LTE-A Base Station Transmitter Tests
According to TS 36.141 Rel. 10

Application Note

Products:
- R&S®FSW
- R&S®FSQ
- R&S®FSV
- R&S®SMW200A
- R&S®SMU200A
- R&S®SMBV100A
- R&S®SMJ100A

3GPP TS36.141 defines conformance tests for E-UTRA base stations (eNodeB). Release 10 (LTE-Advanced) added several tests, such as those for multicarrier scenarios.

This application note describes how all required transmitter (Tx) tests (TS36.141 Chapter 6) can be performed quickly and easily by using signal and spectrum analyzers from Rohde & Schwarz. A few tests additionally require signal generators from Rohde & Schwarz.

Examples illustrate the manual operation. A free software program enables and demonstrates remote operation.

The LTE base station receiver (Rx) tests (TS36.141 Chapter 7) are described in Application Note 1MA195.

The LTE base station performance (Px) tests (TS36.141 Chapter 8) are described in Application Note 1MA162.
# Table of Contents

1 Introduction......................................................................................... 4

2 General Transmitter Test Information............................................. 6
   2.1 Note ............................................................................................. 6
   2.2 Multicarrier Test Scenarios .......................................................... 6
   2.3 Tx Test Setup .............................................................................. 9
   2.4 Instruments and Options .............................................................. 10
   2.5 Multistandard Radios and TS 37.141 .......................................... 13

3 Transmitter Tests (Chapter 6)......................................................... 14
   3.1 Basic Operation ........................................................................ 15
   3.1.1 FSx Spectrum and Signal Analyzer ..................................... 15
   3.1.2 SMx Vector Signal Generator ............................................. 18
   3.1.3 R&S TSrun Demo Program .................................................. 21
   3.2 Base Station Output Power (Clause 6.2) ..................................... 27
   3.2.1 Home BS Output Power Measurements (Clause 6.2.6…6.2.8) .... 29
   3.3 Output Power Dynamics (Clause 6.3) ......................................... 51
   3.3.1 Total Power Dynamic Range (Clause 6.3.2) ............................ 51
   3.4 Transmit ON/OFF Power (Clause 6.4) ....................................... 53
   3.5 Transmitted Signal Quality (Clause 6.5) ..................................... 57
   3.5.1 Frequency Error (Clause 6.5.1) and Error Vector Magnitude (Clause 6.5.2) .... 57
   3.5.2 Time Alignment Error (Clause 6.5.3) ................................... 59
   3.5.3 DL RS Power (Clause 6.5.4) ................................................ 64
   3.6 Unwanted Emissions (Clause 6.6) ............................................... 65
   3.6.1 Occupied Bandwidth (Clause 6.6.1) .................................... 66
   3.6.2 Adjacent Channel Leakage Power (ACLR) (Clause 6.6.2) ....... 68
   3.6.3 Operating Band Unwanted Emissions (SEM) (Clause 6.6.3) ...... 76
   3.6.4 Transmitter Spurious Emissions (Clause 6.6.4) ...................... 78
   3.7 Transmitter Intermodulation (Clause 6.7) ................................... 82

4 Appendix ............................................................................................ 91
   4.1 R&S TSrun Program ................................................................ 91
   4.2 References ............................................................................... 96
   4.3 Additional Information ............................................................ 97
   4.4 Ordering Information ............................................................... 97
The following abbreviations are used in this Application Note for Rohde & Schwarz test equipment:

- The R&S®SMW200A vector signal generator is referred to as the SMW.
- The R&S®SMATE200A vector signal generator is referred to as the SMATE.
- The R&S®SMU200A vector signal generator is referred to as the SMU.
- The R&S®SMBV100A vector signal generator is referred to as the SMBV.
- The R&S®FSQ signal analyzer is referred to as the FSQ.
- The R&S®FSV spectrum analyzer is referred to as the FSV.
- The R&S®FSW spectrum analyzer is referred to as the FSW.
- The SMW, SMATE, SMBV and SMU are referred to as the SMx.
- The FSQ, FSV and FSW are referred to as the FSx.
- The software R&S®TSrun is referred to as the TSrun.
- The software *E-UTRA/LTE and LTE- Advanced Signal Analysis* is referred to as the PC-SW.
1 Introduction

Long Term Evolution (LTE) networks or Evolved Universal Terrestrial Radio Access (E-UTRA) (from Releases 8 and 9) have long since been introduced into daily usage. As a next step, 3GPP has added several extensions in Release 10, known as LTE-Advanced (LTE-A). These include a multicarrier aggregation option, changes to MIMO (up to 8x8 in the downlink and introduction of MIMO in the uplink).

An overview of the technology behind LTE and LTE-Advanced is provided in Application Note 1MA111.

The LTE-A conformance tests for base stations (eNodeB) are defined in 3GPP TS 36.141 Release 10 [1] and include transmitter (Tx), receiver (Rx) and performance (Px) tests. T&M instruments from Rohde & Schwarz can be used to perform all tests easily and conveniently.

This application note describes the transmitter (Tx) tests in line with TS36.141 Chapter 6. It explains the necessary steps in manual operation for signal and spectrum analyzers and signal generators. A free remote-operation software program is additionally provided. With this software, users can remotely control and demo tests on base stations quickly and easily. It also provides the SCPI commands required to implement each test in user-defined test programs.

The receiver (Rx) tests (TS36.141 Chapter 7) are described in Application Note 1MA195 and the performance (Px) tests (TS36.141 Chapter 8) are covered in Application Note 1MA162.

The following abbreviations are used in this application note:

<table>
<thead>
<tr>
<th>Abbreviations for 3GPP standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS 36.141</td>
</tr>
<tr>
<td>E-UTRA FDD or TDD</td>
</tr>
<tr>
<td>UTRA-FDD</td>
</tr>
<tr>
<td>UTRA-TDD</td>
</tr>
<tr>
<td>GSM, GSM/EDGE</td>
</tr>
</tbody>
</table>

Table 1-1: Abbreviations for 3GPP standards

Table 1-2 gives an overview of the Transmitter tests defined in line with Chapter 6 of TS36.141. All can be carried out using instruments from Rohde & Schwarz. These tests are individually described in this application note.
### Covered TX tests

<table>
<thead>
<tr>
<th>Chapter (TS36.141)</th>
<th>Test</th>
</tr>
</thead>
<tbody>
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<td><strong>Base station output power</strong></td>
<td></td>
</tr>
<tr>
<td>6.2</td>
<td>Base station output power</td>
</tr>
<tr>
<td>6.2.6</td>
<td>Home BS output power for adjacent channel WCDMA protection</td>
</tr>
<tr>
<td>6.2.7</td>
<td>Home BS output power for adjacent channel LTE protection</td>
</tr>
<tr>
<td>6.2.8</td>
<td>Home BS output power for co-channel LTE protection</td>
</tr>
<tr>
<td><strong>Output power dynamics</strong></td>
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</tr>
<tr>
<td>6.3.2</td>
<td>Total dynamic range</td>
</tr>
<tr>
<td><strong>Transmit ON/OFF power</strong></td>
<td></td>
</tr>
<tr>
<td>6.4</td>
<td>Transmit ON/OFF power</td>
</tr>
<tr>
<td><strong>Transmitter signal quality</strong></td>
<td></td>
</tr>
<tr>
<td>6.5.1</td>
<td>Frequency error</td>
</tr>
<tr>
<td>6.5.2</td>
<td>Error vector magnitude</td>
</tr>
<tr>
<td>6.5.3</td>
<td>Time alignment error</td>
</tr>
<tr>
<td>6.5.4</td>
<td>DL RS power</td>
</tr>
<tr>
<td><strong>Unwanted emissions</strong></td>
<td></td>
</tr>
<tr>
<td>6.6.1</td>
<td>Occupied bandwidth</td>
</tr>
<tr>
<td>6.6.2</td>
<td>Adjacent channel leakage power ratio</td>
</tr>
<tr>
<td>6.6.3</td>
<td>Operating band unwanted emissions</td>
</tr>
<tr>
<td>6.6.4</td>
<td>Transmitter spurious emissions</td>
</tr>
<tr>
<td><strong>Transmitter intermodulation</strong></td>
<td></td>
</tr>
<tr>
<td>6.7</td>
<td>Transmitter intermodulation</td>
</tr>
</tbody>
</table>

**Table 1-2: Covered TX tests**
2 General Transmitter Test Information

2.1 Note

Very high power occurs on base stations! Be sure to use suitable attenuators in order to prevent damage to the test equipment.

2.2 Multicarrier Test Scenarios

Multicarrier configurations are a significant portion of LTE-A according to Rel. 10. These allow multiple carriers (even those using a different radio access technology) to be transmitted simultaneously, but independently of one another, from a single base station (multicarrier, MC). Another special attribute of LTE-A is the ability to link multiple carriers using carrier aggregation (CA). This allows an increase in the data rate to an individual subscriber (user equipment, UE). Overlapping of adjacent carriers is also possible, making more effective use of the bandwidth.

A distinction is made between the following CA scenarios:

- Intra-band contiguous
- Inter-band non-contiguous

Intra-band contiguous carrier aggregation

In this scenario, multiple carriers are transmitted in parallel within a single bandwidth of an LTE operating band (bands 1 to 25 for FDD and 33 to 43 for TDD; see [1]). Fig. 2-1 defines carrier aggregation. Table 2-1 lists the CA bands defined in [1]. This scenario is currently possible in bands 1 and 40.
Fig. 2-1: Definition of intra-band contiguous carrier aggregation [1].

<table>
<thead>
<tr>
<th>Intra-band contiguous CA operating bands</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTE CA Band</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>CA_1</td>
</tr>
<tr>
<td>CA_40</td>
</tr>
</tbody>
</table>

Table 2-1: List of bands for intra-band CA

The distance between the individual carriers is calculated as follows:

$$\left| BW_{Channel_1} + BW_{Channel_2} - 0.1BW_{Channel_1} - BW_{Channel_2} \right| 0.3$$

Fig. 2-2: Possible offset between two carriers.
Inter-band non-contiguous carrier aggregation

Carrier aggregation is also possible across multiple frequency bands. At present, this is possible with bands 1 and 5:

<table>
<thead>
<tr>
<th>LTE CA Band</th>
<th>LTE Band</th>
<th>Uplink (DL) operating band</th>
<th>Downlink (DL) operating band</th>
<th>Duplex Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA_1-5</td>
<td>1</td>
<td>1920 – 1980</td>
<td>2110 – 2170</td>
<td>FDD</td>
</tr>
<tr>
<td>CA_1-5</td>
<td>5</td>
<td>824 – 849</td>
<td>869 – 894</td>
<td></td>
</tr>
</tbody>
</table>

Table 2-2: Inter-band non-contiguous CA

Test scenarios for multicarrier tests

To make transmitter tests easy and comparable, TS36.141 Chapter 4.10 [1] defines multicarrier test scenarios. All Tx tests, with the exception of the occupied bandwidth test, follow these basic steps:

1. Within the maximum available bandwidth, the narrowest supported LTE carrier is placed at the lower edge.
2. A 5 MHz carrier is placed at the higher edge.
3. The remaining free spectrum, starting from the right, is filled with 5 MHz carriers until no more carriers fit into the remaining bandwidth.
4. If the base station does not support 5 MHz carriers, then the narrowest supported carrier is used instead.
5. The offset to the edges is as shown in Table 2-3. There are no precise specifications for the bandwidths 1.4 MHz and 3 MHz.

