WinIQSIM2 options for waveform generation*

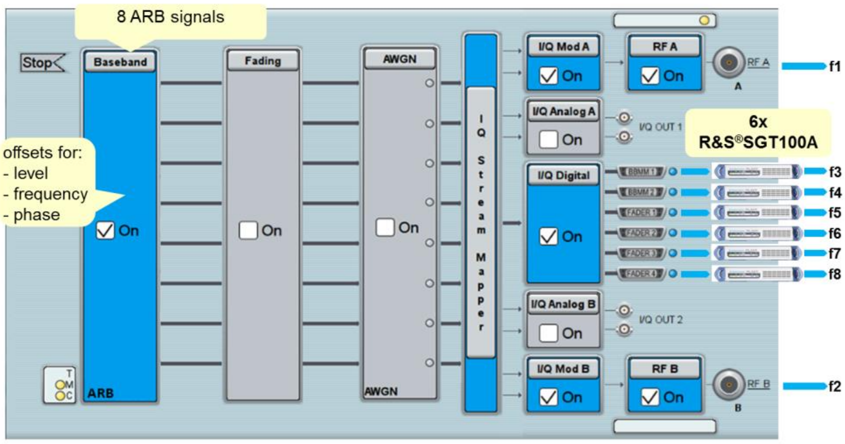
5.1.3 Multi-band w/o fading

This example explains the needed configuration for a setup with 8 different signals. All signals are generated at freely definable RF frequency (up to 6 GHz). Each signal can occupy 80 MHz bandwidth.

5.1.3.1 Instrument setup

All 10 MHz references should be connected.
An additional RF coupler is needed for combination of the RF signals into the Rx antenna of the DUT.

5.1.3.2 SMW System Configuration



System configuration settings: 8 x 1 x 1 coupled sources
IQ stream mapper: all streams routed to separate outputs

5.1.3.3 Recommended instruments and options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
2x	SMW-K18	*Digital baseband output*

optional add-on options:		
2x	SMW-K62	*AWGN*
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*
	SMW-Kxx	*Internal digital standards options or WinIQSIM2 options for waveform generation*

SGT		
mandatory options:		
6x	SGT100A	*Base unit, 3 GHz*
6x	SGT-K18	*Digital baseband connectivity*
optional add-on options:		
6x	SGT-KB106	*Upgrade to 6 GHz*

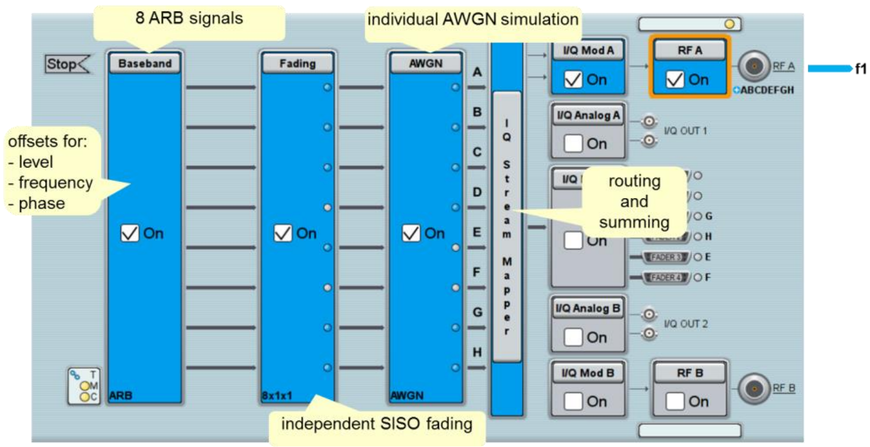
Accessories		
mandatory		
1x	8-to-1 RF combiner	*for RF signal combination*
6x	SMU-Z6	*R&S Digital IQ interface cable*

5.1.4 In-band w/ fading

This example explains the needed configuration for a setup with 8 signals. All signals are generated within 80 MHz total bandwidth. Each signal component is faded individually.

5.1.4.1 Instrument setup

5.1.4.2 SMW System Configuration



System configuration settings: 8 x 1 x 1 coupled sources
IQ stream mapper: all streams summed into RF A

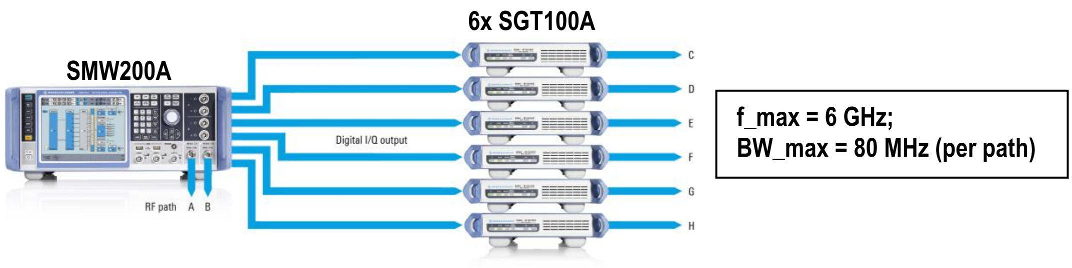
5.1.4.3 Recommended instruments and options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106/-B112/-B120/-B131/-B140	*Frequency option for 1st path, 3, 6, 12.75, 20, 31.8 or 40 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1 GS*
2x	SMW-K71	*Dynamic fading*
2x	SMW-K72	*Enhanced fading models*
	SMW-Kxx	Internal digital standards options or WinIQSIM2 options for waveform generation

5.1.5 Multi-band w/ fading

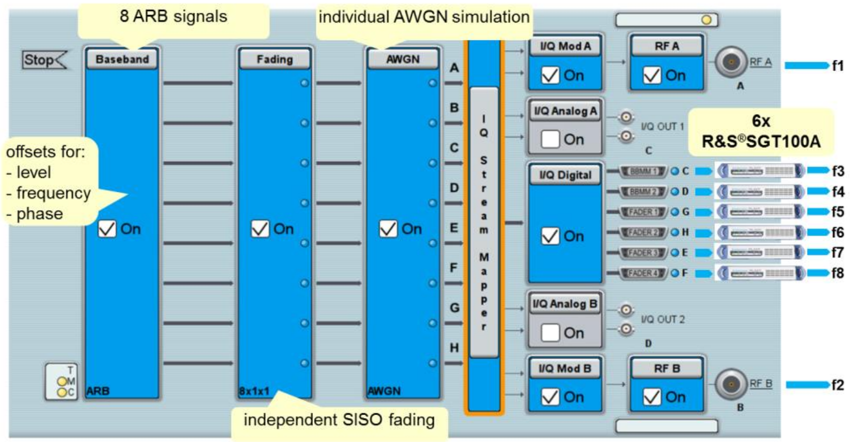
This example explains the needed configuration for a setup with 8 different signals. All signals are generated at freely definable RF frequency (up to 6 GHz). Each signal can occupy 80 MHz bandwidth. Each signal is faded individually.

5.1.5.1 Instrument setup



All 10 MHz references should be connected.
An additional RF coupler is needed for combination of the RF signals into the Rx antenna of the DUT.

5.1.5.2 SMW System Configuration



System configuration settings: 8 x 1 x 1 coupled sources
IQ stream mapper: all streams routed to separate outputs

5.1.5.3 Recommended instruments and options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
2x	SMW-K18	*Digital baseband output*
optional add-on options:		
2x	SMW-K62	*AWGN*
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1 GS*
2x	SMW-K71	*Dynamic fading*
2x	SMW-K72	*Enhanced fading models*
	SMW-Kxx	*Internal digital standards options or WinIQSIM2 options for waveform generation*

SGT		
mandatory options:		
6x	SGT100A	*Base unit, 3 GHz*
6x	SGT-K18	*Digital baseband connectivity*
optional add-on options:		
6x	SGT-KB106	*Upgrade to 6 GHz*

Accessories		
mandatory		
1x	8-to-1 RF combiner	*for RF signal combination*
6x	SMU-Z6	*R&S Digital IQ interface cable*

5.2 Multi-Standard Radio (MSR)

5.2.1 Application Description

Multi-Standard Radio (MSR) testing can be considered as a special case of the general coexistence/multi-RAT/interference test setup which is described in chapter 3.1.

3GPP has published a Multi-Standard-Radio test specification for base station testing:

3GPP TS 37.141 **E-UTRA, UTRA and GSM/EDGE;**
Multi-Standard Radio (MSR) Base Station (BS) conformance testing

This specification defines test cases for base stations which support multiple carriers of one radio access technology (single-RAT) and for base stations which support multiple carriers with different radio access technologies (multi-RAT) at the same time. There are different base station capability sets (CS) defined. Depending on this capability set one or a combination of various configurations is supported:

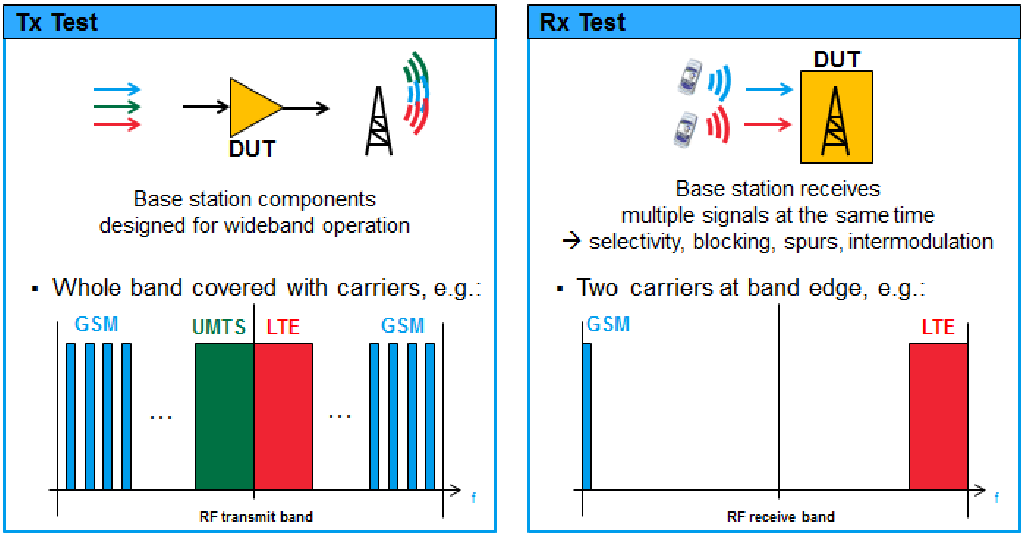
- UTRA Multi-carrier operation (single-RAT)
- E-UTRA Multi-carrier operation (single-RAT)
- UTRA + E-UTRA operation (multi-RAT)
- GSM + UTRA operation (multi-RAT)
- GSM + E-UTRA operation (multi-RAT)
- GSM + UTRA + E-UTRA operation (multi-RAT)

UTRA = WCDMA (FDD, TDD), TD-SCDMA (TDD)
E-UTRA = LTE (FDD, TDD)

A detailed description of the test scenarios can be found in R&S application note:

1MA198: Measuring Multistandard Radio Base Stations
www.rohde-schwarz.com/appnote/1MA198

Both Tx and Rx base station tests are defined in TS 37.141.

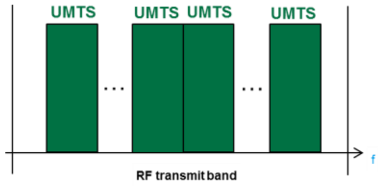


MSR Rx tests require a test signal which consists of maximum two carriers. The carriers can be of same or different radio access technology (RAT) and are typically placed at the band edges. A signal generator is used to generate these test signals to stimulate the receiver.

MSR Tx tests use more complicated signal scenarios which consist of multiple carriers. These multi-carrier signals are typically generated by the DUT and the Tx measurements are performed with a spectrum and signal analyzer. A signal generator is not needed in this case. However, for component tests (filters, PAs, etc.) a signal generator is required which needs to be able to generate also these more complicated scenarios. Generally for the Tx tests the whole band is occupied with a combination of carriers. Typical Tx test configurations (TC) are:

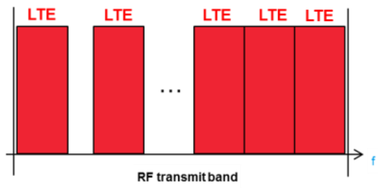
TC1a/TC1b
UMTS Multicarrier operation

Starting from two carriers in the middle of the band the whole band is filled with adjacent carriers
1a = FDD, 1b = TDD



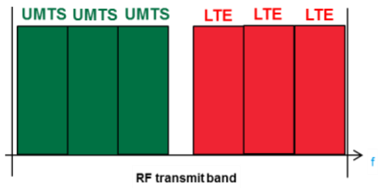
TC2
LTE Multicarrier operation

Starting from two 5 MHz LTE carriers at the upper/lower band edge, the complete band is filled with LTE carriers starting at the upper edge



TC3a/TC3b
UMTS, LTE,
multi-RAT operation

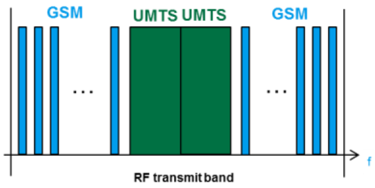
Starting from 5 MHz UMTS at the lower band edge and 5 MHz LTE at the upper band edge the complete band is filled with UMTS carriers from the low end and LTE carriers from the upper end.
3a = FDD, 3b = TDD



TC4a

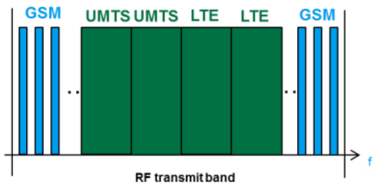
UMTS, GSM
multi-RAT operation

GSM carrier at the upper and lower band edge;
Two UMTS carriers in the middle;
Fill spectrum with GSM carriers at 600 kHz spacing till bandwidth is filled or till max number of supported GSM carriers is reached;



or

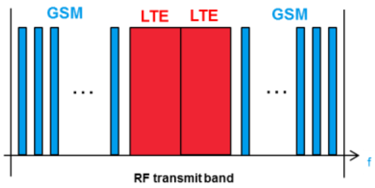
If possible add additional UMTS carriers in the middle



TC4b

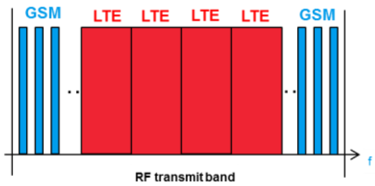
UMTS, LTE
multi-RAT operation

GSM carrier at the upper and lower band edge;
Two LTE carriers in the middle;
Fill spectrum with GSM carriers at 600 kHz spacing till bandwidth is filled or till max number of supported GSM carriers is reached;



or

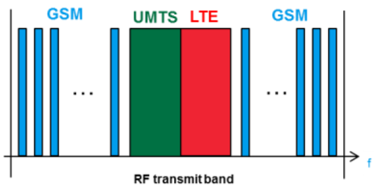
If possible add additional LTE carriers in the middle



TC4c

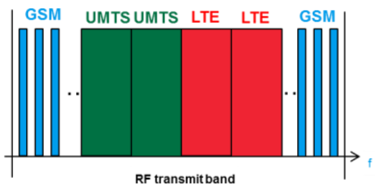
UMTS, LTE, GSM multi-RAT operation

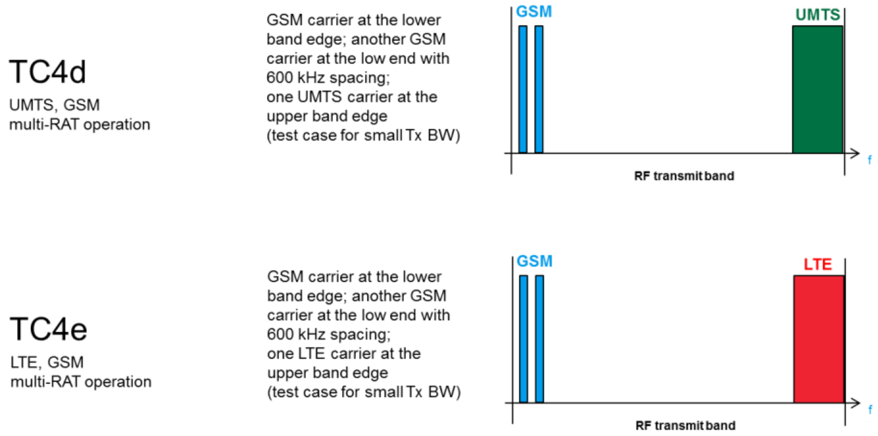
GSM carrier at the upper and lower band edge;
One UMTS and LTE carrier in the middle;
Fill spectrum with GSM carriers at 600 kHz spacing till bandwidth is filled or till max number of supported GSM carriers is reached;



or

If possible add additional UMTS and LTE carriers in the middle





Depending on the supported bandwidth of the DUT, this can mean that a multitude of carriers needs to be generated by a test signal generator.

