Application Note

5G NEW RADIO CONDUCTED BASE STATION TRANSMITTER TESTS

according to TS 38.141-1, Rel. 16

Products:

- ► R&S®FSW
- ► R&S[®]FSV3000
- ► R&S[®]FSVA3000
- ► R&S[®]FSV
- ► R&S[®]FSVA
- R&S[®]FPS



Christian Wicke, Bernhard Schulz, Fabian Bette | GFM313 | Version 3e | 01.2021 https://www.rohde-schwarz.com/appnote/GFM313



Make ideas real

- ► R&S[®]SMW200A
- ► R&S[®]SMBV100B



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1 Introduction

The 5th generation (5G) of mobile networks introduces a paradigm shift towards a user and application centric technology framework.

The goal of 5G New Radio (NR) is to flexibly support three main service families:



Figure 1: 5G New Radio main service families

- Enhanced mobile broadband (eMBB) for higher end-user data rates
- ► Massive machine type communications (mMTC) targets cost-efficient and robust D2X connections
- Ultra-reliable, low latency communications (URLLC) supporting new requirements from vertical industries such as autonomous driving, remote surgery or cloud robotics

3GPP, the responsible standardization body, defines the Radio Frequency (RF) conformance test methods and requirements for NR Base Stations (BS) in the technical specifications TS 38.141 which covers transmitter (Tx), receiver (Rx) and performance (Px) testing.

The technical specification **TS 38.141** consists of two parts depending on whether the test methodology has conducted or radiated requirements:

- ► TS 38.141-1: Part 1 [1]: Conducted conformance testing
- ► TS 38.141-2: Part 2 [2]: Radiated conformance testing

This <u>application note</u> describes how all mandatory **RF transmitter tests (TS 38.141-1, chapter 6)**, according to Release 16 (V16.3.0), can be performed quickly and conveniently with signal or spectrum analyzers from Rohde & Schwarz by either choosing manual operation or a remote control approach. Moreover, one test case requires an additional signal generator for interferer generation. More information can be found in the respective test case section.

Generally, each chapter is structured in three sections:

First, a short introduction at the beginning of a chapter is covering the scope of the individual test case showing the necessary testing parameters and a schematic test setup. Next, there comes the step-by-step description of the manual testing procedure for manual testing enhanced by device images and screenshots. Last but not least, each test case is closed by the corresponding SCPI commands sequence required for remote operation or the implementation in user-defined test software.

Hereinafter, Table 1 gives an overview of all 5G base station transmitter tests covered individually in this document.

| TS 38.141-1 | Test | Single carrier (SC) | Multi carrier (MC) | | | |
|--------------|---|---------------------|--------------------|--|--|--|
| <u>6.2</u> | Base station output power | \checkmark | × | | | |
| <u>6.3</u> | Output power dynamic range | | | | | |
| <u>6.3.2</u> | RE power control dynamic range | \checkmark | × | | | |
| <u>6.3.3</u> | Total power dynamic range | \checkmark | × | | | |
| <u>6.3.4</u> | NB-IoT RB power dynamic range | \checkmark | × | | | |
| <u>6.4</u> | Transmit ON/OFF power | \checkmark | × | | | |
| <u>6.5</u> | Transmitted signal quality | | | | | |
| <u>6.5.2</u> | Frequency error | ✓ | × | | | |
| <u>6.5.3</u> | Modulation quality | ✓ | × | | | |
| <u>6.5.4</u> | Time alignment error | \checkmark | × | | | |
| <u>6.6</u> | Unwanted emissions | | | | | |
| <u>6.6.2</u> | Occupied bandwidth | ✓ | × | | | |
| <u>6.6.3</u> | Adjacent channel leakage power ratio (ACLR) | ✓ | × | | | |
| <u>6.6.4</u> | Operating band unwanted emissions | \checkmark | × | | | |
| <u>6.6.5</u> | Transmitter spurious emissions | ✓ | × | | | |
| <u>6.7</u> | Transmitter intermodulation | \checkmark | × | | | |

Table 1: conducted BS transmitter tests (TS 38.141-1, chapter 6)

Note: This document covers single carrier (SC) tests only.

Additionally, several software libraries come with this application note. They are meant to demonstrate the remote-control approach of base station testing and are provided as is. See Appendix for further information.

Base station (RF) receiver tests (TS 38.141-1, chapter 7) are described in GFM314.

Base station (RF) performance tests (TS 38.141-1, chapter 8) are described in GFM315.

For further reading

Find a more detailed overview of the technology behind 5G New Radio from this Rohde & Schwarz book [3] and <u>www.rohde-schwarz.com/5G</u>.

2 General Test Conditions

2.1 Safety indication



VERY HIGH OUTPUT POWERS CAN OCCUR ON BASE STATIONS. MAKE SURE TO USE SUITABLE ATTENUATORS IN ORDER TO PREVENT DAMAGE TO THE TEST EQUIPMENT.

2.2 Base station classes and configurations

The minimum RF characteristics and performance requirements for 5G NR in-band base stations are generally described in 3GPP document TS 38.104 [4].

2.2.1 BS type 1-C and 1-H reference points (TS 38.104, chapter 4.3)

This application note covers conducted measurements only. In [1] and [4] two different base station types are defined for frequency range one (FR1).

2.2.1.1 BS type 1-C (FR1, conducted)

For this type of BS, the transceiver antenna connector (port A) is accessible directly. If any external equipment such as an amplifier, a filter or the combination of both is used, the test requirements apply at the far end antenna connector (port B) of the whole system.



Figure 2: BS type 1-C transmitter interface [1]

2.2.1.2 BS type 1-H (FR1, hybrid)

This base station type has two reference points fulfilling both radiated and conducted requirements.

Conducted characteristics are defined at the transceiver array boundary (TAB) which is the conducted interface between the transceiver unit array and the composite antenna equipped with connectors for conducted measurements. All test cases described in this application note apply to conducted measurements at the transceiver array boundary (TAB).

Radiated characteristics are defined over-the-air (OTA) and to be measured at the radiated interface boundary (RIB). The specific requirements and test cases are defined in TS 38.141-2 [2]. Furthermore, the specific OTA measurements are described in extra Rohde & Schwarz application notes [5] and [6].



Transceiver array boundary connector (TAB)

Figure 3: Radiated and conducted reference points for BS type 1-H [1]

2.2.2 BS classes (TS 38.104, chapter 4.4)

This specification distinguishes three different base station classes.

Table 2: Base station classes

| Name | Cell size | Minimum coupling loss |
|--------------|------------|-----------------------|
| Wide area | Macro cell | 70 dB |
| Medium range | Micro cell | 53 dB |
| Local area | Pico cell | 45 dB |

2.3 5G NR frequency ranges

The frequency ranges in which 5G NR can operate according to Rel. 16 (V16.3.0) are shown in Table 3.

Table 3: Frequency ranges [4], chapter 5

| Frequency range designation | Corresponding frequency range |
|-----------------------------|-------------------------------|
| FR1 | 410 MHz - 7125 MHz |
| FR2 | 24250 MHz - 52600 MHz |

2.4 R&S devices and options

Any of the following Rohde & Schwarz signal and spectrum analyzers can be used for the tests described in this document:

- ► R&S®FSW
- R&S[®]FSV3000 and R&S[®]FSVA3000
- ► R&S[®]FSV and R&S[®]FSVA
- ► R&S®FPS
- ► R&S[®]VSE Signal Analysis Software

Furthermore, the 5G NR Downlink Measurements software option is needed:

▶ R&S[®]FSW-/FSV3-/FSV-/FPS-/VSE-K144

For further information on R&S signal and spectrum analyzers, please see:

https://www.rohde-schwarz.com/signal-spectrum-analyzers

The **Transmitter Intermodulation Test Case (6.7)** requires an additional interfering signal. This interferer can be generated by any of the following Rohde & Schwarz vector signal generators equipped with **-K144 5G NR software** option:

- R&S[®]SMW200A
- ► R&S®SMBV100B

For demonstration purposes any of these signal generators mentioned before can be used to simulate a 5G NR base station as well.

For further information on R&S signal generators, please see:

https://www.rohde-schwarz.com/signalgenerators

The following test equipment and abbreviations are used in this application note:

- ► The R&S[®]FSW spectrum analyzer is referred to as the **FSW**
- The R&S[®]SMW200A vector signal generator is referred to as the SMW

3 RF Transmitter Tests (TS 38.141-1, chapter 6)

Specification TS 38.141-1 [1] defines the tests required in the various frequency ranges and positions (Bottom, Middle, Top) in the operating band. In instruments from Rohde & Schwarz, the frequency range can be set to any frequency within the supported range independently of the operating bands.

Please note that this version of the application note describes single carrier tests (SC) only.

In order to allow comparisons between tests, test models (TMs) standardize the resource block (RB) allocations. For NR, these are called enhanced NR TMs with the frequency range (e.g. NR-FR1-TM1.1). The NR-TMs are stored as predefined settings on instruments from Rohde & Schwarz.

Table 4 provides an overview of the basic parameters for the individual tests numbered by the chapters of TS 38.141-1 and linked to the corresponding chapters in this application note. Both, the required test models (TM) and the frequency positions (B, M, T) to be measured are shown.

| Table 4: Transmitte | r tests | covered i | n this | application | note |
|---------------------|---------|-----------|--------|-------------|------|
|---------------------|---------|-----------|--------|-------------|------|

| Test Case (TS 38.141-1) | Measurement | ТМ | Channels | Single carrier | Comment |
|----------------------------|--|--|----------|-------------------|----------------------------|
| <u>6.2</u> | Base station output power | TM1.1 | B, M, T | Any SC | |
| <u>6.3</u> | Output power dynamic range | | 1 | 1 | |
| <u>6.3.2</u> | RE power control dynamic range | TM2 TM2a TM3.1 TM3.1a TM3.2 TM3.3 | B, M, T | Any SC | Tested together with 6.5.3 |
| <u>6.3.3</u> | Total power dynamic range | TM2 TM2a TM3.1 TM3.1a | Μ | Any SC | |
| <u>6.3.4</u> | NB-IoT RB power dynamic range | TM1.1 TM1.2 | В, М, Т | Any SC | Tested together with 6.6.4 |
| <u>6.4</u> | Transmit ON/OFF power | TM1.1 | М | Any SC | TDD only |
| <u>6.5</u> | Transmitted signal quality | | | | |
| <u>6.5.2</u> | Frequency error | TM2 TM2a TM3.1 TM3.1a TM3.2 TM3.3 | B, M, T | Any SC | |
| <u>6.5.3</u> | Modulation quality | TM2 TM2a TM3.1 TM3.1a TM3.2 TM3.3 | B, M, T | Any SC | |
| <u>6.5.4</u> | Time alignment error | TM1.1 | М | Any SC | |
| <u>6.6</u> U | nwanted emissions Unwanted emissions | | | | |
| <u>6.6.2</u> O | 6.6.2 Occupied bandwidth | | М | Any SC | |
| 6.6.3 A | 6.6.3 Adjacent channel leakage power ration (ACLR) | | В, М, Т | Any SC | |
| <u>6.6.4</u> O | 6.6.4 Operating band unwanted emissions | | В, М, Т | Any SC | |
| <u>6.6.5</u> T | ransmitter spurious emissions | TM1.1 | В, Т | Any SC | |
| <u>6.7</u> T | ransmitter intermodulation | TM1.1 | М | Any SC | Interferer (SCS:15kHz) |

3.1 Complete Tx test setup overview

Figure 4 shows the general test setup for transmitter tests. A FSW spectrum analyzer is used to perform the measurements. A SMW signal generator acts as interferer. Some tests require a modified setup which is described in the respective sections in detail.