<table>
<thead>
<tr>
<th>Channel bandwidth [MHz]</th>
<th>$F_{offset}$ [MHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4, 3.0</td>
<td>Not defined</td>
</tr>
<tr>
<td>5, 10, 15, 20</td>
<td>$BW_{Channel}/2$</td>
</tr>
</tbody>
</table>

Table 2-3: Calculation of $F_{offset}$
Example

The process for multicarrier configuration is explained based on an example (fictitious) base station using the following parameters:

1. Aggregated channel bandwidth \( (BW_{Channel,CA}) = 20 \text{ MHz} \)
2. Support for 1.4 MHz and 5 MHz

1. The 1.4 MHz carrier is placed at the lower edge; the offset is not defined. \( F_{offset} = 0.7 \text{ MHz} \) is used.
2. The first 5 MHz carrier is placed at the upper edge at an offset of 2.5 MHz.
3. The remaining two 5 MHz carriers are placed following the above formula at an offset of 4.8 MHz from the adjacent carrier to the right (carrier aggregation, CA). No additional carriers fit in the spectrum, leaving a free area of 4 MHz (Fig. 2-3).

Fig. 2-3: Example MC scenario. \( BW_{Channel,CA} \) is 20 MHz. One 1.4 MHz carrier and three 5 MHz carriers fit into the 20 MHz bandwidth.

2.3 Tx Test Setup

Fig. 2-4 shows the basic setup for the Tx test. An FSx is used to perform the test. An attenuator connects the FXs to the DUT. An external trigger is additionally required for some tests (such as TDD tests). In several tests, the SMx feeds an additional signal
via a circulator. A few tests (on/off power and time alignment) require special setups; these are described in the respective sections.

Fig. 2-4: Basic Tx test setup; some tests require a special setup.

### 2.4 Instruments and Options

Several different spectrum analyzers can be used for the tests described here:

- FSW
- FSQ
- FSV

The **E-UTRA/LTE measurements** software option is available for each of the listed analyzers. The following are needed for the Tx tests:

- FSx-K100  E-UTRA/LTE FDD downlink measurements
- FSx-K102  E-UTRA/LTE downlink MIMO measurements
- FSx-K104  E-UTRA/LTE TDD downlink measurements
Test instruments can also be controlled via the external PC software application **E-UTRA/LTE and LTE-Advanced Signal Analysis**:

- FSx-K100PC  E-UTRA/LTE FDD downlink measurements
- FSx-K102PC  E-UTRA/LTE downlink MIMO measurements
- FSx-K104PC  E-UTRA/LTE TDD downlink measurements

This software requires either an installed option (FSx-K10x; see above) on the test instrument or else a dongle installed on a PC. The PC SW can also be used to control an RTO oscilloscope as a test instrument.

![Fig. 2-5: LTE FW option versus external PC SW.](image)

A few tests require additional signals; for example, to simulate adjacent carriers. These are provided via vector signal generators. The following are suitable:

- SMW
- SMU
- SMJ
- SMATE
- SMBV

One of the tests (home BS output power with co-channel LTE and option 2) requires two LTE signals. These signals can be generated by using a two-path generator or by adding a generator. The following software options are required:

- SMx-K55  LTE
- SMx-K42  W-CDMA
- SMx-K62  AWGN

**Table 2-4** gives an overview of the required instruments and options.
Table 2-4: Overview of required instruments and software options

<table>
<thead>
<tr>
<th>Number</th>
<th>Measurement</th>
<th>LTE analysis</th>
<th>LTE SW</th>
<th>Interferer</th>
<th>Simulation</th>
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<tr>
<td></td>
<td></td>
<td>FSX</td>
<td>FS/K00</td>
<td>SMx</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FS/K104</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>TDD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>FS/K104</td>
<td></td>
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<td>6.2</td>
<td>Base station output power</td>
<td>☑</td>
<td>☑</td>
<td></td>
<td>K-42, K-62</td>
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<tr>
<td>6.2.6</td>
<td>Home BS with adjacent W-CDMA</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>K-65, K-62</td>
</tr>
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<td>6.2.6</td>
<td>Home BS with adjacent LTE</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>K-65</td>
</tr>
<tr>
<td>6.2.6</td>
<td>Home BS with co-channel LTE</td>
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<td>☑</td>
<td>☑</td>
<td>K-55 (two paths), K-62</td>
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<td>6.3</td>
<td>Output power dynamics</td>
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<td></td>
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<tr>
<td>6.3.2</td>
<td>Total power dynamics</td>
<td>☑</td>
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<td>6.4</td>
<td>Transmit ON/OFF</td>
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<td>☑</td>
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<td>6.5</td>
<td>Transmitted signal quality</td>
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<td>Frequency error</td>
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<td>Error vector magnitude</td>
<td>☑</td>
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<td>6.5.3</td>
<td>Time alignment</td>
<td>☑</td>
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<td>☑</td>
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<td>6.6</td>
<td>Unwanted emissions</td>
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<td>Occupied bandwidth</td>
<td>B</td>
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<td>☑</td>
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<td>B</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6.7</td>
<td>Transmitter intermodulation</td>
<td>C</td>
<td></td>
<td>☑</td>
<td>K-65</td>
</tr>
</tbody>
</table>

- ☑ needed for the measurement
- ☑ can do the measurement
- ☑ needed for demonstration program
- B uses basic function of Spectrum Analyzer
- C Combined measurements: ACLR, SEM and Spurious emissions

Notes:
- 6.5.3 Time alignment for CA: RTO is recommended for the test
- 6.2.6 Home BS co-channel LTE: Simulation requires 3 LTE signals
2.5 Multistandard Radios and TS 37.141

TS 37.141 applies when more than one radio access technology (RAT) is supported on a signal base station (multi-RAT). The conformance specifications overlap for some Tx tests, which can alternatively be performed in line with 37.141. See TS37.141 [5] and Chapter 4.9 from TS36.141 [1]. Refer also to the application note Measuring Multistandard Radio Base Stations according to TS 37.141 [6].

<table>
<thead>
<tr>
<th>TS36.141 and TS37.141 RF requirement</th>
<th>Clause in TS36.141</th>
<th>Clause in TS 37.141</th>
</tr>
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<tbody>
<tr>
<td>Base station output power</td>
<td>6.2.5</td>
<td>6.2.1.5</td>
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<tr>
<td>Transmit ON/OFF power</td>
<td>6.4</td>
<td>6.4</td>
</tr>
<tr>
<td>Transmitter spurious emissions</td>
<td>6.6.4.5</td>
<td>6.6.1.5</td>
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<tr>
<td>Operating band unwanted emissions</td>
<td>6.6.3.5.1, 6.6.3.5.2</td>
<td>6.6.2.5</td>
</tr>
<tr>
<td>Transmitter intermodulation</td>
<td>6.7.5</td>
<td>6.7.5.1</td>
</tr>
</tbody>
</table>

Table 2-5: Overlaps between TS36.141 and TS37.141
3 Transmitter Tests (Chapter 6)

Specification TS36.141 defines the tests required in the various frequency ranges (bottom, middle, top, B M T) of the operating band. The same applies for multicarrier scenarios. In instruments from Rohde & Schwarz, the frequency range can be set to any frequency within the supported range independently of the operating bands.

In order to allow comparisons between tests, test models (TMs) standardize the resource block (RB) allocations. For LTE, these are called enhanced TMs (E-TM) to differentiate them from the TMs for W-CDMA. The E-TMs are stored as predefined settings in instruments from Rohde & Schwarz.

Table 3-1 provides an overview of the basic parameters for the individual tests. The chapter in TS36.141 and the corresponding chapter in the application note are both listed. Both the required E-TMs and the frequencies to be measured (B M T) are included. There is also a column listing the single carriers (SC) and multicarriers (MC) to be used for the test. The following terms are used:

- Any: Any supported channel BW
- Max: The maximum supported channel BW
- The occupied bandwidth must be measured using several different MC combinations
### Basic parameter overview

<table>
<thead>
<tr>
<th>Chapter</th>
<th>AppNote</th>
<th>Name</th>
<th>Test models</th>
<th>Channels</th>
<th>Single/Multi-carrier</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.2</td>
<td>3.2</td>
<td>BS Max Output Power</td>
<td>E-TM1.1</td>
<td>B M T</td>
<td>Max SC Max MC</td>
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<td>6.2.6</td>
<td>3.2.1</td>
<td>Home BS Output Power adjacent W-CDMA</td>
<td>E-TM1.1 (TM1)</td>
<td>M</td>
<td>Any SC</td>
<td></td>
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<tr>
<td>6.2.7</td>
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<td>Home BS Output Power adjacent LTE</td>
<td>E-TM1.1 (E-TM1.1)</td>
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<td>Any SC</td>
<td></td>
</tr>
<tr>
<td>6.2.6</td>
<td></td>
<td>Home BS Output Power co-channel LTE</td>
<td>E-TM1.1 (any)</td>
<td>M</td>
<td>Any SC</td>
<td></td>
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<td>3.3.1</td>
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<td>B M T</td>
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<td>3.4</td>
<td>Transmit ON/OFF Power</td>
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<td>Max SC Max MC</td>
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<td>3.5.1</td>
<td>Frequency Error</td>
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<td>B M T</td>
<td>Any SC</td>
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<td>Error Vector Magnitude (EVM)</td>
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<td>Max SC Max MC</td>
<td>TX, MIMO CA</td>
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<td>3.5.3</td>
<td>Reference Symbol Power</td>
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<td>3.6.1</td>
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<td>Different MCs</td>
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<td>6.6.2</td>
<td>3.6.2</td>
<td>Adjacent Channel Leakage Power (ACLR)</td>
<td>E-TM1.2</td>
<td>B M T</td>
<td>Any SC</td>
<td>Max MC</td>
</tr>
<tr>
<td>6.6.3</td>
<td>3.6.3</td>
<td>Operating Band Unwanted Emissions (SEM)</td>
<td>E-TM1.1</td>
<td>B M T</td>
<td>Any SC</td>
<td></td>
</tr>
<tr>
<td>6.6.4</td>
<td>3.6.4</td>
<td>Transmitter Spurious Emissions</td>
<td>E-TM1.1</td>
<td>B M T</td>
<td>Any SC</td>
<td></td>
</tr>
<tr>
<td>6.7</td>
<td>3.7</td>
<td>Transmitter Intermodulation</td>
<td>E-TM1.1</td>
<td>B M T</td>
<td>Max SC Max MC</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-1: Basic parameter overview

### 3.1 Basic Operation

#### 3.1.1 FSx Spectrum and Signal Analyzer

Most of the tests described here follow the same initial steps. They are explained here once:

1. Launch the LTE test application
   a) FSW, FSV: Press the MODE key. Select **LTE**.
Transmitter Tests (Chapter 6)

Basic Operation

1. MA154e

Rohde & Schwarz

Fig. 3-1: FSW: launching the LTE option.

b) FSQ: Navigate through the lower hardkey menu bar. Select LTE.

c) PC SW: Launch the PC software and type in the remote address (see the manual)

2. Choose Downlink as the direction

3. Set the duplex mode (FDD or TDD)

4. Select the wanted test model (E-TM) (example: 10 MHz with E-TM1.1)

Fig. 3-2: FSW: setting duplex mode, direction, and test model.

Tx tests can be fundamentally divided into demodulation tests and spectrum measurements. In demodulation tests, the LTE signal is acquired and then various test results are calculated based on the I/Q data. Spectrum measurements determine the level versus frequency of a selected signal. Fig. 3-3 shows the available selection in the FSW.
For MC scenarios a special MC filter is available for the demodulation tests. It can be set under DEMOD. The filter minimizes influences from adjacent carriers:

An FSW is used whenever possible in the sections below to illustrate the test examples. Special settings such as external triggers for TDD signals are discussed in the individual sections.

5. Set the frequency

6. Set the attenuation and reference level (these settings are available via hardkey AMPT)

Fig. 3-5 shows the LTE demodulation measurement in the FSW.
3.1.2 SMx Vector Signal Generator

The SMx is used here to generate additional LTE or W-CDMA signals, such as interferers or adjacent channel signals. Only the basic steps for LTE are provided here. Several special settings are needed for the individual tests. Significantly different settings, such as those for W-CDMA, are discussed directly in the corresponding chapters.