The RF signal requirements for MSR Tx tests are less demanding than for MSR Rx tests. For component tests, this generally allows generating the multi-carrier signals in the baseband and to output the RF test stimulus via one common RF path.

To avoid dependencies between adjacent carriers, adjacent carriers should be generated in an uncorrelated way. I.e. two adjacent carriers are normally not allowed to be exactly the same, but need to be generated with different data content.

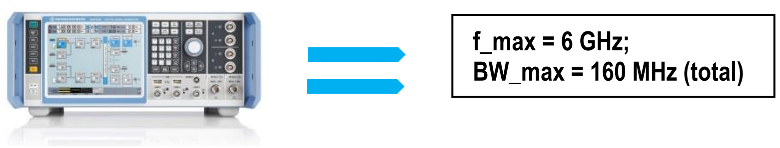
A big difference in power levels for the different signals can lead to challenging dynamic range requirements. As a rule of thumb, a requirement for greater than 50 dB difference between carriers will make it necessary to generate the carriers via separate RF paths.

Due to the different test signal needs, the minimally required signal generator configuration is different for Rx tests and Tx tests.

5.2.2 Signals for Rx tests

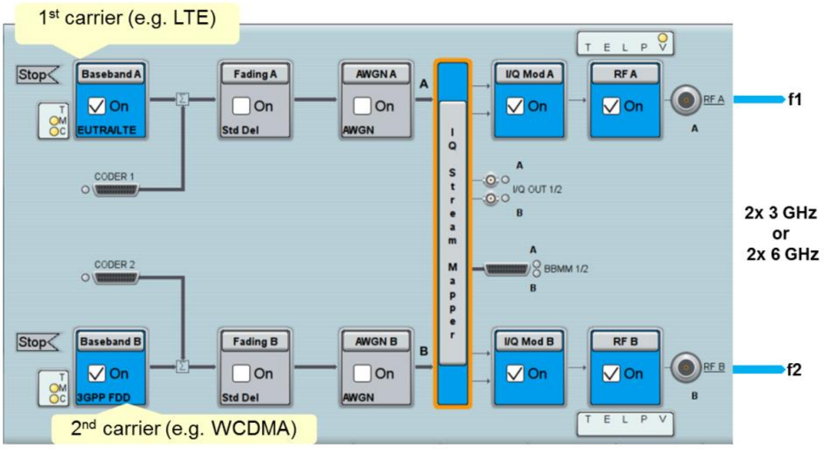
MSR receiver tests in line with 3GPP TS 37.141 generally require a large dynamic range (> 50 dB) to simulate the strong interferer signal as well as the low power wanted signal. This normally makes it necessary to use two separate RF paths for these tests.

5.2.2.1 Instrument setup



An additional RF coupler is needed for combination of the RF signals into the Rx antenna of the DUT.

5.2.2.2 SMW System Configuration



System configuration settings:	Standard mode (2 x 1 x 1 separate sources)
IQ stream mapper:	all streams routed to separate RFs

5.2.2.3 Recommended options

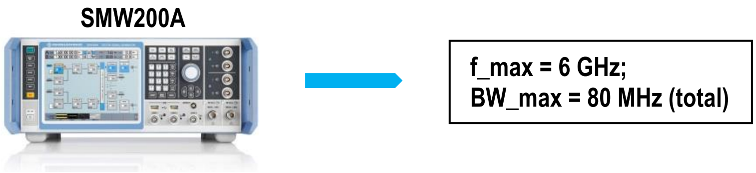
SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K40	*GSM*
2x	SMW-K42	*WCDMA*
1x	SMW-K50	*TD-SCDMA*
2x	SMW-K55	*LTE*
optional add-on options:		
1x	SMW-K41	*Edge Evo*
2x	SMW-K83	*HSPA/HSPA+*
2x	SMW-K85	*LTE-Advanced*
2x	SMW-B14	*Fading module*
2x	SMW-K62	*AWGN*
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*
2x	SMW-K71	*Dynamic fading*
2x	SMW-K72	*Enhanced fading models*
	SMW-Kxx	*Internal digital standards options or WinIQSIM2 options for waveform generation*

Accessories		
mandatory		
1x	2-to-1 RF combiner	*for RF signal combination*

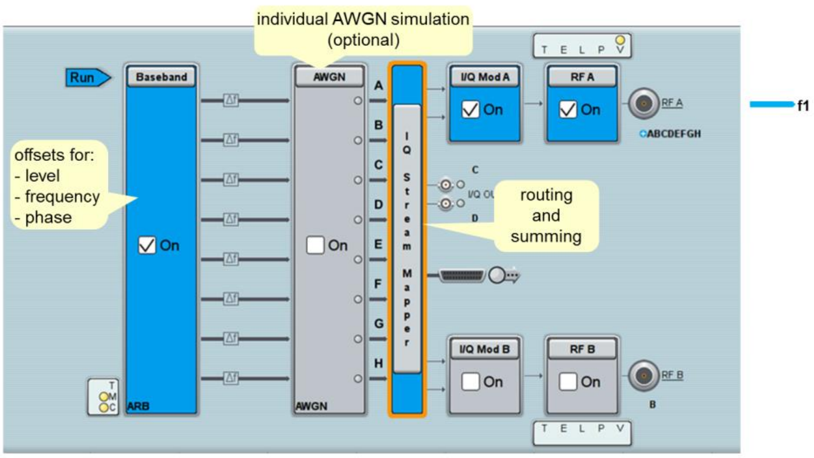
5.2.3 Signals for Tx component tests (single RF)

This example explains the needed configuration for a setup with 8 signals. All signals are generated within 80 MHz total bandwidth.

5.2.3.1 Instrument setup



5.2.3.2 SMW System Configuration



System configuration settings: 8 x 1 x 1 coupled sources
IQ stream mapper: all streams summed into RF A

5.2.3.3 Recommended instruments and options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106/-B112/-B120/-B131/-B140	*Frequency option for 1st path, 3, 6, 12.75, 20, 31.8 or 40 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
2x	SMW-K40	*GSM*
2x	SMW-K42	*WCDMA*
2x	SMW-K50	*TD-SCDMA*
2x	SMW-K55	*LTE*
optional add-on options:		
2x	SMW-K41	*Edge Evo*
2x	SMW-K83	*HSPA/HSPA+*
2x	SMW-K85	*LTE-Advanced*
2x	SMW-K62	*AWGN*
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

5.2.4 Signals for Tx component tests (separate RFs)

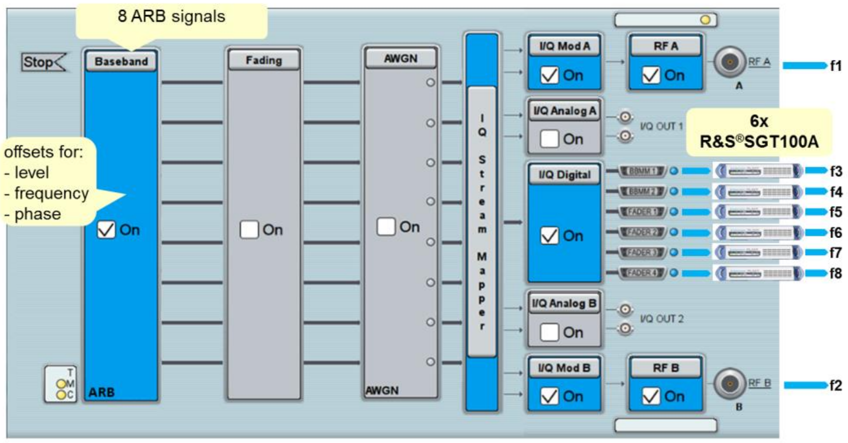
If a big level difference between carriers is required (> 50 dB as a rule of thumb) separate RF paths are required. In this example the needed configuration for a setup with 8 different signals – each generated via its own RF path – is explained. All signals are generated at freely definable RF frequency (up to 6 GHz). Each signal can occupy 80 MHz bandwidth.

In praxis a subset of the RF paths is generally sufficient to meet the dynamic range requirements. Carriers with similar level can often be generated via the same RF path by using the SMW IQ stream mapper for routing the signals accordingly.
However, in the following the maximum configuration is assumed.

5.2.4.1 Instrument setup

All 10 MHz references should be connected.
An additional RF coupler is needed for combination of the RF signals into the Rx antenna of the DUT.

5.2.4.2 SMW System Configuration



System configuration settings: 8 x 1 x 1 coupled sources
IQ stream mapper: all streams routed to separate outputs

5.2.4.3 Recommended instruments and options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
2x	SMW-K18	*Digital baseband output*
2x	SMW-K40	*GSM*
2x	SMW-K42	*WCDMA*
2x	SMW-K51	*TD-SCDMA*
2x	SMW-K55	*LTE*
optional add-on options:		
2x	SMW-K41	*Edge Evo*
2x	SMW-K83	*HSPA/HSPA+*
2x	SMW-K85	*LTE-Advanced*
2x	SMW-K62	*AWGN*
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

SGT		
mandatory options:		
6x	SGT100A	*Base unit, 3 GHz*
6x	SGT-K18	*Digital baseband connectivity*
optional add-on options:		
6x	SGT-KB106	*Upgrade to 6 GHz*

Accessories		
mandatory		
1x	8-to-1 RF combiner	*for RF signal combination*
6x	SMU-Z6	*R&S Digital IQ interface cable*

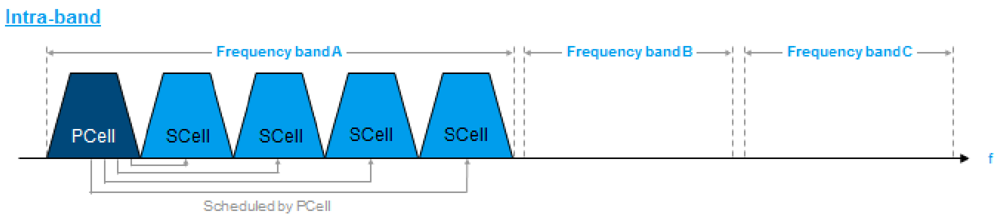
5.3 LTE Carrier Aggregation (CA)

5.3.1 Application Description

LTE-Advanced defines that up to 5 carriers can be aggregated in downlink direction. The SMW is able to generate all 5 component carrier signals (CC1 to CC5) from a single instrument. The SMW baseband configuration is conveniently done via a common LTE signal generation dialog. All carriers can be individually configured. Cross-carrier scheduling is also supported. If desired, frequency correct real-time channel simulation can be added for each individual carrier

5.3.1.1 Intra-band carrier aggregation

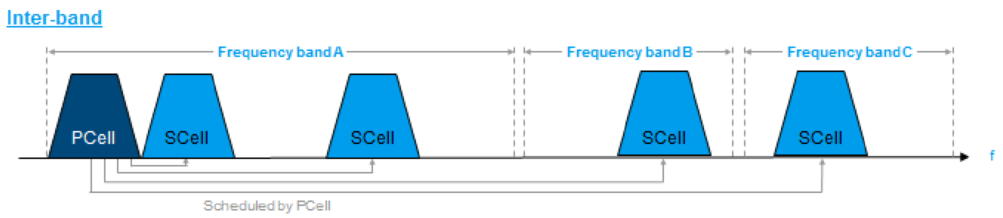
Intra-band carrier aggregation means that all carriers are within one LTE band.



For intra-band scenarios all 5 carriers are added up with frequency offsets/level offsets and output via a common RF path of the SMW.

5.3.1.2 Inter-band carrier aggregation

Inter-band carrier aggregation means that the component carriers are transmitted in multiple LTE bands.

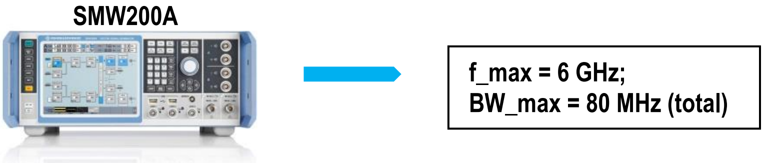


For inter-band scenarios the SMW configuration depends on the spacing between the different component carriers. The SMW features up to two internal RF synthesizers, each with up to 160 MHz bandwidth. I.e. carrier aggregation scenarios with two LTE bands can be covered by a single SMW. More bands can be covered by adding additional SGT vector RF sources to the setup. If required, every component carrier can be placed in a separate frequency band.