Figure 4: Complete Tx test setup overview

3.2 Recommended R&S devices and options

| Test Case | Measurement | Instruments and Options | | | |
|---------------|--|---------------------------------|---------------|------------------|---------------|
| (TS 38.141-1) | | Wanted 5G NR Downlink Signal | | Interferer | |
| | | FSW Base Unit | FSW Option | SMW Base Unit | SMW Option |
| <u>6.2</u> | Base station output power | \checkmark | K144 | × | |
| <u>6.3</u> | Output power dynamic range | | | | |
| <u>6.3.2</u> | RE power control dynamic range | \checkmark | K144 | × | |
| <u>6.3.3</u> | Total power dynamic range | \checkmark | K144 | × | |
| <u>6.3.4</u> | NB-IoT RB power dynamic range | \checkmark | K144 | × | |
| <u>6.4</u> | Transmit ON/OFF power | \checkmark | K144 | × | |
| <u>6.5</u> | Transmitted signal quality | | | | |
| <u>6.5.2</u> | Frequency error | \checkmark | K144 | × | |
| <u>6.5.3</u> | Modulation quality | \checkmark | K144 | × | |
| <u>6.5.4</u> | Time alignment error | \checkmark | K144 | × | |
| <u>6.6</u> | Unwanted emissions Unwanted emission | าร | | | |
| <u>6.6.2</u> | Occupied bandwidth | ✓, B | × | × | |
| <u>6.6.3</u> | Adjacent channel leakage power ration (ACLR) | ✓ | K144 | × | |
| <u>6.6.4</u> | Operating band unwanted emissions | \checkmark | K144 | × | |
| <u>6.6.5</u> | Transmitter spurious emissions | ✓, B | × | × | |
| <u>6.7</u> | Transmitter intermodulation | ✓ | С | ✓ | K144 |

Table 5: Overview of required instruments and software options

 \checkmark : mandatory for the measurement

B: uses basic function: spectrum analyzer mode

C: combined measurements: ACLR, SEM and spurious emissions

*: not applicable for the measurement

3.3 Basic FSW operations

Most of the tests described in this application note follow the same initial steps which are explained hereinafter.

3.3.1 Reset the instrument

Before executing any test, it is recommended to reset the instrument to the default state by pressing the **PRESET** key at the front panel of the instrument.



3.3.2 Using external references

For some measurements the FSW must be synchronized via an external reference to a high precision time reference. After the external reference signal has been connected to the reference input on the rear panel, it is necessary to change the reference frequency input to **External Reference** by the following steps:

- ► Enter the instrument's setup menu by pushing the ① SETUP key on the front panel (1)
- Select 2 Reference from the sidebar
- Select the corresponding ③ External Reference (10MHz, 1...50MHz, 100MHz, 1GHz) from the list box of the popup windows



3.3.3 Performing a single-shot measurement

The buttons controlling the acquisition status are located on the front panel under Function Keys section.

- ▶ (1) RUN SINGLE starts a new single-shot measurement and stops the acquisition afterwards.
- ► ② RUN CONT starts continuous and repetitive measurements.



3.3.4 Changing operation and measurement modes

For the following base station transmitter tests different operation modes (Spectrum or 5G NR) are required. The mode which is required for each test is specified in the respective sections.



Depending on the operation mode, different measurements are available. What measurement is required for which test is specified in the respective section. Select the measurement by pressing **Select measurement** at the overview-screen or by pressing **MEAS** key on the front panel of the instrument.

3.3.4.1 Measurements in Spectrum mode

- (1): Used for Occupied bandwidth (OBW) (6.6.2)
- (2): Used for Transmitter spurious emissions (6.6.5)



3.3.4.2 Measurements in 5G NR mode

- (1): Used for Base station output power (6.2), Frequency error (6.5.2) and modulation quality (6.5.3)
- (2): Used for <u>Time alignment error (TAE) (6.5.4)</u>
- 3: Used for <u>Transmit on/off power (6.4)</u>
- (4): Used for Adjacent channel leakage power (ACLR) (6.6.3)
- (5): Used for Operating band unwanted emissions (OBUE) (SEM) (6.6.4)



3.3.5 Settings for 5G NR signal analysis

The FSW spectrum analyzer provides an overview-screen where the most important common settings for analyzing a 5G NR signal can be made:

- (2): Select Deployment, Channel bandwidth and test model
- 3: Set center-frequency, reference level and FSW attenuation



- After selecting 2 the Signal Configuration tab opens
 - Select ① Deployment, ② Channel Bandwidth, ③ Test Model



After selecting ③ the Input/Frontend tab opens





3.4 Remote control operations by using SCPI commands



Figure 5: Overview [7]

First released in 1990, the SCPI consortium standardized **SCPI (Standard Commands for Programmable Instruments)** as an additional layer on top of the IEEE 488.2 specification creating a common standard for syntax and commands to use in controlling T&M devices.

SCPI commands are ASCII textual strings sent to an instrument over a physical layer (e.g. GPIB, RS-232, USB, Ethernet, etc.). For further details, refer to the <u>SCPI-99</u> standard.

All Rohde & Schwarz instruments are using SCPI command sequences for remote control operations. The format used by Rohde & Schwarz is called the **canonical form**. Furthermore, all of our user manuals contain

a chapter **Remote Control Commands** which is explaining general conventions and the SCPI commands supported by an instrument. It's also described in there whether the command is available as a set command or a query command or both.

Here, a quick overview [8] of rules to remember by the example of

'TRIGger<m>:LEVel<n>[:VALue] <Level>'

- ► SCPI commands are case-insensitive
- Capital letter parts are mandatory
- Lowercase letters can be omitted (which is then called short form)
- ▶ Parts within square brackets *[…]* are not mandatory and can be left out
- Parts within '<...>' brackets are representing parameters
- Multiple SCPI commands can be combined into a single-line string by using a semicolon ';'
- ► To reset the command tree path to the root, use the colon character ':' at the beginning of the second command (e.g. 'TRIG1:SOUR CH1;:CHAN2:STATE ON')

For further reading

https://www.rohde-schwarz.com/drivers-remote-control

3.5 Base station output power (6.2)

The test purpose is to verify the accuracy of the maximum carrier output power across the frequency range and under normal and extreme conditions.

The power declared by the manufacturer must not exceed the values specified in Table 6. Table 7 shows the allowed tolerances.

| BS class | Rated carrier output power limits | | | |
|-----------------|-----------------------------------|--------------------------------|----------|--|
| | BS type 1-C | BS type 1-H | | |
| | Prated | Prated,c,sys Prated,TAB | | |
| Wide area BS | No upper limit | | | |
| Medium range BS | ≤ 38 dBm | ≤ 38 dBm + 10log(N⊤x∪,counted) | ≤ 38 dBm | |
| Local area BS | ≤ 24 dBm | ≤ 24 dBm + 10log(N⊤x∪,counted) | ≤ 24 dBm | |

Table 6: Declared rated output power

Table 7: Requirements BS output power

| Frequency range | Limit (normal conditions) | Limit (extreme conditions) |
|-----------------------|---------------------------|----------------------------|
| f ≤ 3.0 GHz | ± 2.7 dB | ± 3.2 dB |
| 3.0 GHz < f < 6.0 GHz | ± 3.0 dB | ± 3.5 dB |

Test setup



Figure 6: Test setup base station output power

Manual testing procedure

- 1. Select mode 5G NR
- 2. Select measurement EVM/Frequency Err/Power
- 3. Select Test Model
- 4. Set Frequency
- 5. Set Reference level offset to compensate external attenuation
- 6. Enable 3 Ignore DC



7. Start measurement



Figure 7: BS output power in the result summary

SCPI commands sequence

```
INSTrument[:SELect] NR5G
CONFigure[:NR5G]:MEASurement EVM
MMEMory:LOAD:TMODel[:CC<cc>] <TestModel>
[SENSe:]FREQuency:CENTer <Frequency>
INPut:ATTenuation <Attenuation>
CONFigure[:NR5G]:DL[:CC<cc>]:IDC <State>
FETCh[:CC<cc>][:FRAMe<fr>]:SUMMary:POWer:MAXimum?
```

3.6 Output power dynamics (6.3)

3.6.1 RE power control dynamic range (6.3.2)

The RE power control dynamic range is the difference between the power of an RE and the average RE power for a BS at maximum carrier output power ($P_{max,c,TABC}$, or $P_{max,c,AC}$) for a specified reference condition. [1]

No specific test requirements are defined for this test case. The error vector magnitude (EVM) test, as described in 3.8 provides sufficient test coverage for this requirement.

3.6.2 Total power dynamic range (6.3.3)

The total power dynamic range of a base station is the difference between the maximum and the minimum transmit power of an OFDM symbol for a specified reference condition. The upper limit of the dynamic range is the OFDM symbol power for a BS at maximum output power when transmitting on all RBs. The lower limit of the total power dynamic range is the average power for single RB transmission. The OFDM symbol shall carry PDSCH and not contain RS or SSB. [1]

The downlink total power dynamic range for each NR carrier shall be larger than or equal to the levels specified in Table 8.

| NR channel bandwidth (MHz) | Total power dynamic range (dB) | | |
|----------------------------|--------------------------------|------------|------------|
| | 15 kHz SCS | 30 kHz SCS | 60 kHz SCS |
| 5 | 13.5 | 10.0 | N/A |
| 10 | 16.7 | 13.4 | 10.0 |
| 15 | 18.5 | 15.3 | 12.1 |
| 20 | 19.8 | 16.6 | 13.4 |
| 25 | 20.8 | 17.7 | 14.5 |
| 30 | 21.6 | 18.5 | 15.3 |
| 40 | 22.9 | 19.8 | 16.6 |
| 50 | 23.9 | 20.8 | 17.7 |
| 60 | N/A | 21.6 | 18.5 |
| 70 | N/A | 22.3 | 19.2 |
| 80 | N/A | 22.9 | 19.8 |

Table 8: Base station total power dynamic range

| 90 | N/A | 23.4 | 20.4 |
|-----|-----|------|------|
| 100 | N/A | 23.9 | 20.9 |

Test setup



Figure 8: Test setup for total power dynamic range

Manual testing procedure

- 1. Select mode 5G NR
- 2. Select measurement EVM/Frequency Err/Power
- 3. Set Frequency
- 4. Select Test Model