1. Set the center frequency and the levels (Freq and Lev) (Fig. 3-6)
2. Select the LTE standard in baseband block A (E-UTRA/LTE) (Fig. 3-7)
Transmitter Tests (Chapter 6)

Basic Operation

**Fig. 3-6**: SMW: Setting the frequency and level. Digital standards such as LTE are set in the baseband block.

<table>
<thead>
<tr>
<th>TDMA Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM/EDGE...</td>
</tr>
<tr>
<td>Bluetooth...</td>
</tr>
<tr>
<td>TETRA...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CDMA Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>3GPP FDD...</td>
</tr>
<tr>
<td>CDMA2000...</td>
</tr>
<tr>
<td>TD-SCDMA...</td>
</tr>
<tr>
<td>1xEV-DO...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WLAN Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.11...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beyond 3G Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.16 WiMAX...</td>
</tr>
</tbody>
</table>

| EUTRA/LTE...                 |

<table>
<thead>
<tr>
<th>Broadcast Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVB...</td>
</tr>
</tbody>
</table>

**Fig. 3-7**: SMW: selecting LTE in the baseband block.
3. Make the basic settings such as **Duplexing** (FDD or TDD) and the **Link Direction** (normally **Downlink** (OFDMA); one test requires **Uplink**) (Fig. 3-8)

![Fig. 3-8: SMW: general LTE settings: duplexing, link direction.](image)

4. Select a filter. No filters are defined in the LTE. The SMx therefore offers several optimizations (Fig. 3-9).

![Fig. 3-9: SMW: selecting the LTE filter settings.](image)
3.1.3 **R&S TSrun Demo Program**

This Application Note comes with a demonstration program module called **LTE BS Tx Test** for the software **R&S TSrun** which is free of charge. The module covers all required tests (see table below).

The **LTE BS Tx Test** module represents a so called test for the TSrun software. See Section 4.1 for some important points on the basic operation of TSrun.

Each test described in this application note can be executed quickly and easily using the module. Additional individual settings can be applied.

The program offers a straightforward user interface, and SCPI remote command sequence export functions for integrating the necessary SCPI commands into any user-specific test environment. A measurement report will be generated on each run. It can be saved to a file in different formats including PDF and HTML.

Following SCPI resources are needed:

- FSx
- SMx

The module allows both the control of the LTE FW options on the FSx as well as the external PC software (Fig. 3-10).

---

**Fig. 3-10: Overview of the TSrun demo program and LTE test options.** In the setup on the left, TSrun directly controls the LTE FW option on the FSx via VISA. The setup on the right shows the control using the external PC software. In this case, both the PC software and TSrun run on the same PC. TSrun directly controls the PC software.
## Overview: Test cases supported by the program

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Name</th>
<th>FSW</th>
<th>PC SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.2</td>
<td>BS Max Output Power</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>6.2.6</td>
<td>Home BS Output Power adjacent W-CDMA</td>
<td>☑</td>
<td>─</td>
</tr>
<tr>
<td>6.2.7</td>
<td>Home BS Output Power adjacent LTE</td>
<td>☑</td>
<td>─</td>
</tr>
<tr>
<td>6.2.6</td>
<td>Home BS Output Power co-channel LTE</td>
<td>☑</td>
<td>─</td>
</tr>
<tr>
<td>6.3.2</td>
<td>Total Power Dynamic Range</td>
<td>☑</td>
<td>─</td>
</tr>
<tr>
<td>6.4</td>
<td>Transmit ON/OFF Power</td>
<td>☑</td>
<td>☒</td>
</tr>
<tr>
<td>6.5.1</td>
<td>Frequency Error</td>
<td>☑</td>
<td>─</td>
</tr>
<tr>
<td>6.5.2</td>
<td>Error Vector Magnitude (EVM)</td>
<td>☑</td>
<td>─</td>
</tr>
<tr>
<td>6.5.3</td>
<td>Time Alignment Error</td>
<td>☑</td>
<td>─</td>
</tr>
<tr>
<td>6.5.4</td>
<td>Reference Symbol Power</td>
<td>☑</td>
<td>─</td>
</tr>
<tr>
<td>6.6.1</td>
<td>Occupied Bandwidth</td>
<td>☑¹</td>
<td>☑¹</td>
</tr>
<tr>
<td>6.6.2</td>
<td>Adjacent Channel Leakage Power (ACLR)</td>
<td>☑</td>
<td>☒</td>
</tr>
<tr>
<td>6.6.3</td>
<td>Operating Band Unwanted Emissions (SEM)</td>
<td>☑</td>
<td>☒²</td>
</tr>
<tr>
<td>6.6.4</td>
<td>Transmitter Spurious Emissions</td>
<td>☑¹</td>
<td>☑¹</td>
</tr>
<tr>
<td>6.7</td>
<td>Transmitter Intermodulation</td>
<td>☑</td>
<td>☒</td>
</tr>
</tbody>
</table>

☑ Supported by the demo program
─ not stipulated (but can be done carrier by carrier)
☒ Not supported.

### Getting started

This section describes only the module for the **LTE BS Tx tests**. Double-click the test to open the window for entering parameters.
**General settings**

The basic parameters are set at the top right:

- **Reset Devices**: Sends a reset command to all connected instruments
- **Simulation**: Generates a signal using the SMx for demonstration purposes.
- **Ext. PC-SW**: Check this to use the external PC software. The PC software must already be running and configured on the same computer. As the PC software controls the FSx, the remote address of the FSx must be set in the PC software. Use *localhost* as the remote address to control the PC software with TSrun.
- **External ref**: Switches the FSx over to an external reference source (typ. 10 MHz).
Basic Operation

Fig. 3-12: General settings.

The **Attenuation** section is used to enter compensations for external path attenuations.

![Fig. 3-12: General settings.](image)

Fig. 3-13: Attenuation settings.

**Test cases**

This is the main parameter. Select the wanted test case here. All other remaining parameters in the window are grayed out or set active based on the requirements for the selected test case. These parameters are described in detail in the individual sections below.

![Fig. 3-14: Available test cases.](image)
Based on the selected test case, helpful hints are provided in the Comments section and an illustration of the basic test setup is displayed.

**Comments:**

<table>
<thead>
<tr>
<th>6.2 BS Max Output Power:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measures the output power by demodulating the signal. E-TM1.1 at maximum power shall be used. SC and MC configurations are possible. Note: Simulation uses path 1 of SMx.</td>
</tr>
</tbody>
</table>

Fig. 3-15: Brief notes are provided in the Comments section (top right) based on the selected test case.

**Test Setup for Tx Tests:**

<table>
<thead>
<tr>
<th>BS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATT</td>
</tr>
<tr>
<td>FSx</td>
</tr>
</tbody>
</table>

Fig. 3-16: The Test Setup section (bottom right) displays a basic setup for the selected test case along with the location of the signals in the spectrum.

**Settings for measured signal**

Use this section to define the basic parameters for the LTE signal to be measured:

- **Center Frequency** for SC
- The test model **E-TM** (E-TM1.1 is required for most test cases)
- **Duplexing Mode**
- **Ref. Level**: Set here the expected reference level.
- **Bandwidth**
Multi-Carrier

Several tests can be carried out with MC. Selecting the Multi-Carrier option grays out the center frequency and bandwidth parameters and allows you to enter up to ten carriers along with their frequency and bandwidth.

**Note:** No logical checks of the MC settings are made. The frequencies must be entered in rising sequence. In other words, start with TX1 for the lowest frequency and then enter each subsequent frequency, ending with the highest frequency.
More advanced settings for specific tests cases are described in the corresponding sections below.

### 3.2 Base Station Output Power (Clause 6.2)

The rated output power (PRAT) of the base station is the mean power level per carrier for BS operating in single carrier, multicarrier, or carrier aggregation configurations that the manufacturer has declared to be available at the antenna connector during the transmitter ON period [1].

The test is performed for SC as well as MC.

The power declared by the manufacturer must not exceed the values specified in Table 3-2. Table 3-3 shows the allowed tolerances.

<table>
<thead>
<tr>
<th>BS class</th>
<th>PRAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide Area BS</td>
<td>No upper limit</td>
</tr>
<tr>
<td>Local Area BS</td>
<td>≤ ±24 dBm</td>
</tr>
<tr>
<td>Home BS</td>
<td>≤ ±20 dBm</td>
</tr>
</tbody>
</table>

The limit is lower by 3 dB for two ports, by 6 dB for four ports and 9 dB for eight ports for Local Area and Home BS.

<table>
<thead>
<tr>
<th>Maximum rated output power for different BS classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS class</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Wide Area BS</td>
</tr>
<tr>
<td>Local Area BS</td>
</tr>
<tr>
<td>Home BS</td>
</tr>
</tbody>
</table>

Table 3-2: Maximum rated output power
Requirements for BS output power

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>f ≤ 3.0 GHz</td>
<td>±2.7 dB</td>
</tr>
<tr>
<td>3.0 GHz &lt; f ≤ 4.2 GHz</td>
<td>±3.0 dB</td>
</tr>
</tbody>
</table>

Relaxed limits apply for extreme conditions

Table 3-3: Limits for BS output power

Test setup

Fig. 3-19: Test setup for BS output power.

The DUT (base station) transmits at the declared maximum PRAT. E-TM1.1 is required.

Procedure

The test can be performed in one of two different ways:

- Demodulation -> Result Summary: This method uses a single data record from the same test to obtain different values, such as EVM, frequency error, etc. The procedure follows the basic instructions provided in Section 3.1.1. The calculated power is displayed under Power (see Fig. 3-20).

- Channel Power / ACLR: This method can be used to determine the output power and the adjacent channel power simultaneously. Use as channel filter ‘Rect’.

Fig. 3-20: Output power in the result summary.

For MC scenarios, each carrier must be tested individually.

Demo program

No further special settings are needed for this test. The test is carried out as a demodulation. The output power and other measurements are reported. In the case of MC tests, each individual carrier is tested in sequence.
3.2.1 Home BS Output Power Measurements (Clause 6.2.6…6.2.8)

In addition to the general output power requirements, Release 10 also introduced special tests for home BS. There is no conventional network planning for home BS. Instead they are installed as a supplement to the various existing provider networks. This increases the risk of interference because the home BS can transmit on adjacent channels as well as on the same channels as an existing network. As a result, a home BS must adapt (reduce) its output power to the specific conditions. These scenarios are covered by the following requirements.

All three tests are required only for SC.

3.2.1.1 Home BS Output Power for Adjacent UTRA Channel Protection (Clause 6.2.6)

The Home BS shall be capable of adjusting the transmitter output power to minimize the interference level on the adjacent channels licensed to other operators in the same geographical area while optimizing the Home BS coverage. These requirements are only applicable to Home BS. The requirements in this clause are applicable for AWGN radio propagation conditions [1].

A W-CDMA signal is provided for the test on the adjacent channel. In addition, AWGN is simulated in the same channel of the wanted signal. The output power of the home BS is measured at different levels of the W-CDMA and the AWGN signals. $P_{out}$ must not exceed the values in Table 3-4 for the four different input parameter sets.
Transmitter Tests (Chapter 6)
Base Station Output Power (Clause 6.2)

![Diagram of power spectrum with LTE and W-CDMA bands, showing AWGN Co-channel Interference between F_{edge_low} and F_{edge_high}]

Fig. 3-22: Home BS with adjacent W-CDMA signal.

