Application Note

5G NEW RADIO CONDUCTED BASE STATION PERFORMANCE TESTS

according to TS 38.141-1 Rel. 16

Products:

- ► R&S®SMW200A
- ► R&S®SGT100A

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https://www.rohde-schwarz.com/appnote/GFM315

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Contents

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:

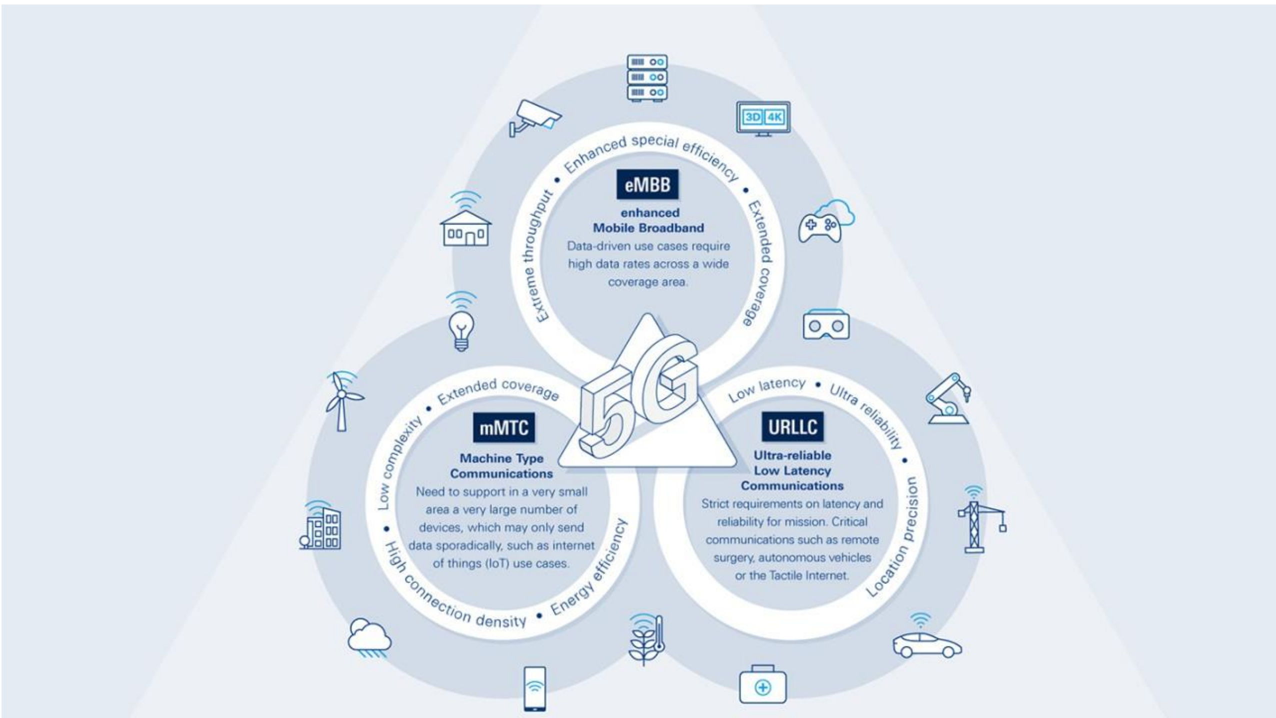


Figure 1: 5G New Radio main service families

- ► 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**: Conducted conformance testing
- ► **TS 38.141-2: Part 2**: Radiated conformance testing

This application note describes how all mandatory **RF performance tests (TS 38.141-1, chapter 8)**, according to Release 16 (V16.7.0), can be performed quickly and conveniently with signal generators from Rohde & Schwarz by either choosing manual operation or a remote control approach.

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 procedure for manual testing. 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 NR base station performance tests covered individually in this document.

Table 1: Conducted performance tests

Chapter TS38.141	Test
8.2	Performance requirements for PUSCH
8.2.1	Performance requirement for PUSCH with transform precoding disabled
8.2.2	Performance requirement for PUSCH with transform precoding enabled
8.2.3	Performance requirements for UCI multiplexed on PUSCH
8.2.4	Performance requirements for PUSCH for high speed train
8.2.5	Performance requirements for UL timing adjustment
8.2.6	Performance requirements for PUSCH with 0.001 % BLER
8.2.7	Performance requirements for PUSCH repetition Type A
8.2.8	Performance requirements for PUSCH Mapping Type B with non-slot transmission
8.2.9	Performance requirements for PUSCH msgA for 2-step RA type
8.3	Performance requirements for PUCCH
8.3.1	Performance requirements for PUCCH format 0
8.3.2	Performance requirements for PUCCH format 1
8.3.3	Performance requirements for PUCCH format 2
8.3.4	Performance requirements for PUCCH format 3
8.3.5	Performance requirements for PUCCH format 4
8.3.6.1	Performance requirements for multi-slot PUCCH format 1
8.4	Performance requirements for PRACH
8.4.1	PRACH false alarm probability and missed detection

Additionally, a Python library comes with this application note. It is meant to demonstrate the remote-control approach of base station testing. Further details can be found in [A].

Base station (RF) transmitter tests (TS 38.141-1, chapter 6) are described in GFM313.

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

For further reading

Find a more detailed overview of the technology behind 5G New Radio from this Rohde & Schwarz book [1] and www.rohde-schwarz.com/5G.

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 [2].

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 [3] and [2] 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.

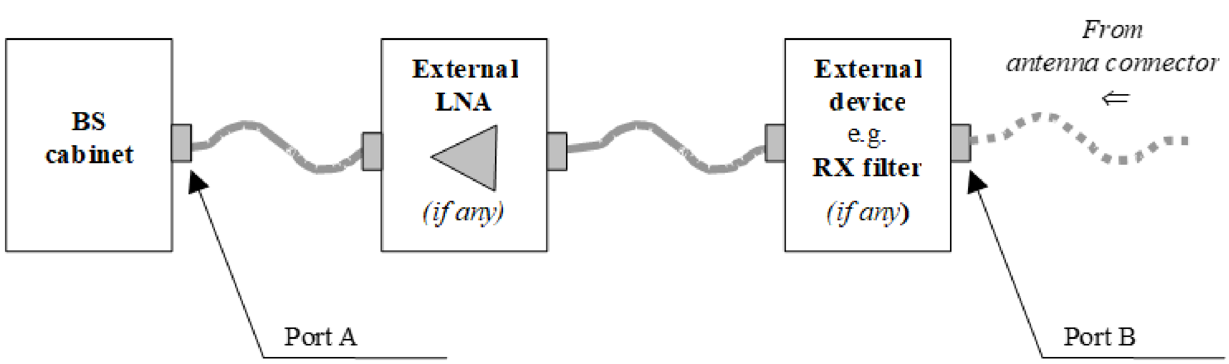


Figure 2: BS type 1-C receiver interface [3]

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 [4]. Furthermore, the specific OTA measurements are described in extra Rohde & Schwarz application notes.

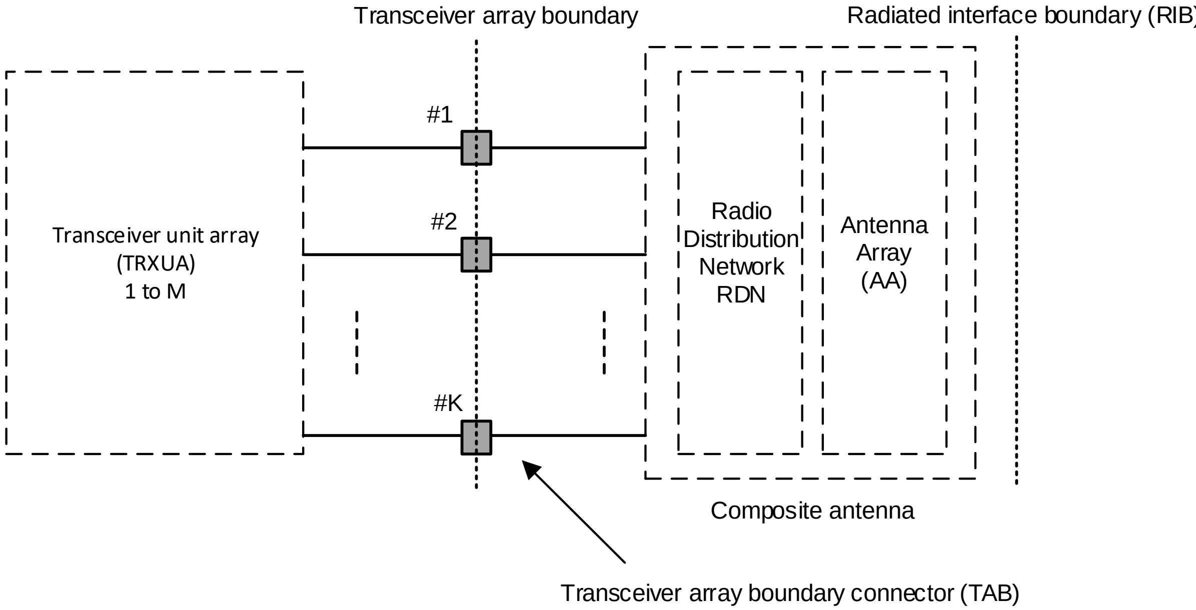


Figure 3: Radiated and conducted reference points for BS type 1-H [3]

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 (V16.7.0) are shown in Table 3.

Table 3: Frequency ranges [2], chapter 5

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

2.4 R&S devices and software options

The following Rohde & Schwarz vector signal generator can be used for the tests described in this document:

- R&S®SMW200A

Furthermore, the **5G NR** software option is needed for the Px tests (a detailed overview about the required options can be found in Table 5):

- R&S®SMW200A -K144 5G New Radio

A couple of tests require four Rx antennas. This can be handled with the following combination of Rohde & Schwarz devices:

- 1 x R&S®SMW200A
- 2 x R&S®SGT100A

To generate signals for eight Rx antennas, one SMW with six external RF generators is used:

- 1 x R&S®SMW200A
- 6 x R&S®SGT100A

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®SMW200A vector signal generator is referred to as the **SMW**
- The R&S®SGT100A SGMA vector RF source is referred to as the **SGT**

3 RF Performance Tests (TS 38.141-1, chapter 8)

Performance tests are for the receiver of the base station. The base station typically measures the throughput (for PUSCH tests) or the ability to detect certain signals (PUCCH and PRACH) under multipath channel conditions.

Fixed reference channels (FRC)

For the performance tests, fixed reference channels (FRCs) are defined. They contain 5G NR channel parameters as modulation, code rate and allocated resource block, etc. They are named according to [5], annex A and split in different subsets:

- ► G-FR1-A3: A3-1...A3-32 (QPSK), with or without transform precoding, UL-DMRS-add position 0 or 1, 1 or 2 layers
- ► G-FR1-A4: A4-1…A4-28 (16QAM), without transform precoding, UL-DMRS-add position 0 or 1, 1 or 2 layers
- ► G-FR1-A5: A5-1…A5-14 (64QAM), without transform precoding, UL-DMRS-add position 0 or 1, 1 layer

For more details refer to [5], annex A. All FRCs are implemented as predefined settings for FDD and TDD in the signal generator family SMW.

Channels

According to [5] the channels to be tested are in the middle (M) and with single carrier of the supported frequency range of the base station.

Table 4: Px tests

Chapter 38.141-1	Name	# Tx	# Rx	AWGN	Fading	HARQ Feedback
8.2.1	Px requirements for PUSCH with transform precoding disabled	1/2	2/4/8	✓	✓	✓
8.2.2	Px requirements for PUSCH with transform precoding enabled	1	2/4/8	✓	✓	✓
8.2.3	Px requirements for UCI multiplexed on PUSCH	1	2	✓	✓	-
8.2.4	Px requirements for PUSCH for high speed train	1	1/2/8	✓	✓	✓
8.2.5	Px requirements for UL timing adjustment	1	2	✓	✓	✓
8.2.6	Px requirements for PUSCH with 0.001 % BLER	1	2	✓	-	✓
8.2.7	Px requirements for PUSCH repetition Type A	1	2	✓	✓	✓
8.2.8	Px requirements for PUSCH Mapping Type B with non-slot transmission	1	2	✓	✓	✓
8.2.9	Px requirements for PUSCH msgA for 2-step RA type	1	2	✓	✓	✓

8.3.1	Px requirements for PUCCH Format 0	1	2/4/8	✓	✓	-
8.3.2	Px requirements for PUCCH Format 1	1	2/4/8	✓	✓	-
8.3.3	Px requirements for PUCCH Format 2	1	2/4/8	✓	✓	-
8.3.4	Px requirements for PUCCH Format 3	1	2/4/8	✓	✓	-
8.3.5	Px requirements for PUCCH Format 4	1	2/4/8	✓	✓	-
8.3.6.1	Px requirements for multi-slot PUCCH format 1	1	2	✓	✓	-
8.4.1	Px requirements for PRACH false alarm probability and missed detection	1	2/4/8	✓	✓	-

3.1 Complete Px test setup overview

Figure 4 shows the general test setup for performance tests. A SMW is used to perform the tests. Some tests are for four or eight Rx antennas. One SMW with additional two RF sources like the SGT can generate the necessary signals for four Rx antennas. To generate signals for eight Rx antennas, one SMW with additional six RF sources like SGT are needed.

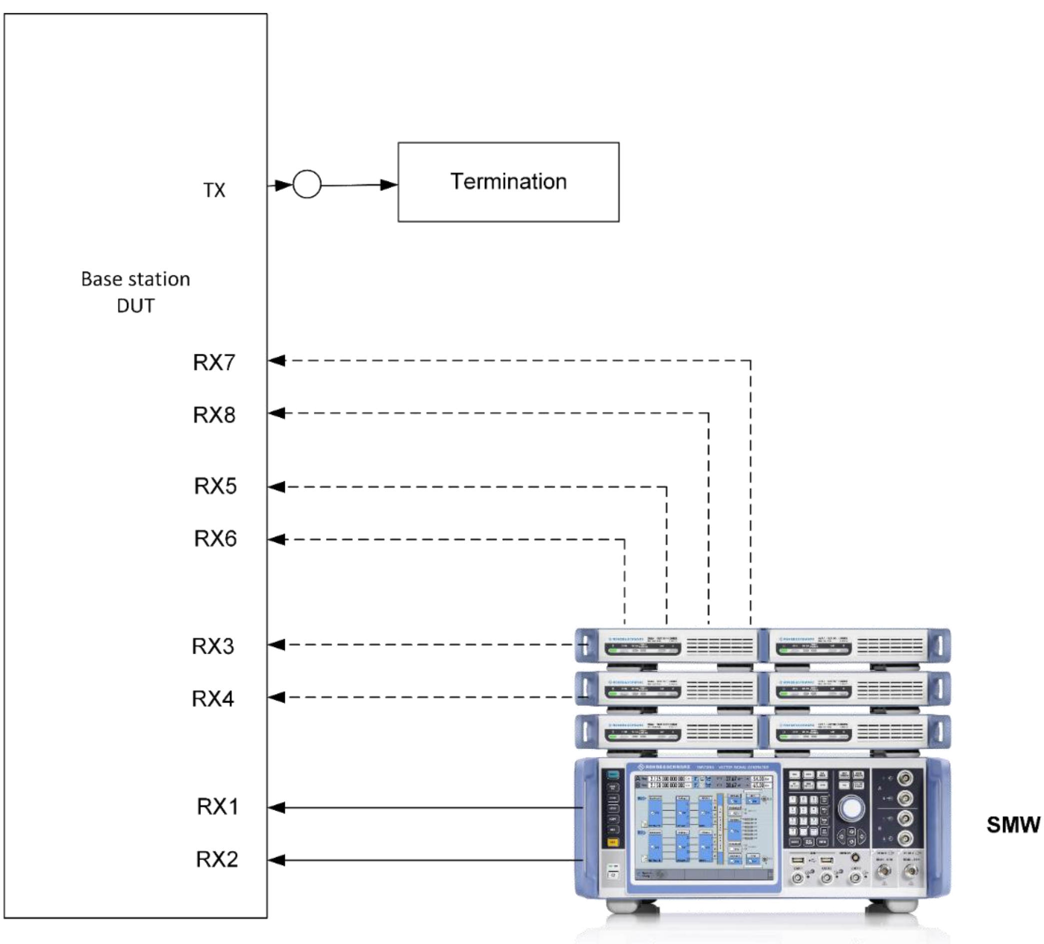


Figure 4: Complete Px test setup overview

3.2 Recommended R&S devices and options

Table 5: Needed instruments and options

Chapter TS38.141	#Tx	#Rx	SMW200A options												#SGT
			RF A	RF B	BB	BB	Fading	AWGN	Dyn. Fad	MIMO Fad./ Rout.	5G NR Rel. 15/16		5G NR Cl. Loop	Dig. BB out	
			B100x	B200x	B13T or B13XT	B9 or B10	B14 or B15	K62	K71	K74	K144	K148	K145	K18/ K19	
8.2.1	1	2	1	1	1	1	2	2	-	-	1	-	1	-	-
	1	4	1	1	1	2	4	2	-	1	1	-	1	2	2
	1	8	1	1	1	2	4	2	-	1	1	-	1	2	6
	2	2	1	1	1	2	2	2	-	1	2	-	2	-	-
	2	4	1	1	1	2	4	2	-	1	2	-	2	2	2
	2	8	1	1	1	2	4	2	-	1	2	-	2	2	6
8.2.2	1	2	1	1	1	2	2	2	-	-	1	-	1	-	-
	1	4	1	1	1	2	4	2	-	-	1	-	1	2	2
	1	8	1	1	1	2	4	2	-	-	1	-	1	2	6
8.2.3	1	2	1	1	1	2	2	2	-	-	1	-	1	-	-
8.2.4	1	1	1	-	1	1	1	1	1	-	1	-	1	-	-
	1	2	1	1	1	2	2	2	1	-	1	-	1	-	-
	1	8	1	1	1	2	2	2	1	1	1	-	1	2	6
8.2.5	1	2	1	1	1	2	2	2	1	-	2	1	1	-	-
8.2.6	1	2	1	1	1	2	-	2	-	-	2	2	2	-	-
8.2.7	1	2	1	1	1	2	-	2	-	-	1	1	1	-	-
8.2.8	1	2	1	1	1	2	-	2	-	-	1	1	1	-	-
8.2.9	1	2	1	1	1	2	-	2	-	-	1	1	1	-	-
8.3.1	1	2	1	1	1	2	2	2	-	1	1	-	-	-	-
8.3.1	1	4	1	1	1	2	4	2	-	1	1	-	-	2	2
8.3.1	1	8	1	1	1	2	4	2	-	1	1	-	-	2	6
8.3.2	1	2	1	1	1	2	2	2	-	1	1	-	-	-	-
8.3.2	1	4	1	1	1	2	4	2	-	1	1	-	-	2	2
8.3.2	1	8	1	1	1	2	4	2	-	1	1	-	-	2	6
8.3.3	1	2	1	1	1	2	2	2	-	1	1	-	-	-	-
8.3.3	1	4	1	1	1	2	4	2	-	1	1	-	-	2	2
8.3.3	1	8	1	1	1	2	4	2	-	1	1	-	-	2	6
8.3.4	1	2	1	1	1	2	2	2	-	1	1	-	-	-	-

8.3.4	1	4	1	1	1	2	4	2	-	1	1	-	-	2	2
8.3.4	1	8	1	1	1	2	4	2	-	1	1	-	-	2	6
8.3.5	1	2	1	1	1	2	2	2	-	1	1	-	-	-	-
8.3.5	1	4	1	1	1	2	4	2	-	1	1	-	-	2	2
8.3.5	1	8	1	1	1	2	4	2	-	1	1	-	-	2	6
8.3.6	1	2	1	1	1	2	2	2	-	1	1	-	-	-	-
8.4.1	1	2	1	1	1	2	2	2	-	1	1	-	-	-	-
8.4.1	1	4	1	1	1	2	4	2	-	1	1	-	-	2	2
8.4.1	1	8	1	1	1	2	4	2	-	1	1	-	-	2	6

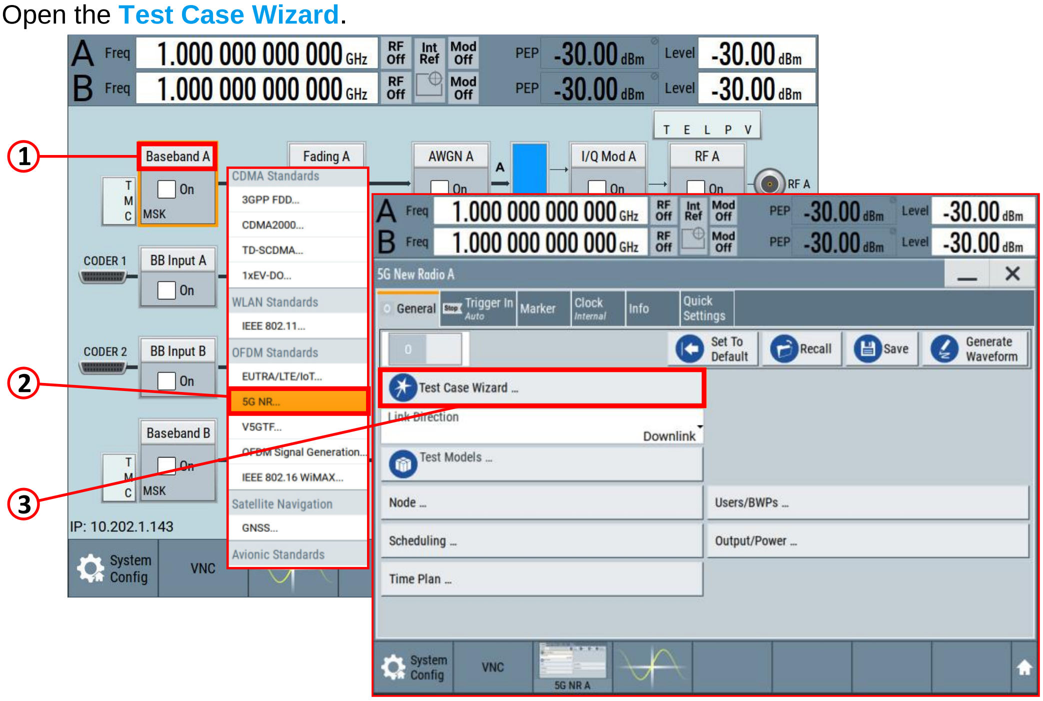
3.3 Basic SMW Test Case Wizard operations

The SMW firmware version 5.00.044.34 (and higher) provides a so-called **Test Case Wizard** for base station performance tests. The **Test Case Wizard** supports tests on base stations in conformance with the 3GPP specification TS 38.141 [5]. With this wizard it is very easy to perform highly complex test scenarios with just a few keystrokes.