Test models for first measurement:

- If 256QAM is supported by base station
 - with power back off: TM 3.1
 - without power back off: TM3.1a
- If 256QAM is not supported by base station
 - TM3.1

Test models for second measurement:

- If 256QAM is supported by base station: TM2a
- If 256QAM is not supported by BS: TM2
- 5. Start measurement
- 6. Subtract the OSTP-values of the two measurements: Total power dynamic range = OSTP_{first measurement} - OSTP_{second measurement}

| 0.0 ms 2.0 ms/ | 20 | .0 ms 🛛 (| J.0 Hz | 9.83 MHz | / 98.28 MHz 📗 | IBH (1 M | | | Demed |
|--------------------------|--------|-----------|---------|--------------|------------------|-----------|-------------------|-------------|--------------------|
| 2 Result Summary | | | Selec | ted Averaged | 5 Power Spectrum | O1 Clrw | 6 Constellat | ion Diagram | 1 Demou |
| Frame Results Averaged | Mean | Limit | Мах | Min | | | Points Measured : | 681200 | |
| EVM PDSCH QPSK (%) | 0.43 | 18.50 | 0.43 | 0.43 | 60 d0m ///n | | | | Evaluation |
| EVM PDSCH 16QAM (%) | | 13.50 | | | -60 uBm/H2 | | | | Range |
| EVM PDSCH 64QAM (%) | | 9.00 | | | 70 d0m (1) | | | | - |
| EVM PDSCH 256QAM (%) | | 4.50 | | | -70 uBm/H2 | | | | |
| EVM All (%) | 0.43 | | 0.43 | 0.43 | | | | | Result |
| EVM Phys Channel (%) | 0.43 | | 0.43 | 0.43 | -80 dBm/Hz | | - | | Settings |
| EVM Phys Signal (%) | 0.42 | | 0.42 | 0.42 | | | | | |
| Frequency Error (Hz) | -0.02 | | 0.01 | -0.05 | -90 dBm/Hz | | 1: | | . Display |
| Sampling Error (ppm) | | | | | | | | | 1 Config |
| I/Q Offset (dB) | -66.69 | | -66.54 | -66.85 | -100 dBm/Hz | | | | |
| I/Q Gain Imbalance (dB) | | | | | | | | | |
| I/O Ouadrature Error (°) | - | | - | - | -110 dBm/Hz | | | | 10-10-10-10-10-10- |
| OSTP (dBm) | 25.19 | | 25.19 | 25.19 | | - { | | | _→,→= |
| Power (dBm) | 24.87 | | 24.87 | 24.87 | 120 dBm/Hz | | | | |
| Crest Factor (dB) | 11.72 | | | | | | | | Overview |
| | | | | | 0.0 Hz 1 | 22.88 MHz | | | Overview |
| ~ | | | Svnc F | ound | | | Ready | | 25.09.2019 |
| | | | - Oyner | | | | | REF | 09:36:38 |

Figure 9: BS output power in the result summary

SCPI commands sequence

```
INSTrument[:SELect] NR5G
CONFigure[:NR5G]:MEASurement EVM
[SENSe:]FREQuency:CENTer <Frequency>
MMEMory:LOAD:TMODel[:CC<cc>] <TestModel>
FETCh[:CC<cc>][:ISRC<ant>][:FRAMe<fr>]:SUMMary:OSTP[:AVERage]?
```

3.6.3 NB-IoT RB power dynamic range (6.3.4)

The NB-IoT RB power dynamic range (or NB-IoT power boosting) is the difference between the average power of NB-IoT REs (which occupy certain REs within a NR transmission bandwidth configuration plus 15 kHz at each edge but not within the NR minimum guard band GB_{Channel}) and the average power over all REs (from both NB-IoT and the NR carrier containing the NB-IoT REs). [1]

| BS channel bandwidth (MHz) | NB-IoT RB frequency position | NB-IoT RB power dynamic range (dB) |
|-------------------------------|---|---------------------------------------|
| 5, 10 | Any | +5.6 |
| 15 | Within center 77*180kHz+15kHz at each edge | +5.6 |
| | Other | +2.6 |
| 20 | Within center 102*180kHz+15kHz at each edge | +5.6 |
| | Other | +2.6 |
| 25, 30, 40, 50, 60, | Within center 90% of BS channel bandwidth | +5.6 |
| 70, 80, 90, 100 | Other | +2.6 |

Table 9: NB-IoT RB power dynamic range for NB-IoT operation in NR in-band

This requirement is tested together with Operating band unwanted emissions (OBUE) (SEM) (6.6.4).

3.7 Transmit on/off power (6.4)

Transmit OFF power requirements apply only to TDD operation of NR BS. Transmitter OFF power is defined as the mean power measured over 70/N μ s filtered with a square filter of bandwidth equal to the transmission bandwidth configuration of the BS (BW_{config}) centered on the assigned channel frequency during the transmitter OFF period.

N = SCS/15, where SCS is sub carrier spacing in kHz. [1]



Figure 10: Definition of transmitter ON and OFF periods [1]

Figure 10 shows the definition of the ranges and Table 10 lists the limits.

Table 10: Transmitter OFF power limit

| Frequency range | Limit |
|-----------------------|---------------|
| f ≤ 3.0 GHz | -83.0 dBm/MHz |
| 3.0 GHz < f ≤ 6.0 GHz | -82.5 dBm/MHz |

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 can be used to absorb the reflected power for limiters for optimizing the VSWR.



Figure 11: Test setup for transmit ON/OFF power measurements

Manual testing procedure

- 1. Select mode 5G NR
- 2. Select measurement Transmit ON/OFF Power
- 3. Set Frequency
- 4. Select Test model
- 5. Select 1 Power unit
- 6. It is recommended to enable (2) Noise Cancellation



7. Start measurement



Figure 12: Tx ON/OFF measurement

SCPI commands sequence

```
INSTrument[:SELect] NR5G
CONFigure[:NR5G]:MEASurement TPOO
SENSe:]FREQuency:CENTer <Frequency>
MMEMory:LOAD:TMODel[:CC<cc>] <TestModel>
[SENSe:]NR5G:OOPower:NCORrection <State>
UNIT:OPOWer <Unit>
TRAC6:DATA? LIST
```

3.8 Transmitted signal quality (6.5)

3.8.1 Frequency error (6.5.2) and modulation quality (6.5.3)

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

Table 11 shows the limits for the different base station classes.

Table 11: Frequency error requirements

| BS class | Accuracy |
|-----------------|----------------------|
| Wide Area BS | ± (0.05 ppm + 12 Hz) |
| Medium Range BS | ± (0.1 ppm + 12 Hz) |
| Local Area BS | ± (0.1 ppm + 12 Hz) |

For this measurement, the FSW must be synchronized via an external reference to a high precision time reference.

Modulation quality is defined by the difference between the measured carrier signal and a reference signal. Modulation quality can be expressed as error vector magnitude (EVM), e.g. the error vector magnitude is a reading of the difference between the ideal symbols and the measured symbols after the equalization. This difference is called the error vector. [1]

Table 12: EVM requirements

| Modulation scheme for PDSCH | Required EVM (%) |
|-----------------------------|------------------|
| QPSK | 18.5 % |
| 16QAM | 13.5 % |
| 64QAM | 9 % |
| 256QAM | 4.5 % |

Test setup



Figure 13: Test setup for frequency error and EVM

The DUT (base station) transmits with the declared maximum P_{rat} . The following configurations are specified: Used TM depends on the supported TMs by the base station:

- ► NR-FR1-TM3.1(a)
- ► NR-FR1-TM3.2
- ▶ NR-FR1-TM3.3
- NR-FR1-TM2(a)

Manual testing procedure

- 1. Select mode 5G NR
- 2. Select measurement EVM/Frequency Err/Power
- 3. Select Test model
- 4. Set Frequency
- 5. Enable 3 Ignore DC

| | | | | 2 | 1 | |
|---|-------------------------|---------------------------------|------------------|---------------------|----------|--------------------------------------|
| | (Front Panel Simulation | 1) | | | | |
| I | Signal Configurati | on | | | × | 5G NR |
| | Signal Description | n Radio Frame Config | Ant Port Mapping | Advanced Settings | | Signal |
| | CC 1 0.00 dBm F | | | | | Description |
| 3 | Global Settings | Handling of Carrier Leakag | e None | TIO 3 Max 4 Alloc 1 | | Radio Frame Config |
| | | Frame Number n_f | None | PBCH DMRS | Not Used | |
| | Reference Point A | RF Upconversion | Ignore DC | | | Trigger/ |
| | | Phase Compensation | Compensate | | | Signal Capture |
| | Coexistence | f_0 = s/ 20.1 ms 0 Hz | CF Man | ual | | Parameter Estimation/ Tracking |

6. Start measurement



Figure 14: Frequency error (6.5.2) and modulation quality (6.5.3)

SCPI commands sequence

```
INSTrument[:SELect] NR5G
CONFigure[:NR5G]:MEASurement EVM
MMEMory:LOAD:TMODel[:CC<cc>] <TestModel>
[SENSe:]FREQuency:CENTer <Frequency>
CONFigure[:NR5G]:DL[:CC<cc>]:IDC <State>
FETCh[:CC<cc>][:ISRC<ant>][:FRAMe<fr>]:SUMMary:FERRor[:AVERage]?
FETCh[:CC<cc>][:ISRC<ant>][:FRAMe<fr>]:SUMMary:EVM[:ALL][:AVERage]?
```

3.8.2 Time alignment error (TAE) (6.5.4)

Frames of the NR signals being present at the BS transmitter antenna connectors or TAB connector are not perfectly aligned in time and may experience certain timing differences in relation to each other. [1]

Time alignment error (TAE) is defined as the largest timing difference between any two signals. This requirement applies to frame timing in Tx diversity, MIMO transmission, carrier aggregation and their combinations.

Table 13 lists the limits for various combinations.

Table 13: Time alignment error limits

| Transmission combination | Limit |
|---|----------|
| MIMO/Tx diversity at each carrier frequency | 90 ns |
| Intra-band CA with or without MIMO or Tx diversity | 285 ns |
| Intra-band non-contiguous CA with or without MIMO or Tx diversity | 3.025 μs |
| Inter-band CA with or without MIMO or Tx diversity | 3.025 μs |

The DUT (base station) typically transmits with NR-FR1-TM1.1 with MIMO transmission or carrier aggregation.

Test setup

The following setup is used for this test. The antennas to be measured are connected via one (or more cascaded) hybrid coupler(s). The FSW is connected via an attenuator. To achieve precise measurements, the RF cables being used should be equal in electrical length.

Figure 15: Test setup time alignment error

Up to four antennas can be measured in parallel. The measurement is taken on the reference signal (DM-RS) of the individual antennas and PDSCHs are ignored. The measurement is always relative to one reference antenna.