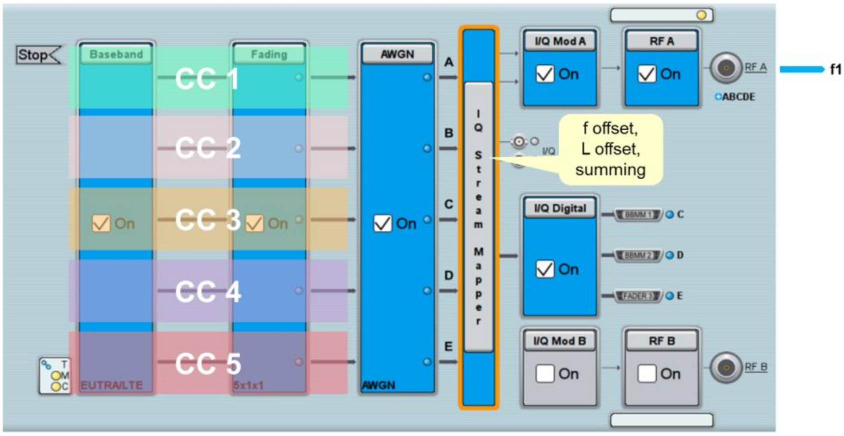
5.3.2 Intra-band CA with individual SISO fading

This example explains the needed configuration for a setup with 5 LTE component carriers. All signals are generated within a single LTE band of maximum 80 MHz total bandwidth. Each component carrier is faded individually.

5.3.2.1 Instrument setup



5.3.2.2 SMW System Configuration



System configuration settings: 5 x 1 x 1 coupled sources
IQ stream mapper: all streams routed to RF A

5.3.2.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
2x	SMW-K55	*LTE*
2x	SMW-K85	*LTE-Advanced*

optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

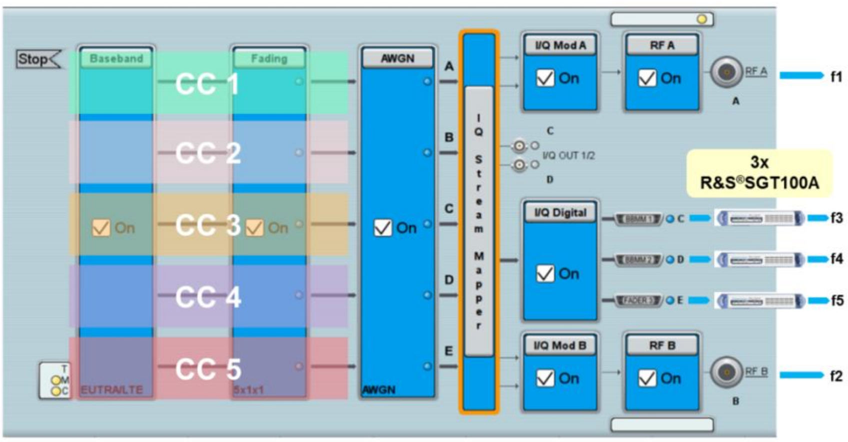
5.3.3 Inter-band CA with individual SISO fading

In the following, the maximum setup with 5 component carriers, each in a different LTE band, is assumed. I.e. each component carrier is output by its own dedicated RF path. If less than 5 different bands are to be covered (or if two carriers in different bands are spaced less than 80 MHz from each other), the number of SGT RF extension units can be reduced accordingly.

5.3.3.1 Instrument setup

All 10 MHz references should be connected.
An additional RF coupler is needed for combination of the RF signals into the Rx antenna of the DUT.

5.3.3.2 SMW System Configuration



System configuration settings: 5 x 1 x 1 coupled sources
IQ stream mapper: all streams routed to separate outputs

5.3.3.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
2x	SMW-K18	*Digital baseband output*
2x	SMW-K55	*LTE*
2x	SMW-K85	*LTE-Advanced*
optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

SGT		
mandatory options:		
3x	SGT100A	*Base unit, 3 GHz*
3x	SGT-K18	*Digital baseband connectivity*
optional add-on options:		
3x	SGT-KB106	*Upgrade to 6 GHz*

Accessories		
mandatory		
1x	5-to-1 RF combiner	*for RF signal combination*
3x	SMU-Z6	*R&S Digital IQ interface cable*

5.4 Phase Coherent RF carriers

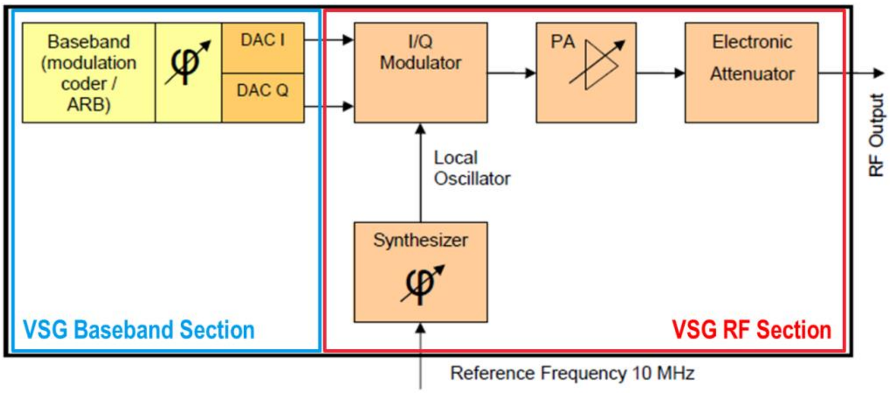
5.4.1 Application Description

Active antenna systems (AAS) in mobile communications as well as phased array radar antennas in A&D applications use phase coherence and beam forming techniques to add directivity to the signals that are generated.

The following Rohde & Schwarz application notes describe phase coherence and beam forming in more detail.

1GP67: Phase Adjustment of Two MIMO Signal Sources with Option B90
1MA187: LTE Beam Forming Measurements

For a signal generator that is used for phase coherence applications, there is generally a need to create multiple RF signals with a defined phase and level relation as well as a stable timing between all simulated TX or RX antenna signals. Furthermore, LO coupling between the different IQ modulators (by using one RF synthesizer to feed all) is typically used to maintain the phase stability over time. These phase locked RFs generally do not allow changing the RF phase of one signal generation path independently from the other RF paths. However, changing the signal phases individually is mandatory for phase calibration purposes.
In a vector signal generator like the SMW this challenge is solved via setting the phase in the digital baseband section of the instrument instead and not in the synthesizer(s). This phase change has to be possible for each signal path individually and in real-time.

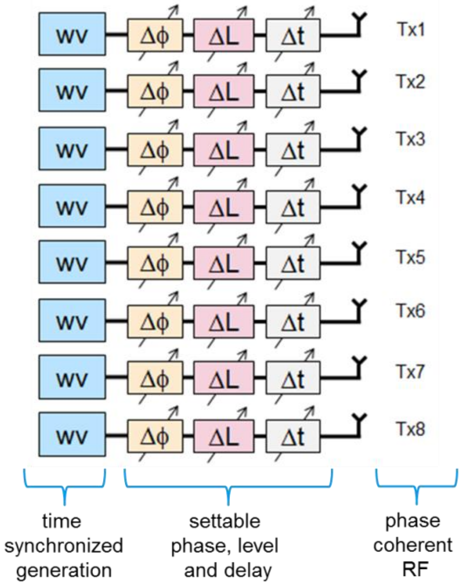


Generation chain of a vector signal generator (VSG)

All in all a vector signal generator for beam forming / phase coherence needs to offer the following capabilities:

- Generation of multiple phase coherent RF signals
- Generation of correctly coded baseband signals, one for each RF path
- Synchronous signal start
- Possibility to set levels of all signals for output level calibration
- Possibility to set phase and time delays between all signals without signal interruption during playback for calibration

For an 8-channel setup, a signal generator needs to enable:



The SMW meets all these requirements in an unrivaled way:

Requirement	SMW feature
Generation of multiple RF signals	2 internal RF paths; plus connection of: - up to 2 SGS - up to 2 SGS/SGU combinations - up to 6 SGT
Phase coherency between RF signals	SMW-B90 for LO coupling between SMW RF and externally connected SGS/SGU/SGT (with -K90 option)
Individual baseband signals for each RF path	SMW-K76 for generation of up to eight baseband signals (e.g. ARB) from a single SMW
Synchronous signal start	One common baseband section with inherent synchronization of all baseband signals inside SMW
Settable signal phase for phase calibration	Baseband phase offsets for each individual baseband signal
Settable signal level for output level calibration	RF step attenuator in combination with settable digital attenuation for the different RF outputs (in SMW as well as in SGT)
Time delay compensation	Global trigger offset; settable IQ delay (ps resolution) for each signal

The SMW-K76 enables the SMW200A to generate eight time-synchronized baseband signals from its internal baseband generators (2x SMW-B10) – with individual phase and level offsets for each baseband signal. Together with additional RF extension units SGT or SGS, which can be coupled in phase coherent way to the SMW RF, this turns a single SMW into a versatile multi-channel signal generator for beam forming applications. Since all functionality is under control of the SMW, time-alignment, RF phase calibration and baseband signal generation is simplified.

Depending on the desired maximum frequency different setups are recommended. These setups are described in the following sections.

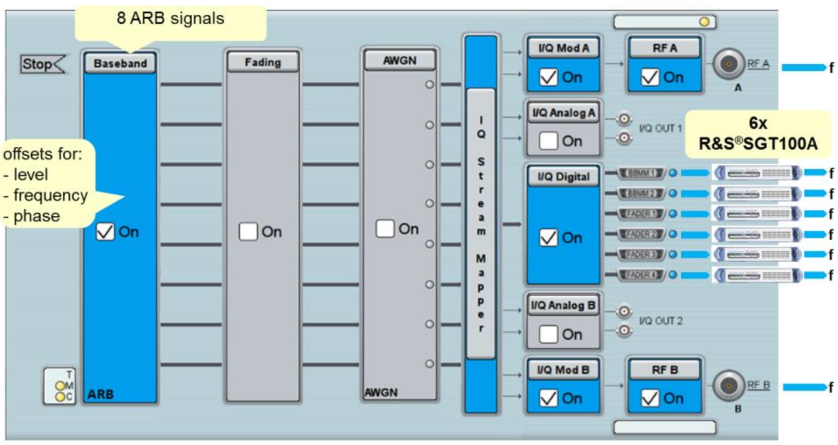
5.4.2 Phase Coherence up to 6 GHz

A combination of one dual-path SMW and six SGT RF sources with phase coherence option (SMW-B90/ SGT-K90) allows generation of eight phase coherent RF signals up to 6 GHz. If more RF paths are required, the complete setup can be multiplied. The maximum bandwidth for each signal is 80 MHz.

5.4.2.1 Instrument setup

Additionally, the LO out of the SMW has to be connected to the LO input of the first SGT. The LO output of the first SGT to the input of the second SGT, and so on. I.e. there is a daisy chain for the LO coupling of all SGTs. Alternatively, a power splitter can be used to split the SMW LO signal and feed it to the different SGTs. In the latter case a sufficient LO level has to be maintained e.g. via additional LO amplification. With all LO setups it is mandatory to use suitable cables for LO distribution.

5.4.2.2 SMW System Configuration



System configuration settings:	8 x 1 x 1 coupled sources
IQ stream mapper:	all streams routed to separate outputs

5.4.2.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
2x	SMW-K18	*Digital baseband output*
1x	SMW-B90	*Phase coherence*
optional add-on options:		
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

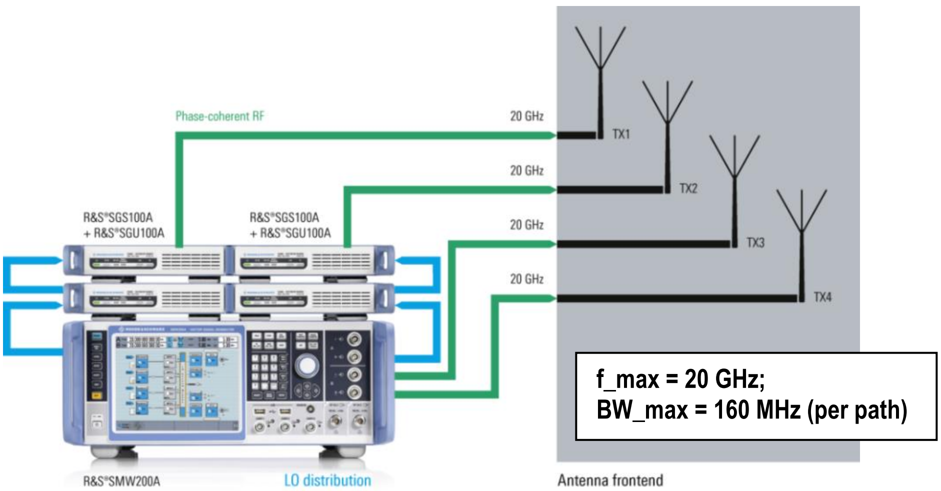
SGT		
mandatory options:		
6x	SGT100A	*Base unit, 3 GHz*
6x	SGT-K18	*Digital baseband connectivity*
6x	SGT-K90	*Phase coherence*
optional add-on options:		
6x	SGT-KB106	*Upgrade to 6 GHz*

Accessories		
mandatory		
6x	SMU-Z6	*R&S Digital IQ interface cable*

5.4.3 Phase Coherence up to 20 GHz

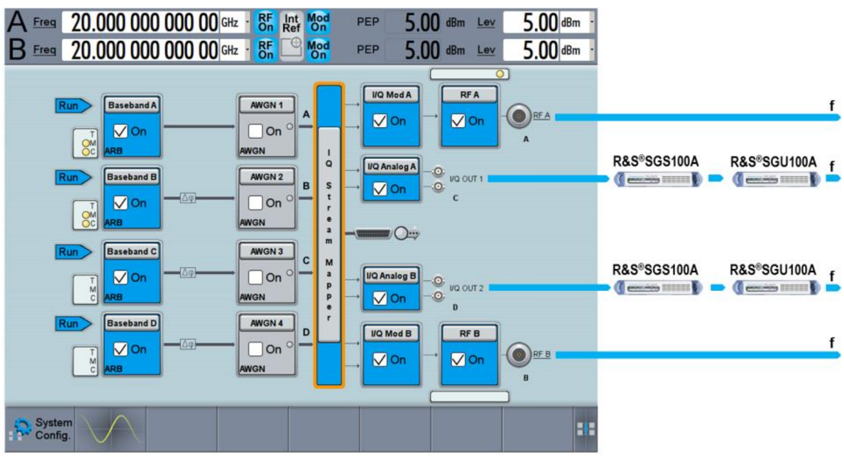
A combination of one dual-path SMW, two SGS RF sources and two SGU RF up-converters with phase coherence option (SMW-B90/SGS-K90) allows generation of four phase coherent RF signals up to 20 GHz. The maximum bandwidth for each signal is 160 MHz. If more RF paths are required, the complete setup can be multiplied.

5.4.3.1 Instrument setup



The LO from the SMW is distributed to the two SGS/SGU setups.
It is mandatory to use suitable (phase stable) cables for LO distribution.
The baseband signals generated by SMW are distributed to the SGS/SGU via analog I/Q cables.