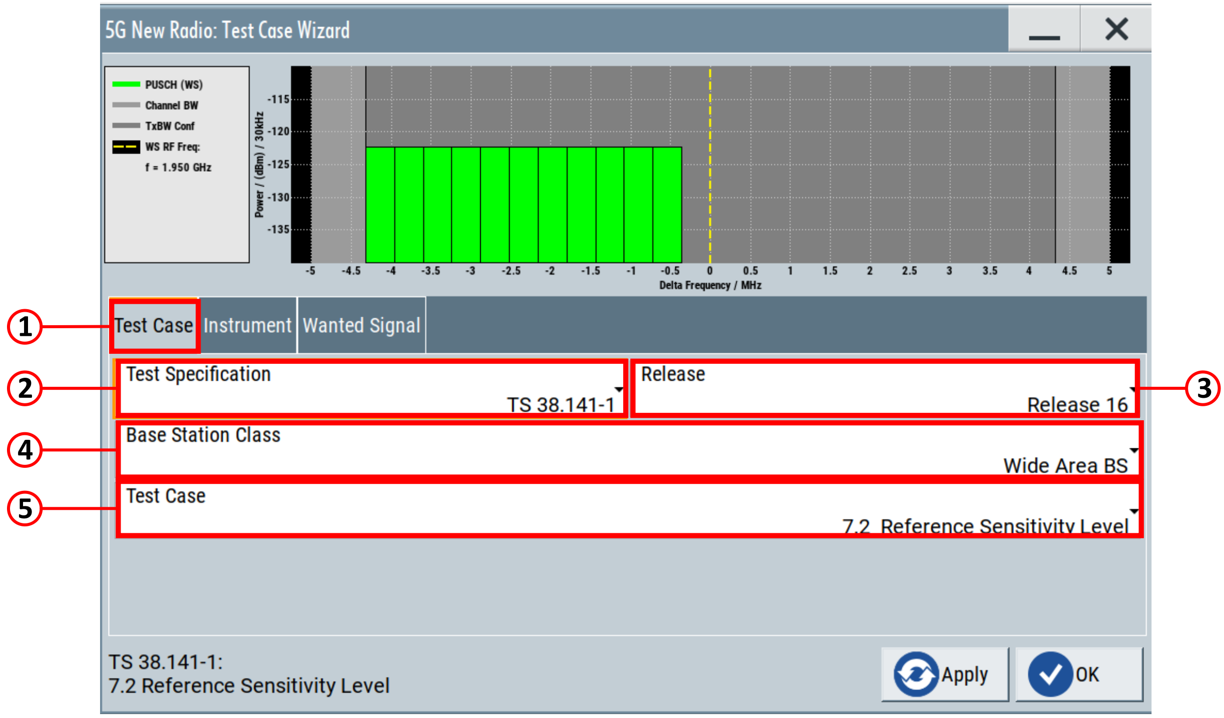
The SMW firmware 5.00.044.34 is implemented on the basis of TS 38.141 Rel. 16, V16.7.0. It is assumed that this firmware version is already installed on the SMW200A.

The following short step-by-step guide gives a brief insight into the operation of the test case wizard.

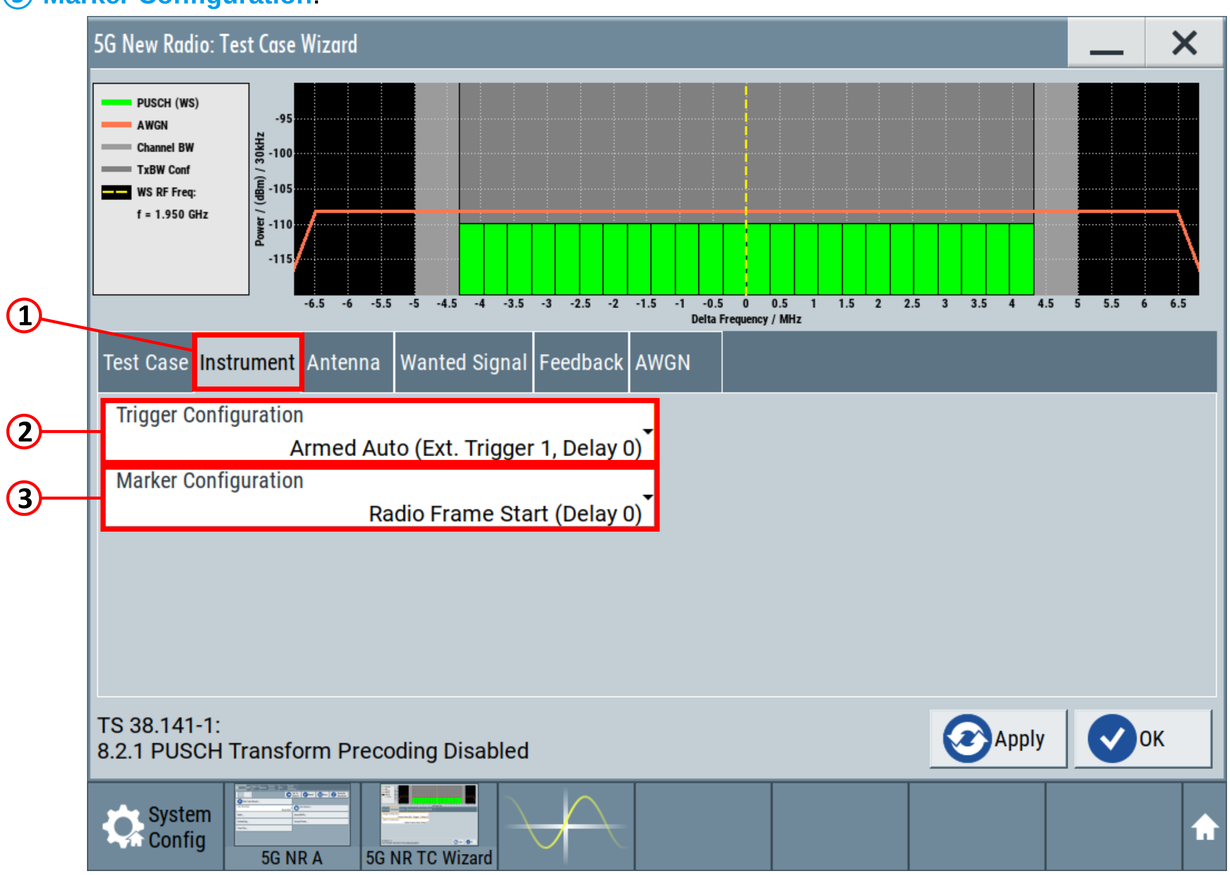
► Open the **Test Case Wizard**.



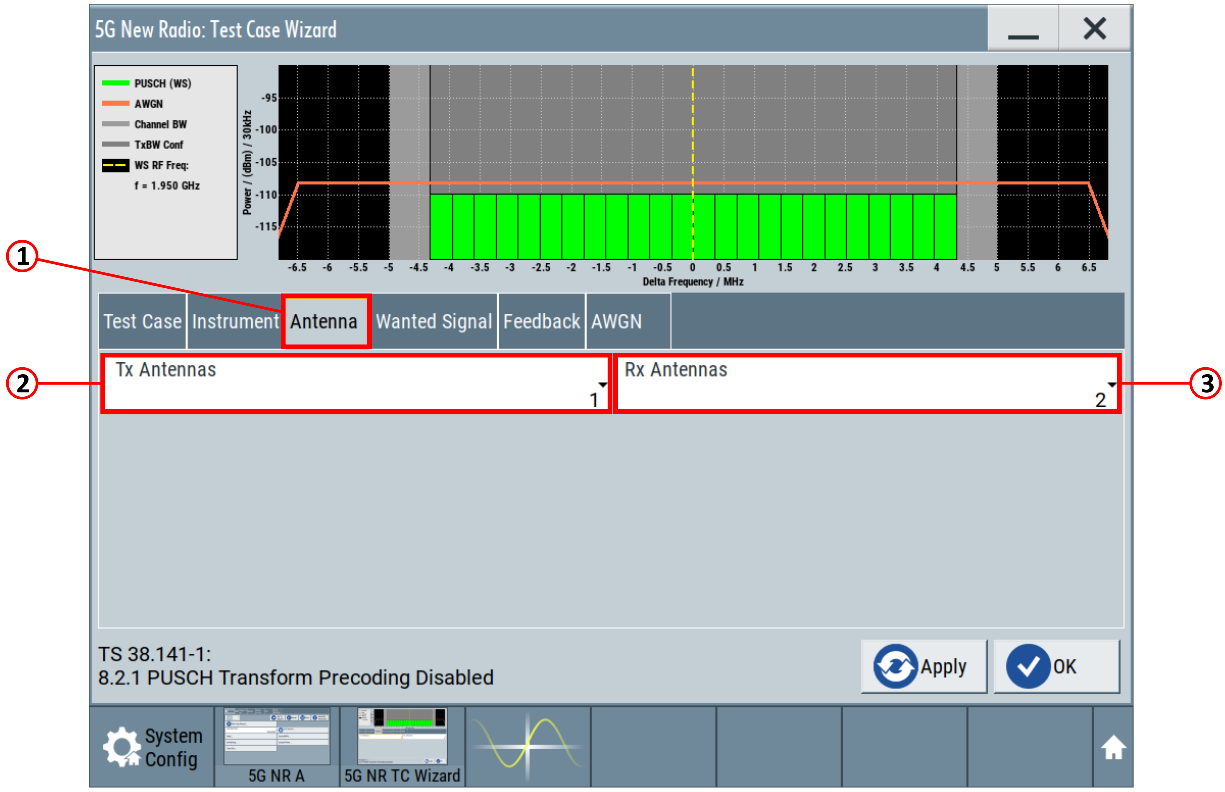
► At tab ① **Test Case** the ② **3GPP test specification,** ③ **3GPP release**, ④ **Base Station Class** and the ⑤ **Test Case** that should be performed (the numbering refers to the numbering in TS 38.141-1) can be selected.



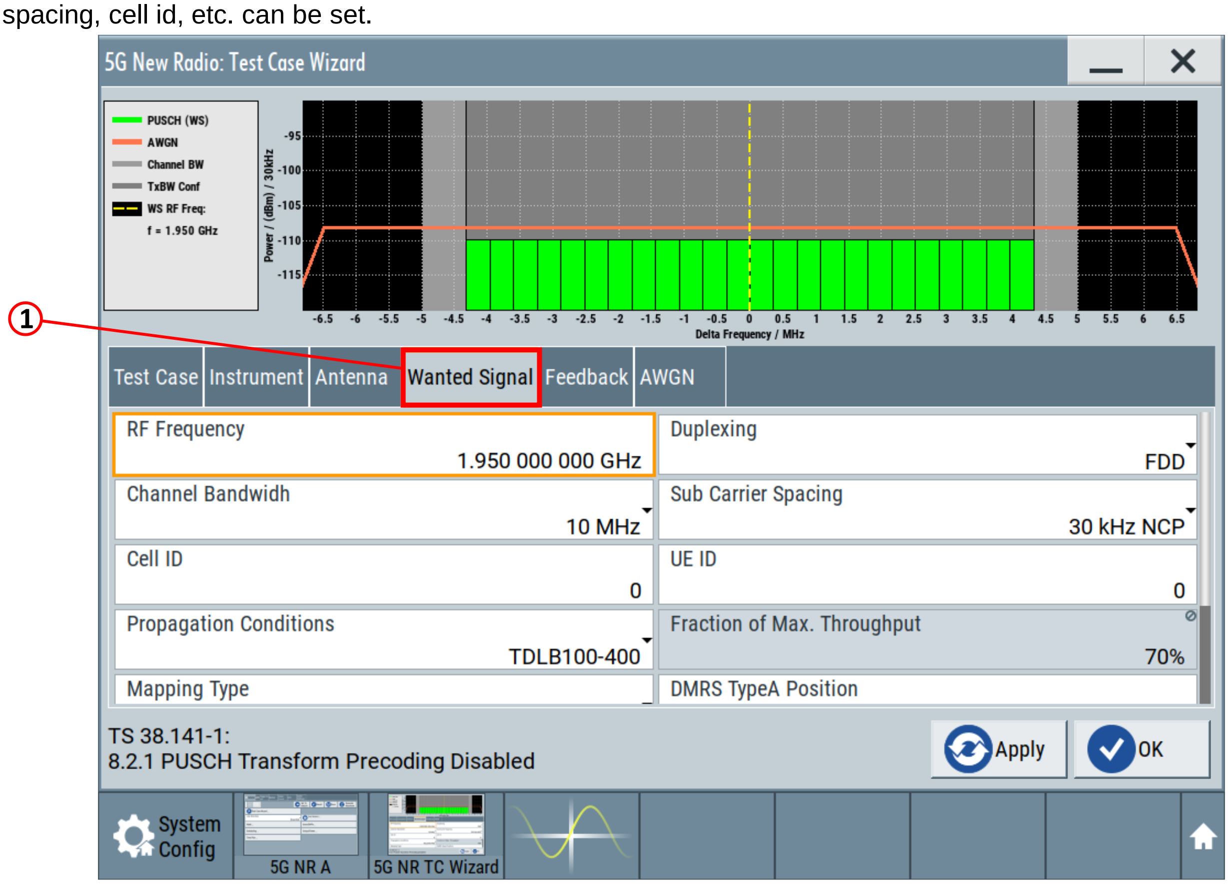
► At tab ① **Instrument** the instrument-related settings can be set, like ② **Trigger Configuration** and ③ **Marker Configuration**.



► At tab ① **Antenna** the number of ② **Transmit-** and ③ **Receive-** antennas can be set.

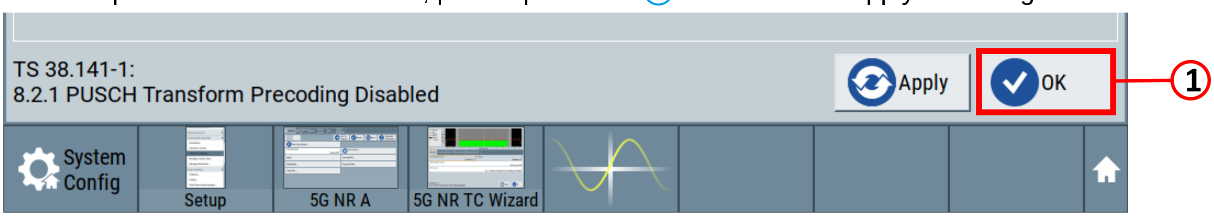


► At tab ① **Wanted Signal** the basic parameters like RF frequency, channel bandwidth, sub carrier spacing, cell id, etc. can be set.

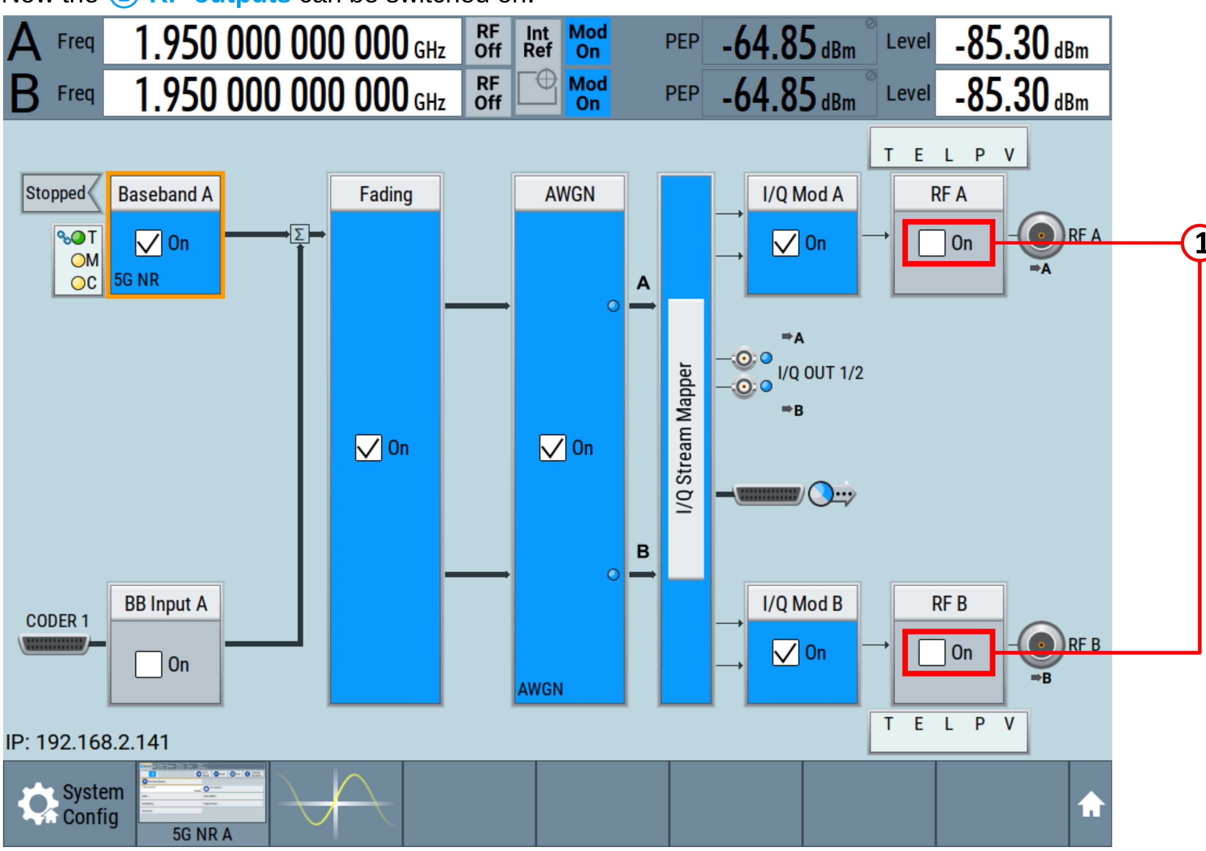


- Depending on the selected test case, new tabs will be added to the header bar. These additional tabs include some test specific parameter settings. More information can be found in the respective test sections. The following screenshot shows the ① **header bar** of test "8.2.1 PUSCH with transform precoding disabled".

- When all parameters have been set, please press the ① **OK button** to apply all settings.



- Now the ① **RF-outputs** can be switched on.



List of TCW parameters & SCPI commands

Tab “Test Case”

- Test Specification
  - Determines the 3GPP test specification used as a guide line for the test cases
  - `:BB:NR5:TCW:SPEC <TestSpec>`
- Release
  - Determines the 3GPP test specification release version used as a guide line for the test cases
  - `:BB:NR5:TCW:RELease <Release>`
- Base Station Class
  - Determines whether the test is to be performed for an NR local area, NR medium area or an NR wide area base station. The different base station classes are specified for different output power
  - `:BB:NR5G:TCW:BSCLass <BSClass>`
- Test Case
  - Selects the test case
  - `:BB:NR5G:TCW:TC <TestCase>`

Tab “Instrument”

- Trigger Configuration
  - Selects the trigger configuration. The trigger is used to synchronize the signal generator to the other equipment.
  - `:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>`
- Marker Configuration
  - Selects the marker configuration. The marker can be used to synchronize the measuring equipment to the signal generator.
  - `:BB:NR5G:TCW:MARKerconfig <MarkerConfig>`

Tab “Antenna”

- Tx Antennas
  - Shows or sets the number of Tx antennas used for test case
  - `:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>`
- Rx Antennas
  - Shows or sets the number of Rx antennas used for test case
  - `:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>`

Tab “Wanted Signal”

- Additional DMRS
  - Enables or disabled the additional DMRS. Additional DMRS signals increase the probability that the UE receives the demodulation reference symbols. It leads to a support of lower SNR conditions.
  - `:BB:NR5G:TCW:WS:ADMRs:STATe <AddDmrs>`
- Cell ID
  - Sets the cell ID
  - `:BB:NR5G:TCW:WS:CELLid <WSCellId>`
- CSI Part
  - Defines the CSI part selected for the test case
  - `:BB:NR5G:TCW:WS:UCI:CSIPart <CSIPart>`
- CSI 1 Pattern
  - Defines the frequency and time domain of the CSI part 1 subcarrier location
  - `:BB:NR5G:TCW:WS:UCI:CSI1:PATTern <CSI1Pattern>`
- CSI 2 Pattern
  - Defines the frequency and time domain of the CSI part 2 subcarrier location
  - `:BB:NR5G:TCW:WS:UCI:CSI2:PATTern <CSI2Pattern>`
- Channel Bandwidth
  - Selects the channel bandwidth
  - `:BB:NR5G:TCW:WS:CBW <WSChBw>`
- DMRS Type A Position
  - Sets the position of first DM-RS symbol for PUSCH (and PDSCH) mapping type A
  - `:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>`
- Fraction of Max. Throughput
  - The required throughput is expressed as a fraction of maximum throughput for the FRC. The performance requirements assume HARQ retransmissions
  - `:BB:NR5G:TCW:WS:FMTHroughput <FMT>`
- FRC
  - Displays the fixed reference channel used
  - `:BB:NR5G:TCW:WS:FRC:TYPE <WSFrc>`
- Frequency Offset
  - Sets the frequency offset used for the PRACH
  - `:BB:NR5G:TCW:WS:FROFfset <FreqOffset>`
- Mapping Type
  - Sets the mapping type A or B for the PUSCH
  - `:BB:NR5G:TCW:WS:MAPType <MapType>`

- Mode
  - Switches between the detection rate (Pd) and the false detection rate (Pfa)
  - `:BB:NR5G:TCW:WS:Mode <Mode>`
- Number of OFDM Symbols
  - Sets the number of used OFDM symbols
  - `:BB:NR5G:TCW:WS:SYMNumber <SymbolNumber>`
- Preamble Format
  - Sets the designated PRACH preamble format
  - `:BB:NR5G:TCW:WS:PRACh:FORMat <PrachFormat>`
- Power Level
  - Displays the power level, depending on the selected test case
  - `:BB:NR5G:TCW:WS:PLEVel <WSPowLev>`
- Propagation Conditions
  - The propagation conditions define the multipath fading environment
  - `:BB:NR5G:TCW:WS:PROCondition <PropagCond>`
- PTRS
  - Enables PTRS (phase-tracking reference signal) for the wanted signal
  - `:BB:NR5G:TCW:WS:PTRS:STATe <PTRS>`
- RB Offset
  - Sets the shift of the allocated wanted signal in No. of RBs
  - `:BB:NR5G:TCW:WS:RBOFfset <WSRbOffset>`
- Restricted Set
  - Selects the restricted set type for the PRACH used in the test case
  - `:BB:NR5G:TCW:WS:RSET <RestrictedSet>`
- RF Frequency
  - Sets the RF frequency of the wanted signal
  - `:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>`
- Sub Carrier Spacing / Sub Carrier Spacing (BWP)
  - Sets the subcarrier spacing using normal cyclic prefix (NCP) or extended cyclic prefix (ECP)
  - `:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>`
- Sub Carrier Spacing (PRACH)
  - Sets the subcarrier spacing for PRACH
  - `:BB:NR5G:TCW:WS:PRACh:SCSPacing <PrachSCS>`
- Test Requirement
  - Selects the test environment
  - `:BB:NR5G:TCW:WS:TREQuire <TestRequirement>`

- Test setup
  - With the test setup selector, the signal definitions can be switched
  - `:BB:NR5G:TCW:WS:TSETup <TestSetup>`
- Timing Offset Base Value
  - Displays the timing offset base value
  - `:BB:NR5G:TCW:WS:TIOBase?`
- UCI Bits
  - Set the number of UCI bits used
  - `:BB:NR5G:TCW:WS:UCI:BITS <UCIBits>`
- UE ID
  - Sets the UE ID
  - `:BB:NR5G:TCW:WS:UCI:UEID <WSUeId>`
- Virtual Downlink RF Frequency
  - Sets the virtual downlink RF frequency
  - `:BB:NR5G:TCW:WS:VDRF <VirtualDlRF>`

Tab “Frequency allocation settings”

- Frequency Allocation of the Interfering signal
  - Determines the frequency position of the wanted and the interfering signal
  - `:BB:NR5G:TCW:FA:FRALlocation <VFreqAlloc>`

Tab “Interfering signal”

- Band
  - Set the frequency band (n1 to n86) for the interfering signal
  - `:BB:NR5G:TCW:IS:BAND <Band>`
- n
  - Set the offset factor for the interfering signal
  - `:BB:NR5G:TCW:IS:OFN <OffsetFactorN>`
- Duplexing
  - The duplexing mechanism used for the interfering signal can be switched between FDD and TDD
  - `:BB:NR5G:TCW:IS:DUPLex <ISDuplexing>`
- Test Model
  - Shows the test model set for the test case. The NR-TMs for FR1 are defined in TS 38.141-1 section 4.9.2
  - `:BB:NR5G:TCW:IS:TMODel?`