Manual testing procedure

- 1. Select mode 5G NR
- 2. Select measurement Time Alignment Error
- 3. Select Test model
- 4. Set Frequency

5. Select the **6** Number of layers

| | == ☞ 🖺 🖵 👟 👰 🔍 🗟 🎆 🔲 🔅 🐊 🎙? ? | 5G NR | |
|--------|---|--|----------|
| | Overview 💿 🗙 | Signal Description | |
| 2 | EVM/Hrequency Error/Power | Radio Frame Config | |
| 3_ | #CCs 1 Frequency 13.25 GHz Source Free Run Bandwidth 100MHz Ref Level 0.0 dBm Offset 0.0 s Cet ID Auto Att 10.0 dB No of Subframes 10 Phase Tracking Off ▲ ■ Signal Description → → Tnput/Frontend → Trigger/ Signal Capture → | Trigger/ Signal Capture Parameter (Estimation/ Tracking | |
| _ | Signal Configuration | ∢ Demod | |
| | Signal Description Radio Frame Config Ant Port Mapping Advanced Settings | Evaluation Range | |
| 4- | CC 1 10 db Frame Count 1 of 1(1) Frame 1 Copy Frame To Selected 1 Copy Frame Paste Frame Paste to all | Result (Settings | |
| \sim | Synchronization BWP Config Slot Config PDSCH/PDCCH Config | Display I Config | |
| (5)- | Bandwidth Part Number 0 PDSCH Enhanced Settings | ** | \frown |
| | Selected Slot 0 Prev Slot Next Slot # User Configurable Slots 5 Copy | Overview | (1) |
| | SF Slot Slot Slot PDSCH Repeated Ref Number Number Allocations Format Allocations Slot No Signals O O Data O Configure User None | | |
| | PROCULE-hand Cathings | V | |
| 6 | User ID 0 VRB-to-PRB Interleaver Non-Interleaved • | | |
| 67 | PDSCH DiviRS Config Phase-tracking RS Config (PTRS) Scrambling/Coding | | |
| | Config Type and those 1 | | |
| | First DMRS symb rel to (Mapping Type) Slot start (A) Layers/Codewords 2/1 | antas friba karafea | |
| | First DMRS Symb 2 Antenna Ports 1000 + 0,1 | - | |

6. Start measurement

Figure 16: Time alignment error (TAE)

SCPI commands sequence

```
INSTrument[:SELect] NR5G
CONFigure[:NR5G]:MEASurement TAER
MMEMory:LOAD:TMODel[:CC<cc>] <TestModel>
[SENSe:]FREQuency:CENTer <Frequency>
CONFigure:DL[:CC<cc>]:FRAMe<fr>:BWPart<bwp>:SLOT<sl>:ALLocation<al>:CLMapping
<Mapping>
FETCh:TAERror[:CC<cc>]:ANTenna<ant>MINimum?
FETCh:TAERror[:CC<cc>]:ANTenna<ant>MAXimum?
FETCh:TAERror[:CC<cc>]:ANTenna<ant>[:AVERage]?
```

3.9 Unwanted emissions (6.6)

Unwanted emissions consist of out-of-band emissions and spurious emissions according to ITU definitions. In ITU terminology, 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. The out-of-band emissions requirement for the BS transmitter is specified both in terms of adjacent channel leakage power ratio (ACLR) and operating band unwanted emissions (OBUE). [1]

The maximum offset of the operating band unwanted emissions mask from the operating band edge is Δf_{OBUE} . The operating band unwanted emissions define all unwanted emissions in each supported downlink operating band plus the frequency ranges Δf_{OBUE} above and Δf_{below} each band. Unwanted emissions outside of this frequency range are limited by a spurious emissions requirement. Table 14: Maximum offset of OBUE outside the downlink operating band

| BS type | Operating band characteristics ΔfOBUE (MHz) | | |
|--|--|----|--|
| BS type 1-C $F_{DL_{high}} - F_{DL_{low}} \le 200 \text{ MHz}$ | | 10 | |
| | $200 \text{ MHz} < F_{\text{DL}_high} - F_{\text{DL}_low} \leq 900 \text{ MHz}$ | 40 | |
| BS type 1-H F _{DL_high} – F _{DL_low} < 100 MHz | | 10 | |
| | $100 \text{ MHz} \leq F_{\text{DL_high}} - F_{\text{DL_low}} \leq 900 \text{ MHz}$ | 40 | |

3.9.1 Occupied bandwidth (OBW) (6.6.2)

The 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. The value of $\beta/2$ shall be taken as 0.5%. [1]

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 15.

| Bandwidth | BS channel bandwidth BWChannel (MHz) | | | | | |
|--------------------------------------|---|-----|-----|-----|--|--|
| | 5 | 10 | 15 | 20 | > 20 | |
| Span (MHz) | 10 | 20 | 30 | 40 | $2 \times BW_{Channel}$ | |
| Minimum number of measurement points | 400 | 400 | 400 | 400 | $\left[\frac{2 \times BW_{Channel}}{100 kHz}\right]$ | |

The measured bandwidth (OBW) shall be smaller than the nominal bandwidth (see Table 15, top row).

Test setup

Figure 17: Test setup unwanted emissions

The DUT (base station) transmits with declared rated output power. The test model NR-FR1-TM1.1 is required. For TDD signals, the trigger must be set to external.

Manual testing procedure

- 1. Select mode Spectrum
- 2. Select measurement OBW
- 3. Set Frequency
- 4. Only for TDD signals: Use 3 External triggering

5. Set (1) Channel bandwidth (depends on the test model)

6. Start measurement

Figure 18: OBW measurement

SCPI commands sequence

```
INSTrument[:SELect] SAN
CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:SELect OBANdwidth
[SENSe:]FREQuency:CENTer <Frequency>
TRIGger[:SEQuence]:SOURce <Source>
[SENSe:]POWer:ACHannel:BWIDth[:CHANnel<ch>] <Bandwidth>
CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:RESult? OBANdwidth
```

3.9.2 Adjacent channel leakage power (ACLR) (6.6.3)

Adjacent channel leakage power ration (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. [1]

Figure 19: ACLR

Table 16: Base station ACLR absolute basic limit

| BS category / BS class | ACLR absolute basic limit |
|-------------------------|---------------------------|
| Category A Wide Area BS | -13 dBm/MHz |
| Category B Wide Area BS | -15 dBm/MHz |
| Medium Range BS | -25 dBm/MHz |
| Local Area BS | -32 dBm/MHz |

Table 17: Base station ACLR limit

| BS channel bandwidth of lowest/highest NR carrier transmitted BW _{Channel} (MHz) | BS adjacent channel center frequency offset below the lowest or above the highest carrier center frequency transmitted | Assumed adjacent channel carrier (informative) | Filter on the adjacent channel frequency and corresponding filter bandwidth | ACLR limit |
|---|---|--|---|---------------|
| 5, 10, 15, 20 | BWChannel | NR of same BW | Square (BW _{Config}) | 44.2 dB |
| | 2 x BWChannel | NR of same BW | Square (BW _{Config}) | 44.2 dB |
| | BWChannel /2 + 2.5 MHz | 5 MHz E-UTRA | Square (4.5 MHz) | 44.2 dB |
| | BWChannel /2 + 7.5 MHz | 5 MHz E-UTRA | Square (4.5 MHz) | 44.2 dB |
| 25, 30, 40, 50, 60, | BWChannel | NR of same BW | Square (BW _{Config}) | 43.8 dB |
| 70, 80, 90, 100 | 2 x BWChannel | NR of same BW | Square (BW _{Config}) | 43.8 dB |
| | BWChannel /2 + 2.5 MHz | 5 MHz E-UTRA | Square (4.5 MHz) | 43.8 dB |
| | BWChannel /2 + 7.5 MHz | 5 MHz E-UTRA | Square (4.5 MHz) | 43.8 dB |

Test setup

Figure 20: Test setup ACLR

The DUT (base station) transmits with the declared rated power. Test models NR-FR1-TM1.1 and NR-FR-TM1.2 are required. For TDD signals, the trigger must be set to external. Both cases, NR and LTE as adjacent channels, are handled (see Table 17). Both relative and absolute limits apply (see Table 16 for absolute values).

Manual testing procedure

- 1. Select mode 5G NR
- 2. Select measurement Channel Power ACLR
- 3. Select Test model
- 4. Set Frequency

5. For TDD signals only: Use 3 External triggering

| | | | | | (2) | |
|---|--|---|---|----------------------------------|---------------------|-------------------------|
| | ◀ ☎ 🖺 म 🔳 < | h 🔊 🕵 🧟 🛱 📮 | 🔄 👷 🌿 🗔 🍾 ? | ×_+ =+ | Ō | Ch Power |
| (3) | MultiView 💶 Spectrum | n X 5GNR X | | | · | Signal I Description |
| T | Overview Channel Power ACLR | | | | × × | ACLR Mode |
| Trigger And Gate Preview | | | × | 4 | | Noise Cancellation |
| Show Preview Of | On 1 Zero Span | | • 1AP Clrw | Source Level Gated Trigger | Free Run Off | Set CP Reference |
| Frequency 1.0 GHz | -40 dBm Visita that whitter the weather | nne atoli soni cantilio ni padding lida ni ma | al lang panlata kan digas pating kiti kiti a manih par hal na | Trigg | er/Gate | Sweep Time |
| Sweep Time 10.0 ms | -80 dBm CF 1.0 GHz | 1001 pts | 1.0 ms/ | | | Adjust Settings |
| Trigger Source Trig | ger In/Out | Gate Setting | gs Cont. Gate Source | > 📉 Displa | y Config | |
| Source Free | Run | Gated Trigger | On Off | | | CP / ACLR I Config |
| | | Gate Mode | | | | Display I Config |
| Offset 0 s | Slope pts | ising Falling Gate Delay | | | | |
| Result Summary Hysteresis _{tel} 3.0 | dB Holdoff _{Offs} 0 s | Gate Length | | easurement | | |
| Tx Total | Alt | 90.200 Miliz -30.37 200.000 M | 112 - TO.JJ UD. | -48.6 | 2 dBc | Overview |