### Requirements based on input conditions

<table>
<thead>
<tr>
<th>Testcase</th>
<th>P\text{CPICH} (dBm)</th>
<th>P\text{Total} (dBm)</th>
<th>P\text{AWGN} (dBm)</th>
<th>Carrier/Noise (dB)</th>
<th>P\text{out} (dBm)</th>
<th>Limits (normal conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-80</td>
<td>-70</td>
<td>-50</td>
<td>-20</td>
<td></td>
<td>≤ 20</td>
</tr>
<tr>
<td>2</td>
<td>-90</td>
<td>-80</td>
<td>-60</td>
<td></td>
<td></td>
<td>≤ 10 + 2.7 dB (f ≤ 3 GHz)</td>
</tr>
<tr>
<td>3</td>
<td>-100</td>
<td>-90</td>
<td>-70</td>
<td></td>
<td></td>
<td>≤ 8 + 3.0 dB (3 GHz ≤ f ≤ 4.2 GHz)</td>
</tr>
<tr>
<td>4</td>
<td>-100</td>
<td>-90</td>
<td>-50</td>
<td></td>
<td></td>
<td>≤ 10</td>
</tr>
</tbody>
</table>

Table 3-4: Requirements for home BS with adjacent W-CDMA signal

### Test setup

The following setup is used for this test. The FSx measures via a circulator the output power (Tx) of the home BS. The SMx generates both the adjacent W-CDMA carrier and the AWGN and feeds the signal to the home BS via a circulator.

![Diagram of test setup with SMx generating W-CDMA and AWGN signals, FSx measuring Tx power, and ATTs attenuating signals]

Fig. 3-23: Test setup for a home BS with adjacent W-CDMA signal. The SMW generates both the W-CDMA signal and the AWGN. The analyzer measures the Tx power.
Overview of settings:

- The DUT (base station) generates the wanted signal at $F_c$ with $BW_{Channel}$ and E-TM1.1.
- The SMx generates the W-CDMA signal as adjacent channel with TM1, offset $F_c \pm BW_{Channel}/2 \pm 2.5$ MHz (to the right or left of the wanted signal)
- The SMx generates AWGN on the same channel as the wanted LTE signal of the DUT. The bandwidth corresponds to $BW_{Channel}$.

Procedure

The procedure is shown with an example of $BW_{Channel} = 20$ MHz and Testcase 1.

1. Set the frequency of the SMx to the center frequency of the wanted signal

Generating the W-CDMA signal in the adjacent channel

2. Select W-CDMA (3GPP FDD) in baseband block A (Fig. 3-24)

![Fig. 3-24: SMW: selecting the 3GPP FDD (W-CDMA) signal in the baseband block.](image)

3. Go to the Basestations tab (Fig. 3-25)
Transmitter Tests (Chapter 6)
Base Station Output Power (Clause 6.2)

1. **Base Station Output Power (Clause 6.2)**

Fig. 3-25: SMW: W-CDMA base stations.

4. Click **Test Setups/Models**

5. Select a TM1 (any number of channels) (Fig. 3-26)

Fig. 3-26: SMW: selecting TM1 for W-CDMA.

6. Switch on the baseband and set the frequency offset of the wanted LTE carrier in order to set the W-CDMA carrier in the adjacent channel: \( F_{\text{off}} = \frac{\text{BW}_{\text{LTE}}}{2} + 2.5 \text{ MHz} \) (example: \( F_{\text{off}} = \frac{20 \text{ MHz}}{2} + 2.5 \text{ MHz} = 12.5 \text{ MHz} \)) (Fig. 3-27 and Fig. 3-28)

Fig. 3-27: SMW: offsets in the baseband.
7. In the SMx, the default level for the P-CPICH is $-10$ dB relative to the total level of the SMx. Set the total level accordingly (example: Test Case 1: $P_{\text{CPICH}} = -80$ dBm: $P_{\text{total}} = -80$ dBm $- (-10$ dB) $= -70$ dBm)

8. Click the AWGN block and set the bandwidths (Fig. 3-30). (example: System BW = 18 MHz)
9. Go to the Noise Power / Output Results tab and enter the appropriate carrier/noise ratio from Table 3-4 (Fig. 3-31). (example: C/N = -20 dB, Noise Power = -70 dBm)
Transmitter Tests (Chapter 6)  
Base Station Output Power (Clause 6.2)

1MA154_4e  
Rohde & Schwarz  35

Fig. 3-31: AWGN: Setting the noise power relative to the carrier power via the carrier/noise ratio (e.g., the carrier power is $-70$ dBm, so the noise power in test case 1 should be $-50$ dBm: $-70$ dB $- (-50$ dB) = $-20$ dB).

Fig. 3-32: Overview of the SMW for W-CDMA with AWGN. The W-CDMA signal is offset to the adjacent channel in the baseband.

**Measurement with FSx**

Measure the $P_{out}$ of the home BS for all test cases (Table 3-4) and both offsets.

The test can be performed in one of two different ways:

- Demodulation -> Result Summary: This method uses a single data record from the same test to obtain different values, such as EVM, frequency error, etc. The
procedure follows the basic instructions provided in Section 3.1.1. The calculated power is displayed under **Power** (see Fig. 3-33).

- **Channel Power / ACLR:** This method can be used to determine the output power and the adjacent channel power simultaneously. Use as channel filter ‘Rect’.

![Frame Results Summary](image)

**Fig. 3-33: Output power in the result summary.**

### Demo program

For this test, additional parameters must be defined. The test is carried out as a demodulation measurement. The output power and other measurements are reported.

![Home BS Parameters](image)

**Fig. 3-34: Special settings for output power with adjacent W-CDMA.**

The level for the adjacent W-CDMA carrier and AWGN can be entered directly. Please note the settings from the specification listed in Table 3-4.

By default, the W-CDMA carrier is set to the right of the wanted signal. Checking **mirror** sets it to the left.
3.2.1.2 Home BS Output Power for Adjacent E-UTRA Channel Protection (Clause 6.2.7)

The Home BS shall be capable of adjusting the transmitter output power to minimize the interference level on the adjacent channels licensed to other operators in the same geographical area while optimizing the Home BS coverage. These requirements are only applicable to Home BS. The requirements in this clause are applicable for AWGN radio propagation conditions [1].

Fig. 3-36: Home BS with adjacent LTE signal.

An LTE signal is provided for the test on the adjacent channel. AWGN is also simulated in the same channel of the wanted signal. The output power measurements
for the home BS is to be measured at different levels of the LTE signal and the AWGN. $P_{\text{out}}$ must not exceed the values in Table 3-5 for the four different input parameter sets. In the specification, the level of the adjacent LTE signal is set via the reference symbol power using the formula $10 \cdot \log_{10}(N_{\text{DL}}^{\text{RB}} \cdot N_{\text{SC}}^{\text{RB}})$. Because the required test model E-TM1.1 assigns all RBs, the total level ($P_{\text{total}}$) can be entered directly and set on the SMx.

<table>
<thead>
<tr>
<th>Test case</th>
<th>$P_{\text{total}}$ (dBm)</th>
<th>$P_{\text{AWGN}}$ (dBm)</th>
<th>Carrier/Noise (dB)</th>
<th>$P_{\text{out}}$ (dBm)</th>
<th>Limits (normal conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-65</td>
<td>-50</td>
<td>-15</td>
<td>≤ 20</td>
<td>+2.7 dB (f ≤ 3 GHz)</td>
</tr>
<tr>
<td>2</td>
<td>-75</td>
<td>-60</td>
<td>-15</td>
<td>≤ 10</td>
<td>+3.0 dB (3 GHz ≤ f ≤ 4.2 GHz)</td>
</tr>
<tr>
<td>3</td>
<td>-90</td>
<td>-70</td>
<td>-20</td>
<td>≤ 8</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-90</td>
<td>-50</td>
<td>-40</td>
<td>≤ 10</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-5: Requirements for home BS with adjacent LTE signal

Test setup

The following setup is used for this test. The FSx measures via a circulator the output power (Tx) of the home BS. The SMx provides both the adjacent LTE carrier and the AWGN and feeds the signal to the home BS via a circulator.

Fig. 3-37: Test setup for a home BS with adjacent LTE signal. The SMW generates both the LTE signal and the AWGN.

Overview of settings:

- The DUT (base station) generates the wanted signal at $F_C$ with $\text{BW}_{\text{Channel}}$ and E-TM1.1.
- The SMx generates the LTE signal as an adjacent channel with the same $\text{BW}_{\text{Channel}}$ and E-TM1.1, offset $F_C \pm \text{BW}_{\text{Channel}}$ (to the right or left of the wanted signal).
- The SMx generates AWGN on the same channel as the wanted LTE signal of the DUT. The bandwidth corresponds to $\text{BW}_{\text{Channel}}$. 
Procedure

The procedure is shown with an example of $BW_{\text{Channel}} = 20$ MHz and Testcase 1.

1. Set the frequency of the SMx to the center frequency of the wanted signal

Generating the adjacent LTE signal

2. Generate an LTE signal that is equivalent to the wanted signal (see 3.1.2)
3. Select test model E-TM1.1. (Fig. 3-38)(example E-TM1.1 with 20 MHz)

4. Switch on the baseband and set the frequency offset of the wanted LTE carrier in order to set the LTE carrier in the adjacent channel: $F_{\text{off}} = BW_{\text{LTE}}$ (example. 20 MHz) (Fig. 3-39 and Fig. 3-40)

Fig. 3-38: Selecting the test model in LTE.

Fig. 3-39: SMW: offsets in the baseband.
Transmitter Tests (Chapter 6)

Base Station Output Power (Clause 6.2)

5. In the SMx, the total level is set over all RBs and the reference symbol power for each RE is entered relative to the total level (Fig. 3-41). Therefore, just set the total level based on Table 3-5.

![Baseband Offsets Table]

Fig. 3-40: Setting the frequency offset for the W-CDMA carrier (example: 20.0 MHz).

![LTE Signal Settings]

Fig. 3-41: LTE: displaying the RS power per RE.

**AWGN**

6. Click the AWGN block and set the bandwidths (Fig. 3-42). (example System Bandwidth = 18 MHz)
7. Go to the Noise Power / Output Results tab and enter the appropriate carrier/noise ratio from (Fig. 3-43).

Fig. 3-42: AWGN: setting the bandwidth (example: BW_{LTE} = 20 MHz \rightarrow \text{System BW}: 18 MHz).

Fig. 3-43: AWGN: Setting the noise power relative to the carrier power via the carrier/noise ratio (example: the carrier power is –65 dBm, so the noise power in test case 1 should be –50 dBm: –65 dB – (–50 dB) = –15 dB).
Measurement with FSx

Measure the $P_{\text{out}}$ of the home BS for all test cases (Table 3-5) and both offsets.

The test can be performed in one of two different ways:

- **Demodulation -> Result Summary**: This method uses a single data record from the same test to obtain different values, such as EVM, frequency error, etc. The procedure follows the basic instructions provided in Section 3.1.1. The calculated power is displayed under **Power** (see Fig. 3-44).

- **Channel Power / ACLR**: This method can be used to determine the output power and the adjacent channel power simultaneously. Use as channel filter ‘Rect’.

Fig. 3-44: Output power in the result summary.

**Demo program**

For this test, additional parameters must be defined. The test is carried out as a demodulation measurement. The output power and other measurements are reported.

Fig. 3-45: Special settings for output power with adjacent LTE.

The level for the adjacent LTE carrier and AWGN can be entered directly. Please note the settings from the specification listed in Table 3-5.

By default, the LTE carrier is set to the right of the wanted signal. Checking **mirror** sets it to the left.
3.2.1.3 **Home BS Output Power for Co-Channel E-UTRA Protection (Clause 6.2.8)**

To minimize the co-channel DL interference to non-CSG macro UEs operating in close proximity while optimizing the CSG Home BS coverage, Home BS may adjust its output power according to the requirements set out in this clause. These requirements are only applicable to Home BS. The requirements in this clause are applicable for AWGN radio propagation conditions [1].