- Interferer Type
  - Selects the type of the interfering signal
  - `:BB:NR5G:TCW:IS:IFTYpe <InterfererType1>`
- Test Requirement
  - For CW interfering signal, selects whether the standard out-of-band blocking test is performed or the optional test, when the BS is co-located with another BS in a different operating band
  - `:BB:NR5G:TCW:IS:TREQuire <ISTestRequire>`
- RF Frequency
  - Display the center frequency of the interfering signal
  - `:BB:NR5G:TCW:IS:RFFRequency <ISRFFreq>`
- Channel Bandwidth
  - Displays the channel bandwidth of the interfering signal. The bandwidth of the interfering signal is specified by 3GPP for a particular test case
  - `:BB:NR5G:TCW:IS:CHBW?`
- Sub Carrier Spacing
  - Sets the subcarrier spacing for the interfering signal using normal cyclic prefix (NCP) or extended cyclic prefix (ECP)
  - `:BB:NR5G:TCW:IS:SCSPacing?`
- Cell ID
  - Sets the cell ID for the interfering signal
  - `:BB:NR5G:TCW:IS:CLID`
- UE ID
  - Sets the UE ID for the interfering signal
  - `:BB:NR5G:TCW:IS:UEID`
- Number of Resource Blocks
  - The number of RBs used by the 5G NR interfering signal
  - `:BB:NR5G:TCW:IS:NRBLock?`
- RB Offset
  - The position of the RBs allocated by the 5G NR interfering signal is determined automatically, depending on the selected "Channel Bandwidth" and the RBs allocation of the wanted signal
  - `:BB:NR5G:TCW:IS:RBOFfset <ISRBOffset>`
- Power Level
  - The power level of the interfering 5G NR signal is set automatically depending on the selected channel bandwidth
  - `:BB:NR5G:TCW:IS:PLEVel?`

- Frequency Shift m
  - By default, the narrow-band interfering signal is allocated at the most left (interfering signal at higher frequencies)/ most right (interfering signal at lower frequencies) subcarrier in the allocated channel bandwidth. However, the position of the interfering signal can be set by the parameter "Frequency Shift m", i.e. the allocated RB can be offset to a different center frequency
  - `:BB:NR5G:TCW:IS:FRSHift <ISFreqShift>`
- Interfering RB Center Frequency
  - Displays the center frequency of the single resource block interfering signal
  - `:BB:NR5G:TCW:IS:RBCFrequency?`
- Distance
  - Sets the distance between the test object and test antenna injecting the interferer signal
  - `:BB:NR5G:TCW:IS:DISTance <Distance>`

Tab “Moving UE”

- RF Frequency
  - Selects the RF frequency that the signal generator uses for the test
  - `:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>`
- Duplexing
  - Selects the duplexing method used for the test
  - `:BB:NR5G:TCW:WS:DUPLex <Duplexing>`
- Channel Bandwidth
  - Selects the channel bandwidth used for the test
  - `:BB:NR5G:TCW:WS:CBW <WSChBw>`
- Sub Carrier Spacing
  - Selects the subcarrier spacing used for the test
  - `:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>`
- Cell ID
  - Selects the cell ID used for the test
  - `:BB:NR5G:TCW:WS:CELLid <WSCellId>`
- UE ID
  - Selects the UE ID of the DUT
  - `:BB:NR5G:TCW:WS:UEID <WSUeId>`
- Test Requirement
  - Selects the test environment
  - `:BB:NR5G:TCW:WS:TREQuire <TestRequirement>`

- Mapping Type
  - Sets the mapping type A or B for the PUSCH
  - `:BB:NR5G:TCW:WS:MAPType <MapType>`
- FRC
  - Displays the fixed reference channel used
  - `:BB:NR5G:TCW:WS:FRC:TYPE <WSFrc>`
- Transmit SRS
  - Turns transmission of the SRS for the test on and off
  - `:BB:NR5G:TCW:WS:MUE:TSRS <TransmitSRS>`
- Power Level
  - Displays the power level, depending on the selected test case
  - `:BB:NR5G:TCW:WS:PLEVel <WSPowLev>`

Tab “Stationary UE”

- UE ID
  - Selects the UE Id of the DUT
  - `:BB:NR5G:TCW:IS:UEID <ISUEID>`
- Transmit SRS
  - Turns transmission of the SRS for the test on and off
  - `:BB:NR5G:TCW:SUE:TSRS <TransmitSRS>`
- Power Level
  - Displays the power level used in the test
  - `:BB:NR5G:TCW:IS:PLEVel?`

Tab “Feedback”

- Realtime Feedback Mode
  - Defines the serial line mode used for the real-time feedback
  - `:BB:NR5G:TCW:RTF:MODE <RTFMode>`
- Serial Rate
  - Sets the data rate of serial connection used
  - `:BB:NR5G:TCW:RTF:SERRate <SerialRate>`
- Additional User Delay
  - Defines the delay added to the real-time feedback
  - `:BB:NR5G:TCW:RTF:AUSDelay <AddUserDelay>`

- (Moving UE) Connector
  - Sets the connector used for the real-time feedback
  - `:BB:NR5G:TCW:RTF:CONNector <Connector>`
- (Moving UE) Baseband Selector
  - Defines which baseband selector index is used in the serial messages to address the baseband
  - `:BB:NR5G:TCW:RTF:BBSelector <BBSelector>`
- Stationary UE Connector
  - Sets the connector used for the real-time feedback of the stationary UE
  - `:BB:NR5G:TCW:RTF:SUE:CONNector <Connector>`
- Stationary UE Baseband Selector
  - Defines which baseband selector index is used in the serial messages to address the baseband of the stationary UE
  - `:BB:NR5G:TCW:RTF:SUE:BBSelector <BBSelector>`

Tab “AWGN”

- Power Level
  - Displays the power level of the AWGN signal
  - `:BB:NR5G:TCW:AWGN:PLEVel?`

Further reading

For further information about the test case wizard part of the SMW firmware, please have a look to the SMW-K144 manual.

- https://www.rohde-schwarz.com/manual/r-s-smw-k144-k145-k148-5g-new-radio-user-manual-manuals-gb1_78701-559946.html?change_c=true

3.4 Remote control operations by using SCPI commands

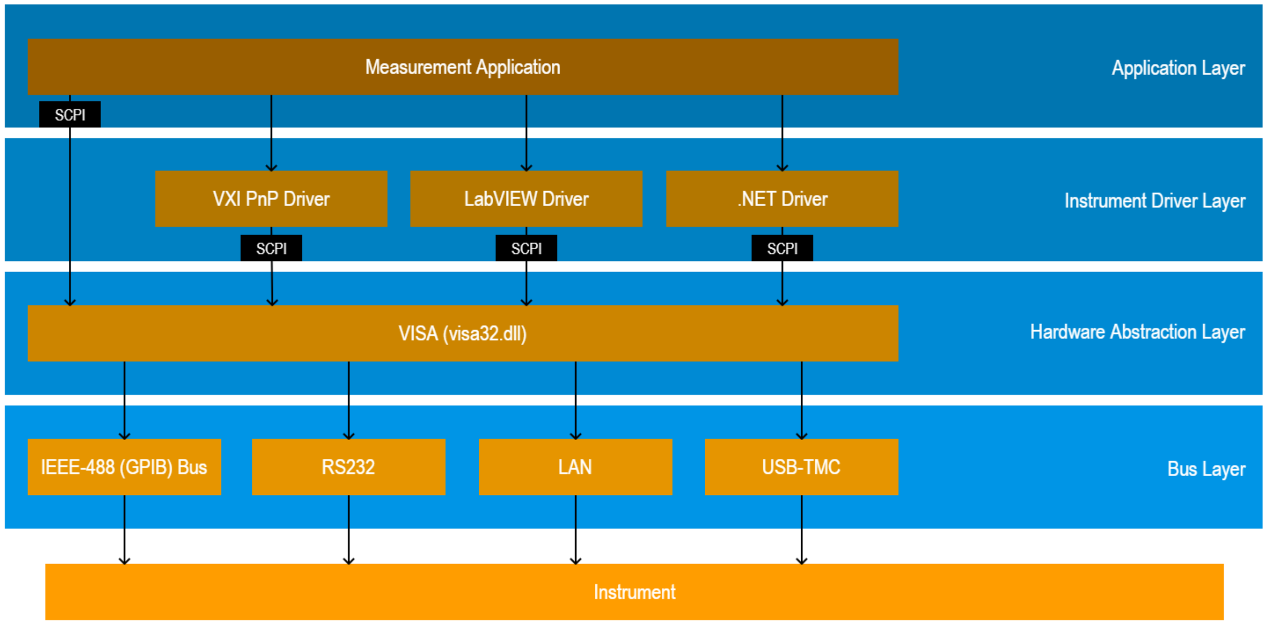


Figure 5: Overview [6]

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 SCPI-99 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 [7] 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 General workflow for carrying out a performance test

1. Connect the instrument(s) and the base station according to the corresponding test setup (part of the test case description)
2. Set the base station to the basic state
   1. Initialize the base station
   2. Set the frequency
   3. Set the base station to transmit the fixed reference channel (FRC)
3. Preset the instrument(s) to ensure a defined instrument state
4. Configure the test case wizard (TCW) according to the "Manual testing procedure" part of every test case
5. Start the measurement
   → Send a start trigger impulse from the BS to the signal generator
6. Calculate the results
   → The BS calculates the BER, BLER or the probability of detection of preamble (Pd)

3.6 Px requirements for PUSCH (8.2)

The physical uplink shared channel (PUSCH) carries user data, that is dynamically shared among different users in a cell. Special issues for single PUSCH tests are described in the related subchapters.

All tests in this subclause are performed for a given SNR where the AWGN power level is given in Table 6.

Table 6: AWGN power level for PUSCH tests

	AWGN power level [dBm]		
Channel bandwidth [MHz]	**SCS 15 kHz**	**SCS 30 kHz**	**SCS 60 kHz**
5	- 86.5 (4.50 MHz)	- 87.1 (3.96 MHz)*	N/A
10	- 83.3 (9.36 MHz)	- 83.6 (8.64 MHz)	- 84.0 (7.92 MHz)*
15	- 81.5 (14.22 MHz)*	- 81.7 (13.68 MHz)*	- 81.9 (12.96 MHz)*
20	- 80.2 (19.08 MHz)	- 80.4 (18.36 MHz)	- 80.7 (17.28 MHz)*
25	- 79.2 (23.94 MHz)*	- 79.3 (23.40 MHz)*	- 79.5 (22.32 MHz)*
30	- 78.4 (28.80 MHz)*	- 78.5 (28.08 MHz)*	- 78.7 (27.36 MHz)*
40	- 77.1 (38.88 MHz)*	- 77.2 (38.16 MHz)	- 77.4 (36.72 MHz)*
50	- 76.2 (48.60 MHz)*	- 76.2 (47.88 MHz)*	- 76.3 (46.80 MHz)*
60	N/A	- 75.4 (58.32 MHz)*	- 75.5 (56.88 MHz)*
70	N/A	- 74.7 (68.04 MHz)*	- 74.8 (66.96 MHz)*
80	N/A	- 74.1 (78.12 MHz)*	- 74.2 (77.04 MHz)*
90	N/A	- 73.6 (88.20 MHz)*	- 73.6 (87.12 MHz)*
100	N/A	- 73.1 (98.28 MHz)	- 73.2 (97.20 MHz)*

* Not mentioned in TS38.141-1, calculated values

The test for PUSCH verifies the achieved throughput of a receiver under multipath fading conditions at a given SNR. The throughput is measured by the base station under test. The required throughput is expressed as a fraction of maximum throughput for the FRCs. HARQ re-transmission is assumed.

Hybrid automatic repeat request (HARQ)-Feedback

The PUSCH tests require a feedback signal from the base station under test to provide feedback for HARQ. The signal generator automatically adjusts the transmitted signal based on the feedback. Software option SMW-K145 Closed Loop BS Tests is needed to perform tests with base station feedback. Use the following input connectors.

Table 7: Signals and connectors for PUSCH tests

Signal	HARQ feedback (from BS)	Frame Trigger (DL timing from BS)
Connector @ SMW with B10/B-14	TM3 + TM6 (rear panel)	USER 3 (front panel)
Connector @ SMW with B9/B-15	TM2 + TM4 (rear panel)	USER 3 (front panel)

SNR correction factor

If the used FRC does not occupy the whole PUSCH bandwidth, a special SNR correction factor is applied which depends on the bandwidth, the SCS and the number of used RBs.

$$\mathrm{SNRCorr} = 10 \cdot \log\left(\frac{\text{used RBs}}{\text{possible RBs}}\right)$$

Equation 1: SNR correction factor

Test setup

Figure 6 to Figure 12 show the test setups.

The wanted signal generated by SMW baseband A is split up in two paths. Multipath fading is simulated in the channel simulators. AWGN is added. For four Rx antennas, the test can be done with just one SMW (two SMW-K18 options required) and 2 SGT. For eight Rx antennas, the test can be also done with just one SMW (two SMW-K18 options required), but with six SGT.

The SMW needs an external trigger signal at connector "USER3". In addition to that a HARQ-Feedback signal from the base station is required. For SMW with B10/B14 use TM3 (+TM6), for SMW with B9/B15 use TM2 (+TM4).