6. You can enable (1) Noise Cancellation

7. Start measurement

| |) 🕮 🔶 🖉 |) <u> </u> | | 🔲 🔂 👷 🕨 | \$? ? | | | Ō | Ch Power |
|--------------|---|-------------------------------|-----------|----------------|---------------|--|---|---|-----------------------|
| MultiView | = Spectrum | ı X | 5G NR | × | | | | | Signal |
| Ref Level 0. | 00 dBm | | RBW 1 | 00 kHz | | | | SGL | 1 b o son prion |
| Att | 12 dB SWT 5 | 0 ms (~855 m | is) 🗢 VBW | 1 MHz Mode Aut | :o FFT | | | | ACLR Mode |
| 1 ACLR | | | | | | | NCAN | •1Rm Clrw | Abs Rel |
| | | | | Tv1 | | | | | |
| -10 dBm | | Ac | dj | 101 | | Adj | | | Noise Cancellation |
| -20 d0m | Alt1 | | | | | | Alt1 | | |
| 20 0011 | | | | | | | | | Set CP |
| -30 dBm | | | | | | | | | Reference |
| | | | | | | | | | |
| -40 dBm | | | | | | | | | Sweep Time |
| | | | | | | | | | |
| -50 dBm | | | | | | | | | Adjust |
| -60 dBm | | | | | | | | | Settings |
| | | | | | | | | | |
| -78 d9m | | I | | | | | | | |
| | | | | | | | | | |
| -80 dBm | | | | | | | | | CP / ACLR |
| -90 dBm | | | | | | | | | Config |
| | and the state of the | hand the second second second | | | an de Bielen | a dilla il sa billanas da Li Anasaria. | بالطمة محافظة ويخبر ليربعهم الأبطية أمطار | and the state of the | |
| CE 1.0 GHz | and a production of | 5 1 S A 6 P | 5191 pt | te | 51.9 ME | Hall and all and a second | Soa | n 519.0 MHz | Display |
| 2 Result Sum | many | | 5151 p | SG NR | 51.9 14 | 127 | 500 | 1131310 10112 | Config |
| Chann | el | Bandwidth | | Offset | P | ower | | | |
| Tx1 (Re | ef) 🤉 | 98.280 MHz | | | -11.2 | O dBm | | | |
| Tx Tota | al | Bandwidth | | Offeet | -111.2 | | Linna | r . | |
| Adi | | 98.280 MHz | | 100.000 MHz | -58. | 89 dBc | -59.61 | BC | Overview |
| Altí | ç | 98.280 MHz | | 200.000 MHz | -58. | 43 dBc | -60.01 | BC | |

Figure 21: ACLR measurement

SCPI commands sequence

INSTrument[:SELect] NR5G CONFigure[:NR5G]:MEASurement ACLR MMEMory:LOAD:TMODel[:CC<cc>] <TestModel> [SENSe:]FREQuency:CENTer <Frequency> TRIGger[:SEQuence]:SOURce <Source> [SENSe:]POWer:NCORrection <State> CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:RESult[:CURRent]? [<Measurement>]

3.9.3 Operating band unwanted emissions (OBUE) (SEM) (6.6.4)

Unless otherwise stated, the operating band unwanted emission (OBUE) limits in FR1 are defined from Δf_{OBUE} below the lowest frequency of each supported downlink operating band up to Δf_{OBUE} above the highest frequency of each supported downlink operating band. [1] The values of Δf_{OBUE} are defined in Table 14.

The test requirements shall apply as per categories either A or B. The minimum mandatory requirement is mentioned in subclause 6.6.4.5 [1].

Test setup

Figure 22: Test setup for SEM

The DUT (base station) transmits with the declared rated output power. The test models NR-FR1-TM1.1 and NR-FR1-TM1.2 are required. For TDD signal, the trigger must be set to external.

Manual testing procedure

- 1. Select mode 5G NR
- 2. Select measurement Spectrum Emission Mask
- 3. Select Test model
- 4. Set Frequency
- 5. For TDD signals only: Use 3 External triggering

| | 3 | | | | | (2 |) | |
|-----------------|-----------------|--|---|------------------------------------|---|---------------|----------|--------------------|
| | E) LL 📃 🕻 | له 🤌 🐼 دهر له | 🕄 🔐 🔲 😥 👷 | ۶€ 📑 ◄٠ | ? ? 🗄 🗄 | 3 + | 0 | SEM |
| MultiViev | w 📰 Spectru | m | | | | | | Sweep |
| Overvie | w | | | | | | × | List |
| Spectrum | 1 Emission Mask | | | | | | | ∢ Sub Blocks |
| | | | | | - | Source | Free Dun | Reference Range |
| | | La ra 🔛 🔂 | scpi ⁹ t≣ └─▶ [*] ? 🧭 🗏 | 4 | 0 | Level | | , Power |
| MultiView = Sp | pectrum | | | | | Gated Trigger | Off | Classes |
| Trigger And Gat | Free Run | extra a state of the state of t | | • | • <mark>×</mark> - | Trigg | ger/Gate | MSR 4 Config |
| Show Preview | Ext Trigger 1 | (ero Span | ner rezeren 1 mat 1800 mar an energi (mat 1800 mar an energi) mat 1800 mar | | O 1 AP Clrw | | | , Standard |
| Settings | Ext Trigger 2 |) dBm | at the attraction of the | | | | | • Files |
| Frequency 1.0 | G Ext Trigger 3 | A MARKAN AND AND AND AND AND AND AND AND AND A | n an i na gun ann an tha ann ann ann ann ann ann ann ann ann a | alahin na 14,41 adalahin si 14,41. | ditti ini ing antisticuto | _ | | List |
| RBW 10.0 | IF Power |) dBm | | | | → / 🔨 Disp | lay | • • Evaluation |
| Sweep Time 10.0 | Time | 1.0.6Hz | 1001 pte | | 1.0 ms (| | | |
| | RF Power | 1.0 01/2 | 1001 pts | | 1.0 ms/ | | | |
| Trigger Source | Power Sensor | | Gate Settin | gs Cont. Gate | Source | | | , Display |
| Source | Free Run | · | Gated Trigger | On | Off | | | . ⁴ Config |
| | | | Gate Mode | | Edge | | | |
| Offset | | | Falling Gate Delay | | ar an | ement | | |
| Hysteresis | | Holdoff 0 s | Gate Length | | | 15.29 dB | 34.71 dB | Overview |
| Range Low | Range Un | RBW Freque | Power Abs | Power Rel | Al imit | | | |

6. Start measurement

Figure 23: Operating band unwanted emissions

SCPI commands sequence

```
INSTrument[:SELect] NR5G
CONFigure[:NR5G]:MEASurement ESPectrum
MMEMory:LOAD:TMODel[:CC<cc>] <TestModel>
[SENSe:]FREQuency:CENTer <Frequency>
TRIGger[:SEQuence]:SOURce <Source>
CALCulate<n>:MARKer<m>:FUNCtion:POWer<sb>:RESult[:CURRent]? [<Measurement>]
```

3.9.4 Transmitter spurious emissions (6.6.5)

The transmitter spurious emission limits shall apply from 9 kHz to 12.75 GHz, excluding the frequency range from Δf_{OBUE} below the lowest frequency of each supported downlink operating band, up to Δf_{OBUE} above the highest frequency of each supported downlink operating band, where the Δf_{OBUE} is defined in Table 14. For some operating bands, the upper limit is higher than 12.75 GHz in order to comply with the 5th harmonic limit of the downlink operating band. [1]

Table 18: General BS transmitter spurious emission limits in FR1, Category A

| Spurious frequency range | Basic limit | Measurement bandwidth |
|--|-------------|-----------------------|
| 9 kHz – 150 kHz | -13 dBm | 1 kHz |
| 150 kHz – 30 MHz | | 10 kHz |
| 30 MHz – 1 GHz | | 100 kHz |
| 1 GHz – 12.75 GHz | | 1 MHz |
| 12.75 GHz – 5th harmonic of the upper frequency edge of the DL operating band in GHz | | 1 MHz |

Table 19: General BS transmitter spurious emission limits in FR1, Category B

| Spurious frequency range | Basic limit | Measurement bandwidth |
|--|-------------|-----------------------|
| 9 kHz – 150 kHz | -36 dBm | 1 kHz |
| 150 kHz – 30 MHz | | 10 kHz |
| 30 MHz – 1 GHz | - | 100 kHz |
| 1 GHz – 12.75 GHz | -30 dBm | 1 MHz |
| 12.75 GHz – 5th harmonic of the upper frequency edge of the DL operating band in GHz | - | 1 MHz |

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

Table 20: BS spurious emissions basic limits for protection of the BS receiver

| BS class | Frequency range | Basic limit | Measurement bandwidth |
|-----------------|------------------------------|-------------|-----------------------|
| Wide Area BS | $F_{UL_low} - F_{UL_high}$ | -96 dBm | 100 kHz |
| Medium Range BS | | -91 dBm | |
| Local Area BS | | -88 dBm | |

Test setup

Figure 24: Test setup spurious emissions

The test requires a notch (or a diplexer) filter that suppresses the frequency range of the NR 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 \rightarrow dynamic is 120 dB).

The DUT (base station) transmits with declared rated power. Test model NR-FR1-TM1.1 is required.

Manual testing procedure

- 1. Select mode Spectrum
- 2. Select measurement Spurious Emission
- 3. Set (2) Frequency ranges and (3) Limits according to Table 18 and Table 19

4. Start measurement

Figure 25: Spurious emissions

SCPI commands sequence

```
INSTrument[:SELect] SAN
INITiate<n>:SPURious
[SENSe:]LIST:RANGe<ri>[:FREQuency]:STARt <Frequency>
[SENSe:]LIST:RANGe<ri>[:FREQuency]:STOP <Frequency>
[SENSe:]LIST:RANGe<ri>[:LIMit]:STARt <Limit>
[SENSe:]LIST:RANGe<ri>[:LIMit]:STOP <Limit>
:SENS:LIST:XADJ;*WAI
:INIT:SPUR
TRACe<n>[:DATA]? LIST
```

3.10 Transmitter intermodulation (6.7)

The transmitter intermodulation requirement is a reading of the capability of the transmitter unit to inhibit the generation of signals in its non-linear elements caused by presence of the wanted signal and an interfering signal reaching the transmitter unit via the antenna, RDN and antenna array.

The transmit intermodulation level is the power of the intermodulation products when a NR signal of the lowest supported channel bandwidth 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. The interfering signal offset is defined relative to the channel edges.

Table 21: Transmit intermodulation parameters

| Wanted signal | Interfering signal | Frequency offset (to channel edge) |
|----------------|--|--|
| NR signal with | NR signal with NR-FR1-TM1.1 with | ± 0.5 * BW _{Interferer} (n=1) |
| NR-FR1-TM1.1 | minimum channel bandwidth with | ± 1.5 * BW _{Interferer} (n=2) |
| | level = P _{rated,t,AC} - 30dB | ± 2.5 * BW _{Interferer} (n=3) |

Test setup

Figure 27: Test setup transmitter intermodulation

- ► The DUT (base station) generates the wanted signal at F_c with BW_{Channel} and NR-FR1-TM1.1.
- ► The SMW generates a NR signal with NR-FR1-TM1.1 and the offsets according to Table 21, without interfering frequencies that are outside of the allocated downlink operation band or interfering frequencies that are not completely within the sub-block gap or within the inter RF bandwidth gap.