A downlink LTE signal with different levels is provided for the test on the same channel. AWGN is also simulated in the same channel. The output power for the home BS is to be measured. For so called option 2, an LTE signal is additionally generated for the uplink.
Because no configurations are defined for the co-channel LTE signals, the test parameters can vary widely:

### Home BS output power for co-channel LTE

<table>
<thead>
<tr>
<th>Input Conditions</th>
<th>P_{out}</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{l}<em>{\text{oh}} (DL) &gt; \text{CRS} \text{Es} + 10 \log</em>{10}(\frac{N_{\text{DL}R}}{N_{\text{DLsc}}}) + 30 \text{ dB}</td>
<td>\leq 10 \text{ dBm}</td>
</tr>
<tr>
<td>\text{l}<em>{\text{oh}} (DL) \leq \text{CRS} \text{Es} + 10 \log</em>{10}(\frac{N_{\text{DL}R}}{N_{\text{DLsc}}}) + 30 \text{ dB}</td>
<td>\leq \max (-10 \text{ dBm}, \min (P_{\text{max}}, \text{CRS} \text{Es} + 10 \log_{10}(\frac{N_{\text{DL}R}}{N_{\text{DLsc}}}) + 30 \text{ dB}))</td>
</tr>
</tbody>
</table>

Table 3-6: Home BS output power for co-channel E-UTRA channel protection [1]

### Requirements based on input conditions for co-channel LTE

<table>
<thead>
<tr>
<th>Test case</th>
<th>P_{\text{DL}} (dBm)</th>
<th>P_{\text{AWGN}} (dBm)</th>
<th>P_{\text{UL}} (dBm)</th>
<th>P_{\text{rate}} (dBm)</th>
<th>Limits (normal conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-10 - 10 \log_{10}(\frac{N_{\text{DL}R}}{N_{\text{DLsc}}}) -50</td>
<td>-50</td>
<td>-98</td>
<td>See condition defined in table 3-6</td>
<td>+2.7 dB (f \leq 3 \text{ GHz}) +3.0 dB (3 \text{ GHz} \leq f \leq 4.2 \text{ GHz})</td>
</tr>
<tr>
<td>2</td>
<td>-20 - 10 \log_{10}(\frac{N_{\text{DL}R}}{N_{\text{DLsc}}}) -60</td>
<td>-60</td>
<td>-98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-40 - 10 \log_{10}(\frac{N_{\text{DL}R}}{N_{\text{DLsc}}}) -70</td>
<td>-70</td>
<td>-98</td>
<td>See condition defined in table 3-6</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-90 - 10 \log_{10}(\frac{N_{\text{DL}R}}{N_{\text{DLsc}}}) -50</td>
<td>-50</td>
<td>-98</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3-7: Requirements based on input conditions for co-channel LTE

The example below uses E-TM1.1 for the downlink signal and FRC1 for the uplink signal, which simplifies the settings (see Table 3-8).
Transmitter Tests (Chapter 6)
Base Station Output Power (Clause 6.2)

Test setup

The following setup is used for this test. The FSx measures via circulator the output power (Tx) of the home BS. The SMx provides both the adjacent downlink LTE carrier and the AWGN and feeds the signal to the home BS via a circulator. For option 2, the SMx additionally provides the LTE uplink signal via the second path.

![Test setup diagram](image)

**Fig. 3-48:** Test setup for a home BS with co-channel LTE signal. The SMW generates both the LTE signal and the AWGN.

Overview of settings:

1. The DUT (base station) generates the wanted signal at $F_c$ with $BW_{channel}$ and E-TM1.1.
2. The SMx generates the co-channel LTE downlink signal with the same $BW_{channel}$. There is no special configuration required.
3. The SMx generates AWGN on the same channel as the wanted LTE signal of the DUT. The bandwidth corresponds to $BW_{channel}$.
4. For option 2, the SMx additionally generates an LTE uplink signal. There is no special configuration required.

Procedure

The procedure is shown with an example of $BW_{channel} = 20$ MHz and Testcase 1. To simplify the settings, E-TM1.1 is used (see Table 3-8).

1. Set the frequency of the SMx to the center frequency of the wanted signal

**Generating the downlink LTE signal**

2. Generate an LTE signal that is equivalent to the wanted signal (see 3.1.2)
3. Select test model E-TM1.1. (Fig. 3-49) (example with 20 MHz)
4. In the SMx, the total level is set over all RBs and the reference symbol power for each RE is entered relative to the total level (Fig. 3-50). Therefore, set the total level based on Table 3-8.

**AWGN**

5. Click the AWGN block and set the bandwidths (Fig. 3-51). (example: System BW = 18 MHz)
6. Go to the Noise Power / Output Results tab and enter the appropriate carrier/noise ratio from (Fig. 3-52).

Fig. 3-52: AWGN: setting the noise power relative to the carrier power via the carrier/noise ratio (example: the carrier power is $-10$ dBm, so the noise power in test case 1 should be $-50$ dBm: $-10$ dB $- (-50$ dB) = $+40$ dB).
Option 2 only: Generating the uplink LTE signal

7. Set the link direction to **Uplink (SC-FDMA)**.

8. Set the corresponding bandwidth.

![Fig. 3-53: Setting the uplink in the LTE.](image)

![Fig. 3-54: Setting the bandwidth BW in the uplink.](image)

9. Click **UE1**.

10. Select the corresponding **FRC** and switch **FRC state On**. (example: FRC A3-7)
Fig. 3-55: Displaying the simulated UE1. The UE parameters can be entered with a mouse click.

Fig. 3-56: Setting the FRC for the UE. (example: A3-7)

**Measurement with FSx**

If E-TM1.1 is used for the wanted signal, Table 3-7 is simplified as follows:

<table>
<thead>
<tr>
<th>Test case</th>
<th>$P_{\text{DL}}$ (dBm)</th>
<th>$P_{\text{AWGN}}$ (dBm)</th>
<th>Carrier/Noise (dB)</th>
<th>$P_{\text{UL}}$ (dBm)</th>
<th>$P_{\text{UL}}$ (dBm)</th>
<th>Limits (normal conditions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>–10</td>
<td>–50</td>
<td>+40</td>
<td>–98</td>
<td>–20</td>
<td>≤ 20</td>
</tr>
<tr>
<td>2</td>
<td>–20</td>
<td>–60</td>
<td>+40</td>
<td>–10</td>
<td>+2.7 dB (f ≤ 3 GHz)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>–40</td>
<td>–70</td>
<td>+30</td>
<td>–10</td>
<td>+3.0 dB (3 GHz ≤ f ≤ 4.2 GHz)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>–90</td>
<td>–50</td>
<td>–40</td>
<td>Pmax</td>
<td>–10</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-8: Requirements for home BS with co-channel LTE signal for an example using E-TM1.1
Measure the $P_{\text{out}}$ of the home BS for all test cases (Table 3-8) and both offsets.

The test can be performed in one of two different ways:

- **Demodulation -> Result Summary:** This method uses a single data record from the same test to obtain different values, such as EVM, frequency error, etc. The procedure follows the basic instructions provided in Section 3.1.1. The calculated power is displayed under **Power** (see Fig. 3-57).

- **Channel Power / ACLR:** This method can be used to determine the output power and the adjacent channel power simultaneously. Use as channel filter ‘Rect’.

![Fig. 3-57: Output power in the result summary.](image)

### Demo program

For this test, additional the parameters must be defined. The test is carried out as a demodulation measurement. The output power and other measurements are reported.

![Fig. 3-58: Special settings for output power with co-channel LTE.](image)

The level for the co-channel LTE carrier and AWGN can be entered directly. The uplink level is needed only for option 2. Please note the settings from the specification listed in Table 3-7.
3.3 Output Power Dynamics (Clause 6.3)

3.3.1 Total Power Dynamic Range (Clause 6.3.2)

The total power dynamic range is the difference between the maximum and the minimum transmit power of an OFDM symbol for a specified reference condition [1].

The measured OFDM symbols shall not contain RS, PBCH or synchronization signals. The test software includes this automatically in the calculation and displays the result as OSTP (OFDM symbol transmit power) in the Result Summary. The test is performed only for SC.

<table>
<thead>
<tr>
<th>Dynamic range requirements</th>
<th>Power dynamic range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel bandwidth (MHz)</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>7.3</td>
</tr>
<tr>
<td>3</td>
<td>11.3</td>
</tr>
<tr>
<td>5</td>
<td>13.5</td>
</tr>
<tr>
<td>10</td>
<td>16.5</td>
</tr>
<tr>
<td>15</td>
<td>18.3</td>
</tr>
<tr>
<td>20</td>
<td>19.6</td>
</tr>
</tbody>
</table>

Table 3-9: BS total power dynamic range, paired spectrum
**Test setup**

![Test setup diagram]

Fig. 3-60: Test setup for BS output power.

The DUT (base station) transmits at the declared maximum PRAT sequentially with two different configurations.

- **E-TM3.1**
- **E-TM2**

**Procedure**

The test can be performed in one of two different ways:

- **Demodulation -> Result Summary:** This method uses a single data record from the same test to obtain different values, such as EVM, frequency error, etc. The procedure follows the basic instructions provided in Section 3.1.1. The calculated power is displayed under **Power** (see Fig. 3-61).

- **Channel Power / ACLR:** This method can be used to determine the output power and the adjacent channel power simultaneously. Use as channel filter ‘Rect’.

<table>
<thead>
<tr>
<th>Result Summary</th>
<th>Frame Results 1/1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>EVM RSCCH QPSK (%)</td>
<td>0.63</td>
</tr>
<tr>
<td>EVM RSCCH 16QAM (%)</td>
<td>0.63</td>
</tr>
<tr>
<td>EVM RSCCH 64QAM (%)</td>
<td>0.63</td>
</tr>
</tbody>
</table>

**Fig. 3-61: Result summary: OSTP (OFDM symbol transmit power).**

Two measurements are taken. The total power dynamic range is the difference between the two measurements \( \text{OSTP}_{E\text{-TM3.1}} - \text{OSTP}_{E\text{-TM2}} \).

**Demo program**

No further special settings are needed for this test. The test is carried out as a demodulation measurement. Two measurements for the different TMs are performed one after the other. The difference is reported as Dynamic range. A dialog box tells the user when to change to the next TM. Simulation is not supported.
### 3.4 Transmit ON/OFF Power (Clause 6.4)

Transmitter OFF power is defined as the mean power measured over 70 µs filtered with a square filter of bandwidth that is equal to the transmission bandwidth configuration of the base station (BW\textsubscript{Config}) centered on the assigned channel frequency during the transmitter OFF period. [1]

For BS supporting intra-band contiguous CA, the transmitter OFF power is defined as the mean power measured over 70 µs filtered with a square filter of bandwidth equal to the aggregated channel bandwidth BW\textsubscript{Channel,CA} centered on \((F_{edge\_high} + F_{edge\_low})/2\) during the transmitter OFF period. [1]

This test applies only for TDD and is defined for both SC and MC.

Fig. 3-63 shows the definition of the ranges and Table 3-10 lists the limits.

![Transmitter ON and OFF periods](image)

**Table 3-10: Transmitter OFF limits**

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(f \leq 3 \text{ GHz})</td>
<td>-83 dBm/MHz</td>
</tr>
<tr>
<td>(3 \text{ GHz} &lt; f \leq 4.2 \text{ GHz})</td>
<td>-82.5 dBm/MHz</td>
</tr>
</tbody>
</table>

![Example report for test case 6.3.1.](image)
Test setup

Additional hardware is required for this test. An RF limiter is used to limit the power received at the analyzer during the transmitter ON periods. This enables the full dynamic range for the measurements in the OFF periods. In addition, an attenuator is used to absorb the reflected power for limiters without optimal VSWR.

![Test setup diagram]

Fig. 3-64: Test setup: transmit ON/OFF.

The DUT (base station) generates the wanted signal at $F_C$ with $BW_{\text{channel}}$ and E-TM1.1.

Procedure

The ON/OFF measurement for single carrier is included in all options. The ability to test multicarriers is currently available only using the external LTE PC SW.

1. In the software, go to MEAS - PVT and select the ON/OFF POWER measurement. Duplexing may already be set up to TDD. The TDD configuration must be defined (UL/DL configuration and special subframe). These parameters are automatically set correctly when the test module (E-TM) is selected.