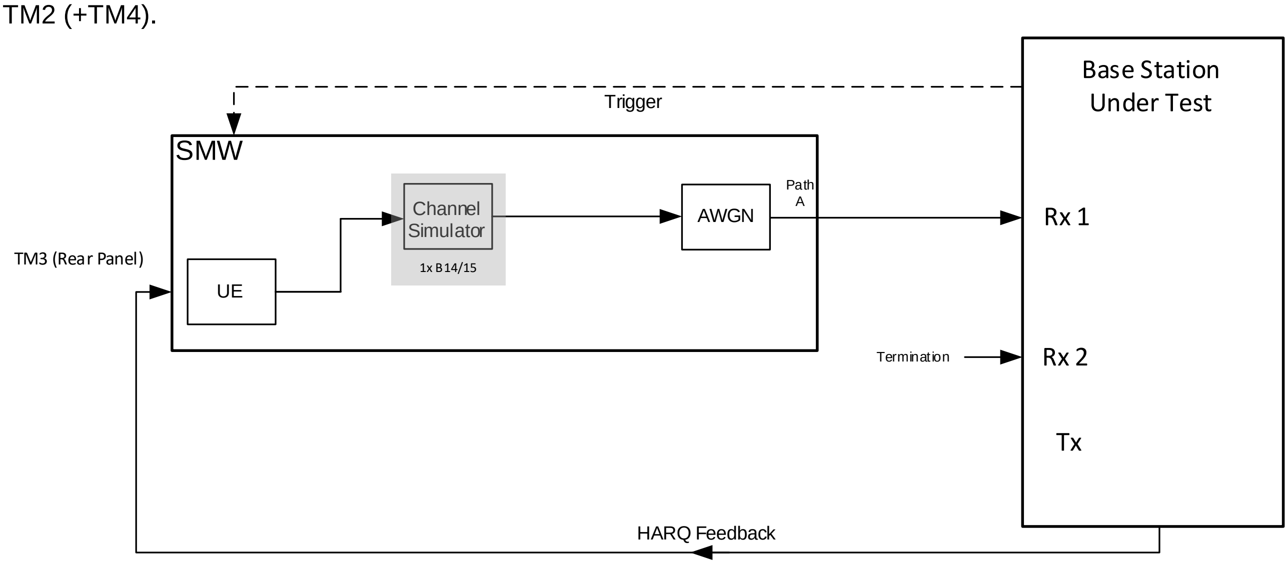


Figure 6: Test setup for PUSCH test for 1Tx and 1 Rx antennas

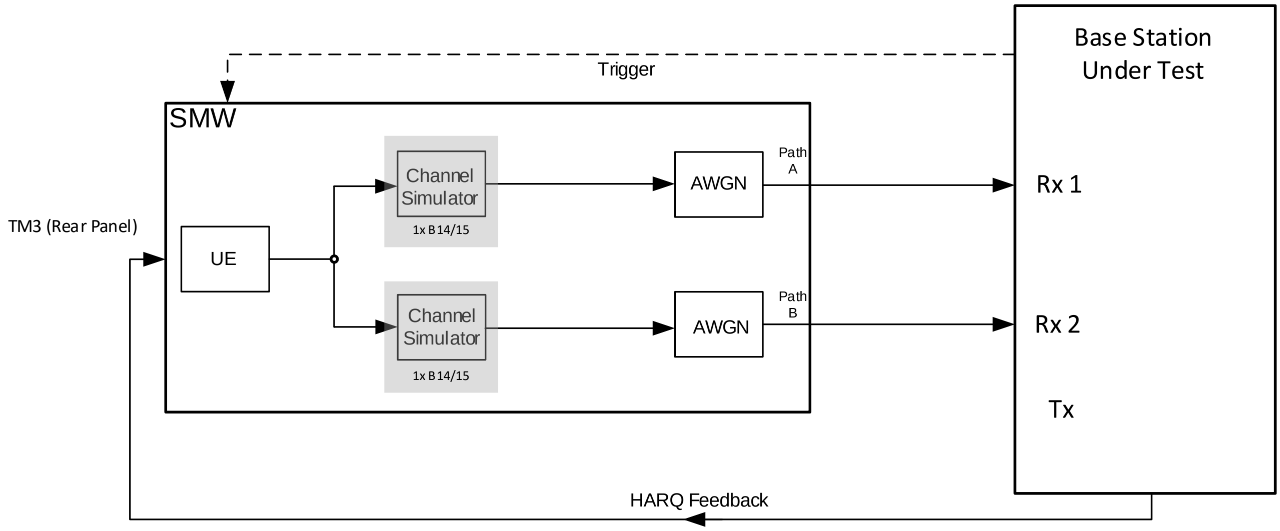


Figure 7: Test setup for PUSCH test for 1 Tx and 2 Rx antennas

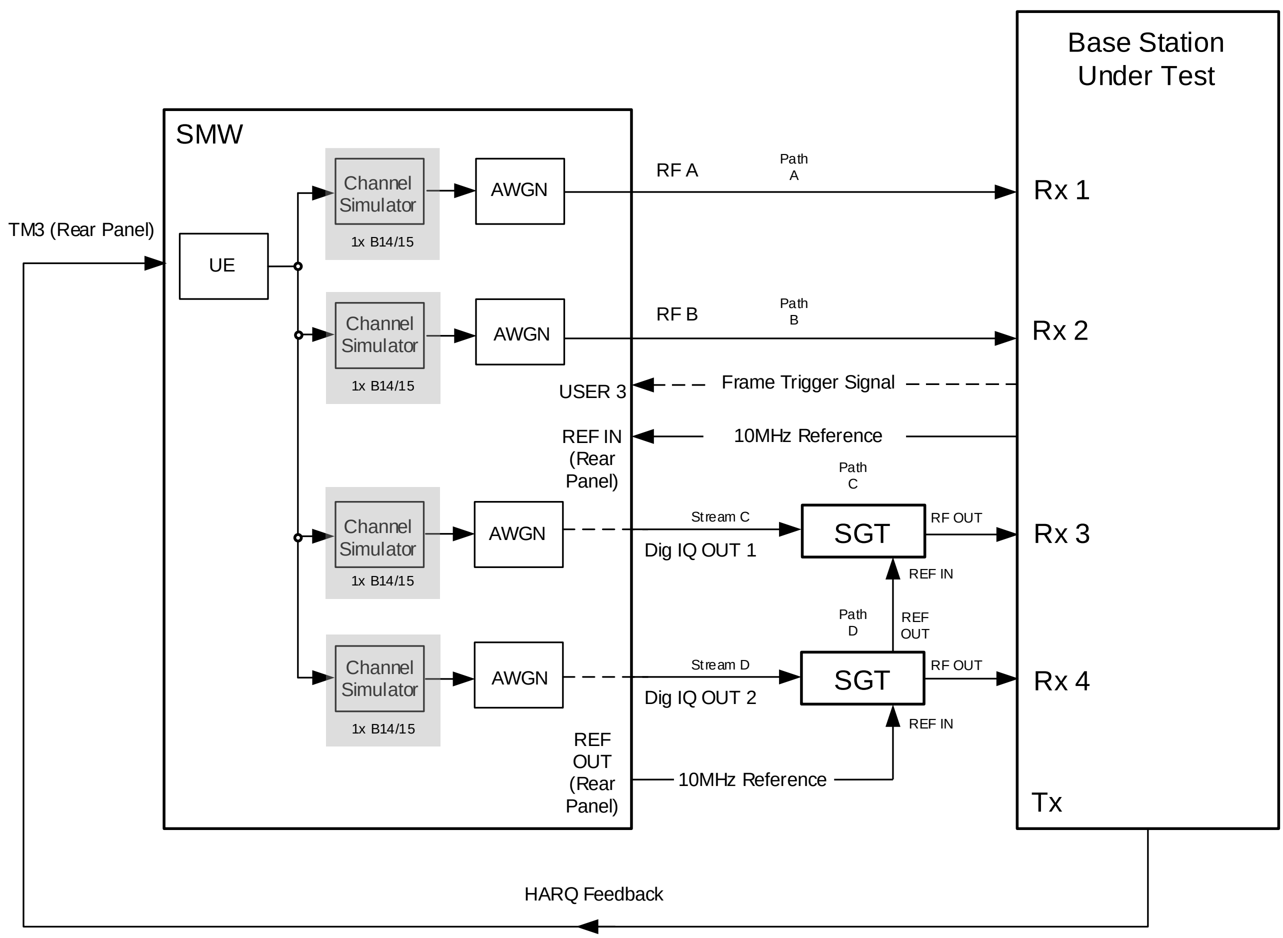


Figure 8: Test setup for PUSCH test for 1 Tx and 4 Rx antennas

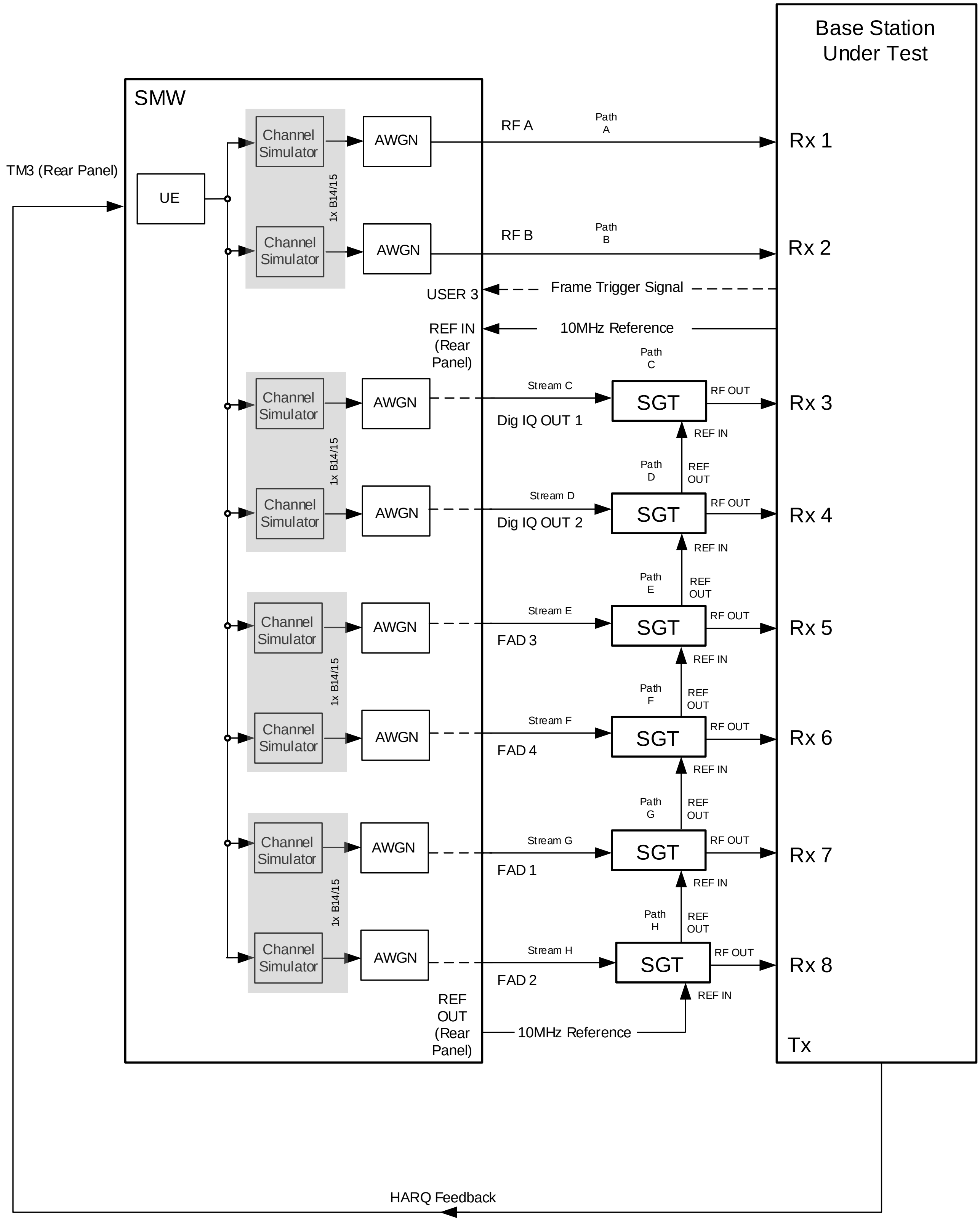


Figure 9: Test setup for PUSCH test for 1 Tx and 8 Rx antennas

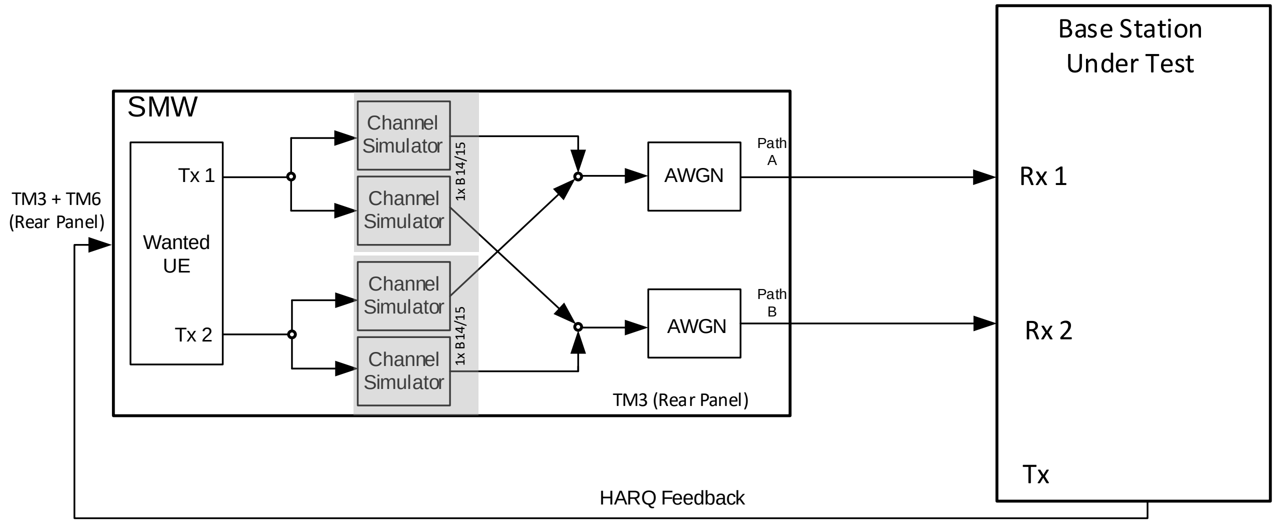


Figure 10: Test setup for PUSCH test for 2 Tx and 2 Rx antennas

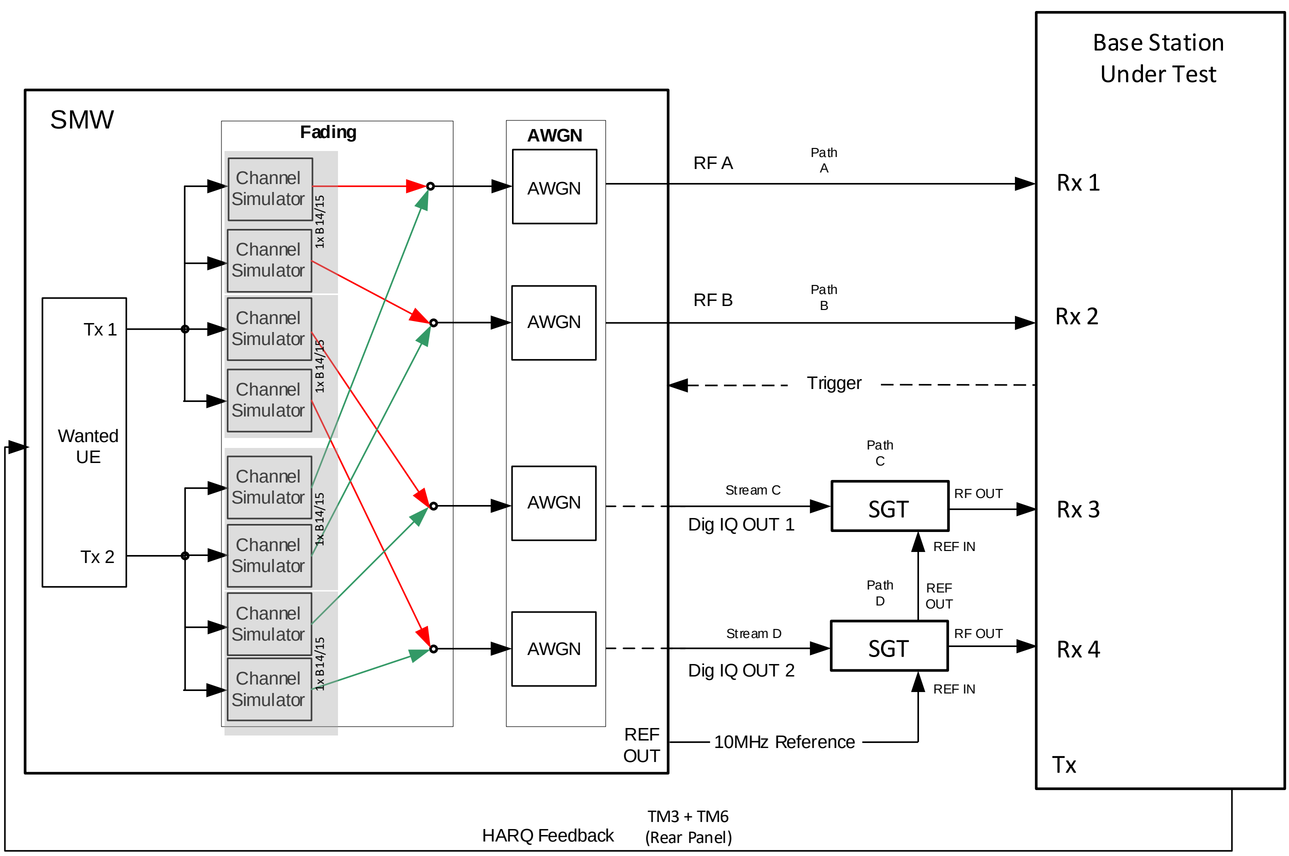


Figure 11: Test setup for PUSCH test for 2 Tx and 4 Rx antennas

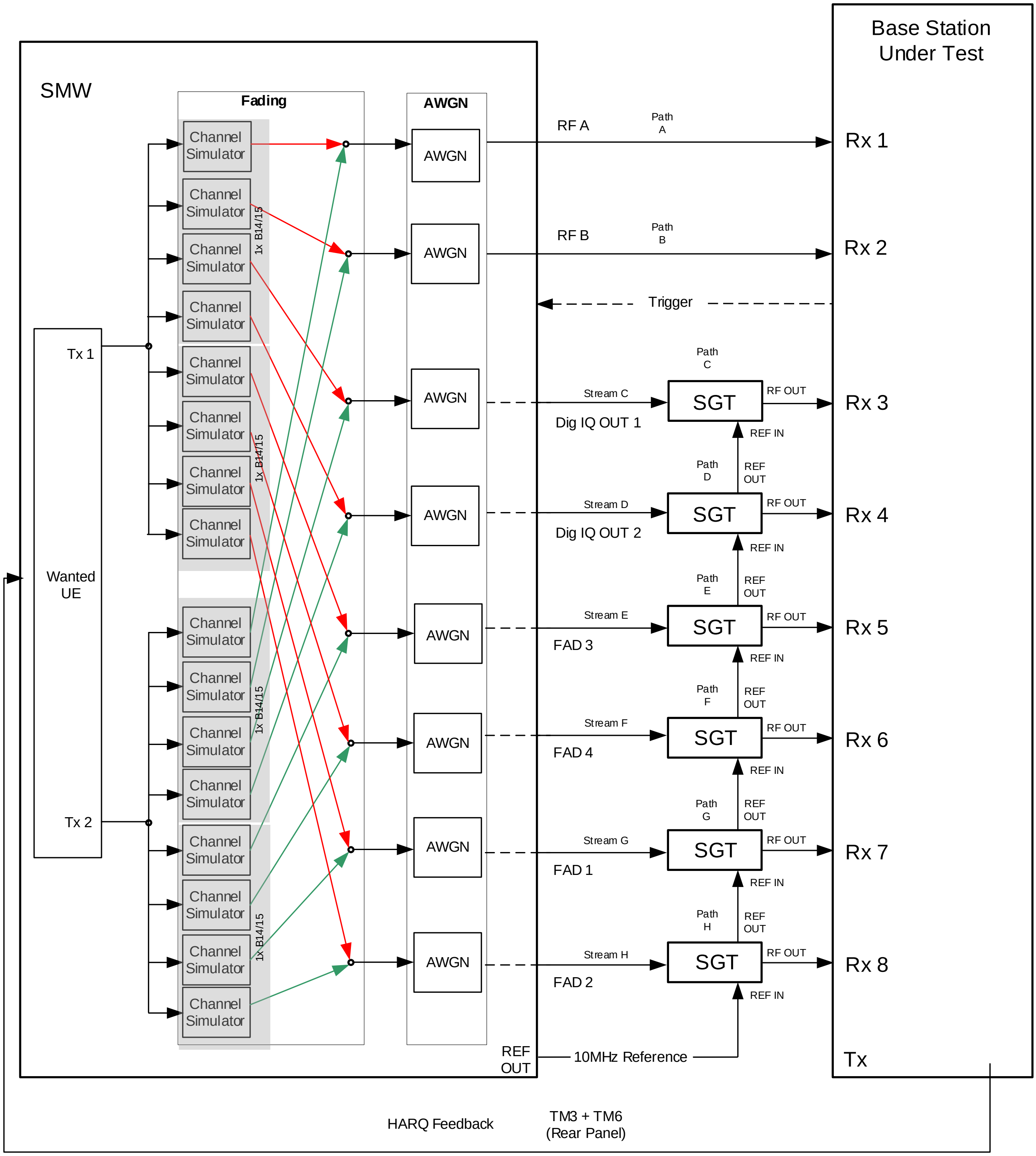


Figure 12: Test setup for PUSCH test for 2 Tx and 8 Rx antennas

3.6.1 Px requirements for PUSCH with transform precoding disabled (8.2.1)

For this test the transform precoding is disabled. Both tests with one (1) and two (2) Tx antennas are required.

The following tables show the test requirements for all bandwidths and all applicable number of Rx antennas (2, 4 and 8) and Tx antennas (1 or 2). For the given parameters, the fraction (70 %) of the maximum throughput has to be achieved.

Table 8: Test parameters

Parameter		Value
Transform precoding		Disabled
Default TDD UL-DL pattern (Note 1)		15 kHz SCS: 3D1S1U, S=10D:2G:2U 30 kHz SCS: 7D1S2U, S=6D:4G:4U
HARQ	Maximum number of HARQ transmissions	4
	RV sequence	0, 2, 3, 1
DM-RS	DM-RS configuration type	1
	DM-RS duration	single-symbol DM-RS
	Additional DM-RS position	pos1
	Number of DM-RS CDM group(s) without data	2
	Ratio of PUSCH EPRE to DM-RS EPRE	-3 dB
	DM-RS port(s)	{0}, {0, 1}
	DM-RS sequence generation	N_{ID}^{0}=0, n_{SCID} =0
Time domain resource assignment	PUSCH mapping type	A, B
	Start symbol	0
	Allocation length	14
Frequency domain resource assignment	RB assignment	Full applicable test bandwidth
	Frequency hopping	Disabled
TPMI index for 2Tx two layer spatial multiplexing transmission		0
Code block group based PUSCH transmission		Disabled
Note 1: The same requirements are applicable to FDD and TDD with different UL-DL patterns.		

The measured throughput shall not be below the limits for the SNR levels specified in Table 9 to Table 22.

Table 9: Test requirements for PUSCH, Type A, 5 MHz channel bandwidth, 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-8	pos1	-1.7
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-8	pos1	10.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-8	pos1	12.9
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-8	pos1	-5.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-8	pos1	6.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-8	pos1	9.4
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-8	pos1	-8.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-8	pos1	3.6
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-8	pos1	6.2
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-22	pos1	1.8
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-22	pos1	19.0
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-22	pos1	-1.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-22	pos1	11.8
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-22	pos1	-4.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-22	pos1	7.6

Table 10: Test requirements for PUSCH, Type A, 10 MHz channel bandwidth, 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-9	pos1	-1.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-9	pos1	10.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-9	pos1	12.8
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-9	pos1	-5.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-9	pos1	6.9
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-9	pos1	9.2
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-9	pos1	-8.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-9	pos1	3.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-9	pos1	6.1
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-23	pos1	2.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-23	pos1	19.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-23	pos1	-1.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-23	pos1	12.0
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-23	pos1	-4.7
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-23	pos1	7.6

Table 11: Test requirements for PUSCH, Type A, 20 MHz channel bandwidth, 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-10	pos1	-1.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-10	pos1	10.6
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-10	pos1	13.0
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-10	pos1	-4.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-10	pos1	6.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-10	pos1	9.2
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-10	pos1	-7.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-10	pos1	3.6
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-10	pos1	6.1
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-24	pos1	2.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-24	pos1	19.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-24	pos1	-1.0
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-24	pos1	11.9
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-24	pos1	-4.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-24	pos1	7.7

Table 12: Test requirements for PUSCH, Type A, 10 MHz channel bandwidth, 30 kHz SCS

Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-11	pos1	-1.7
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-11	pos1	10.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-11	pos1	13.4
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-11	pos1	-5.0
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-11	pos1	7.0
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-11	pos1	9.2
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-11	pos1	-8.0
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-11	pos1	3.9
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-11	pos1	6.1
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-25	pos1	2.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-25	pos1	19.2
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-25	pos1	-1.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-25	pos1	12.0
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-25	pos1	-4.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-25	pos1	7.8

Table 13: Test requirements for PUSCH, Type A, 20 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-12	pos1	-2.3
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-12	pos1	10.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-12	pos1	13.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-12	pos1	-5.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-12	pos1	7.0
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-12	pos1	9.2
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-12	pos1	-8.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-12	pos1	3.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-12	pos1	6.1
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-26	pos1	2.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-26	pos1	18.9
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-26	pos1	-1.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-26	pos1	12.1
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-26	pos1	-4.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-26	pos1	7.7

Table 14: Test requirements for PUSCH, Type A, 40 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-13	pos1	-1.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-13	pos1	10.6
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-13	pos1	13.0
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-13	pos1	-5.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-13	pos1	6.9
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-13	pos1	9.1
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-13	pos1	-8.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-13	pos1	3.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-13	pos1	6.0
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-27	pos1	2.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-27	pos1	20.3
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-27	pos1	-1.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-27	pos1	12.1
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-27	pos1	-4.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-27	pos1	7.7

Table 15: Test requirements for PUSCH, Type A, 100 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-14	pos1	-2.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-14	pos1	10.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-14	pos1	13.6
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-14	pos1	-5.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-14	pos1	7.1
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-14	pos1	9.6
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-14	pos1	-8.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-14	pos1	3.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-14	pos1	6.4
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-28	pos1	2.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-28	pos1	20.0
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-28	pos1	-1.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-28	pos1	12.4
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-28	pos1	-4.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-28	pos1	7.9

Table 16: Test requirements for PUSCH, Type B, 5 MHz channel bandwidth, 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-8	pos1	-1.7
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-8	pos1	10.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-8	pos1	13.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-8	pos1	-5.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-8	pos1	6.9
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-8	pos1	9.5
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-8	pos1	-8.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-8	pos1	3.6
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-8	pos1	6.3
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-22	pos1	2.3
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-22	pos1	19.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-22	pos1	-1.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-22	pos1	11.9
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-22	pos1	-4.6
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-22	pos1	7.6

Table 17: Test requirements for PUSCH, Type B, 10 MHz channel bandwidth, 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-9	pos1	-1.7
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-9	pos1	11.1
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-9	pos1	13.2
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-9	pos1	-5.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-9	pos1	7.1
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-9	pos1	9.5
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-9	pos1	-8.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-9	pos1	3.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-9	pos1	6.4
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-23	pos1	2.8
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-23	pos1	19.5
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-23	pos1	-1.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-23	pos1	12.1
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-23	pos1	-4.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-23	pos1	7.8

Table 18: Test requirements for PUSCH, Type B, 20 MHz channel bandwidth, 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-10	pos1	-1.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-10	pos1	11.0
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-10	pos1	12.9
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-10	pos1	-5.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-10	pos1	6.9
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-10	pos1	9.4
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-10	pos1	-7.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-10	pos1	3.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-10	pos1	6.3
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-24	pos1	2.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-24	pos1	18.9
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-24	pos1	-1.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-24	pos1	12.0
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-24	pos1	-4.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-24	pos1	7.7

Table 19: Test requirements for PUSCH, Type B, 10 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-11	pos1	-1.8
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-11	pos1	10.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-11	pos1	13.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-11	pos1	-5.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-11	pos1	7.0
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-11	pos1	9.2
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-11	pos1	-8.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-11	pos1	3.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-11	pos1	6.2
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-25	pos1	1.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-25	pos1	19.3
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-25	pos1	-1.7
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-25	pos1	12.1
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-25	pos1	-4.8
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-25	pos1	7.8

Table 20: Test requirements for PUSCH, Type B, 20 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-12	pos1	-2.3
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-12	pos1	10.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-12	pos1	13.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-12	pos1	-5.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-12	pos1	6.9
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-12	pos1	9.2
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-12	pos1	-8.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-12	pos1	3.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-12	pos1	6.2
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-26	pos1	2.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-26	pos1	19.0
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-26	pos1	-1.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-26	pos1	12.0
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-26	pos1	-4.6
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-26	pos1	7.8

Table 21: Test requirements for PUSCH, Type B, 40 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-13	pos1	-1.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-13	pos1	10.6
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-13	pos1	13.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-13	pos1	-5.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-13	pos1	6.8
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-13	pos1	9.3
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-13	pos1	-8.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-13	pos1	3.6
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-13	pos1	6.1
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-27	pos1	2.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-27	pos1	19.5
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-27	pos1	-1.3
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-27	pos1	12.0
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-27	pos1	-4.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-27	pos1	7.7

Table 22: Test requirements for PUSCH, Type B, 100 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-14	pos1	-1.9
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-14	pos1	10.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-14	pos1	13.7
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-14	pos1	-5.2
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-14	pos1	6.9
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-14	pos1	9.8
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-14	pos1	-8.1
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-14	pos1	3.7
		Normal	TDLA30-10 Low	70 %	G-FR1-A5-14	pos1	6.5
2	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-28	pos1	2.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-28	pos1	20.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-28	pos1	-1.4
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-28	pos1	12.4
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-28	pos1	-4.5
		Normal	TDLC300-100 Low	70 %	G-FR1-A4-28	pos1	7.9

Table 23: Test requirements for PUSCH with 30 % of maximum throughput, Type A, 5 MHz channel bandwidth, 15 kHz SCS

Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLC300-100 Low	30 %	G-FR1-A4-8	pos1	3.5

Table 24: Test requirements for PUSCH with 30 % of maximum throughput, Type A, 10 MHz channel bandwidth, 30 kHz SCS

Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLC300-100 Low	30 %	G-FR1-A4-11	pos1	3.4

Table 25: Test requirements for PUSCH with 30 % of maximum throughput, Type B, 5 MHz channel bandwidth, 15 kHz SCS

Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLC300-100 Low	30 %	G-FR1-A4-8	pos1	3.4

Table 26: Test requirements for PUSCH with 30 % of maximum throughput, Type B, 10 MHz channel bandwidth, 30 kHz SCS

Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions and correlation matrix (annex G)	Fraction of maximum throughput	FRC (annex A)	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLC300-100 Low	30 %	G-FR1-A4-11	pos1	3.5

Test setup

The test setups can be found in Figure 7 to Figure 12.

Settings

- Set the base station to the basic state (see chapter 3.5)
- The SMW (and the SGTs) are generating the required test signals
- The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received
- The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.1 PUSCH Transform Precoding Disabled"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC821
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:DUPLex <DuplexMethod>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:MAPType <MapType>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:RTF:MODE <RTFMode>
:BB:NR5G:TCW:RTF:SERRate <SerialRate>
:BB:NR5G:TCW:RTF:AUSDelay <AddUserDelay>
:BB:NR5G:TCW:RTF:CONNector <Connector>
:BB:NR5G:TCW:RTF:BBSelector <BBSelector>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_1.py

More information about Python modules can be found in A.

3.6.2 Px requirements for PUSCH with transform precoding enabled (8.2.2)

For this test the transform precoding is enabled.

The following tables show the test requirements for all bandwidths and all applicable number of Rx antennas (2, 4 and 8) and one (1) Tx antennas. For the given parameters, the fraction (70 %) of the maximum throughput has to be achieved. See the following tables for the test parameters and requirements.

Table 27: General parameter PUSCH precoding enabled

Parameter		Value
Transform precoding		Enabled
Uplink-downlink allocation for TDD		15 kHz SCS: 3D1S1U, S=10D:2G:2U 30 kHz SCS: 7D1S2U, S=6D:4G:4U
HARQ	Maximum number of HARQ transmissions	4
	RV sequence	0, 2, 3, 1
DMRS	DMRS configuration type	1
	Maximum number of OFDM symbols for front loaded DMRS	1
	Number of additional DMRS symbols	0, 1
	Number of DMRS CDM group(s) without data	2
	EPRE ratio of PUSCH to DMRS	-3 dB
	DMRS port	0
	DMRS sequence generation	NID=0, group hopping and sequence hopping are disabled
Time domain resource	PUSCH mapping type	A
	PUSCH starting symbol index	0
	PUSCH symbol length	14
Frequency domain resource	RB assignment	15 kHz SCS: 25 PRBs in the middle of the test bandwidth 30 kHz SCS: 24 PRBs in the middle of the test bandwidth
	Frequency hopping	Disabled
Code block group based PUSCH transmission		Disabled

The measured throughput shall not be below the limits for the SNR levels specified in Table 28 to Table 31.

Table 28: Test requirements for PUSCH, Type A, 5 MHz channel BW, 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-31	pos1	-1.8
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-31	pos1	-5.1
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-31	pos1	-7.9

Table 29: Test requirements for PUSCH, Type A, 10 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-32	pos1	-1.9
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-32	pos1	-5.1
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-32	pos1	-7.8

Table 30: Test requirements for PUSCH, Type B, 5 MHz channel bandwidth, 15 kHz SCS

Number of TX antennas	Number of RX antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-31	pos1	-1.7
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-31	pos1	-5.2
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-31	pos1	-8.0

Table 31: Test requirements for PUSCH, Type B, 10 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLB100-400 Low	70 %	G-FR1-A3-32	pos1	-2.1
	4	Normal	TDLB100-400 Low	70 %	G-FR1-A3-32	pos1	-5.4
	8	Normal	TDLB100-400 Low	70 %	G-FR1-A3-32	pos1	-8.2

Test setup

The test setups can be found in Figure 7 to Figure 9.