5.4.3.2 SMW System Configuration



System configuration settings: 4 x 1 x 1 separate sources
IQ stream mapper: all streams routed to separate outputs

5.4.3.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B120	*Frequency option for 1st path, 20 GHz*
1x	SMW-B220	*Frequency option for 2nd path, 20 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
1x	SMW-B90	*Phase coherence*
optional add-on options:		
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

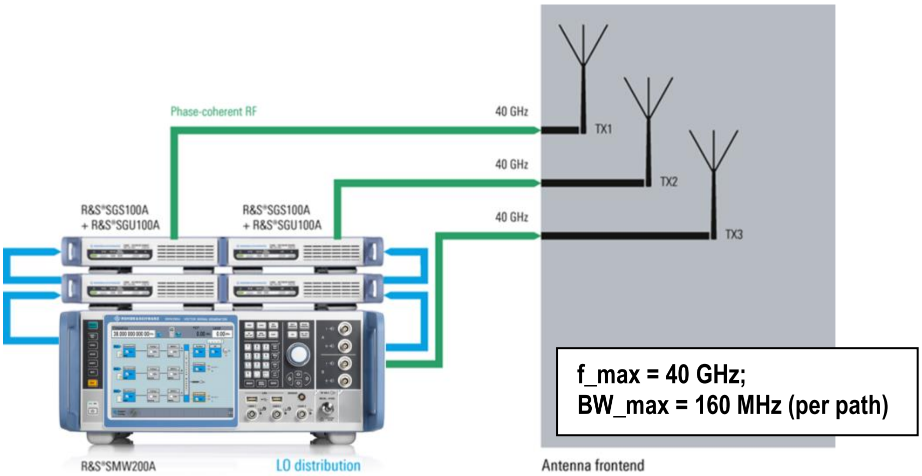
SGS		
mandatory options:		
2x	SGS100A	*RF Source, Base unit*
2x	SGS-B106V	*Frequency 6 GHz*
2x	SGS-B112V	*Frequency extension 12.75 GHz*
2x	SGS-K90	*Phase coherence*

SGU		
mandatory options:		
2x	SGU100A	*RF Up-converter, Base unit*
2x	SGU-B120V	*Frequency 20 GHz*
2x	SGU-B26	*Step attenuator*
2x	SGU-Z4	*Connection kit SGU to SGS*

5.4.4 Phase Coherence up to 40 GHz

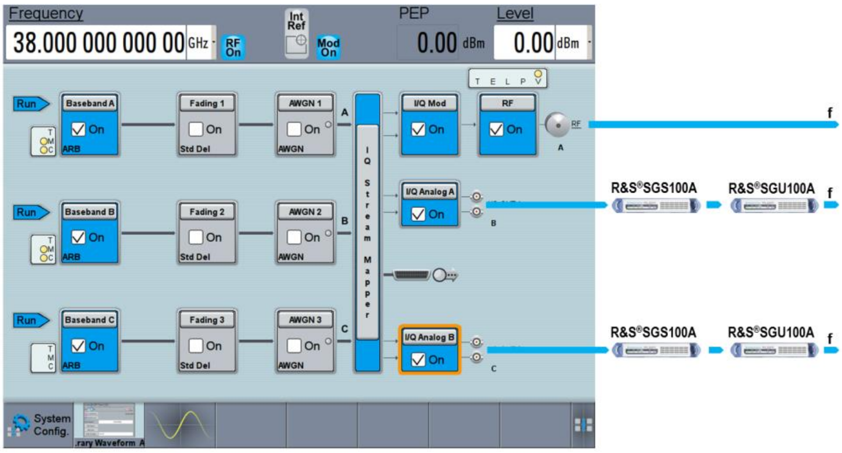
A combination of one single path SMW, two SGS RF sources and two SGU RF up-converters with phase coherence option (SMW-B90/SGS-K90) allows generation of three phase coherent RF signals up to 40 GHz. The maximum bandwidth for each signal is 160 MHz. If more RF paths are required, the complete setup can be multiplied.

5.4.4.1 Instrument setup



The LO from the SMW is distributed to the two SGS/SGU instruments. It is mandatory to use suitable (phase stable) cables for LO distribution. The baseband signals generated by SMW are distributed to the SGS/SGU via analog I/Q cables.

5.4.4.2 SMW System Configuration



System configuration settings: 3 x 1 x 1 separate sources
IQ stream mapper: all streams routed to separate outputs

5.4.4.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B140	*Frequency option for 1st path, 40 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
1x	SMW-B90	*Phase coherence*
optional add-on options:		
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

SGS		
mandatory options:		
2x	SGS100A	*RF Source, Base unit*
2x	SGS-B106V	*Frequency 6 GHz*
2x	SGS-B112V	*Frequency extension 12.75 GHz*
2x	SGS-K90	*Phase coherence*

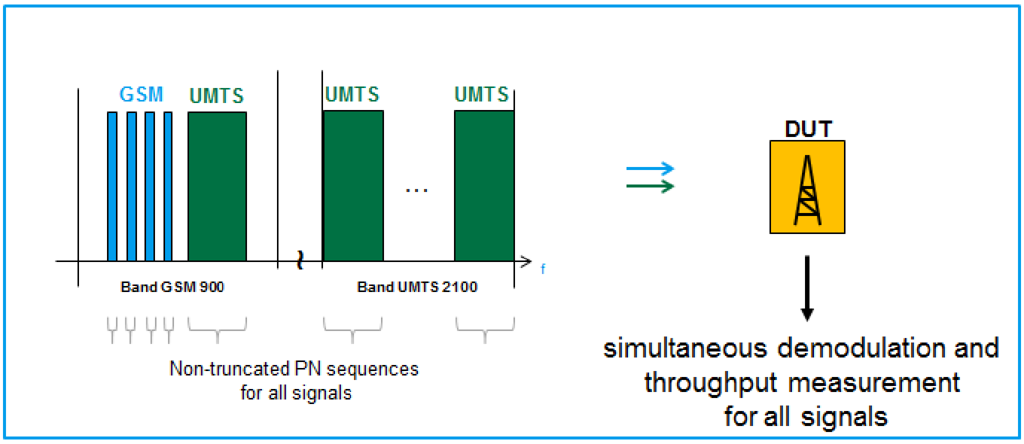
SGU		
mandatory options:		
2x	SGU100A	*RF Up-converter, Base unit*
2x	SGU-B120V	*Frequency 20 GHz*
2x	SGU-B140V	*Frequency extension 40 GHz*
2x	SGU-B26	*Step attenuator*
2x	SGU-Z4	*Connection kit SGU to SGS*

5.5 Parallelized Testing for Test Time Reduction

5.5.1 Application Description

Modern receivers of mobile communication systems are wideband receivers. I.e. they often can demodulate multiple carriers that are placed next to each other simultaneously. This allows testing the receiver´s demodulation capabilities not only for a single carrier at a time, but for all carriers at the same time.

For this test approach it is necessary to have properly generated multi-carrier signals. Each carrier needs to carry sufficient payload data for meaningful statistical bit error rate (BER), block error rate (BLER), packet error rate (PER) or frame error rate (FER) analysis. This generally means that every carrier needs to carry a complete pseudo-random-bit-sequence (PRBS or PN sequence) without truncation.



If many of these carriers are to be generated via a single multi-carrier waveform the waveform size is generally getting too big for a signal generator to be played back, especially if the spacing between the carriers is big.

Even more dramatic is the situation if different digital standards need to be generated with non-truncated PN sequences where each digital standard has different frame timing. This means that the total sequence length of a waveform needs to be lowest common multiple of the individual sequence lengths for each carrier.

Timing raster of different standards:

- UMTS frame = 10 ms
- LTE frame = 10 ms
- GSM/EDGE frame (8 slots) = 120/26 ms ~ 4.615 ms

⇨ LTE and WCDMA have same timing, but GSM/EDGE is different.

If an UMTS and a GSM carrier are to be generated in a combined way via a single multi-carrier waveform – both with non-truncated PN sequences – the required ratio is:

- 13 GSM frames = 6 UMTS frames

For UMTS, 1022 frames need to be generated in order to test with a non-truncated PN9 sequence. This equals 10.22 seconds of sequence length or ~78.5 MSamples @ 7.68 MHz sample clock (3.84 Mcps, oversampling 2).

For both, UMTS and GSM this means:

- 6x 1022 = 6132 UMTS frames = **61.32 s**

  or ~ **471 MSamples** @ 7.68 MHz sample clock (3.84 Mcps, oversampling 2)

⇨ Generally, the need for non-truncating PN9 sequences of multiple carriers with different communication standards results in long signal sequences if the signal is generated via a pre-calculated multi-carrier waveform.

This leads to the following challenges:

⇨ The ARB size of a signal generator is limited and often restricts the use of large pre-calculated multi-carrier waveforms.

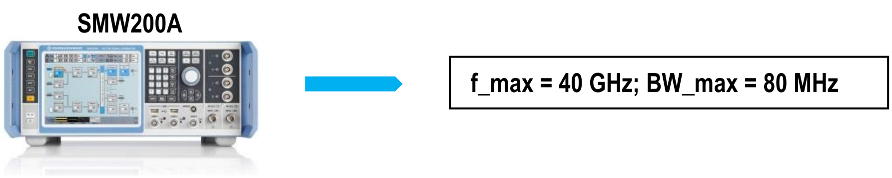
⇨ Calculation time for large multi-carrier waveforms is a factor which might hinder effective work. Whenever a single signal parameter needs to be changed the complete multi-carrier waveform needs to be re-calculated.

⇨ There is often a need for multiple different signal scenarios (e.g. different relative power levels between carriers). This leads to a large number of (at least slightly) different multi-carrier-waveforms that need to be created and maintained.

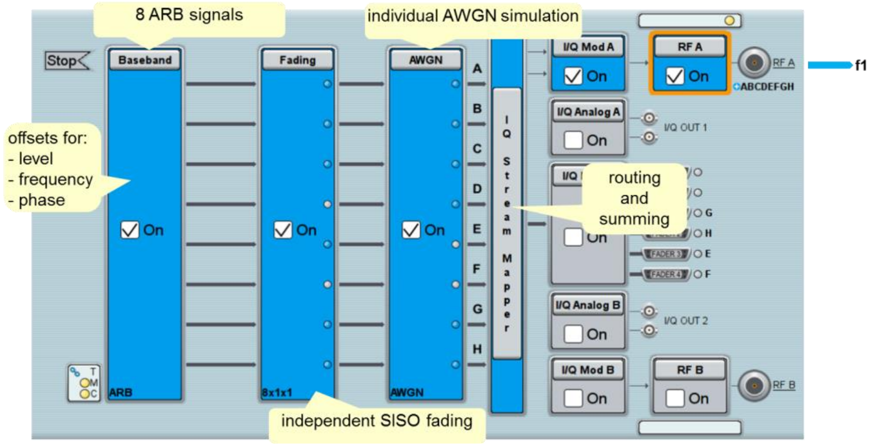
Real-time signal generation of each carrier and real-time addition of the carriers avoids all these problems.

With the SMW-K76 option each of the eight baseband signals in the SMW is generated with its own sequence length and – if desired – with non-truncated PN sequence. Due to the unique capability of the SMW for internal real-time addition and routing, the constraint of having one common multi-carrier waveform does not exist. This is the pre-requisite for simultaneous throughput analysis for multiple carriers by a receiver. By that the SMW-K76 allows new and more time-efficient test concepts for wideband receiver testing.

5.5.2 Instrument setup



5.5.3 SMW System Configuration



System configuration settings: 8 x 1 x 1 coupled sources
IQ stream mapper: all streams summed into RF A

5.5.4 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106/-B112/-B120/-B131/-B140	*Frequency option for 1st path, 3, 6, 12.75, 20, 31.8 or 40 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*
2x	SMW-K71	*Dynamic fading*
2x	SMW-K72	*Enhanced fading models*
	SMW-Kxx	Internal digital standards options or WinIQSIM2 options for waveform generation

5.6 Multi-Emitter Radar Scenarios

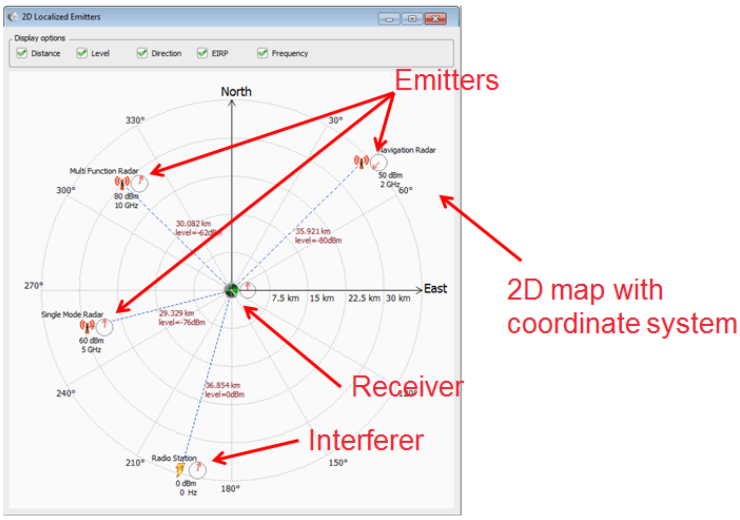
5.6.1 Application Description

For evaluation of a radar receiver's capability to distinguish multiple objects at the presence of other interfering signals, there is a need to stimulate the receiver with a suitable set of signals. Hence radar receivers are typically tested with complex signal scenarios.

The strength at which a certain signal arrives at the receiver is mainly influenced by the emitter TX power and the distance between emitter and receiver. For a signal scenario that consists of multiple emitters (some near the receiver, some far away) this can result in challenging dynamic range requirements. Also receivers typically have a high receive bandwidth, which means that there is a need to place test signals arbitrarily within the receive bandwidth.

By means of the R&S®Pulse Sequencer PC Software (requires options R&S®SMW-K300/-K301), the SMW can easily simulate the required multi-emitter scenarios. Via the software the signal scenario can be planned and created including signal content, TX and RX antenna patterns, emitter position, antenna orientation, antenna scans and much more. Interferer signals (e.g. generated by WinIQSIM2) can be imported as well.

The signal scenario can be setup in R&S®Pulse Sequencer Software by placing the emitters and interferers on a map and configuring each signal as desired.



With the SMW-K76 Multiple Entities option up to eight basebands are available in the SMW. Each of these basebands is generally used for generation of one emitter or interferer signal. The individual pulse sequences created by use of the R&S®Pulse Sequencer Software (or the interferers created via WinIQSIM2) are loaded into the ARB generators of the SMW basebands.

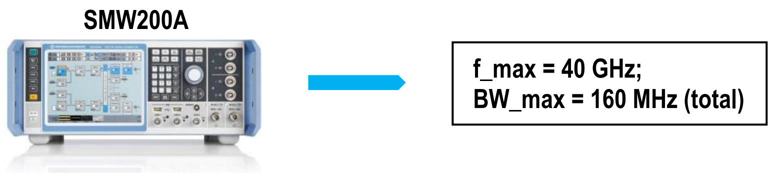
Depending on the maximum radio frequency, the total bandwidth that has to be covered and the number of needed independent signals, either six additional SGTs (up to 6 GHz) or one or two SGS/SGU combinations (up to 40 GHz) are used together with one SMW signal generator.