2. You can change the settings under GENERAL SETTINGS (see Fig. 3-65). For tests with carrier aggregation, enter the frequency range (Lower and Higher Edge) ($BW_{\text{channel}_{\text{CA}}}$) for the test. Under (Center) Frequency, select the frequency of one of the carriers to be measured. The Number of Frames is preset to 50 frames per the specification. Press the Noise Correction button to perform an additional measurement to enable more dynamic by subtraction of the noise. An external trigger is to be used for MC tests. To do this, press the ADJ Timing button before starting the test. This automatically sets the appropriate timings for the actual measurement.

3. The limit can be modified via an XML file (see the manual)
Transmitter Tests (Chapter 6)

Transmit ON/OFF Power (Clause 6.4)

Fig. 3-65: Settings for ON/OFF POWER.
Transmitter Tests (Chapter 6)
Transmit ON/OFF Power (Clause 6.4)

Fig. 3-66 displays the On/Off measurement using the PC SW as an example.

Fig. 3-66: ON/OFF power measurement: At the top is a display of the measured OFF power and the transition period times. At the bottom are the progression versus time and the limit check.

Demo program

This test is possible for TDD only. The measured OFF power is displayed. By default, the test uses Noise Cancellation. At present, the measurement with the PC SW uses one frame only, while the FSW option measurement uses 50 frames. The times for the Rising and Falling Period are also measured and reported.

Fig. 3-67: Noise cancellation at transmit On/Off.
3.5 Transmitted Signal Quality (Clause 6.5)

3.5.1 Frequency Error (Clause 6.5.1) and Error Vector Magnitude (Clause 6.5.2)

The two tests are defined only for SC.

Frequency error is the measure of the difference between the actual BS transmit frequency and the assigned frequency [1].

Table 3-11 shows the limits for the various base stations.

<table>
<thead>
<tr>
<th>BS class</th>
<th>Frequency error requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide Area BS</td>
<td>± (0.05 ppm + 12 Hz)</td>
</tr>
<tr>
<td>Local Area BS</td>
<td>± (0.1 ppm + 12 Hz)</td>
</tr>
<tr>
<td>Home BS</td>
<td>± (0.25 ppm + 12 Hz)</td>
</tr>
</tbody>
</table>

For this measurement the FSx must be synchronized via External Reference to the basestation under test.

The error vector magnitude is a measure of the difference between the ideal symbols and the measured symbols after the equalization. This difference is called the error vector. The EVM result is defined as the square root of the ratio of the mean error vector power to the mean reference power expressed in percent [1].

Table 3-12 shows the limits for the various modulation modes.
Transmitter Tests (Chapter 6)
Transmitted Signal Quality (Clause 6.5)

EVM requirements

<table>
<thead>
<tr>
<th>Modulation scheme PDSCH</th>
<th>EVM [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>QPSK</td>
<td>18.5</td>
</tr>
<tr>
<td>16QAM</td>
<td>13.5</td>
</tr>
<tr>
<td>64QAM</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 3-12: EVM requirements [1]

Test setup

![Test setup diagram]

Fig. 3-69: Test setup for BS output power

The DUT (base station) transmits with the declared maximum PRAT. The following configurations are specified:

- E-TM3.1
- E-TM3.2
- E-TM3.3
- E-TM2

Procedure

The signal is demodulated for the test. The test results are displayed in a scalar overview under RESULT SUMMARY. This method uses a single data record from the same test to obtain different values, such as power, crest factor, etc. The procedure follows the basic instructions provided in Section 3.1.1. The calculated power is displayed under EVM PDSCH and Frequency Error (see Fig. 3-70).

![Result summary table]

Fig. 3-70: Result summary: EVM and frequency error.

In addition to the required measured values for frequency errors and EVM, the summary also includes results such as sample error, I/Q imbalance, etc.
Demo program

No further special settings are needed for this test. The test is carried out as a demodulation measurement. The frequency error and EVM are reported. In the case of MC tests, each individual carrier is measured in sequence.

### 6.5.1 / 6.5.2 Frequency Error / EVM

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Carrier Frequency (MHz)</th>
<th>EVM %</th>
<th>Test Model</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5.1 / 6.5.2 Frequency Error / EVM</td>
<td>2110</td>
<td>10</td>
<td>E-TM1.1</td>
<td>Ignored</td>
</tr>
<tr>
<td>EVM %</td>
<td>2110</td>
<td>10</td>
<td>E-TM1.1</td>
<td>0.06</td>
</tr>
</tbody>
</table>

**Table 3-13: Time alignment error limits**

<table>
<thead>
<tr>
<th>Transmission combination</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIMO/TX diversity single carrier</td>
<td>90 ns</td>
</tr>
<tr>
<td>Intra-band CA with or without MIMO or TX diversity</td>
<td>155 ns</td>
</tr>
<tr>
<td>Inter-band CA with or without MIMO or TX diversity</td>
<td>285 ns</td>
</tr>
</tbody>
</table>

FSx: 0, "No error"

Fig. 3-71: Example report for test case 6.5.1.

### 3.5.2 Time Alignment Error (Clause 6.5.3)

Frames of the LTE signals present at the BS transmitter antenna ports are not perfectly aligned in time. In relation to each other, the RF signals present at the BS transmitter antenna ports experience certain timing differences. [1]

Time alignment error (TAE) is defined as the largest timing difference between any two signals. This test is only applicable for base stations supporting TX diversity, MIMO transmission, carrier aggregation and their combinations.

The test is performed for SC as well as MC.

Table 3-13 lists the limits for various combinations.

Demo program

No further special settings are needed for this test. Take note of the special test setup. The difference is output in ns.
3.5.2.1 Single Carrier (MIMO, Tx Diversity)

Test setup

The following setup is used for this test. The antennas to be measured are connected via a hybrid coupler. The FSx is connected via an attenuator. To achieve precise measurements, the RF cables being used should be equal in electrical length.

Procedure

Up to 4 antennas can be measured in parallel. The measurement is taken on the reference signals (RS) of the individual antennas, and PDSCHs are ignored.

1. Start the test using MEAS and “Time Alignment”
2. The measurement is always relative to one reference antenna. The antenna can be changed under “Reference Antenna”.
3.5.2.2 Multicarrier (CA)

The CA measurement (including intra-band) can be performed in one of two different ways:

- PC SW with RTO: Simple, precise measurement, in parallel with MIMO
- FSx with external trigger: Two-shot measurement, making the test less precise than with the RTO

**PC SW with RTO**

*Test setup*

![Test setup diagram](image)

Fig. 3-75: Test setup for the time alignment error measurement for CA with RTO. The two carriers are measured simultaneously with one RTO.
Procedure

1. In the PC SW, go to General Settings. In the Time Alignment Measurement Settings section, set the Num of Component Carrier field to 2 and then set the corresponding frequency of the second carrier in the (CC2 Frequency) field (Fig. 3-76).

2. Additional settings for the second carrier can be made under CC2 DEMOD SETTINGS.

3. Start the test (Fig. 3-77)

Fig. 3-76: Settings for time alignment measurements with CA.
1. Select the **Time Alignment** measurement
2. Set FSx to **External Trigger**
3. The timing of the start of the frame relative to the external trigger is displayed in the Capture Buffer (**Fig. 3-79**).
3.5.3 DL RS Power (Clause 6.5.4)

DL RS power is the resource element power of downlink reference symbol. The absolute DL RS power is indicated on the downlink shared channel (DL-SCH) in Layer 2.

The test is defined only for SC.

Table 3-14 lists the tolerances dependent on the frequency range.

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Deviation to indicated power</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 3 GHz</td>
<td>± 2.9 dB</td>
</tr>
<tr>
<td>3 GHz ≤ f ≤ 4.2 GHz</td>
<td>± 3.2 dB</td>
</tr>
</tbody>
</table>

Table 3-14: DL RS power requirements

Test setup

![Test setup diagram](image)

Fig. 3-80: Test setup for BS output power.

The DUT (base station) transmits with the declared maximum PRAT. E-TM1.1 is required.

Procedure

The signal is demodulated for the test. The test results are displayed in a scalar overview under RESULT SUMMARY. This method uses a single data record from the same test to obtain different values, such as power, crest factor, etc. The procedure follows the basic instructions provided in Section 3.1.1. The calculated power is displayed under RSTP (see Fig. 3-81).
Demo program

No further special settings are needed for this test. The test is carried out as a demodulation measurement. The reference symbol power is reported.

### 3.6 Unwanted Emissions (Clause 6.6)

Unwanted emissions consist of out-of-band emissions and spurious emissions. Out-of-band emissions are unwanted emissions immediately outside the channel bandwidth resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions. Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emission, intermodulation products and frequency conversion products, but exclude out-of-band emissions [1].
3.6.1 Occupied Bandwidth (Clause 6.6.1)

Occupied Bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage $\beta/2$ of the total mean transmitted power. It defines the spectral properties of emission in a simple manner.

The value of $\beta/2$ shall be taken as 0.5%. This results in a power bandwidth of 99%.

The measurement of the spectrum is carried out with resolution bandwidth (RBW) of 30 kHz or less and the measurement points mentioned in Table 3-15.

<table>
<thead>
<tr>
<th>Channel bandwidth [MHz]</th>
<th>1.4</th>
<th>3</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>20+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span [MHz]</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>2*BW_{Channel, CA}</td>
</tr>
<tr>
<td>Minimum number of</td>
<td>1429</td>
<td>227</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>measurement points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2*BW_{Channel, CA}</td>
</tr>
</tbody>
</table>

Table 3-15: OBW: span and measurement points

The measured bandwidth (OBW) shall be smaller than the nominal bandwidth (see Table 3-15, top row). For multicarrier scenarios, the OBW should be smaller than the aggregated bandwidth. Multiple combinations shall be tested as described in Section 4.10.2 [1].

Test setup

![Test setup diagram](image)

Fig. 3-83: Test setup for BS output power.

The DUT (base station) transmits with the declared maximum PRAT. E-TM1.1 is required.

The general base unit function “OBW” is used for the test. For TDD signals, the trigger must be set to external.

Procedure (example: 10 MHz bandwidth)

1. Press MODE and then select Spectrum
2. Press MEAS and select OBW
3. Verify the %Power Bandwidth default setting of 99%
4. Set the **Channel Bandwidth** (example: 10 MHz)

5. Press **Overview** and select "Bandwidth"

![Bandwidth settings](image)

**Fig. 3-84: OBW: set the bandwidth and sweep.**

6. On the SWEEP tab, set the **sweep points** and **Optimization** to "speed"

7. Set the **Span** per Table 3-15 (example: 20 MHz)

8. The spectrum and the calculated OBW are displayed.

![OBW measurements](image)

**Fig. 3-85: OBW measurements (in the example, an OBW of 8.91 MHz is calculated for a 10 MHz channel).**

The measurement is performed in the same way for multicarrier scenarios. In this case, the aggregated bandwidth is entered manually as the bandwidth (see step 4).

**Demo program**

No further special settings are needed for this test. It is performed in the base unit as a general spectrum measurement, which means that it cannot be performed directly using the PC SW. The measured bandwidth OBW is reported.
3.6.2 Adjacent Channel Leakage Power (ACLR) (Clause 6.6.2)

Adjacent channel leakage power ratio (ACLR) is the ratio of the filtered mean power centered on the assigned channel frequency to the filtered mean power centered on an adjacent channel frequency. The requirements shall apply outside the base station RF bandwidth edges regardless of the type of transmitter (single carrier or multicarrier) [1].
Fig. 3-88: ACLR for multicarrier; red marks the measurement regions.

Table 3-16 through Table 3-18 list the relative and absolute limits.