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW (and the SGTs) are generating the required test signals

► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.2 PUSCH Transform Precoding Enabled"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC822
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:DUPLex <DuplexMethod>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:MAPType <MapType>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:RTF:MODE <RTFMode>
:BB:NR5G:TCW:RTF:SERRate <SerialRate>
:BB:NR5G:TCW:RTF:AUSDelay <AddUserDelay>
:BB:NR5G:TCW:RTF:CONNector <Connector>
:BB:NR5G:TCW:RTF:BBSelector <BBSelector>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_2.py

More information about Python modules can be found in A.

3.6.3 Px requirements for UCI multiplexed on PUSCH (8.2.3)

The performance requirements of UCI multiplexed on PUSCH is determined by two parameters:

- Block error probability (BLER) of CSI part 1
- Block error probability (BLER) of CSI part 2

The performance is measured by the required SNR at block error probability of CSI part 1 not exceeding 0.1 %, and the required SNR at block error probability not exceeding 1 %.

The CSI part 1 BLER is defined as the probability of incorrectly decoding the CSI part 1 information when the CSI part 1 information is sent.

The CSI part 2 BLER is defined as the probability of incorrectly decoding the CSI part 2 information when the CSI part 2 information is sent.

In the test of UCI multiplexed on PUSCH, the UCI information only contains CSI part 1 and CSI part 2 information, there is no HACK/ACK information transmitted.

The number of UCI information bit payload per slot is defined for two cases as follows:

- 7 bits UCI
  - 5 bits in CSI part 1
  - 2 bits in CSI part 2
- 40 bits
  - 20 bits in CSI part 1
  - 20 bits in CSI part 2

The 7 bits UCI information case is further defined with the bitmap

$$[c0 \quad c1 \quad c2 \quad c3 \quad c4] = [0 \quad 1 \quad 0 \quad 1 \quad 0]$$

for CSI part 1 information, where c0 is mapping to the RI information, and with the bitmap

$$[c0 \quad c1] = [1 \quad 0]$$

for CSI part 2 information.

The 40 bits UCI information case is assumed random information bitselection.

In both tests, PUSCH data, CSI part 1 and CSI part 2 are transmitted simultaneously. [5]

Table 32: Test parameters

Parameter		Value
Transform precoding		Disabled
Default TDD UL-DL pattern (Note 1)		30 kHz SCS: 7D1S2U, S=6D:4G:4U
HARQ	Maximum number of HARQ transmissions	1
	RV sequence	0

DM-RS	DM-RS configuration type	1
	DM-RS duration	Single-symbol DM-RS
	Additional DM-RS position	pos1
	Number of DM-RS CDM group(s) without data	2
	Ratio of PUSCH EPRE to DM-RS EPRE	-3 dB
	DM-RS port(s)	{0}
	DM-RS sequence generation	NID0 = 0, nSCID = 0
Time domain resource assignment	PUSCH mapping type	A, B
	Start symbol	0
	Allocation length	14
Frequency domain resource assignment	RB assignment	Full applicable test bandwidth
	Frequency hopping	Disabled
Code block group based PUSCH transmission		Disabled
UC	Number of CSI part 1 and CSI part 2 information bit payload	{5,2}, {20, 20}
	scaling	1
	betaOffsetACK-Index1	11
	betaOffsetCSI-Part1-Index1 and betaOffsetCSI-Part1-Index2	13
	betaOffsetCSI-Part2-Index1 and betaOffsetCSI-Part2-Index2	13
	UCI partition for frequency hopping	Disabled
Note 1: The same requirements are applicable to FDD and TDD with different UL-DL patterns.		

The fractional of incorrectly decoded UCI with CSI part 1 shall be less than 0.1 % for SNR listed in the Table 33 and Table 34. The fractional of incorrectly decoded UCI with CSI part 2 shall be less than 1 % for SNR listed in Table 35 and Table 36.

Table 33: Test requirements for UCI multiplexed on PUSCH, Type A, CSI part 1, 10 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	UCI bits (CSI part 1, CSI part 2)	Additional DM-RS position	FRC	SNR (dB)
1	2	Normal	TDLC300-100 Low	7 (5, 2)	pos1	G-FR1-A4-11	6.0
	2	Normal	TDLC300-100 Low	40 (20,20)	pos1	G-FR1-A4-11	4.9

Table 34: Test requirements for UCI multiplexed on PUSCH, Type B, CSI part 1, 10 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	UCI bits (CSI part 1, CSI part 2)	Additional DM-RS position	FRC	SNR (dB)
1	2	Normal	TDLC300-100 Low	7 (5, 2)	pos1	G-FR1-A4-11	6.4
	2	Normal	TDLC300-100 Low	40 (20,20)	pos1	G-FR1-A4-11	4.7

Table 35: Test requirements for UCI multiplexed on PUSCH, Type A, CSI part 2, 10 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	UCI bits (CSI part 1, CSI part 2)	Additional DM-RS position	FRC	SNR (dB)
1	2	Normal	TDLC300-100 Low	7 (5, 2)	pos1	G-FR1-A4-11	0.4
	2	Normal	TDLC300-100 Low	40 (20,20)	pos1	G-FR1-A4-11	3.0

Table 36: Test requirements for UCI multiplexed on PUSCH, Type B, CSI part 2, 10 MHz channel bandwidth, 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	UCI bits (CSI part 1, CSI part 2)	Additional DM-RS position	FRC	SNR (dB)
1	2	Normal	TDLC300-100 Low	7 (5, 2)	pos1	G-FR1-A4-11	0.9
	2	Normal	TDLC300-100 Low	40 (20,20)	pos1	G-FR1-A4-11	3.2

Test setup

The test setup can be found in Figure 7.

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW (and the SGTs) is/are generating the required test signals

► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.3 UCI multiplexed on PUSCH"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC823
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:DUPLex <DuplexMethod>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:MAPType <MapType>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:WS:UCI:CSIPart <CSIPart>
:BB:NR5G:TCW:WS:UCI:BITS <BITS>
:BB:NR5G:TCW:WS:UCI:CSI1:PATTern <PATTern>
:BB:NR5G:TCW:WS:UCI:CSI2:PATTern <PATTern>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_3.py

More information about Python modules can be found in A.

3.6.4 Px requirements for PUSCH for high speed train (8.2.4)

This test case is optional. The requirements only apply to wide area and medium range base stations. The test shall verify the receiver's ability to achieve throughput under high speed train conditions for a given SNR. HARQ re-transmissions are assumed. [5]

Table 37: Test parameters

Parameter		Value
Transform precoding		Disabled
Uplink-downlink allocation for TDD (Note 1)		15 kHz SCS: 3D1S1U, S=10D:2G:2U 30 kHz SCS: 7D1S2U, S=6D:4G:4U
HARQ	Maximum number of HARQ transmissions	4
	RV sequence	0, 2, 3, 1
DM-RS	DM-RS configuration type	1
	DM-RS duration	single-symbol DM-RS
	First DM-RS position	pos2 or pos3 (NOTE2)
	Additional DM-RS position	pos2
	Number of DM-RS CDM group(s) without data	2
	Ratio of PUSCH EPRE to DM-RS EPRE	-3 dB
	DM-RS port	{0}
	DM-RS sequence generation	NID0=0, nSCID =0
Time domain resource assignment	PUSCH mapping type	A
	Start symbol	0
	Allocation length	14
Frequency domain resource assignment	RB assignment	Full applicable test bandwidth
	Frequency hopping	Disabled
Code block group based PUSCH transmission		Disabled
NOTE 1: The same requirements are applicable to FDD and TDD with different UL-DL patterns. NOTE 2: Either pos2 or pos3 may be selected for conformance testing.		

The measured throughput shall not be below the limits for the SNR levels specified in the following tables.

Table 38: Test requirements for PUSCH, Type A, 10 MHz channel bandwidth, 15 kHz SCS, 350km/h

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	1	Normal	HST Scenario 3-NR350	70 %	G-FR1-A3-33	pos2	[-0.5]
		Normal	HST Scenario 1-NR350	70 %	G-FR1-A3-33	pos2	-3.4
	2	Normal	HST Scenario 1-NR350	70 %	G-FR1-A4-29	pos2	8.7
		Normal	HST Scenario 3-NR350	70 %	G-FR1-A3-33	pos2	-3.3
		Normal	HST Scenario 3-NR350	70 %	G-FR1-A4-29	pos2	9.0
	8	Normal	HST Scenario 1-NR350	70 %	G-FR1-A3-33	pos2	-8.9
		Normal	HST Scenario 1-NR350	70 %	G-FR1-A4-29	pos2	2.9

Table 39: Test requirements for PUSCH, Type A, 40 MHz channel bandwidth, 30 kHz SCS, 350km/h

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	1	Normal	HST Scenario 3-NR350	70 %	G-FR1-A3-34	pos2	[-0.3]
		Normal	HST Scenario 1-NR350	70 %	G-FR1-A3-34	pos2	-3.4
	2	Normal	HST Scenario 1-NR350	70 %	G-FR1-A4-30	pos2	8.8
		Normal	HST Scenario 3-NR350	70 %	G-FR1-A3-34	pos2	-3.3
		Normal	HST Scenario 3-NR350	70 %	G-FR1-A4-30	pos2	9.0
	8	Normal	HST Scenario 1-NR350	70 %	G-FR1-A3-34	pos2	-8.8
		Normal	HST Scenario 1-NR350	70 %	G-FR1-A4-30	pos2	3.0

Table 40: Test requirements for PUSCH, Type A, 10 MHz channel bandwidth, 15 kHz SCS, 500km/h

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	1	Normal	HST Scenario 3-NR500	70 %	G-FR1-A3-33	pos2	[-0.4]
		Normal	HST Scenario 1-NR500	70 %	G-FR1-A3-33	pos2	-3.6
	2	Normal	HST Scenario 1-NR500	70 %	G-FR1-A4-29	pos2	8.8
		Normal	HST Scenario 3-NR500	70 %	G-FR1-A3-33	pos2	-3.3
		Normal	HST Scenario 3-NR500	70 %	G-FR1-A4-29	pos2	9.5
	8	Normal	HST Scenario 1-NR500	70 %	G-FR1-A3-33	pos2	-9.1
		Normal	HST Scenario 1-NR500	70 %	G-FR1-A4-29	pos2	3.0

Table 41: Test requirements for PUSCH, Type A, 40 MHz channel bandwidth, 30 kHz SCS, 500km/h

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	1	Normal	HST Scenario 3-NR500	70 %	G-FR1-A3-34	pos2	[-0.2]
		Normal	HST Scenario 1-NR500	70 %	G-FR1-A3-34	pos2	-3.6
	2	Normal	HST Scenario 1-NR500	70 %	G-FR1-A4-30	pos2	9.0
		Normal	HST Scenario 3-NR500	70 %	G-FR1-A3-34	pos2	-3.3
		Normal	HST Scenario 3-NR500	70 %	G-FR1-A4-30	pos2	8.3
	8	Normal	HST Scenario 1-NR500	70 %	G-FR1-A3-34	pos2	-8.9
		Normal	HST Scenario 1-NR500	70 %	G-FR1-A4-30	pos2	3.1

Table 42: Test requirements for PUSCH, Type A, 5 MHz channel bandwidth, 15 kHz SCS, 350km/h

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	1	Normal	HST Scenario 3-NR350	70 %	G-FR1-A3-33A	pos2	[-0.4]
		Normal	HST Scenario 1-NR350	70 %	G-FR1-A3-33A	pos2	[-3.4]
	2	Normal	HST Scenario 1-NR350	70 %	G-FR1-A4-29A	pos2	[8.8]
		Normal	HST Scenario 3-NR350	70 %	G-FR1-A3-33A	pos2	[-3.3]
		Normal	HST Scenario 3-NR350	70 %	G-FR1-A4-29A	pos2	[8.9]
	8	Normal	HST Scenario 1-NR350	70 %	G-FR1-A3-33A	pos2	[-8.8]
		Normal	HST Scenario 1-NR350	70 %	G-FR1-A4-29A	pos2	[3.1]

Table 43: Test requirements for PUSCH, Type A, 10 MHz channel bandwidth, 30 kHz SCS, 350km/h

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	1	Normal	HST Scenario 3-NR350	70 %	G-FR1-A3-34A	pos2	[-0.4]
		Normal	HST Scenario 1-NR350	70 %	G-FR1-A3-34A	pos2	[-3.3]
	2	Normal	HST Scenario 1-NR350	70 %	G-FR1-A4-30A	pos2	[8.6]
		Normal	HST Scenario 3-NR350	70 %	G-FR1-A3-34A	pos2	[-3.3]
		Normal	HST Scenario 3-NR350	70 %	G-FR1-A4-30A	pos2	[8.9]
	8	Normal	HST Scenario 1-NR350	70 %	G-FR1-A3-34A	pos2	[-8.7]
		Normal	HST Scenario 1-NR350	70 %	G-FR1-A4-30A	pos2	[2.9]

Table 44: Test requirements for PUSCH, Type A, 5 MHz channel bandwidth, 15 kHz SCS, 500km/h

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	1	Normal	HST Scenario 3-NR500	70 %	G-FR1-A3-33A	pos2	[-0.3]
		Normal	HST Scenario 1-NR500	70 %	G-FR1-A3-33A	pos2	[-3.3]
	2	Normal	HST Scenario 1-NR500	70 %	G-FR1-A4-29A	pos2	[9.0]
		Normal	HST Scenario 3-NR500	70 %	G-FR1-A3-33A	pos2	[-3.2]
		Normal	HST Scenario 3-NR500	70 %	G-FR1-A4-29A	pos2	[9.1]
	8	Normal	HST Scenario 1-NR500	70 %	G-FR1-A3-33A	pos2	[-8.8]
		Normal	HST Scenario 1-NR500	70 %	G-FR1-A4-29A	pos2	[3.3]

Table 45: Test requirements for PUSCH, Type A, 10 MHz channel bandwidth, 30 kHz SCS, 500km/h

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	1	Normal	HST Scenario 3-NR500	70 %	G-FR1-A3-34A	pos2	[-0.2]
		Normal	HST Scenario 1-NR500	70 %	G-FR1-A3-34A	pos2	[-3.3]
	2	Normal	HST Scenario 1-NR500	70 %	G-FR1-A4-30A	pos2	[8.9]
		Normal	HST Scenario 3-NR500	70 %	G-FR1-A3-34A	pos2	[-3.1]
		Normal	HST Scenario 3-NR500	70 %	G-FR1-A4-30A	pos2	[8.9]
	8	Normal	HST Scenario 1-NR500	70 %	G-FR1-A3-34A	pos2	[-8.5]
		Normal	HST Scenario 1-NR500	70 %	G-FR1-A4-30A	pos2	[3.2]

Table 46: Test requirements for PUSCH, Type A, 5 MHz channel bandwidth, 15 kHz SCS, multi-path fading channel under high Doppler value

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLC300-600	70 %	G-FR1-A3-33A	pos2	[-1.3]

Table 47: Test requirements for PUSCH, Type A, 10 MHz channel bandwidth, 30 kHz SCS, multi-path fading channel under high Doppler value

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions	Fraction of maximum throughput	FRC	Additional DM-RS position	SNR (dB)
1	2	Normal	TDLC300-1200	70 %	G-FR1-A3-34A	pos2	[-1.4]

Test setup

The test setup can be found in Figure 7 to Figure 9.

Settings

- ► Set the base station to the basic state (see chapter 3.5)
- ► The SMW (and the SGTs) is/are generating the required test signals
- ► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received
- ► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.4 PUSCH for High Speed Train"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC824
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:DUPLex <DuplexMethod>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:FMTHroughput <FMT>
:BB:NR5G:TCW:WS:VDRF <VirtualDlRF>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:WS:FRC:TYPE <WSFrc>
:BB:NR5G:TCW:RTF:MODE <RTFMode>
:BB:NR5G:TCW:RTF:SERRate <SerialRate>
:BB:NR5G:TCW:RTF:AUSDelay <AddUserDelay>
:BB:NR5G:TCW:RTF:CONNector <Connector>
:BB:NR5G:TCW:RTF:BBSelector <BBSelector>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_4.py

More information about Python modules can be found in A.

3.6.5 Px requirements for UL timing adjustment (8.2.5)

The performance requirement of UL timing adjustment is determined by a minimum required throughput measured for the moving UE at given SNR. The performance requirements assume HARQ retransmissions. In the tests for UL timing adjustment, two signals are configured, one being transmitted by a moving UE and the other being transmitted by a stationary UE.

The test shall verify the receiver's ability to achieve throughput measured for the moving UE at given SNR under moving propagation conditions. [5]

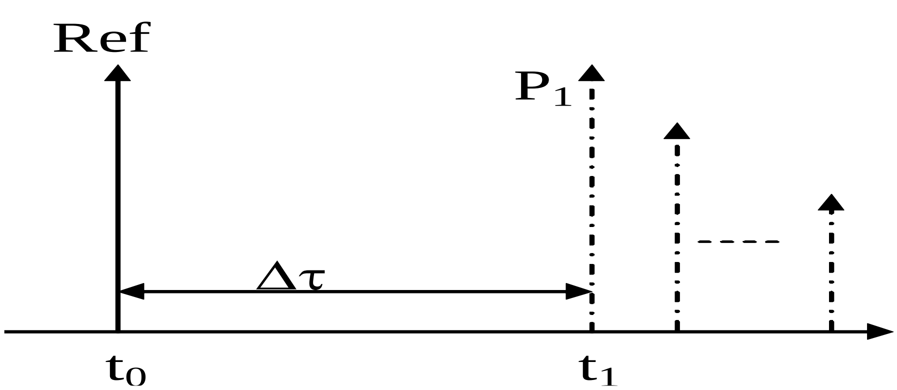
Table 48: Test parameters

Parameter		Value
Transform precoding		Disabled
Uplink-downlink allocation for TDD (NOTE 1)		15 kHz SCS: 3D1S1U, S=10D:2G:2U 30 kHz SCS: 7D1S2U, S=6D:4G:4U
HARQ	Maximum number of HARQ transmissions	4
	RV sequence	0, 2, 3, 1
DM-RS	DM-RS configuration type	1
	DM-RS duration	single-symbol DM-RS
	Additional DM-RS position	Pos2
	Number of DM-RS CDM group(s) without data	2
	Ratio of PUSCH EPRE to DM-RS EPRE	-3 dB
	DM-RS port(s)	{0}
	DM-RS sequence generation	NID0=0, nSCID =0 for moving UE NID0=1, nSCID =1 for stationary UE
Time domain resource assignment	PUSCH mapping type	A, B
	Allocation length	14

Frequency domain resource assignment	RB assignment	5 MHz CBW/15kHz SCS: 12 RB for each UE 10 MHz CBW/15kHz SCS: 25 RB for each UE 10 MHz CBW/30kHz SCS: 12 RB for each UE 40 MHz CBW/30kHz SCS: 50 RB for each UE
	Starting PRB index	Moving UE: 0 Stationary UE: 12 for 5MHz CBW/15kHz SCS, 25 for 10 MHz CBW/15kHz SCS, 12 for 10MHz CBW/30kHz SCS and 50 for 40 MHz CBW/30kHz SCS
	Frequency hopping	Disabled
SRS resource allocation	Slots in which sounding RS is transmitted (NOTE 2)	For FDD: slot #1 in radio frames For TDD: last symbol in slot #3 in radio frames for 15kHz last symbol in slot #7 in radio frames for 30kHz
	SRS resource allocation	15 kHz SCS: CSRS =5, BSRS =0, for 20 RB CSRS = 11, BSRS =0, for 40 RB 30 kHz SCS: CSRS =5, BSRS =0, for 20 RB CSRS = 21, BSRS =0, for 80 RB

NOTE 1: The same requirements are applicable to FDD and TDD with different UL-DL patterns.
NOTE 2: The transmission of SRS is optional. And the transmission comb and SRS periodic are configured as KTC = 2, and TSRS = 10 respectively.

The throughput shall be ≥ 70 % of the maximum throughput of the reference measurement channel for the moving UE at the SNR given in table 8.2.5.5-1 for mapping type A and table 8.2.5.5-2 for mapping type B respectively.



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

Figure 13: Moving propagation conditions [5]

Table 49: Parameters for UL timing adjustment

Parameter	Scenario X	Scenario Y	Scenario Z
Channel model	Stationary UE: AWGN Moving UE: TDLC300-400	Stationary UE: AWGN Moving UE: AWGN	Stationary UE: AWGN Moving UE: AWGN
UE speed	120 km/h	350 km/h	500 km/h
CP length	Normal	Normal	Normal
A	15 kHz: 10 ms 30 kHz: 5 ms	15 kHz: 10 ms 30 kHz: 5 ms	15 kHz: 10 ms 30 kHz: 5 ms
Δw	15 kHz: 0.04 s-1 30 kHz: 0.08 s-1	15 kHz: 0.13 s-1 30 kHz: 0.26 s-1	15 kHz: 0.18 s-1 30 kHz: 0.36 s-1

Test requirements for normal mode

Table 50: Test requirements for UL timing adjustment with mapping type A

Number of TX antennas	Number of RX antennas	Cyclic prefix	Channel Bandwidth [MHz]	SCS [kHz]	Moving propagation conditions and correlation matrix	FRC	SNR [dB]
1	2	Normal	5	15	Scenario X	G-FR1-A4-31A	[11.2]
			10	15	Scenario X	G-FR1-A4-31	[11.8]
			10	30	Scenario X	G-FR1-A4-32A	[11.4]
			40	30	Scenario X	G-FR1-A4-32	[12.6]

Table 51: Test requirements for UL timing adjustment with mapping type B

Number of TX antennas	Number of RX antennas	Cyclic prefix	Channel Bandwidth [MHz]	SCS [kHz]	Moving propagation conditions and correlation matrix	FRC	SNR [dB]
1	2	Normal	5	15	Scenario X	G-FR1-A4-31A	[11.2]
			10	15	Scenario X	G-FR1-A4-31	[11.9]
			10	30	Scenario X	G-FR1-A4-32A	[11.3]
			40	30	Scenario X	G-FR1-A4-32	[13.0]

Test requirements for high speed train

Table 52: Test requirements for UL timing adjustment with mapping type A for high speed train

Number of TX antennas	Number of RX antennas	Cyclic prefix	Channel Bandwidth [MHz]	SCS [kHz]	Moving propagation conditions and correlation matrix	FRC	SNR [dB]
1	2	Normal	5	15	Scenario Y	G-FR1-A4-31A	[8.5]
					Scenario Z	G-FR1-A4-31A	[8.6]
			10	15	Scenario Y	G-FR1-A4-31	[8.8]
					Scenario Z	G-FR1-A4-31	[8.7]
			10	30	Scenario Y	G-FR1-A4-32A	[8.6]
					Scenario Z	G-FR1-A4-32A	[8.6]
			40	30	Scenario Y	G-FR1-A4-32	[8.7]
					Scenario Z	G-FR1-A4-32	[8.8]

Table 53: Test requirements for UL timing adjustment with mapping type B for high speed train

Number of TX antennas	Number of RX antennas	Cyclic prefix	Channel Bandwidth [MHz]	SCS [kHz]	Moving propagation conditions and correlation matrix	FRC	SNR [dB]
1	2	Normal	5	15	Scenario Y	G-FR1-A4-31A	[8.6]
					Scenario Z	G-FR1-A4-31A	[8.6]
			10	15	Scenario Y	G-FR1-A4-31	[8.8]
					Scenario Z	G-FR1-A4-31	[8.8]
			10	30	Scenario Y	G-FR1-A4-32A	[8.6]
					Scenario Z	G-FR1-A4-32A	[8.7]
			40	30	Scenario Y	G-FR1-A4-32	[8.7]
					Scenario Z	G-FR1-A4-32	[8.8]

Test setup

The test setup can be found in Figure 7.