In the following it is distinguished between setups with in-band (four signals within 160 MHz BW or eight signals within 80 MHz BW) and multi-band applications (multiple signals with spacing > 160 MHz).

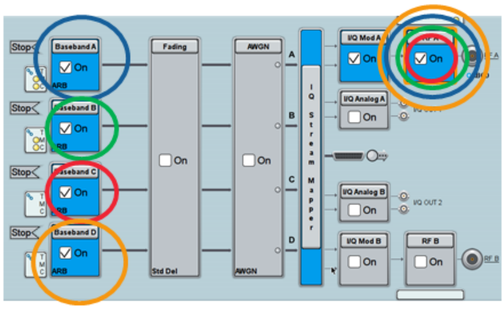
5.6.2 In-band setup

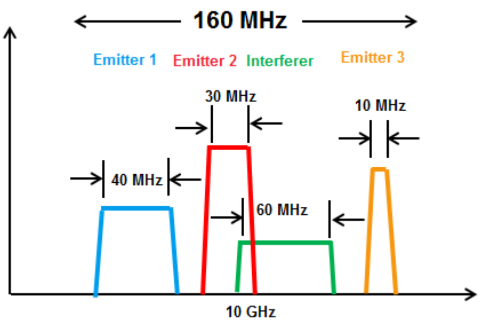
In the example below the SMW is configured to simulate four radar emitters in a frequency range of up to 40 GHz. All emitters are transmitting within a maximum bandwidth of 160 MHz.

5.6.2.1 Instrument setup



5.6.2.2 SMW System Configuration





System configuration settings: 4 x 1 x 1 separate sources
IQ stream mapper: all streams summed into RF A

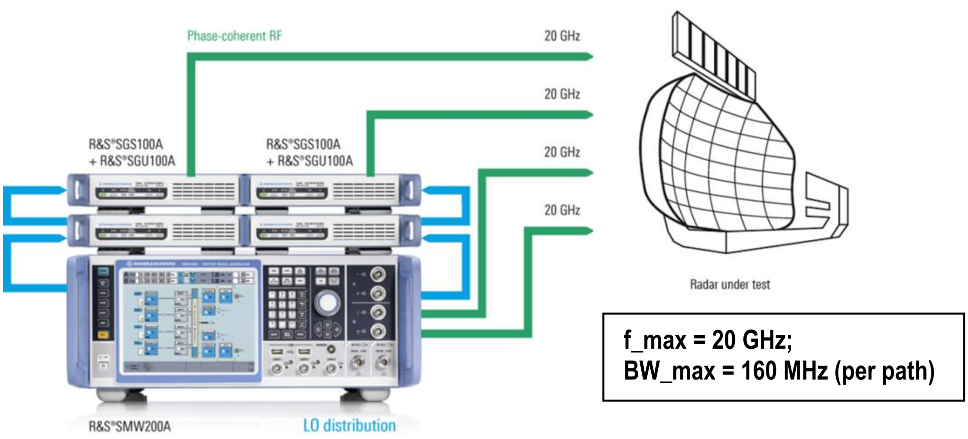
5.6.2.3 Recommended instruments and options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106/-B112/-B120/-B131/-B140	*Frequency option for 1st path, 3, 6, 12.75, 20, 31.8 or 40 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K300	*Pulse Sequencing*
2x	SMW-K301	*Enhanced Pulse Sequencing*
optional add-on options:		
2x	SMW-K62	*AWGN*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*
	SMW-Kxx	*Internal digital standards options or WinIQSIM2 options for interferer waveform generation*

5.6.3 Multi-band setup

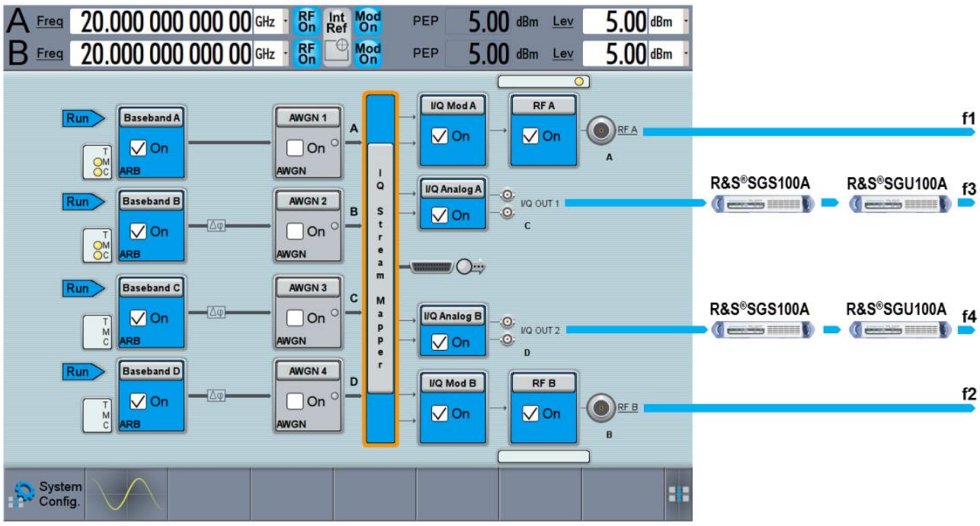
In this example the SMW is configured to simulate four radar emitters in a frequency range of up to 20 GHz, each emitter signal has a maximum bandwidth of 160 MHz.

5.6.3.1 Instrument setup

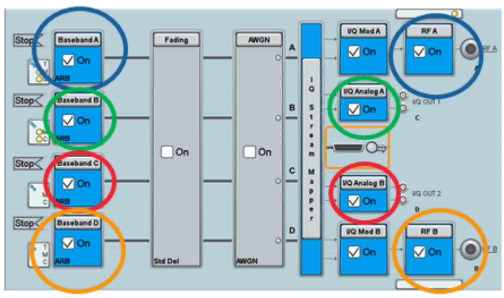


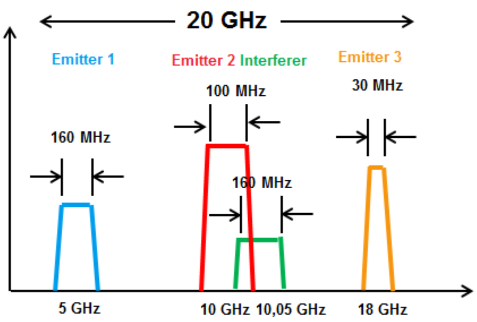
A common 10 MHz reference for all instruments is recommended. If phase coherent RF paths are required, the LO from the SMW can optionally be distributed to the two SGS/SGU instruments. In this case, the 10 MHz connection can be omitted, but it is mandatory to use suitable (phase stable) cables for LO distribution.
The baseband signals generated by SMW are distributed to the SGS/SGU via analog I/Q cables. An additional RF coupler is needed for combination of the RF signals into the Rx port of the Radar receiver (receiver input after the antenna front-end).

5.6.4 SMW System Configuration



System configuration settings: 4 x 1 x 1 separate sources
IQ stream mapper: all streams routed to separate outputs





5.6.5 Recommended instruments and options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B120	*Frequency option for 1st path, 20 GHz*
1x	SMW-B220	*Frequency option for 2nd path, 20 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
2x	SMW-K300	*Pulse Sequencing*
2x	SMW-K301	*Enhanced Pulse Sequencing*
optional add-on options:		
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*
1x	SMW-B90	*Phase coherence*
2x	SMW-K62	*AWGN*
	SMW-Kxx	*Internal digital standards options or WinIQSIM2 options for interferer waveform generation*

SGS		
mandatory options:		
2x	SGS100A	*RF Source, Base unit*
2x	SGS-B106V	*Frequency 6 GHz*
2x	SGS-B112V	*Frequency extension 12.75 GHz*
optional add-on options:		
2x	SGS-K90	*Phase coherence*

SGU		
mandatory options:		
2x	SGU100A	*RF Up-converter, Base unit*
2x	SGU-B120V	*Frequency 20 GHz*
2x	SGU-B26	*Step attenuator*
2x	SGU-Z4	*Connection kit SGU to SGS*

5.7 GSM BTS Rx Test Case for AM suppression

5.7.1 Application Description

The GSM BTS test specification 3GPP 51.021 includes a special “Multi-carrier Rx test case for AM suppression” (chapter 7.8) which requires generation of four real-time GSM signals plus one additional GSM interferer.

In detail, the test case requires:

- Four different GSM carriers (uplink) as wanted signals, two of them with 6 MHz frequency offset from the interferer, the others at the edges of the maximum base station RF bandwidth. The interferer is also located within the base station RF bandwidth.
- A maximum bandwidth of 75 MHz (1800 MHz band) to be covered
- Simultaneous BER measurement on all carriers by the BTS
- A non-truncated PN sequence for each carrier
- A signal duration >30.66 s for the GSM signals
- No fading
- Same power level for all wanted signals; the interferer in the center has a higher power

The following figure taken from the test specification shows the required signal:

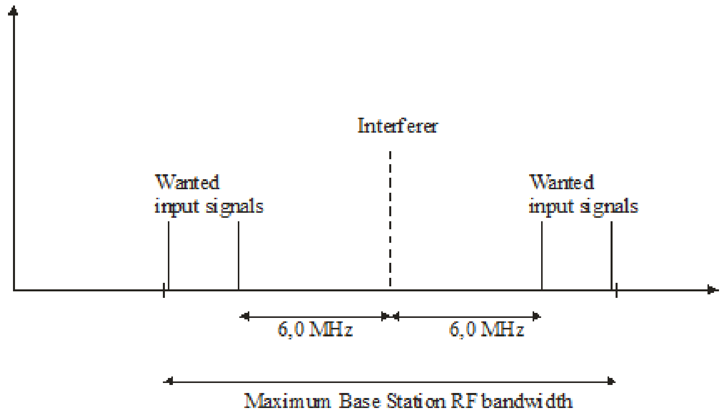


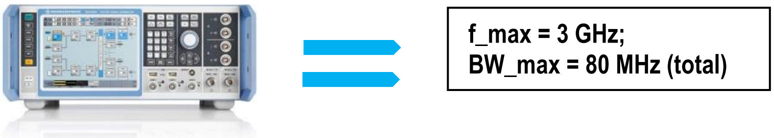
Figure 7.8-1 Allocation of wanted signals and interferer

The long signal duration is necessary to have a non-truncated PN sequence. Generating such a long sequence for multiple carriers generally requires to generate the signal in real-time and not via the ARB (due to ARB memory limitations).

5.7.2 Signal generation using stream duplication

The GSM BTS test case “Multi-carrier Rx test case for AM suppression” requires four real-time GSM carriers (uplink) and one GSM interferer. The SMW-K550 stream extender option enables the generation of all required signals with a single SMW.

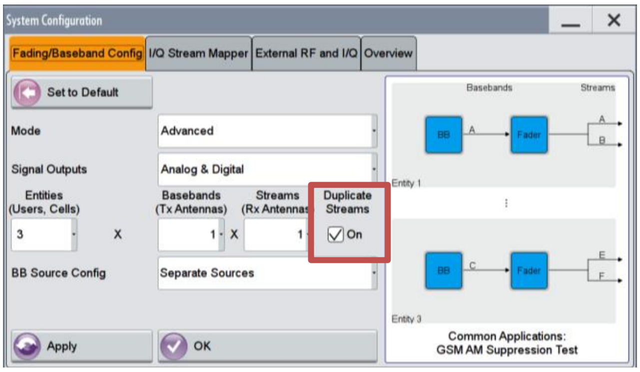
5.7.2.1 Instrument setup

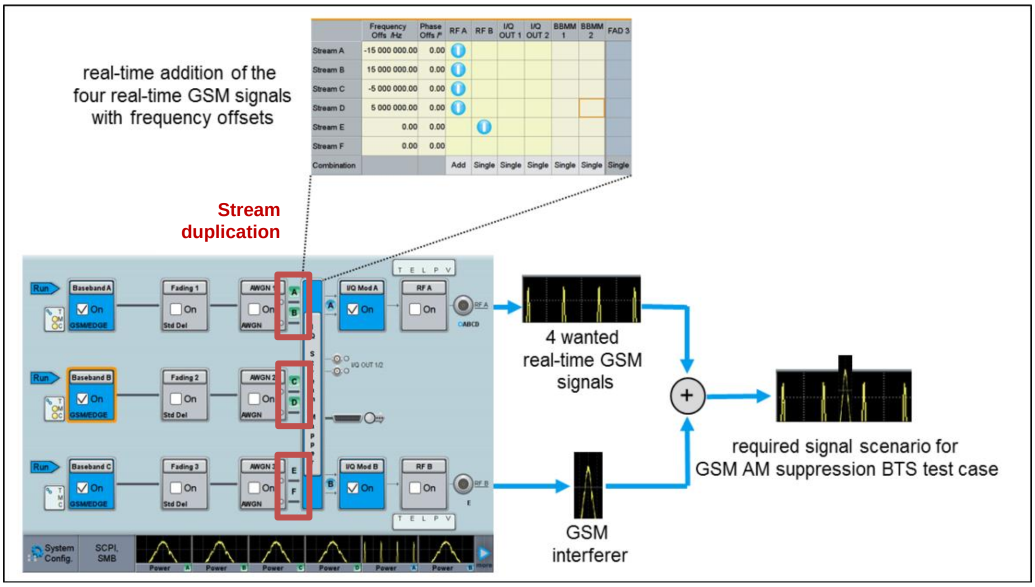


An additional RF coupler is needed for combination of the RF signals into the Rx antenna of the DUT.