<table>
<thead>
<tr>
<th>Channel bandwidth of LTE lowest (highest) carrier transmitted BWChannel [MHz]</th>
<th>BS adjacent channel center frequency offset below the lowest or the above the highest carrier center frequency transmitted</th>
<th>Assumed adjacent channel carrier</th>
<th>Filter on the adjacent channel frequency and corresponding filter bandwidth</th>
<th>ACLR limit [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4, 3.0, 5, 10, 15, 20</td>
<td>BWChannel</td>
<td>LTE of same BW</td>
<td>Square ( BWConfig )</td>
<td>44.2</td>
</tr>
<tr>
<td></td>
<td>2 x BWChannel</td>
<td>LTE of same BW</td>
<td>Square ( BWConfig )</td>
<td>44.2</td>
</tr>
<tr>
<td></td>
<td>BWChannel/2 + 2.5 MHz</td>
<td>3.84 Mcps WCDMA</td>
<td>RRC ( 3.84 Mcps )</td>
<td>44.2</td>
</tr>
<tr>
<td></td>
<td>BWChannel/2 + 7.5 MHz</td>
<td>3.84 Mcps WCDMA</td>
<td>RRC ( 3.84 Mcps )</td>
<td>44.2</td>
</tr>
</tbody>
</table>

Table 3-16: ACLR paired spectrum (FDD)
### Transmitter Tests (Chapter 6)

#### Unwanted Emissions (Clause 6.6)

<table>
<thead>
<tr>
<th>Base station ACLR in unpaired spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel bandwidth of LTE lowest (highest) carrier transmitted</td>
</tr>
<tr>
<td>BWChannel</td>
</tr>
<tr>
<td>1.4, 3.0</td>
</tr>
<tr>
<td>BWChannel/2 + 0.8 MHz</td>
</tr>
<tr>
<td>BWChannel/2 + 2.4 MHz</td>
</tr>
<tr>
<td>5, 10, 15, 20</td>
</tr>
<tr>
<td>2 x BWChannel</td>
</tr>
<tr>
<td>BWChannel/2 + 0.8 MHz</td>
</tr>
<tr>
<td>BWChannel/2 + 2.4 MHz</td>
</tr>
<tr>
<td>BWChannel/2 + 2.5 MHz</td>
</tr>
<tr>
<td>BWChannel/2 + 7.5 MHz</td>
</tr>
</tbody>
</table>

**Table 3-17: ACLR unpaired spectrum (TDD)**

<table>
<thead>
<tr>
<th>Test requirements for ACLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category A</td>
</tr>
<tr>
<td>Wide Area</td>
</tr>
<tr>
<td>Local Area</td>
</tr>
<tr>
<td>Home BS</td>
</tr>
</tbody>
</table>

**Table 3-18: ACLR: absolute minimum requirements**

---

**Test setup**

![Test setup diagram](image)

---

The DUT (base station) transmits with the declared maximum PRAT. E-TM1.1 and E-TM1.2 are required.

Both cases -- LTE and WCDMA as adjacent channels -- are handled (see tables). Both relative and absolute limits apply, although the easier to fulfill have to be met (see Table 3-18 for absolute values). "Paired spectrum" applies to FDD and "unpaired spectrum" to TDD configurations.
For TDD signals, the trigger must be set to external.

**Single carrier**

1. In the LTE option, start the measurement using MEAS and "Channel Power ACLR"

2. Under CP/ACLR CONFIG, set the corresponding parameters. The measurement for single carrier scenarios automatically takes data such as the bandwidth and spacing from the signal description:

![Diagram](image-url)

Fig. 3-90: ACLR: general settings.
Fig. 3-91: ACLR: channel settings: bandwidth for Tx and adjacent channels.

Fig. 3-92: ACLR relative and absolute limits are based on the BS category (see also Table 3-18).
Multicarrier

MC is not supported by the PC SW.

The procedure used to measure signals with multiple carriers is the same in principle as for SC. Only the number of carriers needs to be set. The overall center frequency is calculated automatically:
Odd number of Tx channels: The middle Tx channel is centered to center frequency.

Even number of Tx channels: The two Tx channels in the middle are used to calculate the frequency between those two channels. This frequency is aligned to the center frequency.

The procedure is illustrated here using the multicarriers example from chapter 2.2 (see Fig. 2-3):

Fig. 3-95: Setting the 4 carrier bandwidths, 1.095 MHz + 3 times 4.515 MHz.

Fig. 3-96: Setting the 4 carrier spacings, 1.4 MHz + 3 times 5 MHz.
Note that in this case, two measurements must be taken because the outer carriers have different bandwidths (1.4 MHz and 5 MHz in the example) and therefore the adjacent channels to be measured also have different bandwidths per Table 3-16 and Table 3-17. These must be set under **Adjacent channels** (Fig. 3-95 and Fig. 3-96).

**Demo program**

This test requires additional settings. The BS category affects the limit settings. The adjacent channel to be measured must also be specified. **Noise Cancellation** is enabled by default.

The measured power values for the individual channels are output together with a global limit check. MC tests are not supported by the PC SW.
3.6.3 Operating Band Unwanted Emissions (SEM) (Clause 6.6.3)

The operating band unwanted emission limits are defined from 10 MHz below the lowest frequency of the downlink operating band up to 10 MHz above the highest frequency of the downlink operating band.

In multicarrier or intra-band contiguous carrier aggregation, the test measurement is applicable below the lower edge of the lowest carrier and above the higher edge of the highest carrier in the aggregated channel bandwidth present in an operating band.

The test requirements shall apply as per categories either A or B. The minimum mandatory requirement is mentioned in subclause 6.6.3.5.1 or subclause 6.6.3.5.2 [1], whichever is applicable to the different type of base stations. There are other optional requirements applicable regionally in subclause 6.6.3.5[2-3] [1].

**Test setup**

![Test setup diagram](image)

The DUT (base station) transmits with the declared maximum PRAT. E-TM1.1 and E-TM1.2 are required.
For TDD signals, the trigger must be set to external. MC is not supported at this time. It will follow later in the internal FSW.

Procedure

The test is implemented in the LTE as a spectrum emission mask (SEM).

1. Under MEAS, select "Spectrum Emission Mask" in LTE.

2. The parameters defined under Signal Description (see Fig. 3-101) cause the correct settings for the SEM test to be entered automatically. The BS category is also important in that it determines the limits.

![Signal Description](image)

**Fig. 3-101:** SEM: selecting the predefined settings in LTE.

Fig. 3-102 shows a SEM test. The Result Summary displays the results of the individual ranges. The global limit check is displayed along the top.

![SEM Test Result](image)

**Fig. 3-102:** Operating band unwanted emission (SEM).

Demo program
Transmitter Tests (Chapter 6)

Unwanted Emissions (Clause 6.6)

No further special settings are needed for this test. The test is carried out as a spectrum measurement. The measured power values for the individual ranges are output together with a global limit check. MC tests are not yet supported.

**6.6.3 Operating Band Spurious Emissions (SEM)**

<table>
<thead>
<tr>
<th>SEM (Range)</th>
<th>Start (MHz)</th>
<th>Stop (MHz)</th>
<th>RBW (MHz)</th>
<th>Level (dBm)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power 0</td>
<td>-17.5</td>
<td>-15.5</td>
<td>1.0</td>
<td>-81.02</td>
<td>Ignored</td>
</tr>
<tr>
<td>Power 1</td>
<td>-15.1</td>
<td>-10.1</td>
<td>0.1</td>
<td>-87.98</td>
<td>Ignored</td>
</tr>
<tr>
<td>Power 2</td>
<td>-10.1</td>
<td>-5.1</td>
<td>0.1</td>
<td>-56.91</td>
<td>Ignored</td>
</tr>
<tr>
<td>Power 3</td>
<td>5.1</td>
<td>10.1</td>
<td>0.1</td>
<td>-57.34</td>
<td>Ignored</td>
</tr>
<tr>
<td>Power 4</td>
<td>10.1</td>
<td>15.1</td>
<td>0.1</td>
<td>-88.07</td>
<td>Ignored</td>
</tr>
<tr>
<td>Power 5</td>
<td>15.5</td>
<td>17.5</td>
<td>1.0</td>
<td>-80.85</td>
<td>Ignored</td>
</tr>
<tr>
<td>Overall</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>True</td>
</tr>
</tbody>
</table>

FSk: 0. "No error"

Fig. 3-103: Example report for test case 6.6.3.

### 3.6.4 Transmitter Spurious Emissions (Clause 6.6.4)

Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emission, intermodulation products and frequency conversion products, but exclude out-of-band emissions [1].

![Spurious emissions diagram](image)

The transmitter spurious emission limits apply from 9 kHz to 12.75 GHz, excluding the frequency range from 10 MHz below the lowest frequency of the downlink operating.
band up to 10 MHz above the highest frequency of the downlink operating band. For some operating bands the upper frequency limit is higher than 12.75 GHz [1].

The test is performed for SC as well as MC.

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Maximum level</th>
<th>Measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 kHz – 150 kHz</td>
<td>-13 dBm</td>
<td>1 kHz</td>
</tr>
<tr>
<td>150 kHz – 30 MHz</td>
<td></td>
<td>10 kHz</td>
</tr>
<tr>
<td>30 MHz – 1 GHz</td>
<td></td>
<td>100 kHz</td>
</tr>
<tr>
<td>1 GHz – 12.75 GHz</td>
<td></td>
<td>1 MHz</td>
</tr>
<tr>
<td>12.75 GHz – 5th harmonic of the upper frequency edge of the DL operating band in GHz. Applies only for bands 22, 42 and 43.</td>
<td>-30 dBm</td>
<td>1 MHz Applies only for bands 22, 42 and 43.</td>
</tr>
</tbody>
</table>

Table 3-19: Spurious emissions requirement for Cat A

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Maximum level</th>
<th>Measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 kHz – 150 kHz</td>
<td>-36 dBm</td>
<td>1 kHz</td>
</tr>
<tr>
<td>150 kHz – 30 MHz</td>
<td></td>
<td>10 kHz</td>
</tr>
<tr>
<td>30 MHz – 1 GHz</td>
<td></td>
<td>100 kHz</td>
</tr>
<tr>
<td>1 GHz – 12.75 GHz</td>
<td></td>
<td>1 MHz</td>
</tr>
<tr>
<td>12.75 GHz – 5th harmonic of the upper frequency edge of the DL operating band in GHz. Applies only for bands 22, 42 and 43.</td>
<td>-30 dBm</td>
<td>1 MHz Applies only for bands 22, 42 and 43.</td>
</tr>
</tbody>
</table>

Table 3-20: Spurious emissions requirement for Cat B

The following parameters additionally apply for the protection of the base station receiver:

<table>
<thead>
<tr>
<th>BS</th>
<th>Frequency range</th>
<th>Maximum level</th>
<th>Measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide Area BS</td>
<td>F_{UL,low} – F_{UL,high}</td>
<td>-96 dBm</td>
<td>100 kHz</td>
</tr>
<tr>
<td>Local Area BS</td>
<td>F_{UL,low} – F_{UL,high}</td>
<td>-88 dBm</td>
<td>100 kHz</td>
</tr>
<tr>
<td>Home BS</td>
<td>F_{UL,low} – F_{UL,high}</td>
<td>-88 dBm</td>
<td>100 kHz</td>
</tr>
</tbody>
</table>

Table 3-21: BS spurious emissions limits for protection of the BS receiver

Note:

Additional limits apply for regional coexistence scenarios. These are dependent on the operating band in accordance with Tables 6.6.4.5.4-1 through 6.6.4.5.5-2 [1].
Test setup

The test requires a notch (or a diplexer) filter that suppresses the frequency range of the LTE carrier on the base station. This makes it possible to meet high dynamic requirements (e.g. DUT transmits with 24 dBm, Limit in Protection receiver test –96 dBm -> dynamic is 120 dB).

![Test setup diagram]

Fig. 3-105: Test setup: spurious emissions.

The DUT (base station) transmits with the declared maximum PRAT. E-TM1.1 is required.