Settings

- ► Set the base station to the basic state (see chapter 3.5)
- ► The SMW generates the required test signals
- ► The signal generator starts signal generation when a start trigger impulse from the base station is received
- ► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.5 PUSCH for UL Timing Adjustment"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC825
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:DUPLex <DuplexMethod>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:TREQuire <TestRequirement>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:MAPType <MapType>
:BB:NR5G:TCW:WS:MUE:TSRS <TransmitSRS>
:BB:NR5G:TCW:IS:UEID <ISUEID>
:BB:NR5G:TCW:SUE:TSRS <TransmitSRS>
:BB:NR5G:TCW:RTF:MODE <RTFMode>
:BB:NR5G:TCW:RTF:SERRate <SerialRate>
:BB:NR5G:TCW:RTF:AUSDelay <AddUserDelay>
:BB:NR5G:TCW:RTF:CONNector <Connector>
:BB:NR5G:TCW:RTF:BBSelector <BBSelector>
:BB:NR5G:TCW:RTF:SUE:CONNector <Connector>
:BB:NR5G:TCW:RTF:SUE:BBSelector <BBSelector>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_5.py

More information about Python modules can be found in A.

3.6.6 Px requirements for PUSCH with 0.001 % BLER (8.2.6)

The performance requirement of PUSCH is determined by a maximum required transport block error rate (BLER) for a given SNR. The required BLER is defined as the probability of incorrectly decoding the transport block after reaching the maximum number of HARQ transmissions for the FRCs. The test shall verify the receiver's ability to achieve 0.001 % BLER under AWGN conditions for a given SNR. [5]

Table 54: Test parameters

Parameter		Value
Transform precoding		Disabled
Default TDD UL-DL pattern (Note 1)		15 kHz SCS: 3D1S1U, S=10D:2G:2U 30 kHz SCS: 7D1S2U, S=6D:4G:4U
HARQ	Maximum number of HARQ transmissions	1
	RV sequence	0
DM-RS	DM-RS configuration type	1
	DM-RS duration	single-symbol DM-RS
	Additional DM-RS position	Pos1
	Number of DM-RS CDM group(s) without data	1
	Ratio of PUSCH EPRE to DM-RS EPRE	-3 dB
	DM-RS port(s)	{0}
	DM-RS sequence generation	N_{ID}^{0}=0, n_{SCID} =0
Time domain resource assignment	PUSCH mapping type	A, B
	Start symbol	0
	Allocation length	14
Frequency domain resource assignment	RB assignment	Full applicable test bandwidth
	Frequency hopping	Disabled
Code block group based PUSCH transmission		Disabled
Note 1: The same requirements are applicable to FDD and TDD with different UL-DL patterns.		

The measured BLER shall not be below the limits for the SNR levels specified in the following tables.

The following assumptions hold for all requirements:

► Number of Tx antennas: 1

► Number of Rx antennas: 2

► Cyclic prefix: Normal

► Propagation conditions: AWGN → AWGN power levels according to Table 6

► Additional DM-RS position: pos1

Table 55: Test requirements

SCS [kHz]	Channel BW [MHz]	Type	FRC	BLER	SNR [dB]
15	5	Type A	G-FR1-A3A-1	0.001 %	-3.8
15	10	Type A	G-FR1-A3A-2	0.001 %	-4.6
30	10	Type A	G-FR1-A3A-3	0.001 %	-4.1
30	40	Type A	G-FR1-A3A-4	0.001 %	-4.9
15	5	Type B	G-FR1-A3A-1	0.001 %	-3.9
15	10	Type B	G-FR1-A3A-2	0.001 %	-4.6
30	10	Type B	G-FR1-A3A-3	0.001 %	-4.1
30	40	Type B	G-FR1-A2A-4	0.001 %	-4.9

Test setup

The test setup can be found in Figure 7**.**

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW generates the required test signals

► The signal generator starts signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.6 PUSCH with 0.001 % BLER"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC826
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:DUPLex <DuplexMethod>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:MAPType <MapType>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:RTF:MODE <RTFMode>
:BB:NR5G:TCW:RTF:SERRate <SerialRate>
:BB:NR5G:TCW:RTF:AUSDelay <AddUserDelay>
:BB:NR5G:TCW:RTF:CONNector <Connector>
:BB:NR5G:TCW:RTF:BBSelector <BBSelector>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_6.py

More information about Python modules can be found in A.

3.6.7 Px requirements for PUSCH repetition Type A (8.2.7)

The performance requirement of PUSCH with slot aggregation factor configured is determined by a maximum target BLER for a given SNR. The required BLER is defined as the probability of incorrectly decoding the PUSCH information when the PUSCH information is sent for the FRCs. The performance requirements assume HARQ re-transmissions. The test shall verify the receiver's ability to achieve 1 % BLER with PUSCH repetition Type A under multipath fading propagation conditions for a given SNR. [5]

Table 56: Test parameters

Parameter		Value
Transform precoding		Disabled
Default TDD UL-DL pattern (Note 1)		15 kHz SCS: 3D1S1U, S=10D:2G:2U 30 kHz SCS: 7D1S2U, S=6D:4G:4U
HARQ	Maximum number of HARQ transmissions	4
	RV sequence	0, 3, 0, 3 [Note 2]

DM-RS	DM-RS configuration type	1
	DM-RS duration	single-symbol DM-RS
	Additional DM-RS position	pos1
	Number of DM-RS CDM group(s) without data	2
	Ratio of PUSCH EPRE to DM-RS EPRE	-3 dB
	DM-RS port	0
	DM-RS sequence generation	N_{ID}^{0}=0, n_{SCID} =0
Time domain resource assignment	PUSCH mapping type	A, B
	Start symbol	0
	Allocation length	14
	PUSCH aggregation factor	30 kHz SCS: n2 15 kHz SCS: n2 for FDD and n8 for TDD [Note 3]
Frequency domain resource assignment	RB assignment	Full applicable test bandwidth
	Frequency hopping	Disabled
Code block group based PUSCH transmission		Disabled
Note 1: The same requirements are applicable to FDD and TDD with different UL-DL pattern. Note 2: The effective RV sequence is {0, 2, 3, 1} with slot aggregation. Note 3: The intention of this configuration is to have two effective transmissions of the transport block. To achieve this for the standard TDD pattern captured in this table, a value of n8 is necessary, while for FDD a value of n2 is necessary.		

The BLER measured shall not be above the limits for the SNR levels specified in the following tables.

The following assumptions hold for all tables:

► Number of Tx antennas: 1

► Number of Rx antennas: 2

► Cyclic prefix: Normal

► Propagation conditions: TDLB100-400 Low

► Additional DM-RS position: pos1

► Target BLER: BLER is defined as residual BLER; i.e. ratio of incorrectly received transport blocks / sent transport blocks, independently of the number HARQ transmission(s) for each transport block.

Table 57: Test requirements

SCS [kHz]	Channel BW [MHz]	Type	FRC	Target BLER	SNR [dB]
15	5	Type A	G-FR1-A3A-1	1 %	[-7.9]
15	10	Type A	G-FR1- A3A -2	1 %	[-8.7]
30	10	Type A	G-FR1- A3A -3	1 %	[-8.2]
30	40	Type A	G-FR1- A3A -4	1 %	[-9.7]
15	5	Type B	G-FR1- A3A -1	1 %	[-7.8]
15	10	Type B	G-FR1- A3A -2	1 %	[-9.7]
30	10	Type B	G-FR1- A3A -3	1 %	[-10.2]
30	40	Type B	G-FR1- A3A -4	1 %	[-9.6]

Test setup

The test setup can be found in Figure 7.

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW generates the required test signals

► The signal generator starts signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.7 PUSCH repetition Type A"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC827
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:DUPLex <DuplexMethod>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:MAPType <MapType>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:RTF:MODE <RTFMode>
:BB:NR5G:TCW:RTF:SERRate <SerialRate>
:BB:NR5G:TCW:RTF:AUSDelay <AddUserDelay>
:BB:NR5G:TCW:RTF:CONNector <Connector>
:BB:NR5G:TCW:RTF:BBSelector <BBSelector>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_7.py

More information about Python modules can be found in A.

3.6.8 Px requirements for PUSCH Mapping Type B with non-slot transmission (8.2.8)

The performance requirement of PUSCH mapping Type B is determined by a minimum required throughput for a given SNR. The required throughput is expressed as a fraction of maximum throughput for the FRCs.

The test shall verify the receiver's ability to achieve throughput for PUSCH mapping Type B with 2 symbol length allocated in time domain under multipath fading propagation conditions for a given SNR. [5]

Parameter	Value
Transform precoding	Disabled
Default TDD UL-DL pattern (Note 1)	15 kHz SCS: 3D1S1U, S=10D:2G:2U 30 kHz SCS: 7D1S2U, S=6D:4G:4U

HARQ	Maximum number of HARQ transmissions	1
	RV sequence	0
DM-RS	DM-RS configuration type	1
	DM-RS duration	single-symbol DM-RS
	Number of additional DM-RS	0
	Number of DM-RS CDM group(s) without data	2
	Ratio of PUSCH EPRE to DM-RS EPRE	-3 dB
	DM-RS port	{0}
	DM-RS sequence generation	N_{ID}^{0}=0, n_{SCID} =0
Time domain resource assignment	PUSCH mapping type	B
	Start symbol	0
	Allocation length	2
	PUSCH aggregation factor	1
Frequency domain resource assignment	RB assignment	Full applicable test bandwidth
	Frequency hopping	Disabled
Code block group based PUSCH transmission		Disabled
Note 1: The same requirements are applicable to FDD and TDD with different UL-DL pattern.		

The following assumptions hold for all requirements:

- Number of Tx antennas: 1
- Number of Rx antennas: 2
- Cyclic prefix: Normal
- Propagation conditions: TDLC300-100 Low
- Type B
- Fraction of maximum throughput: 70 %

Table 58: Test requirements

SCS [kHz]	Channel BW [MHz]	FRC	SNR [dB]
15	5	G-FR1-A3B-1	1.1
	15	G-FR1- A3B -2	0.9
30	10	G-FR1- A3B -3	0.9
	40	G-FR1- A3B -4	0.6

Test setup

The test setup can be found in Figure 7.

Settings

- ► Set the base station to the basic state (see chapter 3.5)
- ► The SMW generates the required test signals
- ► The signal generator starts signal generation when a start trigger impulse from the base station is received
- ► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.8 PUSCH Mapping Type B with non-slot transmission"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC828
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:TXANtennas <TxAntennas>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:DUPLex <DuplexMethod>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:FMTHroughput <FMT>
:BB:NR5G:TCW:RTF:MODE <RTFMode>
:BB:NR5G:TCW:RTF:SERRate <SerialRate>
:BB:NR5G:TCW:RTF:AUSDelay <AddUserDelay>
:BB:NR5G:TCW:RTF:CONNector <Connector>
:BB:NR5G:TCW:RTF:BBSelector <BBSelector>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_8.py

More information about Python modules can be found in A.

3.6.9 Px requirements for PUSCH msgA for 2-step RA type (8.2.9)

The performance requirement of MsgA PUSCH is determined by a minimum required block error rate of MsgA received by BS at given SNR for FRCs listed in annex A. The performance requirements assume that the precedent preamble of MsgA is correctly detected. The performance requirements of assume no HARQ retransmission.These requirements are applicable for wide area and medium range BS that support 2-step RA type. The requirements are not applied for a local area BS that supports 2-step RA type. [5]

Table 59: Test parameters

Parameter	Value
Transform precoding	Disabled
Channel bandwidth	15 kHz SCS: 10 MHz
	30 kHz SCS: 40 MHz
MCS	1

DM-RS	DM-RS configuration type	1
	DM-RS duration	single-symbol DM-RS
	DM-RS position (l_0)	2
	Additional DM-RS position	pos2 or pos1 (Note 2)
	Number of DM-RS CDM group(s) without data	2
	Ratio of PUSCH EPRE to DM-RS EPRE	-3 dB
	DM-RS port	{0}
	DM-RS sequence generation	N_{ID}^0=0, n_{SCID} = 0
Time domain resource assignment	PUSCH mapping type	Both A and B
	Allocation length	14
Frequency domain resource assignment	RB assignment	2 PRBs
	Starting PRB index	0
	Frequency hopping	Disabled
Time offset (TO) Cycling (µs)	start:step:end	15k SCS: 0:0.2:3.8
		30k SCS: 0:0.1:2
Test Metric	BLER	0.01

Note 1: The same requirements are applicable to FDD and TDD with different UL-DL patterns.

Note 2: For FR1, either pos 1 or pos 2 may be used for the test FRC. A pass with either of these possibilities is sufficient to demonstrate compliance to the core requirement.

Note 3: The power ratio between preamble and msgA (msgA-DeltaPreamble) is set to be sufficient to achieve 100 % preamble detection. The SNR for the requirement is defined on the msgA PUSCH.

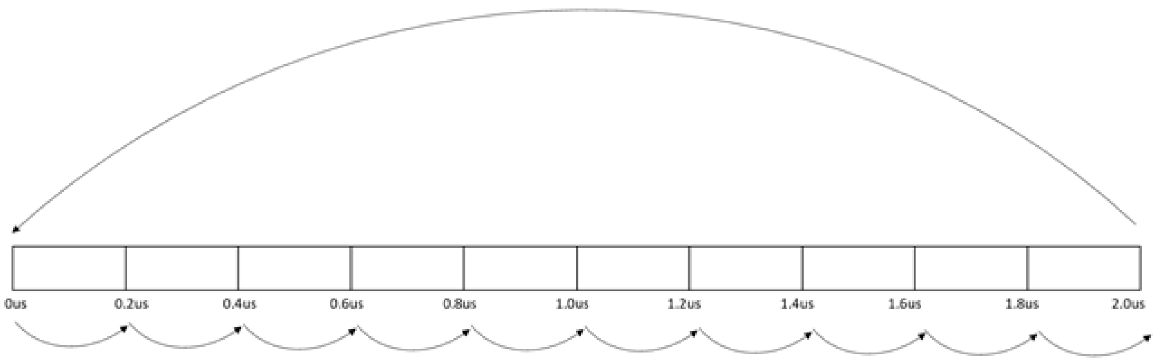


Figure 14: Timing offset scheme for MsgA transmission for BS type 1-C and type 1-H with 30 kHz SCS [5]

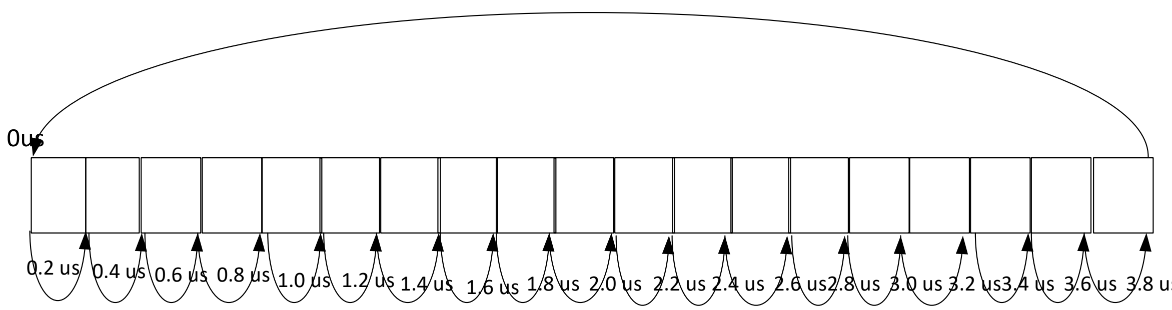


Figure 15: Timing offset scheme for MsgA transmission for BS type 1-C and type 1-H with 15 kHz SCS [5]

The measured BLER shall not be below the limits for the SNR levels specified in the following tables.

The following assumptions hold for all requirements:

- Number of Tx antennas: 1
- Number of Rx antennas: 2
- Cyclic prefix: Normal
- Propagation conditions: TDLC300-100
- Fraction of maximum throughput: 70 %
- The time offset values are described as X, Y, Z where X is the first TO value, Y is the step in which the TO should be incremented, and Z is the largest TO value in the range.

Table 60: Test requirements

SCS [kHz]	Type	FRC	BLER	Time offset [µs]	SNR [dB]
15	Type A	G-FR1-A7-1 or G-FR1-A7-3	1 %	0, 0.2, 3.8	7.9
30	Type A	G-FR1-A7-2 or G-FR1-A7-4	1 %	0, 0.2, 2.0	7.7
15	Type B	G-FR1-A7-1 or G-FR1-A7-3	1 %	0, 0.2, 3.8	7.6
30	Type B	G-FR1-A7-2 or G-FR1-A7-4	1 %	0, 0.2, 2.0	8.2

Test setup

The test setup can be found in Figure 7.

Settings

- ► Set the base station to the basic state (see chapter 3.5)
- ► The SMW generates the required test signals
- ► The signal generator starts signal generation when a start trigger impulse from the base station is received
- ► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.2.9 PUSCH msgA for 2-step RA type "*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC829
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:MAPType <MapType>
:BB:NR5G:TCW:WS:FRC:TYPE <WSFrc>
:BB:NR5G:TCW:WS:RBOFfset <WSRbOffset>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_2_9.py

More information about Python modules can be found in A.

3.7 Px requirements for PUCCH (8.3)

The physical uplink control channel (PUCCH) carries control information in the uplink (UCI), like ACK/NACK, channel state information (CSI) or scheduling requests.

Table 61: AWGN power level for PUCCH tests

	AWGN power level [dBm]		
Channel bandwidth [MHz]	**SCS 15 kHz**	**SCS 30 kHz**	**SCS 60 kHz**
5	- 83.5 (4.50 MHz)	- 84.1 (3.96 MHz)*	n.a.
10	- 80.3 (9.36 MHz)	- 80.6 (8.64 MHz)	- 81.0 (7.92 MHz)*
15	- 78.5 (14.22 MHz)*	- 78.7 (13.68 MHz)*	- 78.9 (12.96 MHz)*
20	- 77.2 (19.08 MHz)	- 77.4 (18.36 MHz)	- 77.7 (17.28 MHz)*
25	- 76.2 (23.94 MHz)*	- 76.3 (23.40 MHz)*	- 76.5 (22.32 MHz)*
30	- 75.4 (28.80 MHz)*	- 75.5 (28.08 MHz)*	- 75.7 (27.36 MHz)*
40	- 74.1 (38.88 MHz)*	- 74.2 (38.16 MHz)	- 74.4 (36.72 MHz)*
50	- 73.2 (48.60 MHz)*	- 73.2 (47.88 MHz)*	- 73.3 (46.80 MHz)*
60	n.a.	- 72.4 (58.32 MHz)*	- 72.5 (56.88 MHz)*
70	n.a.	- 71.7 (68.04 MHz)*	- 71.8 (66.96 MHz)*
80	n.a.	- 71.1 (78.12 MHz)*	- 71.2 (77.04 MHz)*
90	n.a.	- 70.6 (88.20 MHz)*	- 70.6 (87.12 MHz)*
100	n.a.	- 70.1 (98.28 MHz)	- 70.2 (97.20 MHz)*

* Not mentioned in TS38.141-1, calculated values

As the PUCCH only occupies a part of the full bandwidth (one or a couple of RB), a special SNR correction factor is applied which depends on the bandwidth, the SCS and the number of used RBs.

$$\mathrm{SNRCorr} = 10\log\frac{\text{used RBs}}{\text{possible RBs}}$$

Equation 2: SNR correction factor

As an example, the factor for SCS 30 kHz, bandwidth = 100 MHz and one (1) occupied RB leads with

$\mathrm{SNRCorr} = 10\log\left(\frac{1}{273}\right)$ to a factor of $\mathrm{SNRCorr} = -24.36\ \mathrm{dB}$

In principle, all test setups for PUCCH only need one SMW. The wanted signal generated by SMW baseband A is split up in two paths. Multipath fading is simulated in the channel simulators and AWGN is added. For four or eight Rx antennas, the test can also be done with just one SMW (suitable options required). The additional signals are provided through two or six SGT signal generators.