Measurements

The same conditions apply for these measurements as for:

- Adjacent channel leakage power (ACLR) (6.6.3)
- Operating band unwanted emissions (OBUE) (SEM) (6.6.4)
- Transmitter spurious emissions (6.6.5)

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

Table 22: Measurement regions for intermodulation test

| Intermodulation products | Center frequency | Intermodulation width |
|--------------------------|------------------|---|
| 3 rd order | 2 * F1 ± F2 | 2 * BW _{Channel} + 1 * BW _{Int} |
| | 2 * F2 ± F1 | 2 * BW _{Int} + 1 * BW _{Channel} |
| 5 th order | 3 * F1 ± 2 * F2 | 3 * BW _{Channel} + 2 * BW _{Int} |
| | 3 * F2 ± 2 * F1 | 3 * BWInt + 2 * BWChannel |
| | 4 * F1 ± F2 | 4 * BW _{Channel} + 1 * BW _{Int} |
| | 4 * F2 ± F1 | 4 * BW _{Int} + 1 * BW _{Channel} |
| Note: | | • |

F1: Wanted signal F2: Interferer

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 Figure 28). The ranges must be adjusted accordingly. In principle, the following intermodulation products (ranges) can be affected:

- ▶ 2 * F1 + F2
- ▶ 2 * F1 F2
- ▶ 2 * F2 + F1
- ▶ 2 * F2 F1

The settings are explained in this example:

- ▶ Wanted signal: F1 = 2140 MHz with BW_{Channel} = 20 MHz
- ▶ Interferer offset: + 2.5 MHz: F2 = 2140 MHz + BW_{Channel}/2 + 2.5 MHz = 2152.5 MHz
- ► Third order
 - 2 * F1 + F2 = 6432.5 MHz, Intermodulation BW = 45 MHz
 - 2* F1 F2 = 3238.5 MHz, Intermodulation BW = 45 MHz
 - 2 * F2 + F1 = 6445 MHz, Intermodulation BW = 30 MHz
 - 2 * F2 F1 = 2165 MHz, Intermodulation BW = 30 MHz

Figure 28: Measurement regions for the intermodulation test. Regions that overlap with the wanted signal or the interferer must be excluded

Manual testing procedure (FSW)

The Manual testing procedure for this test is similar to the procedure which is mentioned in chapter <u>Adjacent</u> <u>channel leakage power (ACLR) (6.6.3)</u>, <u>Operating band unwanted emissions (OBUE) (SEM) (6.6.4)</u> and <u>Transmitter spurious emissions (6.6.5)</u>.

SCPI commands sequence (FSW)

The SCPI sequence is similar to to the sequence which is mentioned in chapter <u>Adjacent channel leakage</u> <u>power (ACLR) (6.6.3)</u>, <u>Operating band unwanted emissions (OBUE) (SEM) (6.6.4)</u> and <u>Transmitter spurious</u> emissions (6.6.5).

Manual testing procedure (required SMW firmware: higher than 4.70.026.51)

Note: The Test Case Wizard (TCW) is programmed on the basis of TS 38.141-1, Rel. 15. However, because the interferer parameter settings are the same like in TS 38-141-1, Rel 16 V.16.3.0 the TCW can be used.

1. Open the Test Case Wizard

2. Select the 1 Base Station Class, the 2 Test Case and set the 3 further settings through the tabs

SCPI commands sequence (SMW)

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC67
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:PLEVel <WSPowLev>
:BB:NR5G:TCW:FA:FRALlocation <FreqAlloc>
:BB:NR5G:TCW:IS:BAND <Band>
:BB:NR5G:TCW:IS:OFN <OFN>
:BB:NR5G:TCW:IS:DUPLex <Duplexing>
:BB:NR5G:TCW:APPLy
:OUTPut1:STAT 1
```

Python library

As test case 6.7 Transmitter intermodulation includes several previous explained test cases (6.6.3, 6.6.4 and 6.6.5) the python module TC_6_7.py contains only the interfering generation process. To execute the whole test case, please execute TC_6_7.py, TC_6_6_3.py, TC_6_6_4.py and TC_6_6_5.py.

A code example is shown in A.4.

4 Literature

- [1] 3GPP Technical Specification Group Radio Access Network,
 "NR Base station conformance testing, Part 1: Conducted conformance testing, Release 16; TS 38.141-1, V16.3.0", 2020.
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- [2] 3GPP Technical Specification Group Radio Access Network
 "NR Base Station (BS) conformance testing Part 2: Radiated conformance testing, Release 16; TS 38.141-2 V.16.3.0", 2020.
 Available: <u>https://www.3gpp.org/DynaReport/38141-2.htm</u>.
- [3] Rohde & Schwarz, 5G NR Technology Introduction, 2019.
- [4] 3GPP Technical Specification Group Radio Access Network,
 "NR Base Station (BS) radio transmission and reception, Release 16; TS 38.104, V16.3.0", 2020.
 Available: <u>https://www.3gpp.org/DynaReport/38104.htm</u>.
- [5] Rohde & Schwarz, "5G NR Base Station OTA Transmitter Tests (GFM324)," 2020 Available: <u>https://www.rohde-schwarz.com/appnote/GFM324</u>.
- [6] Rohde & Schwarz, "5G NR Base Station OTA Receiver Tests (GFM325)", 2020 Available: <u>https://www.rohde-schwarz.com/appnote/GFM325</u>.
- [7] Rohde & Schwarz, "Remote Control and Instrument Drivers" Available: <u>https://www.rohde-schwarz.com/de/driver-pages/fernsteuerung/uebersicht_110753.html</u>.
- [8] Rohde & Schwarz, "Introducing SCPI Commands" Available: <u>https://www.rohde-schwarz.com/de/driver-pages/fernsteuerung/remote-programming-environments_231250.html</u>.

5 Ordering Information

| Туре | Designation | Order No. |
|--|--------------------------------|---------------------------------|
| R&S [®] FSW43 | Signal and spectrum analyzer | 1331.5003.43 |
| R&S [®] FSW-K144 | 5G-NR downlink measurements | 1338.3606.02 |
| R&S [®] FSV3044 | Signal and spectrum analyzer | 1330.5000.43 |
| R&S [®] FSVA3044 | Signal and spectrum analyzer | 1330.5000.44 |
| R&S [®] FSV3-K144 | 5G-NR downlink measurements | 1330.7219.02 |
| R&S [®] FPS40 | Signal and spectrum analyzer | 1319.2008.40 |
| R&S [®] FPS-K144 | 5G-NR downlink measurements | 1321.4979.02 |
| R&S [®] VSE | Signal analysis software | 1345.1011.06 or 1345.1105.06 |
| R&S [®] VSE-K144 | 5G-NR downlink measurements | 1309.9574.06 |
| R&S [®] SMW200A | Vector signal generator | 1412.0000.02 |
| R&S [®] SMW-B1003 | Frequency option | 1428.4700.02 |
| R&S [®] SMW-B10 or R&S [®] SMW-B9 | Baseband generator option | 1413.1200.02 or 1413.7350.02 |
| R&S [®] SMW-B13T or R&S [®] SMW-B13XT | Baseband main module option | 1413.3003.02 or 1413.8005.02 |
| R&S [®] SMW-K62 | AWGN option | 1413.3484.02 |
| R&S [®] SMW-K144 | 5G New Radio | 1414.4990.02 |
| R&S [®] SMBV100B | Vector signal generator | 1423.1003.02 |
| R&S [®] SMBVB-B103 | Frequency range 8 kHz to 3 GHz | 1423.6270.02 |
| R&S [®] SMBVB-K520 | Baseband real-time extension | 1423.7676.02 |
| R&S [®] SMBVB-K144 | 5G New Radio | 1423.8608.02 |

6 Appendix

A GFM313_Tx_tests Python package

This Python library is providing chapter 6 test cases defined in TS 38.141-1. These Python classes are meant to be integrated easily into existing Python development environment and projects.

By this the time for searching and testing correct SCPI sequences shall be reduced tremendously.

A.1 Terms and conditions

By downloading the Python package, you are agreeing to be bound by the <u>Terms and conditions for royalty</u> <u>free software</u>.

A.2 Requirements

- ► The following setup is recommended:
- Python version 3.8
- ► PyCharm IDE
 - The Community Edition version is sufficient
 - https://www.jetbrains.com/pycharm/
- RsInstrument Python module is required (1.8.2.45 or higher)
 - pypi.org: <u>https://pypi.org/project/RsInstrument/</u>
 - Further details: <u>How to install / update RsInstrument package</u>

For further reading

Please see the <u>Getting Started</u> remote control example using Python in PyCharm.

A.3 Package structure

| V | gfm313-5g-bs-testing-transmitter-tests |
|---|--|
| | GFM313_Tx_tests |
| | 🔻 🛅 General |
| | 🛃initpy |
| | 🕨 👍 GFM313_base.py |
| | 🕨 👍 GFM313_utilities.py |
| | TCs |
| | 🕨 👬 TC_6_2.ру |
| | 🕨 💑 TC_6_3_3.ру |
| | 🕨 樻 ТС_6_4.ру |
| | 🕨 💑 TC_6_5_4.ру |
| | 🕨 🕌 TC_6_5_23.ру |
| | 🕨 💑 TC_6_6_2.ру |
| | 🕨 👬 TC_6_6_3.ру |
| | 🕨 🕌 ТС_6_6_4.ру |
| | 🕨 👬 TC_6_6_5.ру |
| | 🕨 樻 ТС_6_7.ру |
| | 🛃initpy |
| | 🧑 .gitignore |
| | 🛃 Example_Tx_tests.py |
| | 🗐 hardcopy_BSoutputPow.png |
| | 률 README.md |
| | results_663_ACLR.csv |
| | 🗐 results_664_OBUE.csv |
| | 🚽 results_665_SPUR.csv |

Figure 29: Project tree in PyCharm

A.4 Example_Tx_tests.py

The provided Example_Tx_tests.py file shows the usage of this Python library for 5G NR base station transmitter tests.