Procedure

1. In spectrum mode, select MEAS and then "Spurious Emissions".
2. Under Sweep List check the settings and adapt them as necessary. The predefined level values apply for Category A.
3. Press Adjust X-Axis. The settings are prefilled.

![Sweep list table]

Fig. 3-106: Spurious emissions: predefined sweep list.
Transmitter Tests (Chapter 6)

Unwanted Emissions (Clause 6.6)

Fig. 3-107: Spurious emissions up to 12.75 GHz. The carrier is suppressed using filters. The results for the individual ranges are displayed at the bottom, and at the top is the limit check.

Demo program

This test requires additional settings. The BS category affects the limit settings. The test is performed in the base unit as a spectrum measurement, which means that it cannot be performed directly using the PC SW. The measured ranges and a limit check are reported.

Fig. 3-108: Special settings for spurious emissions.

Fig. 3-109: Example report for test case 6.6.4.
3.7 Transmitter Intermodulation (Clause 6.7)

The transmit intermodulation requirement is a measure of the capability of the transmitter to inhibit the generation of signals in its nonlinear elements caused by presence of the own transmit signal and an interfering signal reaching the transmitter via the antenna. The requirement applies during the transmitter ON period and the transmitter transient period.

The transmit intermodulation level is the power of the intermodulation products when an E-UTRA signal of channel bandwidth 5 MHz as an interfering signal is injected into an antenna connector at a mean power level of 30 dB lower than that of the mean power of the wanted signal. [1]

The test is performed for SC as well as MC.

Fig. 3-110: Transmit intermodulation.

<table>
<thead>
<tr>
<th>Transmit intermodulation parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wanted signal</strong></td>
</tr>
<tr>
<td>LTE signal with maximum bandwidth with E-TM1.1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Test setup

![Test setup diagram](image)

Fig. 3-111: Test setup: transmitter intermodulation.

Overview of settings:

- The DUT (base station) generates the wanted signal at \( F_C \) with \( BW_{\text{channel}} \) and E-TM1.1.
- The SMx generates a 5 MHz LTE signal with E-TM1.1 and the offsets in accordance with Table 3-22

Procedure

Use the SMx to generate a 5 MHz LTE signal with E-TM1.1 as described in Section 3.1.2. The frequency offset is entered directly under Frequency as described in Table 3-22. Set the level so that it is 30 dB under the level of the wanted signal.

The measurements shall be limited to the frequency ranges of all third and fifth order intermodulation products, excluding the channel bandwidths of the wanted and interfering signals.

The measurement regions are then calculated according to the table:

<table>
<thead>
<tr>
<th>Measurement regions calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order of intermodulation products</td>
</tr>
<tr>
<td>3rd order</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>5th order</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: \( F_i \): Wanted signal, \( F_j \): Interferer

Table 3-23: Calculating the measurement regions for the intermodulation product
Ranges, which are calculated with subtraction and which have small distance to the wanted signal, may overlap with the wanted signal or the interferer (see example in Fig. 3-112). The ranges must be adjusted accordingly. In principle, the following intermodulation products (ranges) can be affected:

- 2f1 - f2
- 2f2 - f1
- 3f1 - 2f2
- 3f2 - 2f1

The settings are explained in this example:

- Wanted signal: \( F_1 = 2.14 \, \text{GHz} \) with \( \text{BW}_{\text{channel}} = 20 \, \text{MHz} \)
- Interferer offset: 2.5 MHz: \( F_2 = 2.14 \, \text{GHz} + \text{BW}_{\text{channel}}/2 + 2.5 \, \text{MHz} = 2.1525 \, \text{GHz} \)
- 3rd order
  - \( 2F_1 + F_2 = 6.4325 \, \text{GHz} \), Intermodulation BW = 45 MHz
  - \( 2F_1 - F_2 = 3.1275 \, \text{GHz} \), Intermodulation BW = 45 MHz
  - \( 2F_2 + F_1 = 6.445 \, \text{GHz} \), Intermodulation BW = 30 MHz
  - \( 2F_2 - F_1 = 2.165 \, \text{GHz} \), Intermodulation BW = 30 MHz

The ranges for the 5th order can be calculated using the same method.
The following regions result for the example:

\[
\text{BW}_{\text{Meas_region_low}} = 2140 \text{ MHz} - 2127.5 \text{ MHz} - 20 \text{ MHz} / 2 + 45 \text{ MHz} / 2 = 25 \text{ MHz}
\]

\[
\text{BW}_{\text{Meas_region_high}} = 2165 \text{ MHz} - 2140 \text{ MHz} - 20 \text{ MHz} / 2 - 5 \text{ MHz} + 30 \text{ MHz} / 2 = 25 \text{ MHz}
\]

**Measurements**

The same conditions apply for these measurements as for:

- ACLR
- Operating band unwanted emissions (SEM)
- Spurious emissions

The measurement regions can be limited to the regions containing the intermodulation products.

**ACLR**

The procedure for the ACLR measurement is the same as described for ACLR in Section 3.6.2, except that the measurement regions must be adapted:

1. Start the ACLR test
2. Set the bandwidth for TX1 (example: 18 MHz) and for the ADJ channel on the intermodulation bandwidth (e.g. 25 MHz)

![Fig. 3-113: Transmit intermodulation: Setting the bandwidths (18 MHz for the wanted signal and 25 MHz for the intermodulation bandwidth in the example).](image)

3. Set the offset of the left intermodulation product (e.g. \( F_C - F_{C,\text{meas_low}} = 22.5 \text{ MHz} \)).
Transmitter Tests (Chapter 6)

Transmitter Intermodulation (Clause 6.7)

1MA154_4e  Rohde & Schwarz  86

Transmitter Intermodulation (Clause 6.7)

Fig. 3-114: Transmit intermodulation: set the intermodulation product spacing ($F_C - F_{C_{\text{meas\_low}}} = 22.5$ MHz in the example).

4. Set the spacing of the right intermodulation product (example: $F_{C_{\text{meas\_high}}} - F_C = \frac{\text{BW}_{\text{Meas\_region\_low}}}{2} + \frac{\text{BW}_{\text{Channel}}}{2} + \frac{\text{BW}_{\text{Interferer}}}{2} = 27.5$ MHz).

Fig. 3-115: Transmit intermodulation: measuring the left intermodulation product.
Transmitter Tests (Chapter 6)

Transmitter Intermodulation (Clause 6.7)

Fig. 3-116: Transmit intermodulation: Measuring the right intermodulation product. The interferer is excluded from the test.

5. Repeat the procedure for the other tests (3rd + 5th order, each with different offsets)

Operating band unwanted emission (SEM)

The procedure for the SEM measurement is the same as described for SEM in Section 3.6.3, except that the measurement regions must be adjusted:

1. Adjust the measurement region to the intermodulation products. This is done via SPAN (example: intermodulation regions to be measured = 25 MHz on both sides, SPAN = 2 * 25 MHz + 20 MHz (BW\textsubscript{wanted signal}) = 70 MHz)

2. Adjust the SWEEP times for the modified regions in the SWEEP LIST, e.g. by setting to AUTO (Fig. 3-117).
Transmitter Tests (Chapter 6)

Transmitter Intermodulation (Clause 6.7)

Spurious emissions

The procedure for the spurious emissions test is the same as described for Spurious Emissions in Section 3.6.4.
**Demo program**

This test requires additional settings. The BS category affects the limit settings. The offset must be selected under Intermodulation. The test is a combination of ACLR, SEM and Spurious Emission, and therefore cannot be performed directly using the PC SW. The measured regions are reported. The level of the intermodulation signal is set at 30 dB under the reference level.

![Special settings for transmitter intermodulation](image)

**Fig. 3-119:** Special settings for transmitter intermodulation.
Fig. 3-120: Example report for test case 6.7. The measurement is taken on the intermodulation products.
4 Appendix

4.1 R&S TSrun Program

The TSrun software application makes it possible to combine tests (modules) provided by Rohde & Schwarz into test plans to allow rapid and easy remote control of test instruments. This program is available free of charge from our website.

Requirements

Operating system:
- Microsoft Windows XP / Vista / Windows 7 / Windows 8
- .NET framework V4.0 or higher

General PC requirements:
- Pentium 1 GHz or faster
- 1 Gbyte RAM
- 100 Mbyte space harddisk
- XGA monitor (1024x768)

Remote control interface:
- National Instruments VISA
- GPIB card

Or
- LAN connection

After TSrun is launched, the following splash screen appears:
Tests and test plans

Tests are separate, closed modules for TSrun. A test plan can consist of one or more tests.

Fig. 4-1: Overview TSrun
Fig. 4-2: Overview of a test plan in TSrun. The test plan in the example contains only one test (LTE_BS_Tx_Test). After the test is completed, the bar along the bottom can be used to display the measurement and SCPI reports.

The LTE BS tests can be found under Tests/ApplicationNotes.

Click RUN to start the current test plan.

**SCPI connections**

Under Resources|SCPI Connections you can add all required instruments for remote control.
Fig. 4-3: Setting the SCPI connections.

Use **Configure…** to open a wizard for entering the VISA parameters (Fig. 4-5). Enter "localhost" for the external PC SW. Use the **Test Connection** button to test the connection to the instrument. When the **Demo Mode** button is enabled, no instruments need to be connected because TSrun will run in demo mode and output a fictitious test report.

Fig. 4-4: SCPI connections.
Fig. 4-5: Wizard for entering VISA parameters. Both the IP address and a host name can be entered directly.

Reports: Measurement and SCPI

After the test is completed, TSrun automatically generates both a measurement and a SCPI report.

The measurement report shows the actual results and the selected settings.

The SCPI report returns a LOG file of all transmitted SCPI commands. These can then be copied and easily used in separate applications.
4.2 References


4.3 Additional Information

Please send your comments and suggestions regarding this white paper to

TM-Applications@rohde-schwarz.com

4.4 Ordering Information

<table>
<thead>
<tr>
<th>Ordering information for signal generators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector signal generator</td>
</tr>
<tr>
<td><strong>Product description</strong></td>
</tr>
<tr>
<td>Vector Signal Generator</td>
</tr>
<tr>
<td>Baseband Generator</td>
</tr>
<tr>
<td>Baseband Generator</td>
</tr>
<tr>
<td>SMU-B11 Baseband Generator</td>
</tr>
<tr>
<td>Baseband Main Module</td>
</tr>
<tr>
<td>1st RF path</td>
</tr>
<tr>
<td>2nd RF path</td>
</tr>
<tr>
<td>AWGN</td>
</tr>
<tr>
<td>Digital Standard LTE/E-UTRA</td>
</tr>
<tr>
<td>LTE Release 10 / LTE-Advanced</td>
</tr>
<tr>
<td>3GPP FDD</td>
</tr>
</tbody>
</table>
### Ordering information for signal generators

<table>
<thead>
<tr>
<th>Product description</th>
<th>Type</th>
<th>Ordering No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector Signal Generator</td>
<td>SMW200A</td>
<td>1412.0000.02</td>
</tr>
<tr>
<td>Baseband Generator</td>
<td>SMW-B10</td>
<td>1413.1200.02</td>
</tr>
<tr>
<td>SMU-B11 Baseband Generator</td>
<td>SMW-B11</td>
<td>1159.8411.02</td>
</tr>
<tr>
<td>Baseband Main Module</td>
<td>SMW-B13</td>
<td>1141.8003.04</td>
</tr>
<tr>
<td>1st RF path</td>
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<td>SMW-K85</td>
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### Ordering information for analyzers

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<th>Signal and spectrum analyzers</th>
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<td>Up to 8, 13, 26, or 43 GHz</td>
<td>FSW</td>
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<td>FSW-K100</td>
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<td>Up to 3, 8, 26, 31 or 40 GHz</td>
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<td>Up to 3, 7, 13, 30, or 40 GHz</td>
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About Rohde & Schwarz

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

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Environmental commitment

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

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