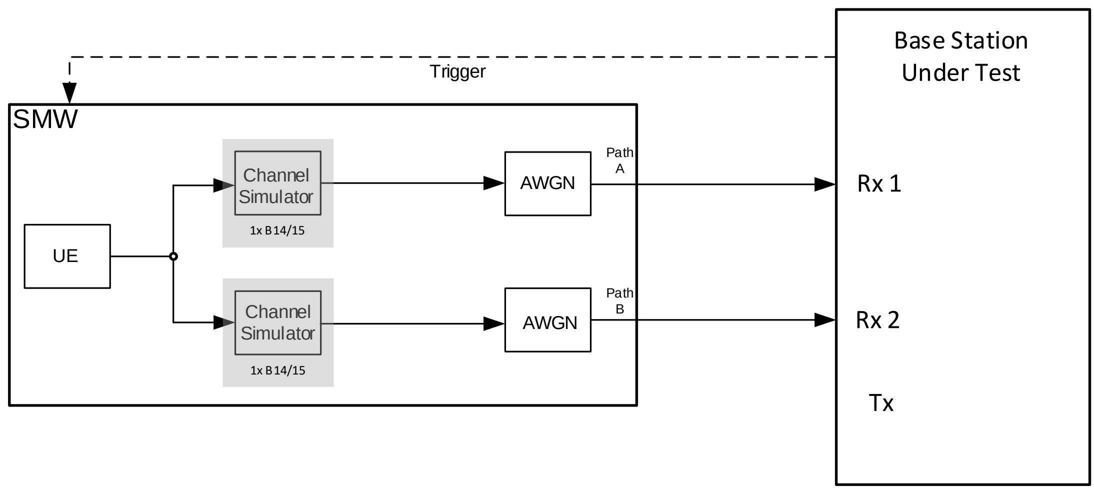


Figure 16: Test setup for PUCCH/PRACH tests with 1 Tx and 2 Rx antennas

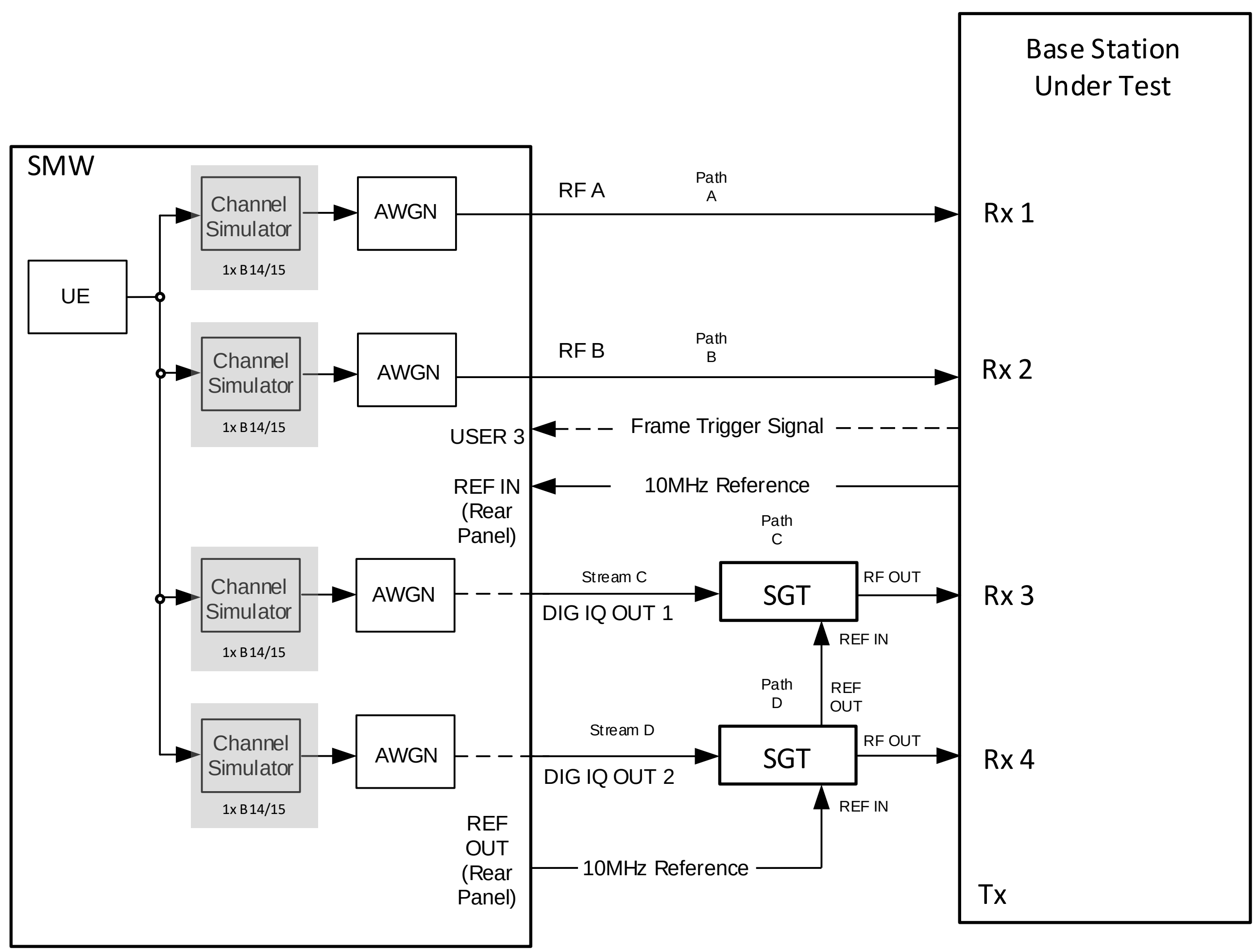


Figure 17: Test setup for PUCCH/PRACH tests with 1 Tx and 4 Rx antennas

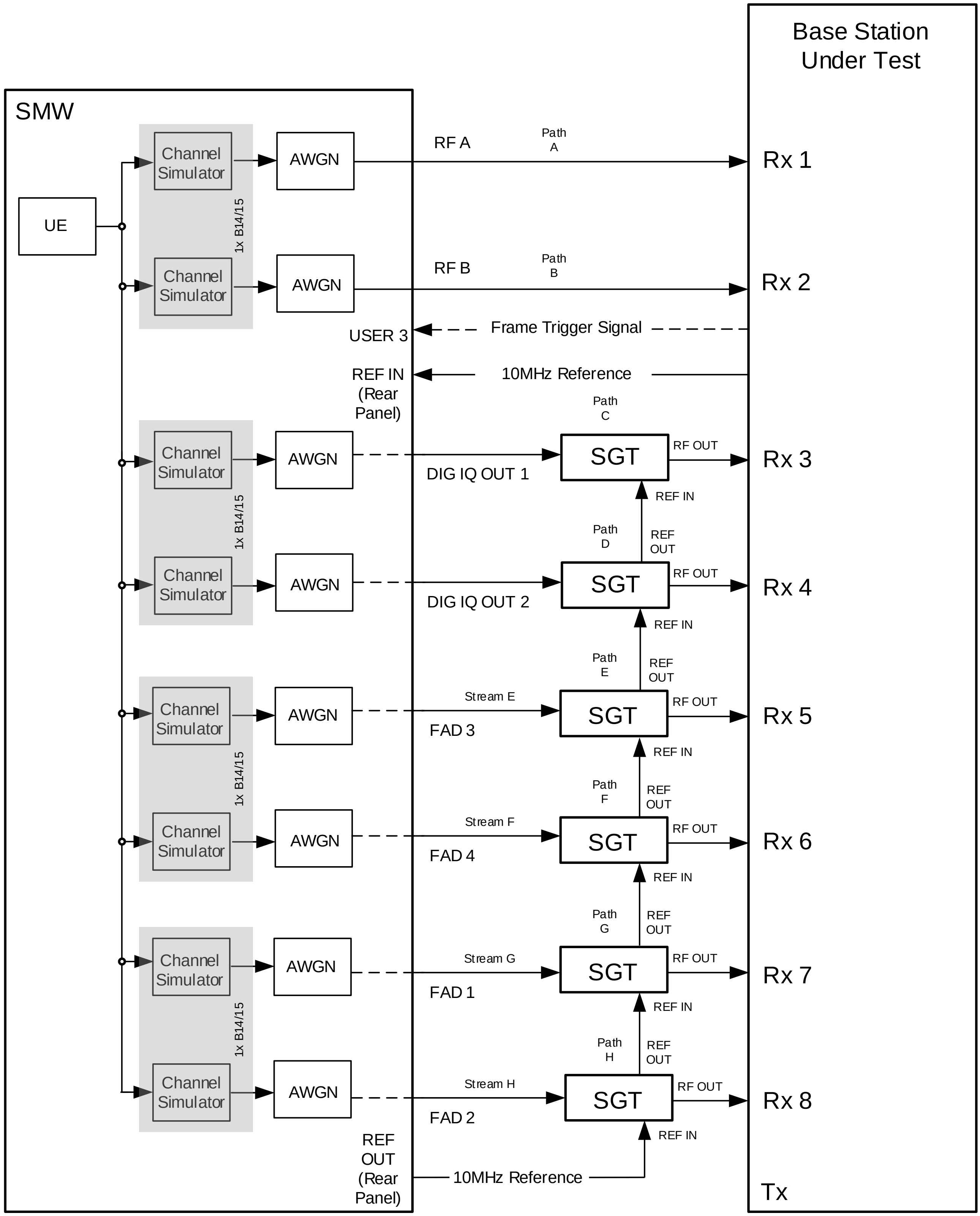


Figure 18: Test setup for PUCCH/PRACH tests with 1 Tx and 8 Rx antennas

Special issues for single PUCCH tests are described in the related subchapters.

3.7.1 Px requirements for PUCCH format 0 (8.3.1)

The test verifies the receiver's performance at detecting ACK under multipath fading conditions for a given SNR. The probability of detection of the ACK shall be equal or greater to 0.99. The probability of false detection of the ACK shall be 0.01 or less. The statistics are kept by the base station under test. This test is applicable for all categories of base stations.

For the test one bit of information ACK (≡ '1') is transmitted in the PUCCH format 1a with following pattern:

Figure 19: Pattern [5]

Table 62: Test parameters

Parameter	Test
number of UCI information bits	1
Number of PRBs	1
First PRB prior to frequency hopping	0
Intra-slot frequency hopping	N/A for 1 symbol enabled for 2 symbols
First PRB after frequency hopping	The largest PRB index – (Number of PRBs – 1)
Group and sequence hopping	neither
Hopping ID	0
Initial cyclic shift	0
First symbol	13 for 1 symbol 12 for 2 symbols

The wanted signal generated by SMW baseband A is split up in two paths (or four paths or eight paths). Multipath fading is simulated in the channel simulators, AWGN is added.

The fraction of falsely detected ACKs shall be less than 1 % and the fraction of correctly detected ACKs shall be larger than 99 % for the SNR listed in Table 63 and Table 64.

Table 63: Test requirements for PUCCH format 0 and 15 kHz SCS

Number of Tx antennas	Number of RX antennas	Propagation conditions and correlation matrix	Number of OFDM symbols	Channel bandwidth / SNR (dB)		
				5 MHz	10 MHz	20 MHz
1	2	TDLC-300-100 Low	1	10.0	9.4	9.9
			2	3.4	4.3	3.9
1	4	TDLC-300-100 Low	1	3.6	3.5	3.8
			2	-0.4	0.1	-0.2
1	8	TDLC-300-100 Low	1	-0.5	-0.5	-0.5
			2	-3.5	-3.3	-3.4

Table 64: Test requirements for PUCCH format 0 and 30 kHz SCS

Number of TX antennas	Number of RX antennas	Propagation conditions and correlation matrix	Number of OFDM symbols	Channel bandwidth / SNR (dB)			
				10 MHz	20 MHz	40 MHz	100 MHz
1	2	TDLC-300-100 Low	1	10.4	10.4	10.1	9.8
			2	4.8	4.2	4.4	4.1
1	4	TDLC-300-100 Low	1	4.0	4.0	3.6	3.9
			2	0.3	0.2	0.1	-0.2
1	8	TDLC-300-100 Low	1	-0.4	-0.4	-0.5	-0.4
			2	-3.1	-3.2	-3.4	-3.3

Test setup

The test setup can be found in Figure 16 to Figure 18.

Settings

- ► Set the base station to the basic state (see chapter 3.5)
- ► The SMW (and the SGTs) are generating the required test signals
- ► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received
- ► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.1 Performance requirements for PUCCH Format 0"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC831
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:MODE <Mode>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:SYMNumber <SYMNumber>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_1.py

More information about Python modules can be found in A.

3.7.2 Px requirements for PUCCH format 1 (8.3.2)

The tests for PUCCH format 1 consist of two tests. First the NACK to ACK detection test. Second the ACK missed detection test. For both tests the test parameters are the same. The sub-chapters explain the test specialties.

Table 65: Test parameters

Parameter	Values
Number of information bits	2
Number of PRBs	1
Number of symbols	14
First PRB prior to frequency hopping	0
Intra-slot frequency hopping	enabled
First PRB after frequency hopping	The largest PRB index - (Number of PRBs -1)
Group and sequence hopping	neither
Hopping ID	0
Initial cyclic shift	0
First symbol	0
Index of orthogonal cover code (timeDomainOCC)	0

3.7.2.1 NACK to ACK detection (8.3.2.1)

The test verifies the receiver's performance at detecting NACK to ACK under multipath fading conditions for a given SNR. The probability of the NACK to ACK detection shall be equal or less to 0.001. The probability of false detection of the ACK shall be 0.01 or less. The statistics are kept by the base station under test.

The probability of false detection of the ACK is defined as a conditional probability of erroneous detection of the ACK at particular bit position when input is only noise. Each false bit detection is counted as one error.

The NACK to ACK detection probability is the probability of detecting an ACK bit when a NACK bit was sent on particular bit position. Each NACK bit erroneously detected as ACK bit is counted as one error. Erroneously detected NACK bits in the definition do not contain the NACK bits which are mapped from DTX, i.e. NACK bits received when DTX is sent should not be considered.

The transient period as specified in TS 38.101-1 [3] clause 6.3.3.1 is not taken into account for performance requirement testing, where the RB hopping is symmetric to the CC center, i.e. intra-slot frequency hopping is enabled. [5]

The fraction of falsely detected ACK bits shall be less than 1 % and the fraction of NACK bits falsely detected as ACK shall be less than 0.1 % for the SNR listed in Table 66 and Table 67.

Table 66: Required SNR for PUCCH format 1 with 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)		
				5 MHz	10 MHz	20 MHz
1	2	Normal	TDLC-300-100 Low	-3.2	-3.0	-3.0
	4	Normal	TDLC-300-100 Low	-7.8	-7.0	-7.8
	8	Normal	TDLC-300-100 Low	-11.2	-10.8	-10.8

Table 67: Required SNR for PUCCH format 1 with 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)			
				10 MHz	20 MHz	40 MHz	100 MHz
1	2	Normal	TDLC-300-100 Low	-2.2	-2.7	-3.3	-2.9
	4	Normal	TDLC-300-100 Low	-7.5	-7.7	-6.9	-7.4
	8	Normal	TDLC-300-100 Low	-10.9	-10.6	-10.1	-10.7

Test setup

The test setup can be found in Figure 16 to Figure 18.

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW (and the SGTs) are generating the required test signals

► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.2.1 NACK to ACK Detection for PUCCH Format 1"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC8321
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_2_1.py

More information about Python modules can be found in A.

3.7.2.2 ACK missed detection (8.3.2.2)

The performance requirement of PUCCH format 1 for ACK missed detection is determined by the two parameters: probability of false detection of the ACK and the probability of detection of ACK. The performance is measured by the required SNR at probability of detection equal to 0.99. The probability of false detection of the ACK shall be 0.01 or less.

The probability of false detection of the ACK is defined as a conditional probability of erroneous detection of the ACK when input is only noise.

The probability of detection of ACK is defined as conditional probability of detection of the ACK when the signal is present. [5]

For the test one bit of information ACK (≡ '1') is transmitted in the PUCCH format 1 with following pattern:

Figure 20: Pattern [5]

The fraction of falsely detected ACK bits shall be less than 1 % and the fraction of correctly detected ACK bits shall be larger than 99 % for the SNR listed in Table 68 and Table 69.

Table 68: Required SNR for PUCCH format 1 with 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)		
				5 MHz	10 MHz	20 MHz
1	2	Normal	TDLC-300-100 Low	-4.4	-3.8	-4.4
	4	Normal	TDLC-300-100 Low	-8.0	-7.6	-7.9
	8	Normal	TDLC-300-100 Low	-10. 1	-10.9	-10.9

Table 69: Required SNR for PUCCH format 1 with 30 kHz SCS

Number of Tx antennas	Number of RX antennas	Cyclic Prefix	Propagation conditions and correlation matrix	Channel Bandwidth / SNR (dB)			
				10 MHz	20 MHz	40 MHz	100 MHz
1	2	Normal	TDLC-300-100 Low	-3.3	-3.8	-3.8	-3.6
	4	Normal	TDLC-300-100 Low	-7.4	-7.5	-7.8	-7.7
	8	Normal	TDLC-300-100 Low	-10.8	-10.8	-10.8	-10.8

Test setup

The test setup can be found in Figure 16 to Figure 18.

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW (and the SGTs) are generating the required test signals

► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.2.2 ACK Missed Detection for PUCCH Format 1"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC8322
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:MODE <Mode>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_2_2.py

More information about Python modules can be found in A.

3.7.3 Px requirements for PUCCH format 2 (8.3.3)

The tests for PUCCH format 1 consist of two tests. The basic settings are the same. The sub-chapters explain the test specialties.

The wanted signal generated by SMW baseband A is split up in two paths (or four paths or eight paths). Multipath fading is simulated in the channel simulators, AWGN is added.

3.7.3.1 ACK missed detection (8.3.3.1)

The test verifies the receivers´ performance at detecting ACK under multipath fading conditions for a given SNR. The probability of detection of the ACK shall be equal or greater to 0.99. The probability of false detection of the ACK shall be 0.01 or less. The probability of false detection of the ACK is defined as a probability of erroneous detection of the ACK when input is only noise. The statistics are kept by the base station under test.

For the test four (4) bits of information ACK (≡'1111') are transmitted in the PUCCH format 2 with following pattern:

Figure 21: Pattern [5]

Table 70: Test parameters PUCCH format 2 ACK missed

Parameter	Value
Modulation order	QPSK
First PRB prior to frequency hopping	0
Intra-slot frequency hopping	N/A
First PRB after frequency hopping	The largest PRB index - (Number of PRBs - 1)
Number of PRBs	4
Number of symbols	1
The number of UCI information bits	4
First symbol	13
DM-RS sequence generation	$N_{ID}^{0}=0$

Table 71: Required SNR for PUCCH format 2 with 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)		
				5 MHz	10 MHz	20 MHz
1	2	Normal	TDLC300-100 Low	6.4	6.2	6.5
	4	Normal	TDLC300-100 Low	1.0	1.1	0.9
	8	Normal	TDLC300-100 Low	-2.9	-2.9	-2.9

Table 72: Required SNR for PUCCH format 2 with 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)			
				10MHz	20MHz	40MHz	100MHz
1	2	Normal	TDLC300-100 Low	6.1	6.2	6.1	6.3
	4	Normal	TDLC300-100 Low	0.9	0.8	0.9	1.0
	8	Normal	TDLC300-100 Low	-3.0	-3.0	-2.9	-2.7

Test setup

The test setup can be found in Figure 16 to Figure 18.

Settings

- Set the base station to the basic state (see chapter 3.5)
- The SMW (and the SGTs) are generating the required test signals
- The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received
- The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.3.1 ACK Missed Detection for PUCCH Format 2"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC8331
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:MODE <Mode>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_3_1.py

More information about Python modules can be found in A.

3.7.3.2 UCI BLER performance requirements (8.3.3.2)

The test verifies the receivers´ performance at detecting UCI under multipath fading conditions for a given SNR. The UCI block error probability shall be 0.01 or less. The statistics are kept by the base station under test.

For the test 22 bits of information UCI (='1111…') are transmitted in the PUCCH format two with following pattern:

Figure 22: Pattern [5]

Table 73 shows the basic parameters.

Table 73: Test parameters for PUCH format 2 UCI BLER

Parameter	Value
Modulation order	QPSK
First PRB prior to frequency hopping	0
Intra-slot frequency hopping	enabled
First PRB after frequency hopping	The largest PRB index - (Number of PRBs - 1)
Number of PRBs	9
Number of symbols	2
The number of UCI information bits	22
First symbol	12
DM-RS sequence generation	N_{ID}^{0}=0

Table 74: Required SNR for PUCCH format 2 with 15 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)		
				5 MHz	10 MHz	20 MHz
1	2	Normal	TDLC300-100 Low	0.8	1.4	1.8
	4	Normal	TDLC300-100 Low	-3.0	-2.6	-2.6
	8	Normal	TDLC300-100 Low	-6.2	-6.1	-6.2

Table 75: Required SNR for PUCCH format 2 with 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic Prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)			
				10MHz	20MHz	40MHz	100MHz
1	2	Normal	TDLC300-100 Low	1.1	1.7	1.0	0.9
	4	Normal	TDLC300-100 Low	-2.7	-2.3	-2.7	-2.8
	8	Normal	TDLC300-100 Low	-5.2	-5.2	-6.1	-5.3

Test setup

The test setup can be found in Figure 16 to Figure 18.

Settings

- ► Set the base station to the basic state (see chapter 3.5)
- ► The SMW (and the SGTs) are generating the required test signals
- ► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received
- ► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.3.2 UCI BLER for PUCCH Format 2"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC8332
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_3_2.py

More information about Python modules can be found in A.

3.7.4 Px requirements for PUCCH format 3 (8.3.4)

The test verifies the receivers´ performance at detecting UCI under multipath fading conditions for a given SNR. The UCI block error probability shall be 0.01 or less. The UCI block error probability is defined as the conditional probability of incorrectly decoding the UCI information when the UCI information is sent. The UCI information does not contain CSI part 2. The statistics are kept by the base station under test.

For the test 16 bits of information UCI (≡'1111…') is transmitted in the PUCCH format 3 with following pattern:

Figure 23: Pattern [5]

Table 76: Basic parameters PUCCH format 3 UCI BLER

Parameter	Test setup 1	Test setup 2
Modulation order	QPSK	
First PRB prior to frequency hopping	0	
Intra-slot frequency hopping	enabled	
First PRB after frequency hopping	The largest PRB index – (Number of PRBs - 1)	
Group and sequence hopping	neither	
Hopping ID	0	
Number of PRBs	1	3
Number of symbols	14	4
The number of UCI information bits	16	
First symbol	0	

Table 77: Required SNR for PUCCH format 3 with 15 kHz SCS

Test	# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions and correlation matrix	Additional DM-RS configuration	Channel BW / SNR (dB)		
						5 MHz	10 MHz	20 MHz
1	1	2	Normal	TDLC300-100 Low	No additional DM-RS	0.8	1.7	0.9
					Additional DM-RS	0.5	1.1	0.5
		4	Normal	TDLC300-100 Low	No additional DM-RS	-3.2	-2.7	-3.2
					Additional DM-RS	-3.7	-3.4	-3.4
		8	Normal	TDLC300-100 Low	No additional DM-RS	-6.4	-6.1	-6.3
					Additional DM-RS	-7.1	-6.9	-7.1
2	1	2	Normal	TDLC300-100 Low	No additional DM-RS	2.0	2.8	2.6
		4	Normal	TDLC300-100 Low	No additional DM-RS	-2.5	-1.9	-1.9
		8	Normal	TDLC300-100 Low	No additional DM-RS	-5.9	-5.4	-5.6

Table 78: Required SNR for PUCCH format 3 with 30 kHz SCS

Test	# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions and correlation matrix	Additional DMRS configuration	Channel BW / SNR (dB)			
						10 MHz	20 MHz	40 MHz	100 MHz
1	1	2	Normal	TDLC300-100 Low	No additional DM-RS	1.5	1.2	1.2	1.5
					Additional DM-RS	1.1	0.9	0.6	0.7
		4	Normal	TDLC300-100 Low	No additional DM-RS	-2.5	-2.8	-2.6	-2.9
					Additional DM-RS	-3.1	-3.5	-3.4	-3.6
		8	Normal	TDLC300-100 Low	No additional DM-RS	-6.0	-6.1	-6.2	-6.2
					Additional DM-RS	-6.9	-7.0	-7.0	-7.1
2	1	2	Normal	TDLC300-100 Low	No additional DM-RS	2.4	2.6	2.6	2.1
		4	Normal	TDLC300-100 Low	No additional DM-RS	-2.3	-2.4	-1.8	-2.4
		8	Normal	TDLC300-100 Low	No additional DM-RS	-5.8	-5.4	-5.8	-5.6

Test setup

The test setup can be found in Figure 16 to Figure 18.

Settings

- ► Set the base station to the basic state (see chapter 3.5)
- ► The SMW (and the SGTs) are generating the required test signals
- ► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received
- ► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.4 Performance requirements for PUCCH Format 3"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC834
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:TSETup <setup>
:BB:NR5G:TCW:WS:ADMRs:STATe <state>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_4.py

More information about Python modules can be found in A.

3.7.5 Px requirements for PUCCH format 4 (8.3.5)

The test verifies the receiver's performance at detecting UCI under multipath fading conditions for a given SNR. THE UCI block error probability shall be 0.01 or less. The statistics are kept by the base station under test.

For the test 22 bits of information UCI (≡ '1111…') are transmitted in the PUCCH format 4 with following pattern:

Figure 24: Pattern [5]

Table 79: Basic parameter PUCCH format 3 UCI BLER

Parameter	Value
Modulation order	QPSK
First PRB prior to frequency hopping	0
Number of PRBs	1
Intra-slot frequency hopping	enabled
First PRB after frequency hopping	The largest PRB index - (Number of PRBs - 1)
Group and sequence hopping	neither

Hopping ID	0
Number of symbols	14
The number of UCI information bits	22
First symbol	0
Length of the orthogonal cover code	n2
Index of the orthogonal cover code	n0

Table 80: Required SNR for PUCCH format 4 with 15 kHz SCS

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions and correlation matrix	Additional DM-RS configuration	Channel bandwidth / SNR (dB)		
					5 MHz	10 MHz	20 MHz
1	2	Normal	TDLC300-100 Low	No additional DM-RS	2.4	3.2	2.8
				Additional DM-RS	2.2	3.0	2.4
	4	Normal	TDLC300-100 Low	No additional DM-RS	-1.7	-1.3	-1.6
				Additional DM-RS	-2.3	-2.0	-2.1
	8	Normal	TDLC300-100 Low	No additional DM-RS	-5.3	-5.1	-5.2
				Additional DM-RS	-6.0	-5.8	-5.7

Table 81: Required SNR for PUCCH format 4 with 30 kHz SCS

# Tx ant.	# Rx ant.	Cyclic prefix	Propagation conditions and correlation matrix	Additional DM-RS configuration	Channel bandwidth / SNR (dB)			
					10 MHz	20 MHz	40 MHz	100 MHz
1	2	Normal	TDLC300-100 Low	No additional DM-RS	3.7	3.4	3.7	3.4
				Additional DM-RS	3.4	2.9	3.7	2.8
	4	Normal	TDLC300-100 Low	No additional DM-RS	-1.1	-1.3	-1.1	-1.5
				Additional DM-RS	-1.4	-1.9	-1.9	-1.8
	8	Normal	TDLC300-100 Low	No additional DM-RS	-5.0	-4.9	-4.9	-4.9
				Additional DM-RS	-5.6	-5.5	-5.8	-5.6

Test setup

The test setup can be found in Figure 16 to Figure 18.

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW (and the SGTs) are generating the required test signals

► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.5 Performance requirements for PUCCH Format 4"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC835
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:ADMRs:STATe <state>
:BB:NR5G:TCW:WS:PROCondition <PropagCond>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_5.py

More information about Python modules can be found in A.

3.7.6 Px requirements for multi-slot PUCCH format 1 (8.3.6.1)

3.7.6.1 NACK to ACK detection

The test shall verify the receiver's ability not to falsely detect NACK bits as ACK bits under multipath fading propagation conditions for a given SNR.