```
from GFM313 Tx tests import *
resource_string_FSW_hislip = 'TCPIP::192.168.1.1::hislip0' # Hi-Speed LAN connection - see 1MA208
resource_string_FSW_vxi11 = 'TCPIP::192.168.1.1::INSTR' # VXI-11 connection
# Signal generator required for TC 6.7
resource_string_SMW_hislip = 'TCPIP::192.168.1.2::hislip0' # Hi-Speed LAN connection - see 1MA208
resource_string_SMW_vxi11 = 'TCPIP::192.168.1.2::INSTR' # VXI-11 connection
resource_string_SMW_usb = 'TCPIP::0x0AAD::0x0119::022019943:INSTR' # USB-TMC
try:
    # Example for TC 6.2 Base station output power
    # Initialization
    mytest62 = TC62(resource_string_FSW_hislip)
    # Set some test specific parameters
    mytest62.frequency = 1000
    mytest62.reference_level_offset = 3
    mytest62.testmodel = 'NR-FR1-TM1_1__TDD_10MHz_15kHz'
    # Start measurement
    mytest62.start_measurement()
    # Print results
    print(mytest62.return_results())
    # Export results to csv
    mytest62.csv_export()
    # Screenshot of analyzer
    mytest62.hardcopy_analyzer('hardcopy_2')
    # Close the connection
    mytest62.close_analyzer()
except RsException as e:
    print(e.args[0])
else:
```

print('Test execution successful')

Figure 30: Example_Tx_tests.py

Code example for 6.7 Transmitter intermodulation test case

```
# Example for TC 6.7 Transmitter intermodulation
# Interferer generation with SMW
mytest67 = TC67(resource_string_SMW_hislip)
mytest67.interferer_duplex = 'TDD'
mytest67.frequency = 1200
mytest67.channel_bw = 20
mytest67.apply_swm_configuration()
mytest67.output_on(1)
# Adjacent channel leakage power measurement
mytest663 = TC663(resource_string_FSW_hislip)
mytest663.frequency = mytest67.frequency
mytest663.channelBW = mytest67.channel_bw
mytest663.start_measurement()
mytest663.csv_export()
# Operating band unwanted emissions measurement
mytest664 = TC664(resource_string_FSW_hislip)
mytest664.frequency = mytest67.frequency
mytest664.channel_bw = mytest67.channel_bw
mytest664.start_measurement()
mytest664.csv_export()
# Transmitter spurious emissions measurement
mytest665 = TC665(resource_string_FSW_hislip)
```

```
mytest665 = TC665(resource_string_FSW_hislip)
mytest665.frequency_5thharmonic = 17500
mytest665.start_measurement()
mytest665.csv_export()
```

Figure 31: Code example for test case 6.7 Transmitter intermodulation

A.5 Quick Documentation in PyCharm

By pressing the shortcut Ctrl + Q the quick documentation can be displayed. This then shows a short description about the corresponding parameter or function.

Figure 32: Quick Documentation

A.6 CSV export function

Every implemented test case class provides a csv-export function. This function delivers an easy table structured overview of the measurement results. The exported .csv-file is stored to the project directory and can be used for further measurement analyzes.

```
mytest62.csv_export()
```

Figure 33: csv-export function call

A.7 Hardcopy function

In addition to the above described csv export function, every test case class provides a hardcopy function. By this the user can easily screenshot the connected spectrum analyzer and store the .png-file with an individual file name to the project directory.