5.7.2.2 SMW System Configuration

With SMW-K550 there is a checkbox in the system configuration dialog for enabling stream duplication:





System configuration settings:	3 x 1 x 1	separate sources
IQ stream mapper:	streams A, B, C, D summed into RF A	
	stream E routed to RF B	

5.7.2.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103	*Frequency option for 1st path, 3 GHz*
1x	SMW-B203	*Frequency option for 2nd path, 3 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
2x	SMW-K40	*GSM*
1x	SMW-K76	*Multiple entities*
1x	SMW-K550	*Stream extender*
optional add-on options:		
2x	SMW-K62	*AWGN*
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS; data list memory 16 Gbit*
2x	SMW-K512	*ARB memory ext. to 1GS; data list memory 32 Gbit*

Accessories		
mandatory		
1x	2-to-1 RF combiner	*for RF signal combination*

6 MIMO Applications

6.1 LTE Carrier Aggregation with MIMO

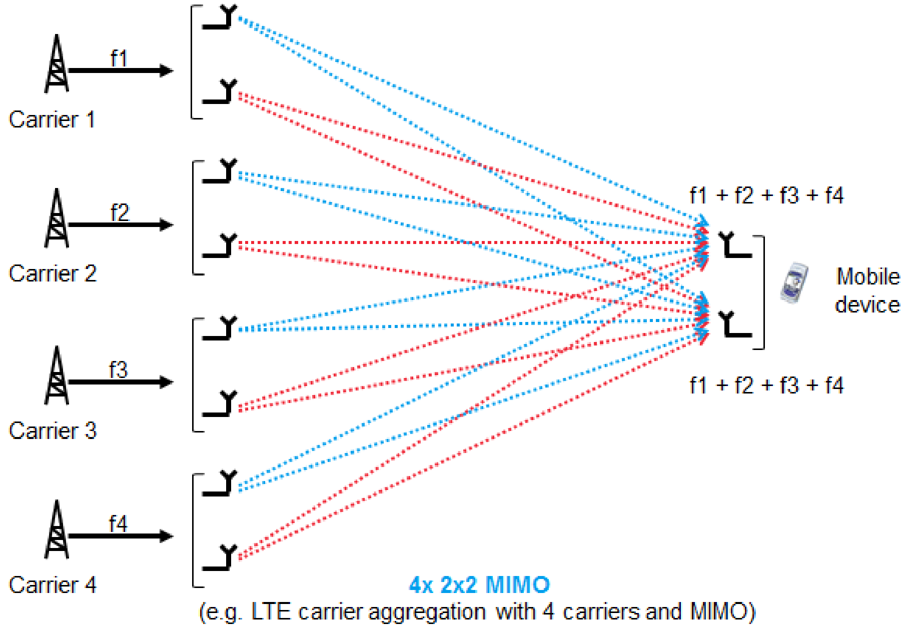
6.1.1 Application Description

As described in section 5.3, LTE can utilize multiple aggregated carriers to achieve a higher data throughput than it would be possible with a single carrier. To enhance the throughput even further, LTE allows that each of the component carriers can additionally make use of MIMO/spatial multiplexing techniques.

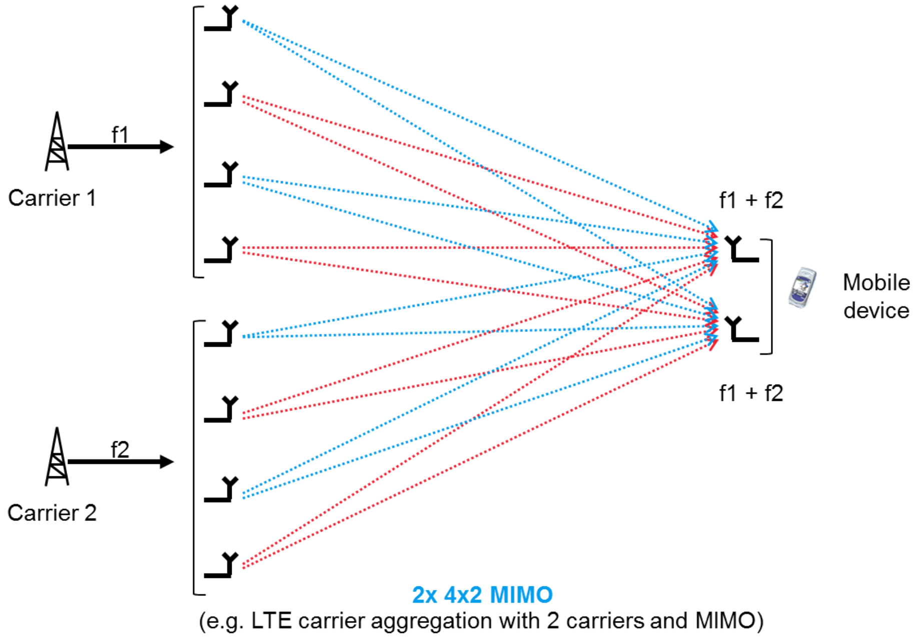
The SMW is a versatile multi-channel signal generator. With the SMW-K76 Multiple Entities option and SMW-K74 MIMO/Routing option the SMW allows generation of multiple separate MIMO systems – one for each carrier – by a single instrument. Depending on the number of carriers, the number of frequency bands and the MIMO order that is desired, different SMW configurations are recommended.

Two exemplary use cases of the SMW are shown in below pictures.

Example 1: Four carriers with 2x2 MIMO (intra-band or inter-band)



Example 2: Two carriers with 4x2 MIMO (intra-band or inter-band)



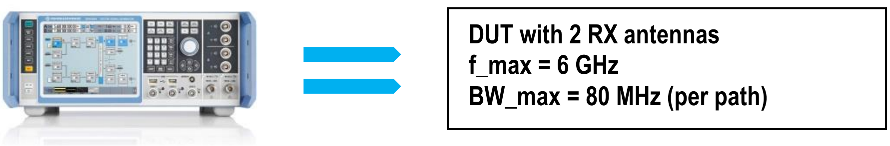
For intra-band carrier aggregation, the number of receive antennas at the DUT determines the number of required RF outputs of the signal generator. For inter-band configurations, the product of “number of receive antennas at the DUT” times “number of inter-band carriers” determines the number of needed separate RF chains.

In the following section various LTE carrier aggregation scenarios with MIMO are examined and the required SMW configurations are given.

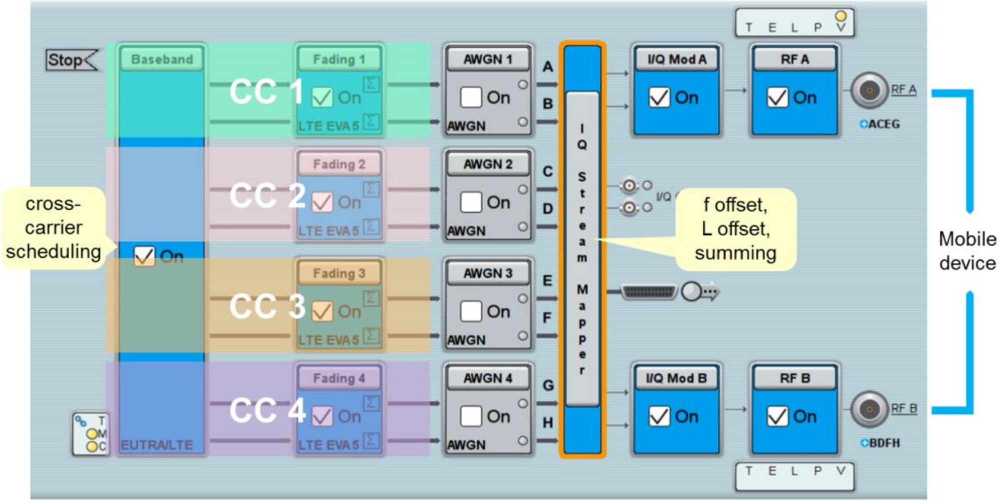
6.1.2 LTE Carrier Aggregation (intra-band) with 2x2 MIMO

This example explains the needed configuration for a setup with 4 LTE-Advanced component carriers (CC1 to CC4), each carrier with 2x2 MIMO and all carriers within a single LTE band of max. 80 MHz bandwidth.

6.1.2.1 Instrument setup



6.1.2.2 SMW System Configuration



System configuration settings:	4 x 2 x 2	coupled sources
IQ stream mapper:	streams A, C, E, G summed into RF A	
	streams B, D, F, H summed into RF B	

6.1.2.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
1x	SMW-K74	*MIMO/Routing*
2x	SMW-K55	*LTE*
2x	SMW-K85	*LTE-Advanced*
optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

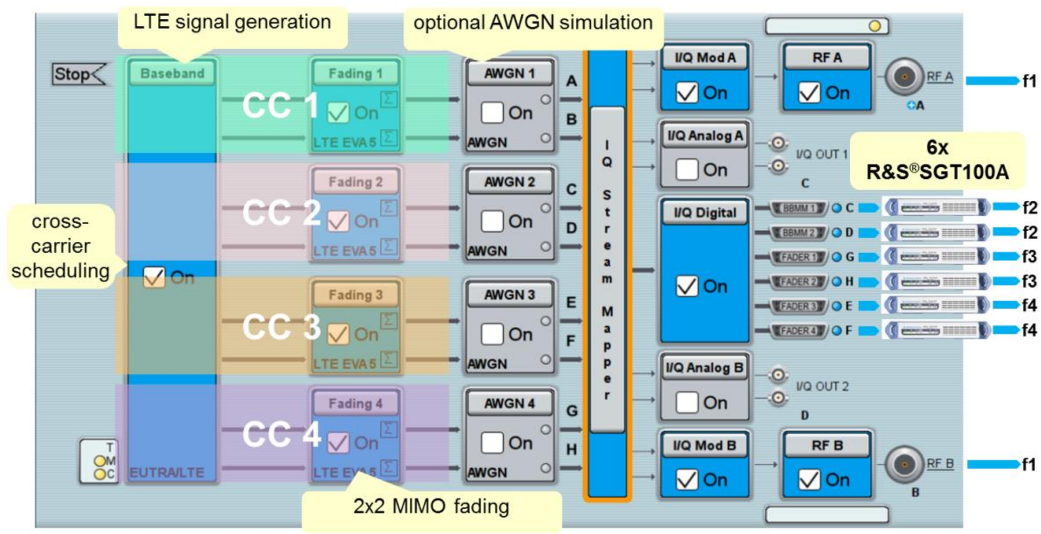
6.1.3 LTE Carrier Aggregation (inter-band) with 2x2 MIMO

This example explains the needed configuration for a setup with 4 LTE-Advanced component carriers, each carrier with 2x2 MIMO and each carrier in a different LTE band.

6.1.3.1 Instrument setup

10 MHz reference coupling between SMW and SGTs required.
The RF signals for Rx antenna 1 (streams A, C, E, G) need to be summed up via a 4-to-1 RF combiner and connected to Rx port 1 of the DUT.
The RF signals for Rx antenna 2 (streams B, D, F, H) need to be summed up via a 4-to-1 RF combiner and connected to Rx port 2 of the DUT.

6.1.3.2 SMW System Configuration



System configuration settings:	4 x 2 x 2	coupled sources
IQ stream mapper:	all streams routed to separate outputs	

6.1.3.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
1x	SMW-K74	*MIMO/Routing*
2x	SMW-K55	*LTE*
2x	SMW-K85	*LTE-Advanced*
2x	SMW-K18	*Digital baseband outputs*
optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

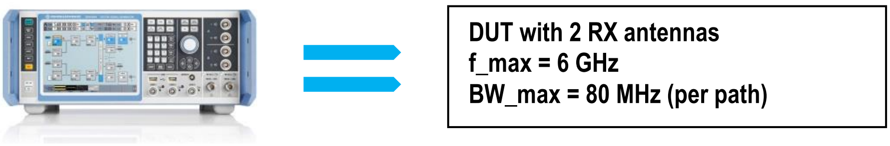
SGT		
mandatory options:		
6x	SGT100A	*Base unit, 3 GHz*
6x	SGT-K18	*Digital baseband connectivity*
optional add-on options:		
6x	SGT-KB106	*Upgrade to 6 GHz*

Accessories		
mandatory		
2x	4-to-1 RF combiner	*for RF signal combination*
6x	SMU-Z6	*R&S Digital IQ interface cable*

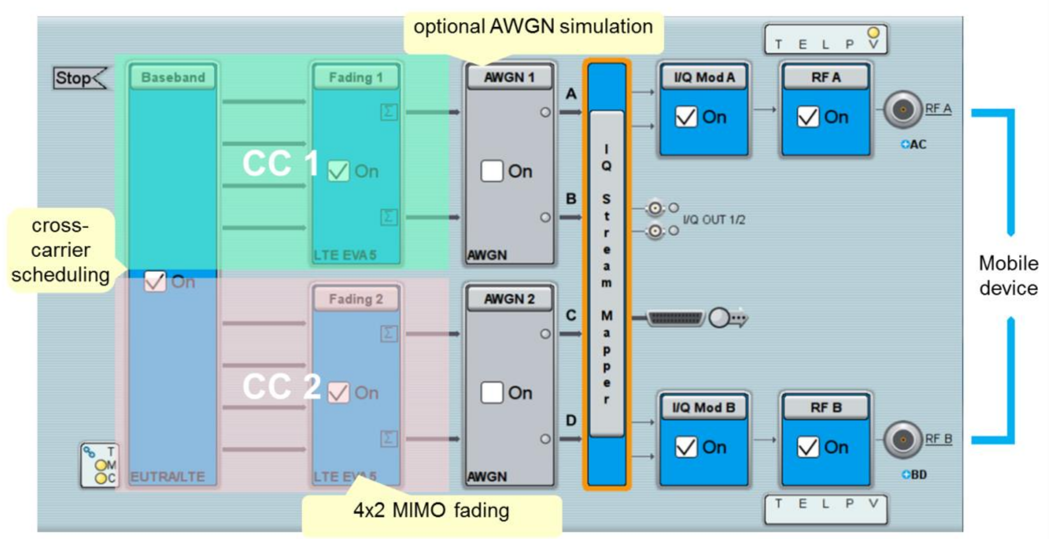
6.1.4 LTE Carrier Aggregation (intra-band) with 4x2 MIMO

This example explains the needed configuration for a setup with 2 LTE-Advanced component carriers, each carrier with 4x2 MIMO. Both carriers are generated within a single LTE band of max. 80 MHz bandwidth.

6.1.4.1 Instrument setup



6.1.4.2 SMW System Configuration



System configuration settings:	2 x 4 x 2	coupled sources
IQ stream mapper:	streams A and C summed into RF A	
	streams B and D summed into RF B	

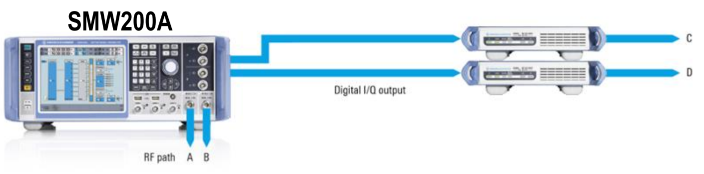
6.1.4.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
1x	SMW-K74	*MIMO/Routing*
2x	SMW-K55	*LTE*
2x	SMW-K85	*LTE-Advanced*
optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

6.1.5 LTE Carrier Aggregation (inter-band) with 4x2 MIMO

This example explains the needed configuration for a setup with 2 LTE-Advanced component carriers, each carrier with 4x2 MIMO. Both carriers are generated in different LTE bands.