The performance is measured by the required SNR at probability of the NACK to ACK detection equal to 0.1 % or less. The probability of false detection of the ACK shall be 0.01 % or less.

The probability of false detection of the ACK is defined as a conditional probability of erroneous detection of the ACK at particular bit position when input is only noise. Each false bit detection is counted as one error.

The NACK to ACK detection probability is the probability of detecting an ACK bit when a NACK bit was sent on particular bit position. Each NACK bit erroneously detected as ACK bit is counted as one error.

Erroneously detected NACK bits in the definition do not contain the NACK bits which are mapped from DTX, i.e. NACK bits received when DTX is sent should not be considered.

The signal generator sends random codeword from applicable codebook, in regular time periods. [5]

Table 82: Test parameters for multi-slot PUCCH format 1

Parameter	Test
Number of information bits	2
Number of PRBs	1
Number of symbols	14
First PRB prior to frequency hopping	0
Intra-slot frequency hopping	disabled
Inter-slot frequency hopping	enabled
First PRB after frequency hopping	The largest PRB index - (Number of PRBs – 1)
Group and sequence hopping	neither
Hopping ID	0
Initial cyclic shift	0
First symbol	0
Index of orthogonal cover code (timeDomainOCC)	0
Number of slots for PUCCH repetition	2

Table 83: Minimum requirements for multi-slot PUCCH format 1 with 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)
				40 MHz
1	2	Normal	TDLC-300-100 Low	-5.7

Test setup

The test setup can be found in Figure 17.

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW is generating the required test signals

► The signal generator starts signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.6.1A NACK to ACK Detection for Multi-Slot PUCCH Format 1"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC8361A
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_6_1_A.py

More information about Python modules can be found in A.

3.7.6.2 ACK missed detection

The test shall verify the receiver's ability to detect ACK bits under multipath fading propagation conditions for a given SNR. The performance is measured by the required SNR at probability of detection equal to 0.99. The probability of false detection of the ACK shall be 0.01 or less.

The probability of false detection of the ACK is defined as a conditional probability of erroneous detection of the ACK when input is only noise.

The probability of detection of ACK is defined as conditional probability of detection of the ACK when the signal is present.

The signal generator sends random codewords from applicable codebook, in regular time periods. [5]

Table 84: Test parameters for multi-slot PUCCH format 1

Parameter	Test
Number of information bits	2
Number of PRBs	1
Number of symbols	14
First PRB prior to frequency hopping	0
Intra-slot frequency hopping	disabled
Inter-slot frequency hopping	enabled
First PRB after frequency hopping	The largest PRB index - (Number of PRBs – 1)
Group and sequence hopping	neither
Hopping ID	0
Initial cyclic shift	0
First symbol	0
Index of orthogonal cover code (timeDomainOCC)	0
Number of slots for PUCCH repetition	2

Table 85: Minimum requirements for multi-slot PUCCH format 1 with 30 kHz SCS

Number of Tx antennas	Number of Rx antennas	Cyclic prefix	Propagation conditions and correlation matrix	Channel bandwidth / SNR (dB)
				40 MHz
1	2	Normal	TDLC-300-100 Low	-7.0

Test setup

The test setup can be found in Figure 17.

Settings

- ► Set the base station to the basic state (see chapter 3.5)
- ► The SMW is generating the required test signals
- ► The signal generator starts signal generation when a start trigger impulse from the base station is received
- ► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.3.6.1B ACK Missed Detection for Multi-Slot PUCCH Format 1"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC8361B
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:WS:MODE <Mode>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_3_6_1_B.py

More information about Python modules can be found in A.

3.8 Px requirements for PRACH (8.4)

3.8.1 PRACH false alarm probability and missed detection (8.4.1)

The test shall verify the receiver's ability to detect PRACH preamble under static conditions and multipath fading propagation conditions for a given SNR.

The performance requirement of PRACH for preamble detection is determined by the two parameters: total probability of false detection of the preamble (Pfa) and the probability of detection of preamble (Pd). The performance is measured by the required SNR at probability of detection, Pd of 99 %. Pfa shall be 0.1 % or less.

Pfa is defined as a conditional total probability of erroneous detection of the preamble (i.e. erroneous detection from any detector) when input is only noise.

Pd is defined as conditional probability of detection of the preamble when the signal is present. The erroneous detection consists of several error cases – detecting only different preamble(s) than the one that was sent, not detecting any preamble at all, or detecting the correct preamble but with the out-of-bounds timing estimation value. [5]

For AWGN and TDLC300-100, a timing estimation error occurs if the estimation error of the timing of the strongest path is larger than the time error tolerance values given in Table 86.

Table 86: Time error tolerance for AWGN and TDLC300-100

PRACH preamble	PRACH SCS (kHz)	Time error tolerance	
		AWGN	TDLC300-100
0	1.25	1.04 us	2.55 us
A1, A2, A3, B4, C0, C2	15	0.52 us	2.03 us
	30	0.26 us	1.77 us

The test preambles for normal mode are listed in Table 87.

Table 87: Test preambles for Normal Mode in FR1

Burst format	SCS (kHz)	Ncs	Logical sequence index	v
0	1.25	13	22	32
A1, A2, A3, B4, C0, C2	15	23	0	0
	30	46	0	0

The signal generator sends a preamble and the receiver tries to detect it. This pattern is repeated as illustrated in the following pattern:

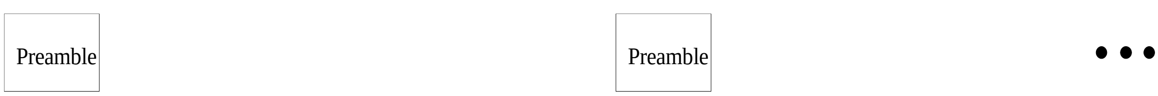


Figure 25: PRACH preamble test pattern [5]

The timing offset base value for PRACH preamble format 0 is set to 50 % of Ncs. This offset is increased within the loop, by adding in each step a value of 0.1us, until the end of the tested range, which is 0.9us. Then the loop is being reset and the timing offset is set again to 50 % of Ncs. The timing offset scheme for PRACH preamble format 0 is presented in Figure 26. [5]

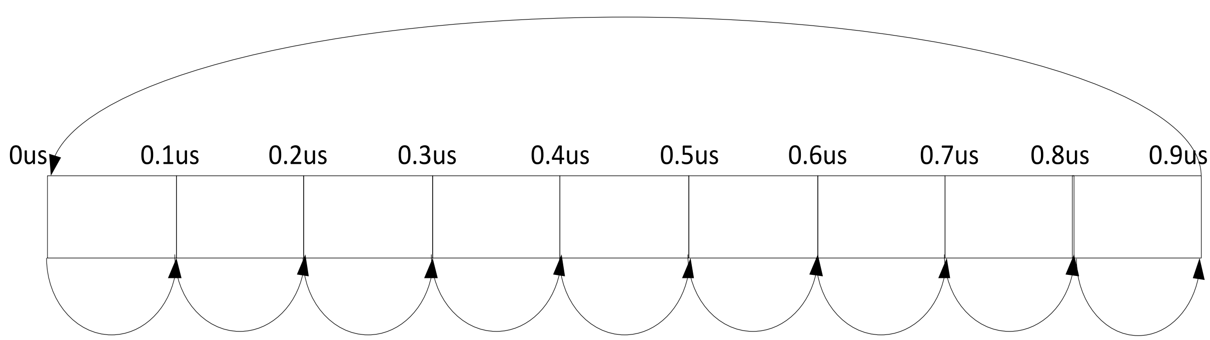


Figure 26: Timing offset scheme for PRACH preamble format 0 [5]

The timing offset base value for PRACH preamble format A1, A2, A3, B4, C0 and C2 is set to 0. This offset is increased within the loop, by adding in each step a value of 0.1us, until the end of the tested range, which is 0.8 us. Then the loop is being reset and the timing offset is set again to 0. The timing offset scheme for PRACH preamble format A1, A2, A3, B4, C0 and C2 is presented in Figure 27.

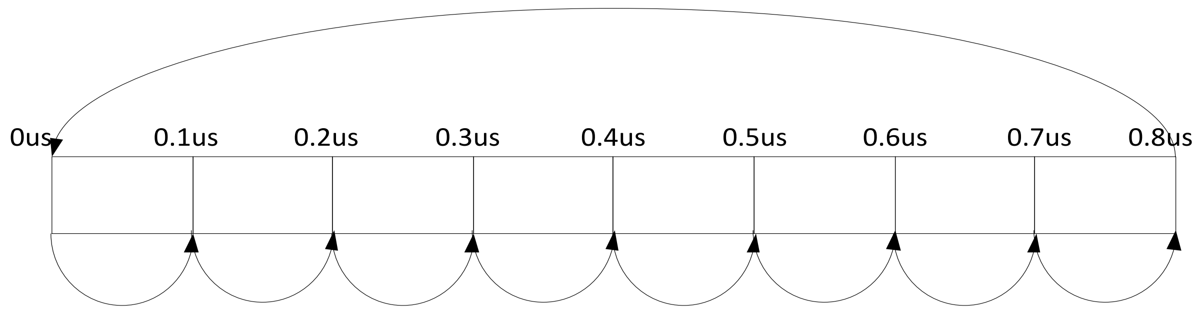


Figure 27: Timing offset scheme for PRACH preamble format A1 A2, A3, B4, C0 and C2 [5]

Test requirements for normal mode

Table 88: PRACH missed detection test requirements for Normal Mode, 1.25 kHz SCS

Number of Tx antennas	Number of Rx antennas	Propagation conditions and correlation matrix	Frequency offset	SNR (dB)
				Burst format 0
1	2	AWGN	0	-14.2
		TDLC300-100 Low	400 Hz	-6.0
	4	AWGN	0	-16.4
		TDLC300-100 Low	400 Hz	-11.3
	8	AWGN	0	-18.6
		TDLC300-100 Low	400 Hz	-15.2

Table 89: PRACH missed detection test requirements for Normal Mode, 15 kHz SCS

# Tx ant.	# Rx ant.	Propagation conditions and correlation matrix	Frequency offset	SNR (dB)					
				Burst format A1	Burst format A2	Burst format A3	Burst format B4	Burst format C0	Burst format C2
1	2	AWGN	0	-9.0	-12.3	-13.9	-16.5	-6.0	-12.2
		TDLC300-100 Low	400 Hz	-1.5	-4.2	-6.0	-8.2	1.4	-4.3
	4	AWGN	0	-11.3	-14.0	-15.7	-18.7	-8.4	-13.8
		TDLC300-100 Low	400 Hz	-6.7	-9.7	-11.1	-13.2	-3.7	-9.6
	8	AWGN	0	-13.5	-16.4	-17.9	-20.9	-10.8	-16.3
		TDLC300-100 Low	400 Hz	-10.4	-13.3	-14.6	-16.7	-7.5	-13.3

Table 90: PRACH missed detection test requirements for Normal Mode, 30 kHz SCS

# Tx ant.	# Rx ant.	Propagation conditions and correlation matrix	Frequency offset	SNR (dB)					
				Burst format A1	Burst format A2	Burst format A3	Burst format B4	Burst format C0	Burst format C2
1	2	AWGN	0	-8.8	-11.7	-13.5	-16.2	-5.8	-11.6
		TDLC300-100 Low	400 Hz	-2.2	-5.1	-6.8	-9.3	0.7	-5.0
	4	AWGN	0	-11.1	-13.9	-15.6	-18.7	-8.3	-13.8
		TDLC300-100 Low	400 Hz	-6.6	-9.8	-11.4	-13.9	-3.9	-9.8
	8	AWGN	0	-13.4	-16.3	-17.8	-20.8	-10.7	-16.2
		TDLC300-100 Low	400 Hz	-10.1	-13.1	-14.5	-17.0	-7.2	-13.1

Test requirements for high speed train

Table 91: PRACH missed detection requirements for high speed train, burst format 0, restricted set type A, 1.25 kHz SCS

# Tx ant.	# Rx ant.	Propagation conditions and correlation matrix	Frequency offset	SNR (dB) Burst format 0
1	2	AWGN	625 Hz	-11.7
		AWGN	1340 Hz	-13.5
		TDLC300-100 Low	0 Hz	-5.7
	4	AWGN	625 Hz	-14.2
		AWGN	1340 Hz	-15.9
		TDLC300-100 Low	0 Hz	-11.2
	8	AWGN	625 Hz	-16.2
		AWGN	1340 Hz	-18.1
		TDLC300-100 Low	0 Hz	-15.6

Table 92: PRACH missed detection requirements for high speed train, burst format 0, restricted set type B, 1.25 kHz SCS

# Tx ant.	# Rx ant.	Propagation conditions and correlation matrix	Frequency offset	SNR (dB) Burst format 0
1	2	AWGN	625 Hz	-11.3
		AWGN	2334 Hz	-12.8
		TDLC300-100 Low	0 Hz	-5.4
	4	AWGN	625 Hz	-13.7
		AWGN	2334 Hz	-15.1
		TDLC300-100 Low	0 Hz	-11.1
	8	AWGN	625 Hz	-16.0
		AWGN	2334 Hz	-17.1
		TDLC300-100 Low	0 Hz	-15.4

Table 93: PRACH missed detection requirements for high speed train, 15 kHz SCS

# Tx ant.	# Rx ant.	Propagation conditions and correlation matrix	Frequency offset	SNR (dB)		
				Burst format A2	Burst format B4	Burst format C2
1	2	AWGN	1740 Hz	-11.0	-14.0	-10.8
	4	AWGN	1740 Hz	-13.2	-16.4	-13.1
	8	AWGN	1740 Hz	-15.3	-17.9	-15.2

Table 94: PRACH missed detection requirements for high speed train, 30 kHz SCS

# Tx ant.	# Rx ant.	Propagation conditions and correlation matrix	Frequency offset	SNR (dB)		
				Burst format A2	Burst format B4	Burst format C2
1	2	AWGN	3334 Hz	-10.9	-14.3	-10.7
	4	AWGN	3334 Hz	-13.1	-16.4	-13.1
	8	AWGN	3334 Hz	-15.1	-18.1	-15.1

Test setup

The test setup can be found in Figure 16 to Figure 18.

Settings

► Set the base station to the basic state (see chapter 3.5)

► The SMW (and the SGTs) are generating the required test signals

► The signal generator(s) start(s) signal generation when a start trigger impulse from the base station is received

► The base station calculates the results internally

Manual testing procedure

1. Open the test case wizard*
2. Select base station class*
3. Select test "8.4.1 PRACH false alarm probability and missed detection"*
4. Set the test parameters in the different tabs of the test case wizard*
5. Switch RF A and RF B on

*More information can be found in 3.3

SCPI commands sequence

```
:BB:NR5G:TCW:BSCLass <BSClass>
:BB:NR5G:TCW:TC TS381411_TC841
:BB:NR5G:TCW:TRIGgerconfig <TrigConfig>
:BB:NR5G:TCW:MARKerconfig <MarkerConfig>
:BB:NR5G:TCW:ANT:RXANtennas <RxAntennas>
:BB:NR5G:TCW:WS:MODE <Mode>
:BB:NR5G:TCW:WS:RFFRequency <WSRFFreq>
:BB:NR5G:TCW:WS:CBW <WSChBw>
:BB:NR5G:TCW:WS:SCSPacing <WSSubCarSpacing>
:BB:NR5G:TCW:WS:PRACh:FORMat <Format>
:BB:NR5G:TCW:WS:PRACh:SCSPacing <PRACH SCS>
:BB:NR5G:TCW:WS:CELLid <WSCellId>
:BB:NR5G:TCW:WS:UEID <WSUeId>
:BB:NR5G:TCW:WS:FROFfset <Offset>
:BB:NR5G:TCW:WS:PROCondition <Condition>
:BB:NR5G:TCW:WS:TAPos <WSTypeAPos>
:BB:NR5G:TCW:APPLy
:OUTPut1:STATe 1
:OUTPut2:STATe 1
```

Python module

GFM315_Px_test/TCs/TC_8_4_1.py

More information about Python modules can be found in A.

4 Literature

[1] Rohde & Schwarz, 5G NR Technology Introduction, 2019.

[2] 3GPP Technical Specification Group Radio Access Network, „NR Base Station (BS) radio transmission and reception, Release 16; TS 38.104, V16.7.0,“ 2021. [Online]. Available: https://www.3gpp.org/DynaReport/38104.htm.

[3] 3GPP Technical Specification Group Radio Access Network, „NR User Equipment (UE) radio transmission and reception, TS 38.101-1, Release 15, V. 0.0.1,“ 2019. [Online]. Available: https://www.3gpp.org/DynaReport/38101-1.htm.

[4] 3GPP Technical Specification Group Radio Access Network, „NR Base Station (BS) conformance testing Part 2: Radiated conformance testing, Release 15; TS 38.141-2 V.15.4.0,“ 2020. [Online]. Available: https://www.3gpp.org/DynaReport/38141-2.htm.

[5] 3GPP Technical Specification Group Radio Access Network, „NR Base station conformance testing, Part 1: Conducted conformance testing, Release 16; TS 38.141-1, V16.7.0,“ 2021. [Online]. Available: https://www.3gpp.org/DynaReport/38141-1.htm.

[6] Rohde & Schwarz, „Remote Control and Instrument Drivers,“ [Online]. Available: https://www.rohde-schwarz.com/de/driver-pages/fernsteuerung/uebersicht_110753.html.

[7] Rohde & Schwarz, „Introducing SCPI Commands,“ [Online]. Available: https://www.rohde-schwarz.com/de/driver-pages/fernsteuerung/remote-programming-environments_231250.html.

5 Ordering Information

Type	Designation	Order No.
R&S®SMW200A	Vector signal generator	1412.0000.02
R&S®SMW-B1007	Frequency range: 100 kHz to 7 GHz, RF path A	1428.7700.02
R&S®SMW-B2007	Frequency range: 100 kHz to 7 GHz, RF path B	1428.7900.02
R&S®SMW-B13T	Baseband main module, two I/Q paths to RF section	1413.3003.02
R&S®SMW-B13XT	Wideband baseband main module, two I/Q paths to RF	1413.8005.02
R&S®SMW-B9 or **R&S®SMW-B10**	Wideband baseband generator, 500 MHz, 256 MS Baseband generator with realtime coder and ARB (64 MS), 120 MHz RF bandwidth	1413.7350.02 1413.1200.02
R&S®SMW-B14	Fading simulator	1413.1500.02
R&S®SMW-B15	Fading simulator and signal processor	1414.4710.02
R&S®SMW-K62	Additional white Gaussian noise	1413.3484.02
R&S®SMW-K71	Dynamic fading	1413.3532.02
R&S®SMW-K74	MIMO fading and routing	1413.3632.02
R&S®SMW-K144	5G New Radio	1414.4990.02
R&S®SMW-K145	5G NR Closed-Loop BS Test	1414.6506.02
R&S®SMW-K18 or **R&S®SMW-K19**	Digital baseband output Digital Baseband Output for SMW Wideband BB	1413.3432.02 1414.3865.02
R&S®SGT100A	Signal generator	1419.4501.02
R&S®SGT-KB106	Frequency extension 6GHz (SL)	1419.5708.02
R&S®SGT-K18	Digital baseband connectivity (SL)	1419.6240.02

6 Appendix

A GFM315_Px_tests Python package

This Python library is providing chapter 8 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, and making extensive use of the Test Case Wizard (TCW) of the RF generator used, the time for searching and testing correct SCPI sequences shall be reduced tremendously.

Another benefit of the lately introduced TCW is that parameters not explicitly specified are using correct default values that are compliant with the specification.

However, for invalid parameters that are not in conformance with the specifications an error handling procedure will be triggered and a detailed exception message will be available.

A.1 Terms and conditions

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

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: https://pypi.org/project/RsInstrument/
  - Further details: How to install / update RsInstrument package

For further reading

Please see the Getting Started remote control example using Python in PyCharm.

A.3 Package structure

Figure 28: Project tree in PyCharm

A.4 Example_Px_tests.py

The provided `Example_Px_tests.py` file shows the usage of this Python library for 5G NR base station performance tests.

```python
from GFM315_Px_tests import *

resource_string_1 = 'TCPIP::192.168.0.100::hislip0'  # Hi-Speed LAN connection - see 1MA208
resource_string_2 = 'TCPIP::192.168.0.100::INSTR'  # VXI-11 connection
resource_string_3 = 'USB::0x0AAD::0x0119::022019943::INSTR'  # USB-TMC (Test and Measurement Class)

try:
    # Initialization
    mytest821 = TC821(resource_string_1)
    # Set some test specific parameters
    mytest821.channel_bw = 10
    mytest821.mapping_type = 'A'
    # Apply signal configuration
    mytest821.apply_configuration()
    # Switching on the two RF ports
    mytest821.output_on(1)
    mytest821.output_on(2)
    # Close the connection
    mytest821.close()
except RsException as e:
    print(e.args[0])
else:
    print('Test execution successful')
```

Figure 29: Example_Px_tests.py

A.4.1 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.

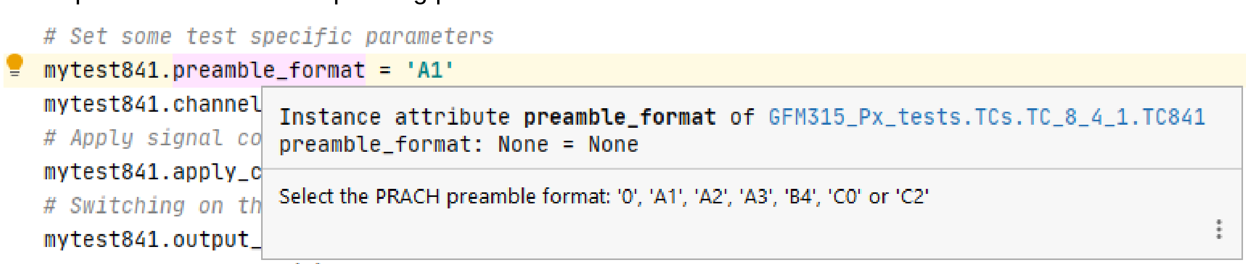


Figure 30: Quick Documentation

A.4.2 K-Options Availability Check

Whenever a test case is executed, the RF generator is queried for the list of installed options per default. If the minimum software options requirements are not met, the execution of the test case is aborted and a detailed exception message is returned.

Please note: at current only the K-options for meeting the minimum test requirements (e.g. the basic antenna configuration of one Tx/Rx antenna) are checked. Extended test setups that may require additional options are out of scope of this K-options availability check.

B Abbreviations

Table 95: Abbreviations

Abbreviation	Description
5G NR	5G New Radio
ACK	Acknowledgement
ACS	Adjacent channel selectivity
AWGN	Additive white gaussian noise
BLER	Block error rate
BS	Base station
CA	Carrier aggregation
CSI	Channel status information
DM-RS	Demodulation reference signal
DTX	Discontinuous transmission
DUT	Device under test
EPRE	Energy per resource element
FDD	Frequency division duplex
FR1	Frequency range 1
FRC	Fixed reference channel
HARQ	Hybrid automatic repeat request
MIMO	Multiple input multiple output
NACK	Negative acknowledgement
OBUE	Operating band unwanted emissions
OTA	Over the air
PDSCH	Physical downlink shared channel
PRACH	Physical random access channel
P_{rat}	Rated output power
PRB	Physical resource block
PUCCH	Physical uplink control channel
PUSCH	Physical uplink shared channel
Px-	Performance-
RB	Resource block
RBW	Resolution bandwidth
RF	Radio frequency

RI	Rank indicator
RIB	Radiated interface boundary
RS	Reference signal
Rx-	Receiver-
SC	Single carrier
SCS	Subcarrier spacing
SNR	Signal-to-noise ratio
SSB	Synchronization signal block
TAB	Transceiver array boundary
TAE	Time alignment error
TDD	Time division duplex
TM	Test model
TPMI	Transmitted precoding matrix indicator
Tx-	Transmitter-
UCI	Uplink control information
UE	User equipment
VSWR	Voltage standing wave ratio

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