```
mytest62.hardcopy_analyzer('hardcopy_2')
```

Figure 34: Hardcopy function call: Stores a screenshot of the connected analyzer as a .png-file to the project directory

B R&S[®] QuickStep

The QuickStep software application makes it possible to combine testmodules provided by Rohde & Schwarz into test plans to allow rapid and easy remote control of test instruments. The program needs a R&S License. The testmodules for 5G NR base station tests are free of charge.

B.1 Terms and conditions

By downloading the QuickStep package you are agreeing to be bound by the <u>Terms and conditions for</u> royalty free software.

B.2 Requirements

Operating system:

- Windows 10
- Windows 8.1
- Microsoft Windows 7 (64 bit, SP 1, universal C runtime)

General PC requirements: Standard PC

Remote control interface:

- ► R&S[®] Visa
- LAN connection

B.3 First steps

Please use the provided test procedure as a first step. This allows you to skip very basic settings.

Figure 35: QuickStep overview

You can find all 5G NR base station transmitter tests on the left side under **Block Library NR_BS_TransmitterTests**. In the middle under **Test Procedure**, you can find the active **Testsequence**.

🍕 R&S QuickStep 5.0.3.0 - Licenses (occupation): QS-APP, QS-DEV - Valid until: 2020-03-13 09:00:00 || C\UsersPublic\Documents\Rohde-Schwar\QuickStep)Projects\SG, NR, Basestation\SG, NR, Basestation\Tx.tpl || User : Developer

| 踵 Test Execution 📥 Testplan Editor 🔯 Results View | er 🗄 Testprocedure Editor 🛷 System (| Configurator | | |
|--|--------------------------------------|--------------------------------------|--------------------------------------|--|
| 😵 Reload Block Library 🛛 🗞 Forum Script 🔹 🗞 P | Python Script 🛛 🍇 Matlab Script 💧 C | ++/C# Block Development | 🍓 Report Designer 💧 Project Settings | |
| Block Library | - 4 | Test Procedure Before Test Procedure | Test Procedure After | |
| Expand All | | | | |
| General Fock/Join BlockFunction H Or End End<td></td><td></td><td>NR.BS_TransmitterTests Basics</td><td></td> | | | NR.BS_TransmitterTests Basics | |

Figure 36: QuickStep test procedure

It is possible to create your own **test procedure** by using drag-and-drop. Select the testmodule from the block library and drag it into the **Test Procedure** section. Please make sure to connect the bottom port of a block to the top port of the next block.

To start a test, go to the tab **Testplan Editor** and click on the button **Single Run**.

| – Testplan Editor 📂 Results Viewer 🚽 | Testprocedure | e Editor | ord Syste | em Configurator | Test Execution | | |
|---|---------------------------|--------------------|-----------|----------------------------------|----------------|----------------|--------|
| Add Test Step 🗙 Remove Test Step | p Test System: | System | 1 | • 🕨 | Single Run | Continuous Run | 🚱 Upda |
| est Project Browser Group Sequence Remove Control Statements Test Project Parameters Testrun Before [1] DUT Loop Before [1] Test Steps Test Steps DUT Loop After [1] Testrun After [1] | Test Step Id Er 0 1 | setting: able B | s | Test Procedure Test Procedure | | | |

Figure 37: Run a test

After the execution run you can find the results under the tab Results Viewer.

R&S QuickStep 5.0.3.0 - Licenses (occupation): QS-APP, QS-DEV - Valid until: 2020-03-13 09:00:00 || C:\Users\Public\Documents\Rohde-Schwarz\QuickStep\ File Settings Help

| 踵 Test Execution 📒 Testplan Editor | 📡 Results Viewer | 금 Testprocedure Editor | ୍ଟ୍ System Configurator | |
|--|--|----------------------------------|-------------------------|--------|
| Browse C:\Users\Public\Docume | nts\Rohde-Schwarz\C | QuickStep\Projects\5G_NR_Bas | sestation\Results | Export |
| Result File Browser | - ù | | | |
| Collapse All | | | | |
| 2020_03_10_12_03_24_867_5G_N 1_MyDUT RepetitionsTimings.log TestStepsTimings.log Report1.pdf | R_Ba.▲_ | | | |
| ExecutionProtocol_000.txt 5G_NR_Basestation_Tx.tpl | | | | |
| — 📄 DUTLoopTimings.log | | | | |
| TestrunTimings.log | | | | |
| ► 📜 2020_03_1010_56_11_252_5G_N | R_Ba | | | |
| ▶ 10_2020_03_1010_50_27_494_5G_N | ▶ <mark>↓</mark> 2020_03_1010_50_27_494_5G_NR_Ba | | | |
| ► 1. 2020_03_10_10_15_09_113_5G_N ► 1. 2020_03_10_10_14_50_347_5G_N | R_Ba | | | |

Figure 38: QuickStep results

A click on **<name of report>.pdf** opens the report on the last run.

ExecutionProtocol_000.txt shows a protocol of the last run which includes all messages from QuickStep and the sent and received SCPI interactions.

B.4 QuickStep Tx blocks

- Initialization
 - Block name: Init
 - part of "Testrun Before" Manual testing procedure

| Proper | ties | | | | 🔺 d | |
|--|-----------|---------------------------|----------------------|---|------|--|
| B_NR | _BS | _TransmitterTests:NR_BS_T | ransmitterTests\Init | | | |
| Enabled 🗹 | | | | | | |
| Name | Name Init | | | | | |
| Condit | tion | | | | | |
| In Pa | rame | eters | | | | |
| Log | De | f | | | | |
| | ✓ | Force sending SCPI comm | False | v | | |
| | ✓ | FSW | \$V.FSW | v | Visa | |
| | ✓ | SMW | \$V.SMW | Ý | Visa | |
| | ✓ | useSMW | ✓ True | × |] | |
| Out P | arar | neters | | | | |
| Log | De | f | | | | |
| | ✓ | ReplyMessage | | | | |
| Description | | | | | | |
| Initialization activities for this block | | | | | | |

Details

Initialization activities for this block, e.g. member initialization, initialization of measurement equipment, starting timer, etc. Typically executed in TestrunBefore.

- ► Basic parameters
 - Block name: Basics
 - provides principal 5G NR settings independently of the further test steps

| Proper | ties | | | → þ | |
|-------------|--------------|------------------------------|-------------------------|------------|--|
| B_NR | _BS_T | ransmitterTests:NR_BS_1 | TransmitterTests\Basics | | |
| Enable | ed 🔽 |] | | | |
| Name Basics | | | | | |
| Condi | tion | | | | |
| In Pa | ramete | ers | | | |
| Log | Def | | | | |
| | \checkmark | Keset | ✓ Irue ~ | | |
| | ✓ | External Reference | False ~ | | |
| | \checkmark | Frequency (MHz) | 1000 | | |
| | \checkmark | Reference Level (dBm) | 5.0 | | |
| | ✓ | Deployment | f <= 3 GHz * | | |
| | ~ | Channel Bandwidth (MHz) | 100 ~ | | |
| | √ | NR-TM | TM 1.1 * | | |
| | ✓ | SCS | 30 kHz * | | |
| | ✓ | Duplex | FDD × | | |
| | ✓ | FSx Attenuation (dB) | 0.0 | | |
| | ✓ | SMW Attenuation (dB) | 0.0 | | |
| | ✓ | Base Station Type | C * | | |
| | ✓ | Use Gating for TDD | False × | | |
| | ✓ | Gate Length | 3 | ms | |
| Description | | | | | |
| Basic | Settings | 5 | | | |
| Details | | | | | |
| Gener | al para | meters like frequency, bandw | idth, | | |

- ► Test 6.2 Output power dynamics
 - Block name: Tx_6_2_OutputPower

| Properties | - ₫ | | | |
|-------------------------------|-----------------------------------|--|--|--|
| B_NR_BS_TransmitterTests:NR_B | S_TransmitterTests\Tx_6_2_OutputP | | | |
| Enabled 🔽 | | | | |
| Name Tx_6_2_OutputPower | | | | |
| Condition | | | | |
| In Parameters | | | | |
| Log Def | | | | |
| Out Parameters | | | | |
| Log Def | | | | |
| OutputPov | ver | | | |
| E E | /M | | | |
| Frequency Er | ror | | | |
| Description | | | | |
| Base station output power | | | | |
| Details | | | | |
| Chapter 6.2 | | | | |

- ► Test 6.3.3 Total power dynamic range
 - Block name: Tx_6_3_3_PowerDynamicRange

| Properties 💌 🕈 |
|--|
| B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_3_3_Power |
| Enabled 🗹 |
| Name Tx_6_3_3_PowerDynamicRange |
| Condition |
| In Parameters |
| Log Def |
| BS supports 256 QAM False ~ |
| □ ✓ with power back off □ False ~ |
| Description |
| Total Power Dynamic Range |
| Details |
| Chapter 6.3.3 |

- ► Test 6.4 Transmit on/off power
 - Block name: Tx_6_4_TransmitOnOff

| Properties | → Ĥ | | | |
|---------------------------|--|--|--|--|
| B_NR_BS | | | | |
| Enabled | \checkmark | | | |
| Name Tx_6_4_TransmitOnOff | | | | |
| Condition | Condition | | | |
| In Param | eters | | | |
| Log De | f | | | |
| ✓ | Noise Cancellation 🗹 True 🗸 | | | |
| Out Para | neters | | | |
| Log De | f | | | |
| | OffPower | | | |
| | TransPeriod | | | |
| Descripti | on | | | |
| Transmit (|)n/Off power | | | |
| Details | | | | |
| includes 6 period | .4.1. Transmitter Off power and 6.4.2 Transmittere transient | | | |

- ► Test 6.5.2 Frequency error and Test 6.5.3 Modulation quality
 - Block name: Tx_6_5_23_FreqErr_ModQual
 - Both tests are implemented in one QuickStep test block

| Properties 🝷 🖡 |
|--|
| B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_23_Freq |
| Enabled 🗹 |
| Name Tx_6_5_23_FreqErr_ModQual |
| Condition |
| In Parameters |
| Log Def |
| Ignore DC 🗹 True 🗸 |
| Out Parameters |
| |
| Frequency Error |
| EVM |
| Power |
| Description |
| Frequency Error and Modulation Quality |
| Details |
| 6.5.2 Frequency Error and 6.5.3 Modulation Quality |
| |
| |
| Test 6.5.4 Time alignment error (TAE) |
| Test 6.5.4 Time alignment error (TAE) — Block name: Tx_6_5_4_TimeAlign |
| Test 6.5.4 Time alignment error (TAE) — Block name: Tx_6_5_4_TimeAlign Properties ▼ ₽ |
| Test 6.5.4 Time alignment error (TAE) − Block name: Tx_6_5_4_TimeAlign Properties ▼ ₽ B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_Time/ |
| Test 6.5.4 Time alignment error (TAE) – Block name: Tx_6_5_4_TimeAlign Properties ▼ ₽ B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_TimeAlign Enabled ✓ |
| Test 6.5.4 Time alignment error (TAE) − Block name: Tx_6_5_4_TimeAlign Properties ▼ ₽ B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_Time/ Enabled ▼ Name Tx_6_5_4_TimeAlign |
| Test 6.5.4 Time alignment error (TAE) – Block name: Tx_6_5_4_TimeAlign Properties ▼ ♀ B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_TimeAlign Enabled ✓ Name Tx_6_5_4_TimeAlign Condition |
| Test 6.5.4 Time alignment error (TAE) – Block name: Tx_6_5_4_TimeAlign Properties ▼ ₽ B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_Time/ Enabled ✓ Name Tx_6_5_4_TimeAlign Condition |
| Test 6.5.4 Time alignment error (TAE) - Block name: Tx_6_5_4_TimeAlign Properties ▼ ♀ B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_Time/ Enabled ✓ Name Tx_6_5_4_TimeAlign Condition In Parameters Log Def |
| Test 6.5.4 Time alignment error (TAE) - Block name: Tx_6_5_4_TimeAlign Properties ▼ ♀ B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_Time/ Enabled ✓ Name Tx_6_5_4_TimeAlign Condition |
| Test 6.5.4 Time alignment error (TAE) – Block name: Tx_6_5_4_TimeAlign Properties Properties B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_Time/ Enabled ✓ Name Tx_6_5_4_TimeAlign Condition In Parameters Log Def ✓ Number Layers 2 Out Parameters |
| Test 6.5.4 Time alignment error (TAE) – Block name: Tx_6_5_4_TimeAlign Properties ● B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_Time/ Enabled ✓ Name Tx_6_5_4_TimeAlign Condition In Parameters Log Def ✓ Out Parameters Log Def |
| Test 6.5.4 Time alignment error (TAE) - Block name: Tx_6_5_4_TimeAlign Properties Properties Pabled Inparameters Log Def In Parameters |
| Test 6.5.4 Time alignment error (TAE) – Block name: Tx_6_5_4_TimeAlign Properties Properties Passes Passes B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_5_4_TimeAlign Enabled V Name Tx_6_5_4_TimeAlign Condition In Parameters Log Def ✓ Number Layers 2 ✓ Out Parameters Log Def ✓ Time Alignment Error |
| Test 6.5.4 Time alignment error (TAE) - Block name: Tx_6_5_4_TimeAlign Properties Properties Pabled Inparameters Log Def In Parameters Log Def Inter Alignment Error |
| Test 6.5.4 Time alignment error (TAE) - Block name: Tx_6_5_4_TimeAlign Properties Properties Properties Properties Properties Prop |

►

- ► Test 6.6.2 Occupied bandwidth (OBW)
 - Block name: Tx_6_6_2_OccupiedBW

| Properties | ▲ ṫ |
|------------|---|
| B_NR_BS | _TransmitterTests:NR_BS_TransmitterTests\Tx_6_6_2_Occur |
| Enabled | \checkmark |
| Name | Tx_6_6_2_OccupiedBW |
| Condition | |
| Out Para | neters |
| Log De | f OccupiedBW |
| Descripti | n |
| Occupied | bandwidth |
| Details | |
| Chapter 6 | 6.2 |

► Test 6.6.3 Adjacent channel leakage power (ACLR)

| Properties | | | • q |
|-----------------------------|---------------------------|-------------------------|-----|
| B_NR_BS_TransmitterTest | s:NR_BS_Tran | smitterTests\Tx_6_6_3_A | CLR |
| Enabled 🗸 | | | |
| Name Tx_6_6_3_ACLR | | | |
| Condition | | | |
| In Parameters | | | |
| Log Def | | | |
| Noise C | Cancellation \checkmark | True ~ | |
| Adjace | nt Channels NR | k (same BW) ~ | |
| Out Parameters | | | |
| Log Def | | | |
| □ ✓ A | CLR Results | | |
| Description | | | |
| Adjacent Channel Leakage Po | wer (ACLR) | | |
| Details | | | |
| Chapter 6.6.3 | | | |
| | | | |

- Block name: Tx 6 6 3 ACLR

- ► Test 6.6.4 Operating band unwanted emissions (OBUE) (SEM)
 - Block name: Tx_6_6_4_UnwantedEmissions

| Properties 🗸 🗸 |
|---|
| B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_6_4_Unwa |
| Enabled 🔽 |
| Name Tx_6_6_4_UnwantedEmissions |
| Condition |
| In Parameters |
| Log Def |
| Category A ~ |
| Out Parameters |
| Log Def |
| Start Freqeuncy |
| Stop Frequency |
| RBW |
| Level |
| Description |
| Operating Band unwanted emissions (SEM) |
| Details |
| Chapter 6.6.4 SEM |

- ► Test 6.6.5 Transmitter spurious emissions
 - Block name: Tx_6_6_5_SpuriousEmissions

| Properties | → ů |
|------------|--|
| B_NR_B | 5_TransmitterTests:NR_BS_TransmitterTests\Tx_6_6_5_Spuri |
| Enabled | |
| Name | Tx_6_6_5_SpuriousEmissions |
| Condition | |
| In Paran | neters |
| Log D | ef |
| | Category A 🗸 |
| Out Para | meters |
| Log D | ef |
| | Start Frequency |
| | Stop Frequency |
| | RBW |
| | Level |
| Descript | on |
| Transmitt | er spurious emissions |
| Details | |
| Chapter 6 | 6.5 |

- ► Test 6.7 Transmitter intermodulation
 - Block name: Tx_6_7_Tx_intermod

| Properties 🔹 🖡 | | | | | | | |
|---|-----|---------------------|----------------|---|--|--|--|
| B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_6_7_TxIntern | | | | | | | |
| Enabled 🗹 | | | | | | | |
| Name Tx_6_7_TxIntermod | | | | | | | |
| Condition | | | | | | | |
| In Parameters | | | | | | | |
| Log | Def | | | 1 | | | |
| | ✓ | BW Interferer (MHz) | 5 [~] | | | | |
| | ✓ | Offset n | 1 × |] | | | |
| | ✓ | Category | Α ~ |] | | | |
| Out Parameters | | | | | | | |
| Log | Def | | | - | | | |
| | ✓ | ACLR | | | | | |
| | ✓ | SEMStartFreq | |] | | | |
| | ✓ | SEMStopFreq | |] | | | |
| | ✓ | SEMRBW | |] | | | |
| | ✓ | SEMPow | |] | | | |
| | ✓ | SpurStartFreq | |] | | | |
| | ~ | SpurStopFreq | |] | | | |
| | ~ | SpurRPW | |] | | | |
| | ✓ | SpurPow | |] | | | |
| Description | | | | | | | |
| Transmitter Intermodulation | | | | | | | |
| Details | | | | | | | |
| Chapter 6.7 | | | | | | | |

- ► Tx_DemoSMW
 - usage optional
 - with this block it is possible to simulate a base station but please note that not all base station functions can be simulated with a vector signal generator

| Properties 🔻 🕈 | | | | | | |
|--|-------------------------------|-----|------|--|--|--|
| B_NR_BS_TransmitterTests:NR_BS_TransmitterTests\Tx_DemoSMW | | | | | | |
| Enabled 🔽 | | | | | | |
| Name | Tx_DemoSMW | | | | | |
| Condition | | | | | | |
| In Parameters | | | | | | |
| Log D | ef | | | | | |
| | RF path B | ~ | | | | |
| | MIMO 2 layers False | v | | | | |
| | SMW TCPIP::192.168.1.3::HISLI | ΡΥ | Visa | | | |
| | Power | -10 | dBm | | | |
| Description | | | | | | |
| 5G NR Downlink signal | | | | | | |
| Details | | | | | | |
| SMW provides 5G NR Downlink signal for demonstration | | | | | | |

C Abbreviations

| Abbreviation | Description |
|------------------|--------------------------------------|
| 5G NR | 5G New Radio |
| ACLR | Adjacent channel leakage power ratio |
| CA | Carrier aggregation |
| DUT | Device under test |
| EVM | Error vector magnitude |
| FDD | Frequency division duplex |
| FR1 | Frequency range 1 |
| MIMO | Multiple input multiple output |
| OBUE | Operating band unwanted emissions |
| OBW | Occupied bandwidth |
| ΟΤΑ | Over the air |
| PDSCH | Physical downlink shared channel |
| P _{rat} | Rated output power |
| Px- | Performance- |
| RB | Resource block |
| RBW | Resolution bandwidth |
| RF | Radio frequency |
| RIB | Radiated interface boundary |
| RS | Reference signal |
| Rx- | Receiver- |
| SC | Single carrier |
| SCS | Subcarrier spacing |
| SSB | Synchronization signal block |
| ТАВ | Transceiver array boundary |
| TAE | Time alignment error |
| TDD | Time division duplex |
| ТМ | Test model |
| Tx- | Transmitter- |
| VSWR | Voltage standing wave ratio |

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