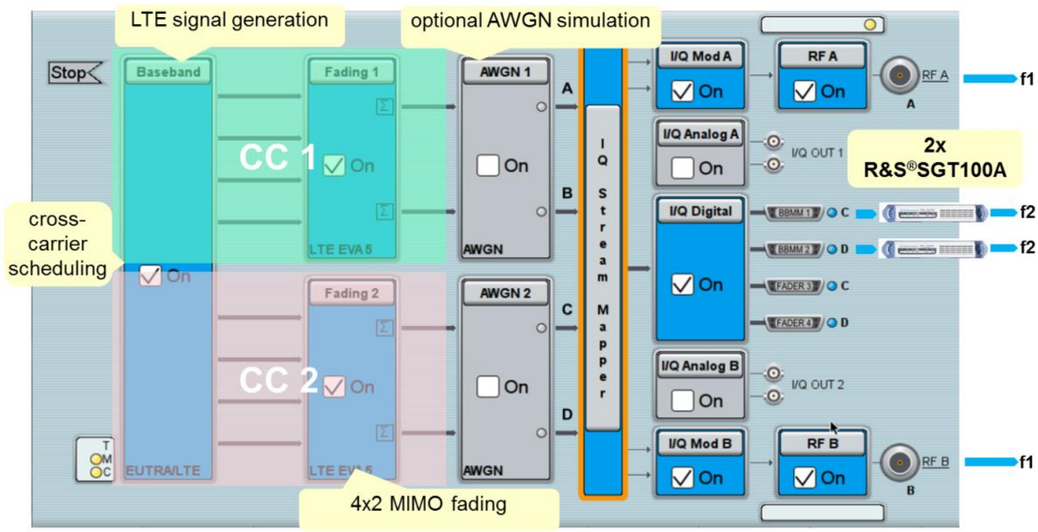
6.1.5.1 Instrument setup



DUT with 2 RX antennas
f_max = 6 GHz
BW_max = 80 MHz (per path)

10 MHz reference coupling between SMW and SGTs required.
The RF signals for Rx antenna 1 (streams A, C) need to be summed up via a 2-to-1 RF combiner and connected to Rx port 1 of the DUT.
The RF signals for Rx antenna 2 (streams B, D) need to be summed up via a 2-to-1 RF combiner and connected to Rx port 2 of the DUT.

6.1.5.2 SMW System Configuration



System configuration settings:	2 x 4 x 2	coupled sources
IQ stream mapper:	all streams routed to separate outputs	

6.1.5.3 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
1x	SMW-K74	*MIMO/Routing*
2x	SMW-K55	*LTE*
2x	SMW-K85	*LTE-Advanced*
2x	SMW-K18	*Digital baseband outputs*
optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

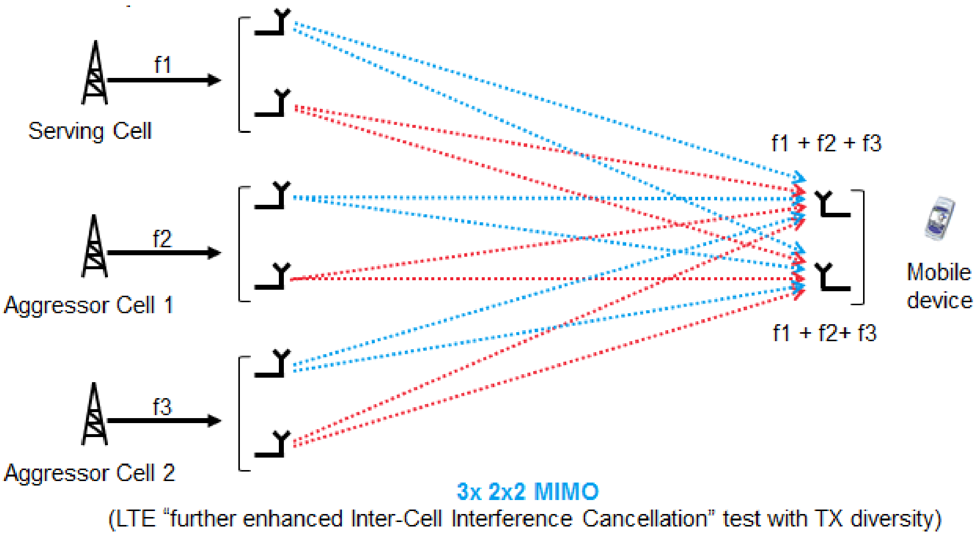
SGT		
mandatory options:		
2x	SGT100A	*Base unit, 3 GHz*
2x	SGT-K18	*Digital baseband connectivity*
optional add-on options:		
2x	SGT-KB106	*Upgrade to 6 GHz*

Accessories		
mandatory		
2x	2-to-1 RF combiner	*for RF signal combination*
2x	SMU-Z6	*R&S Digital IQ interface cable*

6.2 LTE feICIC (Rel.11): Simulation of 3 cells with 2x2 MIMO (3x2x2)

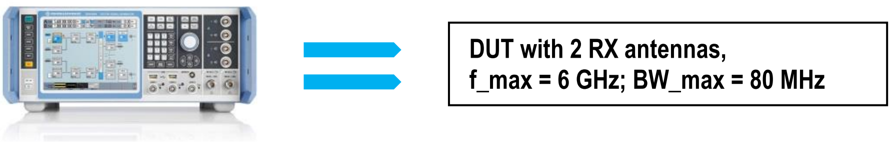
6.2.1 Application Description

LTE-Advanced Release 11 defines methods for interference coordination between multiple LTE cells. This LTE features is named “further enhanced Inter-Cell Interference Coordination (=feICIC)”. The test case in line with 3GPP TS 36.521 requires simultaneous simulation of three cells with 2x2 TX diversity.

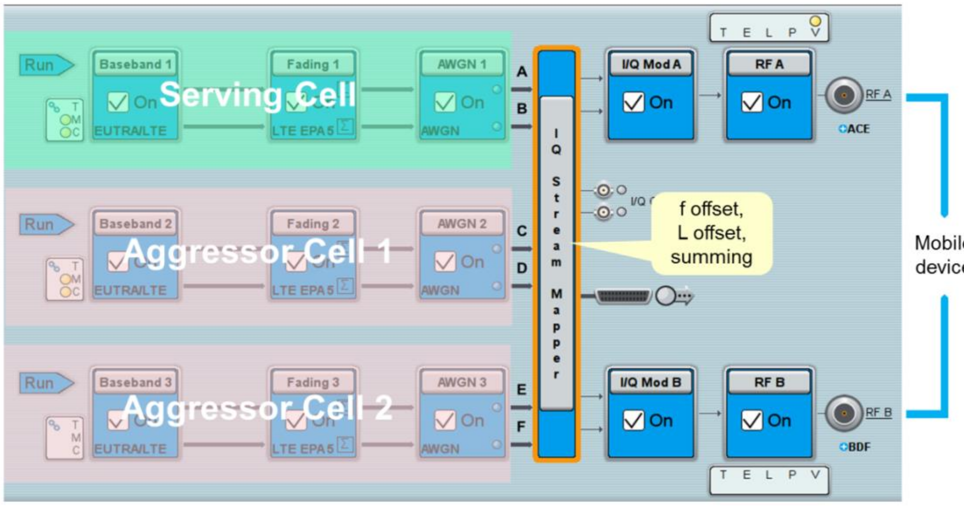


By means of the R&S®SMW200A the required serving cell as well as the two interfering aggressor cells can be simulated by a single instrument

6.2.2 Instrument setup



6.2.3 SMW System Configuration



System configuration settings:	3 x 2 x 2 coupled sources per entity
IQ stream mapper:	streams A, C, E summed into RF A
	streams B, D, F summed into RF B

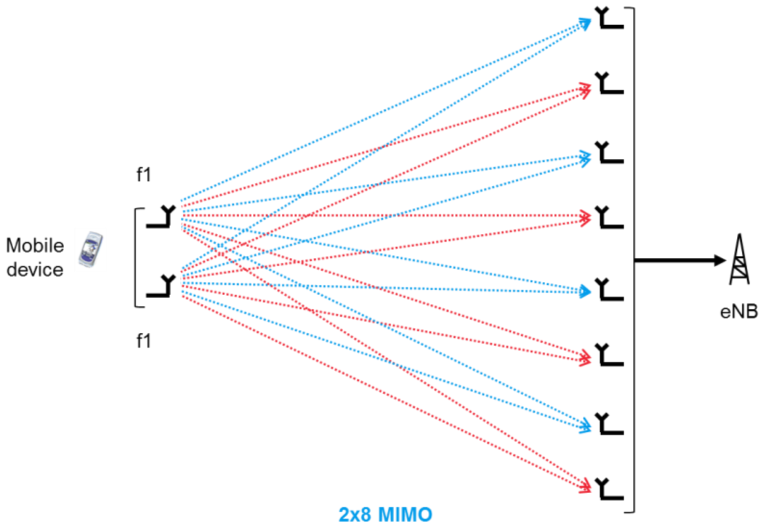
6.2.4 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
1x	SMW-K76	*Multiple entities*
4x	SMW-B14	*Fading module*
1x	SMW-K74	*MIMO/Routing*
2x	SMW-K55	*LTE*
2x	SMW-K85	*LTE-Advanced*
2x	SMW-K62	AWGN
2x	SMW-K112	*LTE Release 11 + enh. features*
optional add-on options:		
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

6.3 LTE with 2x8 uplink MIMO

6.3.1 Application Description

LTE defines a multitude of different MIMO modes for uplink and downlink. A common scenario, especially for TD-LTE is an eNB with 8 receive antennas and a mobile with 2 transmit antennas. Normally, such a setup would require 8 signal generators. With a dual-path SMW200A – by means of the SMW-K74 MIMO/Routing option – the baseband signals for such a test scenario can easily be generated. And with six additional SGT RF sources, eight correctly coded RF signals are available for enhanced eNB MIMO testing.

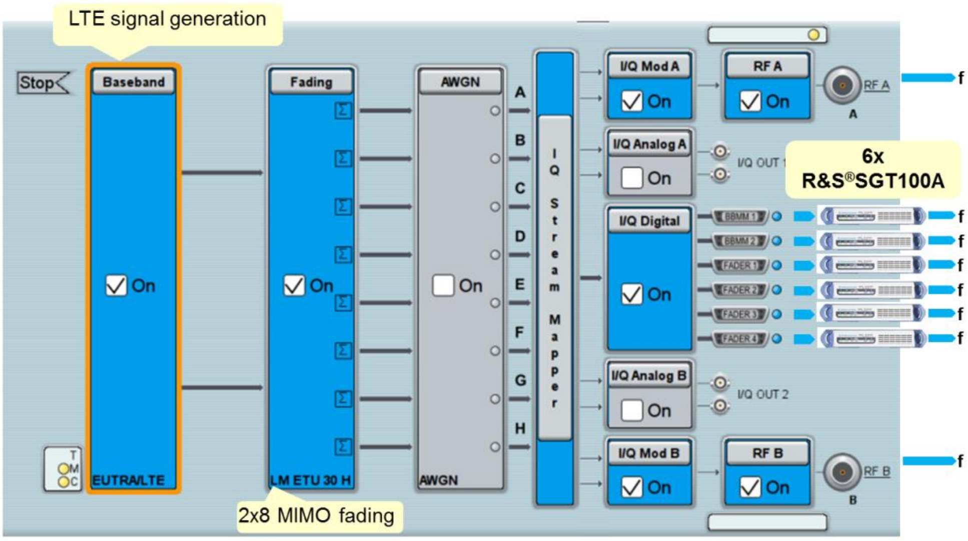


2x8 MIMO
(e.g. LTE Uplink MIMO with fading simulation)

6.3.2 Instrument setup

10 MHz reference coupling between SMW and SGTs required.
Each RF signal is to be connected to one of the 8 RX antennas of the DUT.

6.3.3 SMW System Configuration



System configuration settings:	1 x 2 x 8 coupled sources
IQ stream mapper:	all streams routed to separate outputs

6.3.4 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
4x	SMW-B14	*Fading module*
1x	SMW-K74	*MIMO/Routing*
2x	SMW-K55	*LTE*
2x	SMW-K85	*LTE-Advanced*
2x	SMW-K18	*Digital baseband outputs*
optional add-on options:		
2x	SMW-K62	AWGN
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

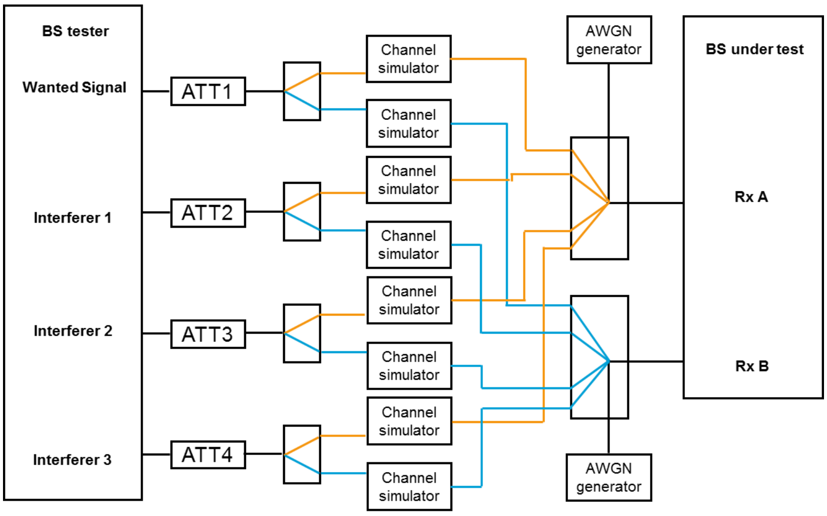
SGT		
mandatory options:		
6x	SGT100A	*Base unit, 3 GHz*
6x	SGT-K18	*Digital baseband connectivity*
optional add-on options:		
6x	SGT-KB106	*Upgrade to 6 GHz*

Accessories		
mandatory		
6x	SMU-Z6	*R&S Digital IQ interface cable*

6.4 LTE Multi-User PUCCH Test

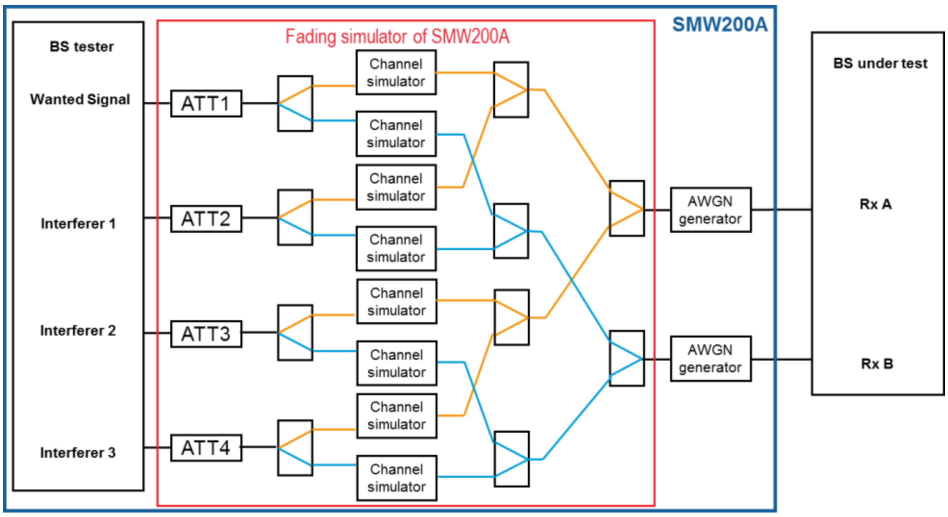
6.4.1 Application Description

The LTE base station conformance test specification 3GPP 36.141 (e.g. Version 11.9.0) defines the minimum required eNB test cases. A very challenging test case is ”ACK missed detection for multi user PUCCH format 1a” which is described in chapter 8.3.3. The needed test setup according to the standard is as follows:

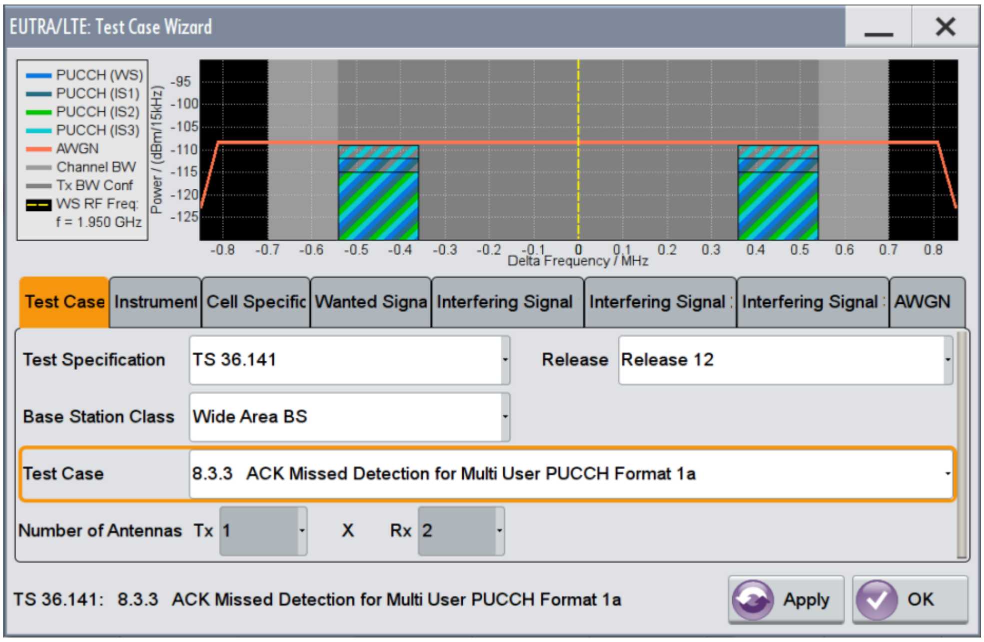


For this test case it is required to generate a wanted LTE signal and three interfering signals. These signals have to be supplied to a DUT with two RX antennas for antenna diversity testing. Additionally, the LTE test signals are faded (ETU70 profile) and AWGN of a certain carrier-to-noise ratio needs to be simulated for every receive antenna.

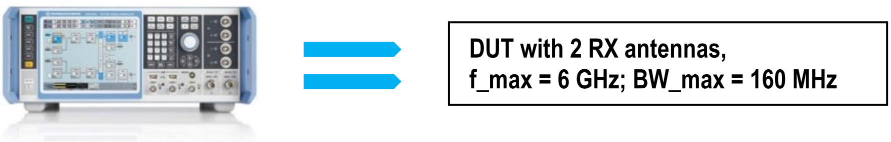
With the SMW, all four LTE test signals, fading as well as the AWGN can be generated by a single instrument, which minimizes the needed HW to realize this test case.



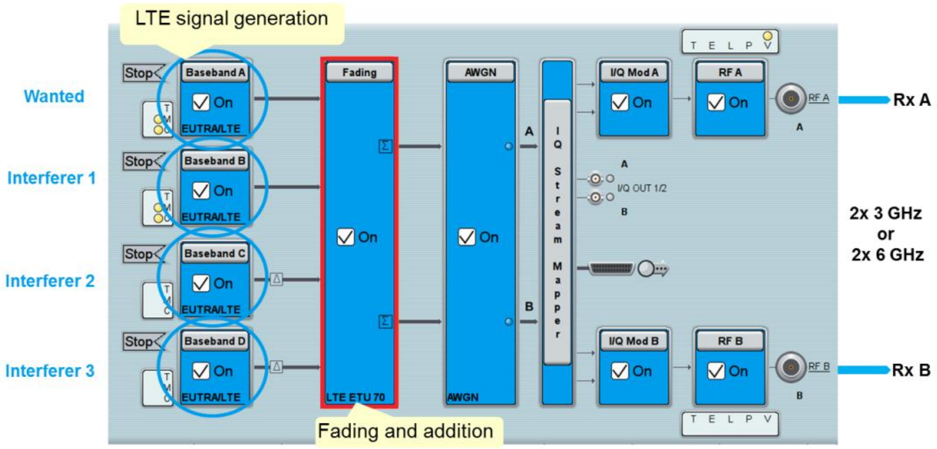
The instrument settings can conveniently by do done my selecting the base station test case ”8.3.3 ACK missed detection for multi user PUCCH format 1a” in the LTE test case wizard of the SMW.



6.4.2 Instrument setup



6.4.3 SMW System Configuration



System configuration settings:	1 x 4 x 2	separate sources
IQ stream mapper:	all streams routed to separate outputs (signal summation happens inside the fader)	

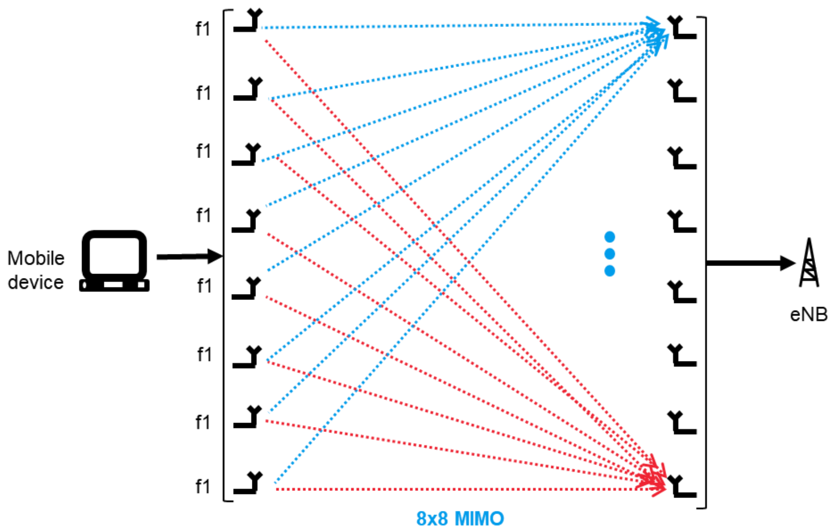
6.4.4 Recommended options

SMW		
mandatory options:		
1x	SMW200A	*Base unit*
1x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
1x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
2x	SMW-B10	*Baseband generator*
1x	SMW-B13T	*Baseband main module, 2 path*
4x	SMW-B14	*Fading module*
1x	SMW-K74	*MIMO/Routing*
2x	SMW-K55	*LTE*
2x	SMW-K62	AWGN
optional add-on options:		
2x	SMW-K522	*160 MHz BW extension*
2x	SMW-K511	*ARB memory ext. to 512 MS*
2x	SMW-K512	*ARB memory ext. to 1GS*

6.5 8x8 MIMO channel emulation

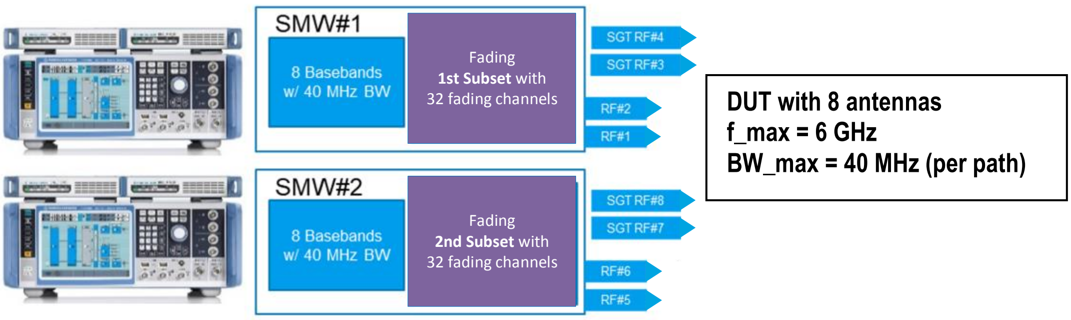
6.5.1 Application description

Standards like LTE feature 8x8 MIMO, one of the most complex MIMO scenario for wireless communication. It involves eight antennas on each side of the link, i.e. at the mobile device and at the base station (eNB). With its option SMW-K821 "MIMO Subsets for Higher Order MIMO Scenarios", the SMW handles this demanding application in a unique way: the option enables two SMWs to operate cooperatively to perform realtime 8x8 MIMO channel emulation. Additional SGT RF sources provide eight RF signals in total. The test solution addresses mobile device as well as base station receiver testing requirements for carrier frequencies up to 6 GHz and RF bandwidths up to 40 MHz.



6.5.2 Instrument setup

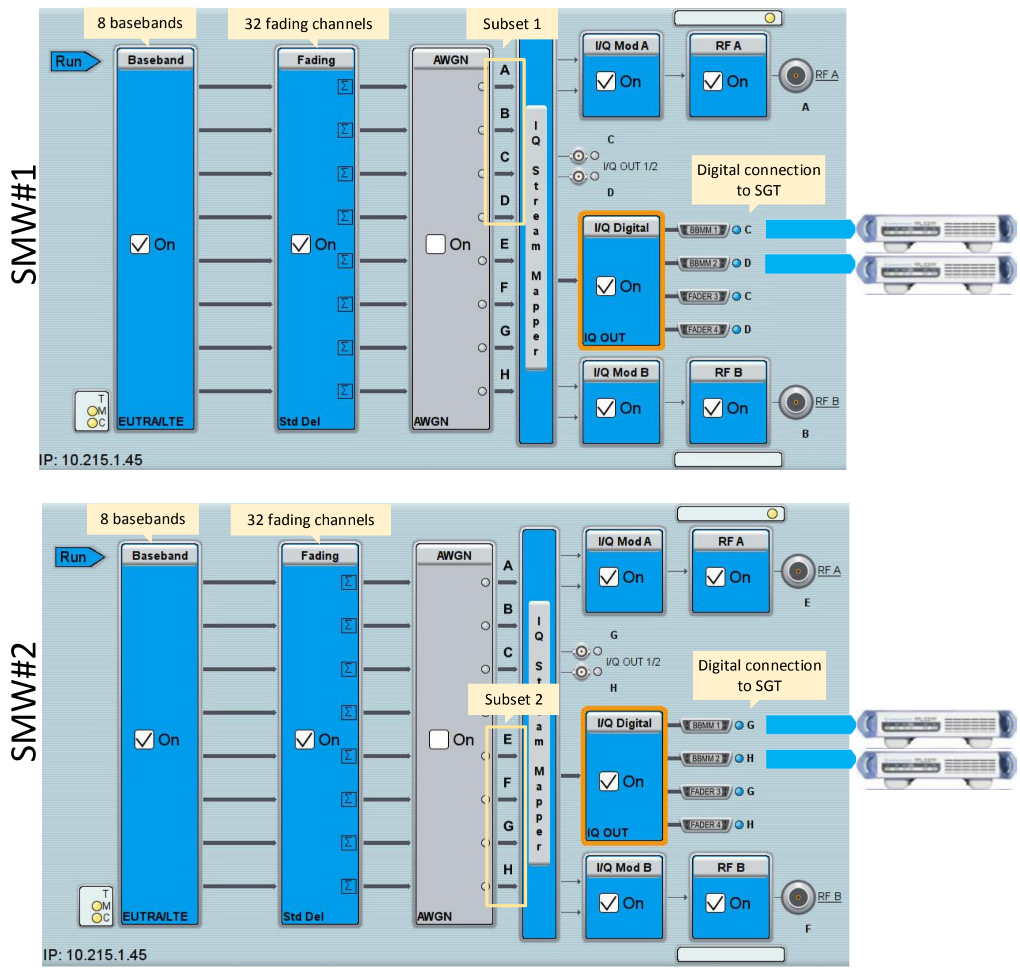
8x8 MIMO is supported by means of two SMWs (with MIMO fading capability and SMW-K821 option) and four SGTs.



10 MHz reference coupling between the two SMWs and the SGTs is required.
A trigger signal is required to synchronize the basebands of the two SMWs. Please see the SMW user manual for a detailed description in section “How to Generate an 8x8 MIMO Signal with Two R&S SMW”.
Each RF signal is to be connected to one of the eight antennas of the DUT.

6.5.3 SMW system configuration

The first SMW generates all eight TX antenna signals in its baseband and emulates 32 fading channels in realtime by means of its fading hardware. These 32 fading channels and the resulting four RX antenna signals are the first subset of the 8x8 MIMO scenario. The second SMW generates the same eight TX antenna signals (a copy) and emulates the remaining 32 fading channels in realtime (no copy). These additional 32 fading channels and the resulting four additional RX antenna signals are the second subset. In total, 64 fading channels are emulated and eight RX antenna signals are provided to test the DUT in an 8x8 MIMO scenario.



System configuration settings: 1 x 8 x 8 coupled sources

IQ stream mapper SMW#1: all streams (A to D, subset 1) routed to the separate outputs
IQ stream mapper SMW#2: all streams (E to H, subset 2) routed to the separate outputs

6.5.4 Recommended options

SMW		
mandatory options:		
2x	SMW200A	*Base unit*
2x	SMW-B103/-B106	*Frequency option for 1st path, 3 GHz or 6 GHz*
2x	SMW-B203/-B206	*Frequency option for 2nd path, 3 GHz or 6 GHz*
4x	SMW-B10	*Baseband generator*
2x	SMW-B13T	*Baseband main module, 2 path*
8x	SMW-B14	*Fading module*
2x	SMW-K74	*MIMO/Routing*
2x	SMW-K75	*Higher Order MIMO*
2x	**SMW-K821**	***MIMO Subsets***
4x	SMW-K18	*Digital baseband outputs*
optional add-on options:		
4x	SMW-K62	AWGN
4x	SMW-K511	*ARB memory ext. to 512 MS*
4x	SMW-K512	*ARB memory ext. to 1GS*

SGT		
mandatory options:		
4x	SGT100A	*Base unit, 3 GHz*
4x	SGT-K18	*Digital baseband connectivity*
optional add-on options:		
4x	SGT-KB106	*Upgrade to 6 GHz*

Accessories		
mandatory		
4x	SMU-Z6	*R&S Digital IQ interface cable*

7 Ordering Information

Please visit the Rohde & Schwarz product websites at www.rohde-schwarz.com for ordering information on the following Rohde & Schwarz products:

- R&S®SMW200A vector signal generator
- R&S®SGT100A SGMA vector RF source
- R&S®SGS100A SGMA RF source
- R&S®SGU100A SGMA Upconverter

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